FROM DEMAND-DRIVEN SUPPLY TOWARDS SUPPLY-DRIVEN DEMAND IN CONSTRUCTION: A “LIVING BUILDING” EXPERIMENT

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ABSTRACT: The “living building” concept presented in this paper is a new approach to life cycle management of built services. The concept represents an adaptable approach that respects the fact that the function and circumstances of built services change faster than the building itself. This is in full contrast to the traditional building paradigm and current practice, which are based on a static approach to the performance of buildings. In traditional practice the demand is fixed at the start of a project and supply is only mobilised to meet the initially established requirements. This is demand driven supply which results in supply of standard products and prevents innovation. The “living building” concept aims to involve all parties in the delivery and use of buildings to deal adequately with changing technology, changing regulations and changing demands throughout the entire life cycle of buildings. Basically the whole life cycle of a built object can be managed and optimised by quantifying and interconnecting the time dependent variables value, costs and price. Application of the “living building” concept would potentially reduce risks and transaction costs substantially. In order to do so the concept must form the basis for life cycle contracts. Recently an experiment has started with a long-term DBMO contract for a new school in Veenendaal in The Netherlands. The budget is 17 million Euro. This paper describes the specific problems encountered in this case with performance measurement and making the actual performance reimbursable.

Keywords: best value, dynamic control, life cycle value, total cost reduction, benefit optimisation.

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.

This paper presents the “living building” concept as a conceptual solution to these problems. The concept is representing a further development of the concept of dynamic control that was introduced by the authors in previous papers (De Ridder & Vrijhoef 2003, 2004, 2005). The concept is based on the essential notion that the world is changing.

Secondly 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 a long time, and the life cycles of built services are lengthy. 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 over time. 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. PURPOSE OF THE “LIVING BUILDING” CONCEPT IN CONSTRUCTION

The rationale of the “living building” concept is based on two underlying problems in construction: perception and process statics. These problems are caused by the fact that the first demand is basically always incorrect or incomplete, because it is impossible to demand before knowing what is available and possible. Supply without knowing at a basic level what is wanted is impossible also. So demand and supply are intrinsically connected, and this should be reflected in the process towards delivery of any product such as built services. However in current construction practice, this is often not the case. Demand and supply are relatively disconnected. This is basically the result of the tension between value and costs, and thus between the client’s interest in added value versus the supplier’s interest in profit.

The expectations what is a successful project are often subjective, implicit and contradictory. For many reasons there is always a need for some kind of change during the 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, parallel involvement of multiple parties, and the absence of one party who has complete overview and authority. However this depends on the procurement strategy and the contract type. The “natural response” in construction has been 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 this kind of fragmented and delegated control, and long demand and supply chains, changes come often too late to be effectively and systematically dealt with. Change orders often take lots of effort to follow up leading to extensive amounts of rework or claims (Othman et al. 2004).

The problems of perception and process statics and the paradox between static control and dynamics of construction life cycles call for a dynamic and comprehensive approach to the demand and supply of built facilities, aimed at systematic and adaptive optimisation of the total life cycle benefit (total value minus total costs). When the total value could be interconnected qualitatively and quantitatively to the total costs of a built service, and parties agree on the algorithm between value and costs, then demanding and supplying parties collaboratively are able to deliver the highest possible benefit to the mutual advantage of both demanding and supplying parties (figure 1).

![Fig. 1. Basic transaction model; value, price and costs](image)

Instead of enforcing the initial planned performance against a fixed price calculated in the first phase of the project, the price is based on the actually delivered performance at the end of the project. The final price goes up to the initially set maximum guaranteed price, not exceeding the planned budget of the client. The range between initial price and maximum budget is the client’s “control budget” for dealing with problems of perception and additional value to be delivered during the process. In addition, the contractor is able to reserve budget for investments to reduce costs or increase value (figure 2). This approach can be defined for the project only, but can be extended to the whole life, and can be applied 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

Particularly in the public sector many clients have fixed and restrictive budgets, and public projects are subjected to investigation by government agencies to assure value for money, control over public funds and public interest in general. In the “living building” concept the client’s budget, public or private, is always higher than the price and includes a buffer for dynamic control by the client. The supplier (e.g. contractor) sets an initial price for the basic solution and the alternative scenarios. The buffer between the budget and the price is used for unforeseen changes; 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. This process can be capped, e.g. by means of a guaranteed maximum price, which in this case equals the budget set in an earlier stage. Similar concepts of target price, guaranteed maximum price, and budget allowance for extra risks and changes have been introduced previously (e.g. Boukendour & Bah 2001, Cain 2003).

Hence the lowest price is not necessarily the client’s main selection criterion and driver. Rather it is necessary to realise that the price 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.) (Wong et al. 2000). 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 (Hatush & Skitmore 1997). 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 (Kumaraswamy & Dissanayaka 1998). 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” (Luu et al. 2003).

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 (Abrahams & Farrell 2003). In a dynamic approach, the client will not put a lot of effort in a complete formulation of the demand and fixation of the price in an early phase of the project, but rather starts with three basic boundary conditions, defining the “procurement space” for an adequate solution to be delivered by the contractor (figure 3):

- a demand strategy showing the positive difference between value and price,
- a maximum price the Client is willing to pay for the basic scenario to be delivered over the lifetime required,
- a minimal required value with associated set of minimum requirements.

![Procurement strategy leading to a “procurement space”](image)

**Fig. 3. Procurement strategy leading to a “procurement space”**

### 3.2 Supply Strategy

Most supply strategies in construction are restricted to project delivery only. Few advanced supply strategies are 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 (Thomson et al. 2003). In general, the “living building” concept requires the industry to move
from a delivery system within a price-based environment towards higher level of performance-based competition (Parmar et al. 2004).

Industry partners must adopt the use of integrated value delivery to facilitate collaborative working to resolve current industry inadequacies regarding design, construction and facility management (Austin & Thomson 1999). 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 (Kelly & Male 2001). Therefore, contractors and other suppliers in construction must develop and improve their marketing strategies, their costing capabilities and their financial risk management (Xu & Tiong 2001). This must result in advanced supply strategies assuring the positive balance between price and costs. Figure 4 shows two different strategies, with the margin between price and costs (profit) as the discriminating selection factor. The supply strategy of the contractor organisation is based on the risk/profit balance it follows on a company level.

![Fig. 4: Two alternative supply strategies](image)

3.3 Integrated Strategy

Different project strategies can be defined as a function of various variables such as type of project, type of client, context, etc. In figure 5 two different supply scenarios are sketched: (1) a “maximum risk” supply strategy as consequence of an eager approach resulting in a “sharp” proposal with a large value price ratio and (2) a “minimum risk” supply strategy as consequence of a reluctant approach resulting in a “safe” proposal with a satisfying value price ratio.
3.4 Contractor Selection

Having defined the supply space, each competitor is able to submit his specific proposal. Each proposal consists of a system (built object) provided with associated system specifications. The set system specifications represent the value of the system. In this way it is easy for the client to select a supplier. The first check is whether the system specifications exceed the minimum requirements. The second check is to establish the value price ratio, which is reflected by the angle alpha in figure 6. The supplier with lowest alpha wins the contract.
### 3.5 Performance Contracting

The contract is based on a value-price relation. The actual value is an important variable and will be measured during the contractual period. With the relation between value and price agreed upon at the start of the project, the price changes automatically after a limited deviation of the actual required value related to the initially defined value. Larger deviations require a revision of the contract. In extreme situations such revisions can also be used to start a new tender procedure in order to collect new biddings.

Measuring value can be relatively easy. The supplier must give the key indicators for the value of the building such as floor space, electric power capacities, energy consumption and indoor climate. Also other indicators may be considered such as time of completion as early completion of building leading to earlier occupation may have financial and non-financial benefits. These indicators are used for establishing the initially required value in the basic scenario. The actually required value after a change of scenario must be established with the same algorithm and compared to the initially required value.

The ultimate goal is to find the best solution for clients and other stakeholders, as well as for the contractor and suppliers. This implies finding the best value for the client and stakeholders at minimum costs for the contractor and suppliers. 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 (Leung & Liu 2003). 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” (Kashiwagi & Khiyara 2002).

The main principle is to measure the delivered value and to establish the corresponding price. This relation is not only valid in the initial design made by the supplier but also in the adjacent area (contract scope) (Figure 7). This area is proposed to be 20 % deviation from the initial design in both the value dimension as well as the price dimension. The value can be measured by the actual set of system specifications at the highest possible abstraction level thus representing the behaviour of the system.
3.6 Integrated Process

The “living building” concept must result in an integrated approach to the design, construction, facility management and use of built facilities. Based on the awareness that perception and increasing knowledge will influence and affect demand as well as the possible solutions during the process, clients and suppliers must team up to develop and deliver the built service, based on a common understanding of the demanded value, possible solutions, and balance value, costs and price dynamically. Both clients and suppliers are no single entities, but often complex configurations of stakeholders, with different value assumptions and interests, 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 (i.e. demand) and deliver best value (i.e. supply) (Newcombe 2003).

The essence of this is the continuous measurement of the changing value in time and the fixed relation between value and price, which implies that the price is also a changing variable. The client will get the desired “value for money” and the supplier will get the “money for value”. The supplier’s profit and risk is covered by taking the initial value-price-cost offer as starting point for the dynamic control. Hence, the relations between value price and costs remain unchanged whereas the value, price and costs are subject of change. The value equals the aggregated performance system of performance aspects (Figure 8). Performance aspect representing the value include: capacity, energy consumption, climate, strength, stability etc. of a building. The total value can be calculated by considering the aspect systems as dimensionless vectors, which in fact is the only way to add up items with different dimensions. This method can be used because the measurement of actual value is relative with respect to the starting point. Hence it is easy to measure the
actual value at any time in the lifecycle and pay the price for it. The performance system representing the value desired by the client equals the set of specifications of the elements plus the set of specifications of the relations between all elements. It is evident that the total set of relations is the basis to measure the total value.

![Diagram](image)

**Fig. 8. Relating performance and object system**

### 4. “LIVING BUILDING” EXPERIMENT: SCHOOL BUILDING

Recently a “living building” experiment has been started in the Netherlands. The experiment includes a dynamically controlled DBMO contract for a new school building in the city of Veenendaal in the Netherlands. The budget is 17 million Euro. The application of the “living building” concept has encountered specific problems with the performance measurement and the way to make the actual performance reimbursable. The first task was to make an appropriate procedure in order to select and contract a contractor according to the principles of “living building”. In addition, the procedure had to comply with European regulations. Next, a process had to be designed that allowed dynamic control.

The starting point for the school is a preliminary design which represents the present insight in running the school, both in functions as well as processes. The demanding party will give insight in a few possible scenarios, which can be helpful for suppliers in order to make a design which is adaptive in a high rate against low costs. At the moment two scenario’s have been considered: (1) a functional scenario in which the building is portioned in a large number of rooms, which can be used autonomously with respect to the function, climate and energy consumption, (2) a technical scenario in which the installations (electrical, water supply, climate, waste water capacity, etc) will be changed significantly. In addition, the architecture of the school building is fixed at the start. Suppliers are invited to:

- present a school at one scale level lower than the preliminary design
- give an initial price for their delivery
- to specify the aspect systems on which the value will be measured

It is noted that the final formation of performance aspect systems and the way they will be measured is subject to contract negotiations, which take
place after contract awarding. These aspect systems play an important role as they must reflect both the client’s interests in the facility, as well as the contractor’s and suppliers’ cost profile in an acceptable way. It should be noted that a correct way is not possible, as value and even price and even costs can be measured in many different ways. The costs of the transformation itself are incorporated in the lifecycle costs and thus the price to be paid for the total facility. However, an extra amount of money will always be charged in order to avoid too frequent changes. In that way a threshold will be built in.

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 resolves 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 the involvement of parties through the life cycle imply a great endeavour for clients as well as contractors.

The main advantage of the dynamic approach is that an agreement between client and supplier/provider, focussing on measuring the value against price under fast changing circumstances, gives both parties opportunities. The client can easily adapt his facility to new demands, changing regulations, changing circumstances, new education systems etc. The supplier is able to introduce new technologies, new materials, new concepts etc. during the contractual period and will be awarded in a corresponding way. However, the client will always be deciding about new solutions proposed by the supplier/contractor, and these must comply with the performance contract, and always lead to more value than costs. In addition, the decision making is easier and more adequate compared to the current practice in which scope and price are mostly fixed at the start against high transaction costs. Often this leads to tension between the contractor and the client in order to keep the building adequate against acceptable costs. In current practice most contracts start with a fixed price against fixed quality within a fixed timescale, and often end with cost and time overrun, and often lots of waste and quality problems too. By contrast, the “living building” concept starts open and ends with a target price within the budget, by means of an open process where client and contractor are equal partners, interacting based on clear agreed-upon rules about the measurement of value and costs, and the establishment of a corresponding price as a result.
6. REFERENCES


Kelly, J. and Male, S. (2001) A value management approach to aligning the team to the client's value system, Proceedings COBRA.


