Breaking through Business and Legal Barriers of Open Collaborative Processes based on Building Information Modelling (BIM)

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Abstract

The involvement of various parties is inevitable due to the increasing complexity of modern building projects. In order to achieve life-cycle sustainability, open integration of information and know-how across different building phases and knowledge disciplines becomes very important. Open collaboration within the project organization requires integrated collaboration frameworks and tools. To a considerable extent, such a need can be met by the state-of-the-art Building Information Modelling (BIM). Unfortunately, there remain significant business and legal barriers. In contrary to the vision of an open and neutral BIM, conflicts of interests (e.g. providing and sharing knowledge) and local constraints can not entirely be avoided in a project organisation. The existing integrated procurement methods have not sufficiently addressed the key issues of open collaborative processes using BIM, such as: the changing roles and responsibilities of the stakeholders, the demand for new roles like a model manager, the legal status of the model and shared information, the new distribution of risks, and the performance-based commissioning and payment schemes. This paper aims at introducing an innovative process management approach to break through the business and legal barriers of open collaboration using BIM. As a research paper, the knowledge is partly based on InPro, an ongoing collaborative R&D project co-funded by the European Commission. A field survey among various stakeholders in Finland, France, Germany, Sweden, Slovenia, and the Netherlands was conducted to define the market viewpoint and current practice experience. The findings from both field and literature surveys are analysed to identify the business and legal issues of BIM in construction projects. A critical review over the existing BIM guidelines is presented. Subsequently, a new approach for BIM-wise process management is proposed together with the relevant business concept and take-up strategy. Finally, the necessary contractual terms for implementation and the direction for future research are discussed.

Keywords: BIM, open collaboration, process management, business concepts, legal issues
1. Introduction

The technical and organisational complexities of a sustainable building project have increased significantly (Sebastian, 2007). Technically, a sustainable building has to meet much higher performance, durability, health, comfort, safety, user-friendliness, and environmental standards. The building also contains various equipments for building automation, makes use of new building materials and construction techniques, and aims to function more effectively with less energy consumption. Organisationally, the building project involves many stakeholders, including: multiple clients and end-users; multidisciplinary advisory, design and engineering teams; numerous construction companies, specialist contractors and suppliers. The way to collaborate between these stakeholders is a subject to the decision on many possible procurement and contractual arrangements.

In order to deal with the increasing complexities, process management was introduced to complement project management. The project management’s mission is to lead a building project on a clear path towards the achievement of the predefined objective. Project management focuses on three main aspects, i.e. quality, cost and time (Wijnen et al., 1993). Consistent with these three aspects, project management aims at delivering a building that meets the previously set quality level within the budget and the planned duration.

Process management deals with processes beyond the limited project boundaries. It operates before project management begins (i.e. before the project definition) and continues throughout and beyond all stages of the project. Process management focuses on two main aspects, namely: information (knowledge) and organisation (collaboration). With regards to these two aspects, process management aims at establishing strategies for collaboration, managing communication, and decision-making among the stakeholders. Based on comprehensive considerations, process management prepares and shapes the path –the project stages, interconnections between global and specific objectives, and involvement of stakeholders– on which project management leads the project through (Allinson, 1997).

For managing complex collaboration and communication processes, integrated collaboration framework and tools are needed. To a considerable extent, such a need can be met by the state-of-the-art Building Information Modelling (BIM). BIM is widely known as an intelligent building model that is able to contain the information and process throughout the life-cycle of a building (NIBS, 2007). Next to the intelligent building model, BIM also comprises a new model-based framework for multidisciplinary collaboration.

At present, BIM has become one of the most important innovations in managing building projects. The technological development of BIM has been advancing rapidly. Open standards, rules, object libraries, and formats, such as: IFC (Industry Foundation Classes), CIS/2 (CIMSteel Integration Standards), IDM (Information Delivery Manual), IFD Library (International Framework for Dictionaries Library), and MVD (Model View Definitions), are being relentlessly improved and more and more software applications support the users to work with BIM (Erabuild, 2008). Although certain technical limitations and R&D problems still exist, and a 100% compatibility and
interoperability level has not yet been achieved, the state-of-the-art of BIM knowledge and technologies makes it possible to deploy BIM in practice.

Despite a sufficient degree of technological readiness, large-scale utilisation of BIM in the building industry has not yet taken place due to existing business and legal barriers. Although BIM is often intended to be open and neutral, conflict of interests and local constraints cannot entirely be avoided in a project organisation. A project-based collaboration is usually shaped after a procurement process and formalized in a contract for a single project. Sharing knowledge openly and neutrally within the context of a one-off project may become disadvantageous for a stakeholder which would not involve in the next projects. In contrary to the universal character of the technology, the local influence at the project level is still strong as methods of procurement and contracting strongly differ between countries. The existing procurement methods have not sufficiently addressed the key issues of open collaboration using BIM, such as: the changing roles and responsibilities of the stakeholders, the demand for a new role such as a model manager, the legal status of the model and shared information, the new distribution of risks, the new collaboration framework, and the performance-based commissioning and payment schemes.

This paper aims at introducing an innovative process management approach to break through the business and legal barriers of open collaboration using BIM. As a research paper, the knowledge is partly based on InPro, an ongoing collaborative R&D project co-funded by the European Commission. A field survey among various stakeholders in Finland, France, Germany, Sweden, Slovenia, and the Netherlands was conducted to define the market viewpoint and current practice experience. The findings from both field and literature surveys are analysed to identify the business and legal issues of BIM in construction projects. A critical review over the existing BIM guidelines is presented. Subsequently, a new approach for BIM-wise process management is proposed together with the relevant business concept and take-up strategy. Finally, the necessary contractual terms for implementation and the direction for future research are discussed.

2. Business and legal issues of using BIM in construction projects

2.1 How does BIM differ from CAD?

BIM is not the same as the well-known Computer Aided Design (CAD) technology. BIM goes further than a tool to generate digital (2D or 3D) drawings. BIM is qualitatively different from CAD because it is not just a depiction, but it is an object-based definition of the facility. The information maintained in a BIM also differs from the level and type of information maintained by CAD (Ashcraft, 2008). In most CAD applications, a building element, for example a wall, is an assemblage of lines that define the geometric constraints of the wall. In BIM, the wall is an object that contains a broad array of information in addition to the geometry or physical shape. Rather than draw lines that describe dimensions of a design, with BIM designers organise intelligent objects into a design. There is a degree of design analysis as well, so BIM is not simply design documentation (London et al.,
BIM can extend beyond the embedded information of object-oriented models. BIM enhances the Data Management System (DMS) as all relevant information is appended and linked to the central model.

Thus, BIM is an integrated framework and a comprehensive tool by which all process and product information is combined, stored, elaborated, and interactively distributed to all relevant stakeholders (Sebastian and Haak, 2009). As a centralised model for all stakeholders in all building phases, BIM develops and evolves as the project progresses. It is meant to be a living model that can be used during the planning, design, construction, and operation of a building. Using BIM, the proposed design and engineering solutions can be measured against the client’s requirements and expected building performance. The functionalities of BIM to support the design process are multidimensional (nD), including: three-dimensional visualisation and detailing, clash detection, material schedule, planning, cost estimate, production and logistic information, and as-built documents. During the construction process, BIM can support the communication between the building site, the factory and the design office – which is crucial for an effective and efficient prefabrication and assembly processes, as well as to prevent or solve problems related to unforeseen errors or modifications.

When the building is in use, BIM is also a repository of data for facility management. BIM can be used in combination with the intelligent building systems to provide and maintain up-to-date information of the building performance and the life-cycle cost.

BIM is not simply CAD on steroids as it also serves as a framework for collaboration (Ashcraft, 2008; InPro D16, 2009). BIM is a means for integration between the ICT and business aspects of collaboration. Its essence lies in the collaboration and communication between the stakeholders (Böhms, 2008). The different facets of integration through BIM are illustrated in Figure 1.

![Figure 1: Integration facets through BIM as a framework for collaboration (Böhms, 2008)](image-url)
2.2 Observation of the barriers of BIM implementation from the business and legal viewpoints

Having learned the new possibilities offered by BIM, certain benefits through BIM implementation in a building project can be expected, such as:

- consistent information resulting from the integration of all data in a centralised model;
- efficient and fast design and engineering, as drawing, analysing, verifying and decision-making are done through simultaneous processes involving all disciplines;
- efficient planning and production based on accurate quantity estimation and coordination;
- high quality buildings due to the elimination of design errors;
- sustainable solutions through continuous validation of the design alternatives against the client requirements; and
- effective facility management using the data contained in the model for managing, remodelling, and maintaining the building over time.

However, there remain many barriers for an optimal implementation of BIM in practice. Ashcraft (2008), Chao-Duivis (2009), Eastman et al. (2008), and InPro D9b (2009) comprehensively observed the actual and potential barriers for BIM from the business and legal viewpoints. The identified barriers can be categorised into five main issues, namely:

- the lack of immediate benefits of BIM for the stakeholders;
- the changing roles, responsibilities and payment arrangements;
- the uncertainty of the legal status and intellectual property of the model;
- the inadequacy of the existing contractual frameworks, including the agreements on liability and risk allocation;
- the lack of consensus on the protection of information in conversion and interoperability, and against loss and misuse of data.

Despite the knowledge of the sustainable benefits of BIM, many concerns remain regarding the immediate benefits of BIM for the client, designer, engineer, and contractor. Based on a reflection on several real cases of complex building projects in the Netherlands, Sebastian (2009) found that most clients struggled to translate their ambition and objective of BIM into effective project implementation strategies, both within their own organisations and in the relationships with the other stakeholders from the building supply-chain. Many clients ask costly advice from renowned business
consultants only to discover that there is still a gap between the business and technology, as well as between the management and operational levels. The decisions on ICT solutions for BIM are often not adequately grounded on the business strategy. In contrary to the ambition to endorse a life-cycle strategy to manage the facility effectively and efficiently, traditional procurement that reflects a fragmented approach is still largely used. The contractual limitations of the roles and responsibilities of the building parties in the traditional procurement method hinder the optimal implementation of an integrated collaboration.

Designers and engineers, even more than the clients, must adopt and invest in the new technology. However, for many designers and engineers, BIM’s immediate benefits are less apparent (Ashcraft, 2008). If properly implemented, BIM should increase the efficiency by reducing duplicative and potentially inconsistent data entry. Multiple-use of consistent data and the ability to quickly explore design alternatives also promote efficiency and improved quality. In order to offer BIM based services, design and engineering firms must adopt the new technology, install the advanced software, train their employees, and champion BIM use. They need to restructure their workflows and reinvent the design processes. The asymmetrical rewards for their investment are a limited share and the relatively short-time involvement of designers and engineers in the building project, which makes it impossible to release the full benefits of BIM.

Contractors can also benefit from BIM through less coordination and engineering effort and reduced fabrication costs. If the quality is increased, the cost decreased, and the delivery time is shortened, the contractor can make an agreement on a bonus payment with the client. However, one of the main concerns is how to get an early involvement in the design and engineering stages instead of just constructing the design against the lowest possible price as agreed through a traditional tender procedure. Another concern is the often difficult and costly adoption of BIM approach in the wide-range of the workflows and construction labourer groups within the company and with the subcontractors and suppliers.

Collaborating BIM-wise requires restructuring of the order of activities and redistribution of the roles and responsibilities of stakeholders. Up to now there is a lack of clarity over the changing roles and responsibilities. Among the most debated questions are: Is the architect still the leading designer in the integrated design and engineering? Who is in charge of the total quality of the design? Who assures that all interface problems (clashes) are solved and that the model is full-proof? Which new agreements on responsibilities and input-output workflows should be made if every discipline is involved almost simultaneously in the process? Since a new role of model manager has come to place, what are the general and specific tasks of the model manager with respect to the project manager and the process manager?

Collaborating BIM-wise leads to a shift of activities from the later stages to the early-design stage. Much, if not all, activities in detailed-design, engineering and quantity specification stages will be done in the earlier stages. It means that designers and engineers can no longer expect a significant proportion of the payment in the detailed-design, engineering and quantity-specification stages – which traditionally count up to 40% of the total design fees (Chao-Duivis, 2009). Moreover, as
engineering and quality-control work is done concurrently with design, a new proportion of fee and a new payment arrangement in the design stage come into force.

The next factor that hinders a wide-scaled use of BIM in a building project is the legal status and intellectual property of the model. Can the model serve as a legal contract document? At present, most building information models do not contain all of the construction details required for a project. Thus, the contract documents need to include some information based on 2D documents to complement in the building information model. Next to this problem, many building permit-issuing agencies are not yet ready to review digital information and require paper-based submissions (Ashcraft, 2008). The other question is: Given that the model is an inherently collaborative work, to what extent can anyone claim ownership of the intellectual property? If the model is a collaborative work, then ownership may not be vested in a single party. Nevertheless, Chao-Duivis (2009) argues that considering the model as a combined work, the intellectual property right (IPR) is similar to those of the conventional teamwork. Although it seems to be a fully-integrated design, the model is actually resulted from a combination of works/elements, for instance: the outline of the building design is created by the architect the design for the electrical system is created by the electrical contractor. In terms of a combined work, the IPR of each element rests with its creator. However, due to the large amount of information and complex work processes, such a model-server with an automatic authorship registration function is needed to be able to keep track of the IPR in BIM.

Some questions remain regarding the required legal and regulatory framework, which addresses the coverage on liability and the allocation of risks, e.g. Are there any regulatory impediments to BIM Standards proceeding? What new regulation needs to be put in place? Who is liable for the information in the digital model? How are the users protected? Currently no BIM specific legal framework exists, except for the national BIM standards for project development recently introduced in Finland, Norway, Denmark, and USA (CIE, 2009).

Deciding on the type of standard contract for BIM-wise collaboration is another important legal issue. There is a wide range of forms of contract to meet the diverse needs of the collaboration in the building projects. In the UK, the Joint Contract Tribunal (JCT) makes a distinction between the traditional contract forms and integrated ones, i.e. design-and-build, management, and partnering, and provides a comprehensive description and some guidelines to select the most appropriate type of contract in relation to the procurement methods (JCT, 2007). However, the standard contract forms are country-specific, and the terms for BIM based projects are very limitedly addressed; for instance, in the latest version of the Uniform Administrative Terms for Integrated Contracting in the Netherlands, only a brief note on life-cycle approach has been added (CROW, 2005). Does a BIM based project always require an alliance contract? Eastman et al. (2008) and Chao-Duivis (2009) state that there is no obligation to adopt an alliance or integrated contract for a BIM based project. However, if the stakeholders intend to achieve an open collaboration, they should opt for an integrated contract. In any case, BIM-wise collaboration requires a changing use, new interpretations and reformulated clauses of any type of contract.

The protection of information in conversion and interoperability, and against loss and misuse of data is a legal issue that is strongly related to the technical capability of BIM. There are many
international norms, standards and agreements available for use of data management; however, in most cases the protection of information is attached to the contractual frameworks which are country-specific. What needed is an agreement on the standard of care and possible conflict resolution on data management as an integral part of the contract.

2.3 Findings from field surveys in Europe

Before a novel business concept and legal framework for BIM-wise collaboration can be defined, the knowledge of the current situation in the building industry is essential. Within the InPro research project, a European survey was conducted (InPro D9a, 2009). The main surveys were carried out in four countries, i.e. Germany, France, Sweden, and Finland. Additionally, a minor inquiry was conducted in the Netherlands. The survey was done by using a questionnaire distributed among the key stakeholders of building projects, i.e. clients, architects, specialist designers, engineers, contractors, project managers, and model managers. The main findings of the field survey can be summarised as follows.

- The concept of BIM-wise collaboration is well known, but most respondents have little experience of its application.

- The advantages of a BIM-wise collaboration are known and evident in the recent BIM based projects (e.g. 3D visualisation, clash detections, energy simulations, determination of volumes and masses, minimising risks). However, the achieved project success up to now has strongly been dependent to a few qualified teams with sufficient competencies and experience.

- In most cases, the existing organisational structures and project approach are not adequate to support BIM-wise collaboration. The new role of model manager is important, but need to be clearly formulated.

- Partnering is seen as the appropriate type of procurement for BIM-wise collaboration.

The survey findings show the high market potential for BIM based projects in Europe. However, incompetence due to the lack of know-how and past experience, and uncertainty due to the lack insight in possible new risks are weighing down the decision to fully release the capacity of BIM in building projects.

3. Existing BIM guidelines for building projects

Currently there are many initiatives across the globe to develop guidelines for deploying BIM in building projects. Several initiatives which are most referred to and have been accepted in the practice to a certain extent are: the National Building Information Modeling Standard (NBIMS) by NIBS (2007) from United States, the Integrated Project Delivery (IPD) by IAI (2007) from United
States, the BIM Requirements by Senate Properties (2007) from Finland, and the open standards developments by BuildingSMART International Alliance for Interoperability (described by Böhms, 2008; Erabuild, 2008; and InPro D19, 2009).

The National Building Information Modeling Standard (NBIMS) by NIBS (2007) describes a technically standardised process to develop and deploy BIM along with the relevant open standards and tools. It aims at promoting open and interoperable information exchanges through BIM. NBIMS document presents the scope and definition of BIM and information exchange and sharing. It recognises and incorporates American and international open standards development processes and products, such as American National Standard Institute (ANSI), International Standard Organization (ISO), International Alliance for Interoperability (IAI), and Open Standards Consortium for Real Estate (OSCRE). NBIMS also illustrates the framework through which a long-term vision of open standard-based BIM may be seen in the facility life-cycle helix (Figure 2). NBIMS sets the minimum requirements of quantity and quality of information to define a building information model. It also discusses the capability and maturity of the model. It explains the procedures of developing and incorporating open standards and templates for BIM, especially Industry Foundation Classes (IFC), Information Delivery Manual (IDM), and Model View Definition (MVD). NBIMS document focuses further on the technical protocols to reach a consensus in using generic BIM Guides and validating data in BIM.

Figure 2: Facility life-cycle BIM repository (NIBS, 2007)

NBIMS focuses on information management and contains comprehensive ICT, definition and standardisation background and procedures of BIM development and deployment. However, it discusses little about the use of BIM in a building project or about managing the inter-relationships between BIM and the project processes and stakeholders. In this sense, the Integrated Project Delivery (IPD) by AIA (2007) can be seen as complementary to NBIMS. IPD focuses on the implementation of BIM in the processes of a building project. IPD describes how BIM can be applied
to a variety of procurement and contractual arrangements. It specifies the roles, activities and required contributions of the stakeholders in each project stage. It points out the consequences of BIM for process restructuring whereby certain project stages are shifted or redefined (see Figure 3). IPD encourages early contribution of knowledge and experience and requires proactive involvement of key participants. However, several limitations can still be found, i.e. the principles have not been accepted in the common practice; the proposed process structure and corresponding contractual arrangements have not been validated; and the transition from the traditional towards the integrated approach is rather moderate and based on the currently available procurement methods.

Figure 3: Differences in traditional and integrated project delivery (AIA, 2007)

In Finland, the institutional establishment of BIM based projects has recently taken place. The Senate Properties –that is the state enterprise under the Ministry of Finance which provides property services to government clients– has been developing and adopting BIM requirements according to the documents by Senate Properties (2007). The documents contain the general operation procedures over how BIM can be generated and utilised in building projects, especially those under Senate Properties’ supervision. The documents represent comprehensive guidelines on how an intelligent building model should be structured in 3D layers and levels of detail, i.e. client requirements model, spatial group BIM, spatial BIM, preliminary building element BIM, and building element BIM. The documents describe the modelling process and the required general and detailed contents of the models in each project stage for each discipline, i.e. architectural design, structural design, MEP design, and facility management. In addition to this, several special BIM functionalities are described, i.e. use of models for visualisation purposes, MEP and energy analyses, quality assurance, quantity take-off, and merging of models.

Despite the extensive coverage of BIM Requirements documents, Senate Properties still acknowledges that a further development is needed, especially with regards to the innovative restructuring of the processes of a building project. The current guidelines focus mainly on managing the models, instead of managing the BIM based projects. Moreover, the guidelines depict how BIM is utilised within the conventional sequence of stages and activities of design and engineering. Senate Properties is fully aware that BIM will not only partially change the documentation from drawings into models, but will also revise the entire investment, design, and construction process. Model-based decision-making will result in the changes to the internal processes of the project stakeholders. The analyses performed through the multidisciplinary collaboration at an early stage must be emphasised.
in order to achieve the benefits of using the models to support decision-making and to make the comparison between available design alternatives.

On the international level, BuildingSMART is an international alliance of organisations within the construction and facilities management industries that actively promote interoperability and open standardisation of BIM. BuildingSMART has jointly developed a neutral data scheme or an open standard, known as the Industry Foundation Classes (IFC). BuildingSMART initiatives are dedicated to encourage neutral BIM. Neutral means that it is open and it is not limited to commercial design processes or software tools, or in another word it is not proprietary (public or owned by a non-profit organisation). In neutral BIM, the data is based on a neutral data structure and is stored in a shared database that is accessible and interpretable for all stakeholders (InPro D19, 2009). Although BuildingSMART initiatives and activities extend internationally and embraces many important industrial parties involved in BIM development and implementation, it mainly focuses on ICT. Its intention for the further innovation of building processes faces challenges of the locality of the markets and regulations.

Parallel with the BuildingSMART initiatives, certain international and regional workgroups with a similar aim at further developing and promoting interoperability have been established, such as: the Implementer Support Group (ISG), the Model Support Group (MSG), and the W3C XG Incubator Group on Product Modelling (Böhms, 2008). These initiatives focus mainly on proposing R&D strategies and produce guidelines for technical developments, which are more relevant for ICT companies rather than for most building stakeholders that are primarily interested in the implementation and use of the technology in their building projects.

4. Proposed approach for BIM-wise process management

In order to progress beyond the state-of-the-art, this paper proposes a new approach for BIM-wise process management. In this section, a shift from a linear-sequential towards an iterative-concurrent process based on BIM is described. The two main aspects of process management are addressed respectively. Regarding the aspect of information (knowledge), this paper proposes a way for integrated design and engineering based on open-source object libraries of industrialised solutions. Regarding the aspect of organisation (collaboration), this paper proposed the synergy of the roles of the process manager, project manager, and model manager.

A building project is traditionally structured in a linear process that is characterised by fragmented and sequential activities, decision-making, and involvement of stakeholders. Often the party in charge for the next project stage is assigned just after the sign-off of the preceding stage; for example, the manufacturer and contractor who will produce the building elements and construct the building are selected after the architect finishes the design. Another example is that the specialist designers, energy advisors, and facility managers are not yet involved during the translation of the client’s requirements into the preliminary design by the architect. Such a linear-sequential process brings along problems in terms of major or minor design changes, for instance regarding the buildability of
the design. If design errors are discovered just before or during the construction stage, ad hoc changes must be made while delays and claims are inevitable.

This paper proposes an iterative-concurrent process structure instead. In a BIM based project, the whole life-cycle phases of the building can iteratively be considered in each project stage and the design can be developed concurrently by different disciplines. Through such an iterative-concurrent process, the complete building can be virtually constructed, modified, and improved very many times in a short time. Using an intelligent building model, design alternatives can continuously be validated against the client’s requirements and expected performance in operation. At the same time, interface problems and design errors can be eliminated using clash detection function of BIM. The proposed process structure is illustrated in Figure 4.

Figure 4: Schematic illustration of the proposed BIM-wise process structure

Unlike in the traditional linear-sequential process, in the iterative-concurrent process a clear distinction is made between the building life-cycle phases and the project decision stages. The building life-cycle phases are: initiation, design, realisation, operation, maintenance, renovation, and recyle or demolition. The project decision stages are directly related with the items on which decisions on the continuity or progress of the project are made. These decision stages apply generically either in a new building or a renovation project. The project decision stages are: requirements definition, early design, detailed design, production and procurement, construction plan, delivery. The whole life-cycle phases are addressed dynamically as a yellow spiral in the process; in a somewhat similar idea to the facility life-cycle helix (NIBS, 2007). In each project decision stage, the whole life-cycle of the building is addressed. All relevant stakeholders are involved in a
multidisciplinary project team consists of the client, end-user, architect, specialist designer, engineer, general contractor, specialist contractor, manufacturer, supplier, facility manager, energy advisor, etc. These collaborating stakeholders are represented by the blue circle. The coordination between these stakeholders is carried out on multiple levels by the process manager (strategic collaboration level), the project manager (project operational level), and the model manager (information management level).

The stakeholders collaborate through iterative processes according to the InPro principle, as shown by the green circle, which is further elaborated in Figure 5. According to the principle of InPro collaborative process, each decision is taken after verifying the design based on the requirements and performance analysis. In the decision-making process, ideas are translated into concepts, and then elaborated in proposals for the approval.

![InPro collaborative processes](image)

Figure 5: InPro collaborative processes (Sebastian & Haak, 2009, refer to F. Verhofstad)

At the centre of the process, BIM facilitates the integration of the activities and outcomes. BIM is represented in this scheme by the red circle, further elaborated in Figure 6. In the iterative-concurrent process structure, BIM comprises three main aspects: 1) the intelligent building model that consists of 3D geometry and details, specifications, and analytical calculation over cost, energy, planning, etc.; 2) open-standard object libraries of industrialised solutions or building components; and 3) open-source model server and communication platform for information sharing. Beyond the building sector, the ongoing COINS and VISI programme in the infrastructure sector in the Netherlands shows an industry-wide BIM initiative to develop object libraries, communication protocols, and a model server (www.coinsweb.nl; www.visi.nl).
Although each project is unique, standard solutions and industrialised building components are largely applicable for the majority of buildings. Using BIM there is a new way for integrated design and engineering. BIM enables the extension of open-standard object-libraries to include as many possible industrialised solutions and building components. Using open-source BIM, designers can access and retrieve the stored objects. Designers do not need to “start from scratch” any longer as a large variety of building typologies, systems and subsystems are available as the basis of their designs. BIM can serve as a dynamic configurator in an iterative and creative design process. In this way, the designers’ creativity remains highly valued and can be effectively integrated with the industrialisation approach. Buildings with high architectural quality can, therefore, be designed, produced, and delivered according to systematic procedures which allow effective control and value optimisation for the clients and end-users. The manufacturers and suppliers will naturally be encouraged to provide and update the object libraries with their products. This will lead to the mass-customisation and open building manufacturing concepts as promoted among others by the European research project ManuBuild (Fuster et al, 2009).

Collaborative working using BIM demands a new expert role of a model manager that possesses ICT as well as construction process competencies (InPro D9b, 2009). The model manager deals with the system as well as with the actors. He provides and maintains the technological solutions required for BIM functionalities, manages the information flow, and improves the ICT skills of the stakeholders. The model manager does not take decisions on design and engineering solutions, nor the organisational processes, but he holds a supporting role in the chain of decision-making that is focused on:

- the development of BIM and relevant tools, in terms of defining the structure and detail level of the model, models checking and merging, and clash detections;
• the contribution to collaboration methods, in terms of facilitating decision-making and communication protocols, and integration of task planning and risk management;

• the management of information, in terms of data flow and storage, identification of communication errors, and decision or process (re-)tracking.

The new role of a model manager is not necessarily conflicting with the existing roles of a project manager and a process manager. In general, the project manager represents the client in a building project. Once the project scope, objectives, resources, and time span have been decided, the project manager exercises the mandate he receives from the client to manage the project in this context (Lautier, 2005). With his mandate, the project manager is entitled to take decisions on behalf of the project. He is also in charge of assuring all stakeholders to fulfil their obligations in conformity to their contracts with the client. When taking decisions related to the technical content of the project (e.g. design, engineering and construction solutions), the project manager can rely on the model manager, who can provide him the necessary information of the project embedded in BIM.

As explained earlier in this paper, the role of the process manager is intended to complement that of the project manager. The main attention of the process manager is given towards the collaboration between the stakeholders on the strategic level. The process manager shapes the inter-organisational processes to achieve an effective collaboration that will benefit the project in short and long-term. In consultation with the client and in cooperation with the model manager, the process manager can, therefore, translate the strategies for communication and decision-making into the BIM based collaboration methods, protocols, and risk management plans. In addition to the qualifications pertaining to their domain, the project manager and process manager of a BIM based project must master the principles of BIM-wise collaboration and management.

5. Proposed business concept, contractual terms, and take-up strategy

The business concept, BIM contractual terms, and take-up strategy presented in this paper mainly are the outcomes of research in the InPro project (InPro D9b, 2009; InPro D11, 2009). The main purpose of the business concept is to ensure the successful BIM implementation by the stakeholders in the building sector. The InPro business concept discusses an innovative approach to partnering, the interface management in the teamwork, the stimulating incentive and payment schemes, and the management of risks.

When thinking about a new business concept, the inevitable questions is: What is the economic gain of open collaboration for the stakeholders in the building industry? Since open collaboration is a quite new, discussions on this subject are still ongoing. Openness issue is also actual in other industries. A thought on the economic value of openness has very recently been posted by Jonathan Rosenberg, Senior Vice President, Product Management of Google (on the Official Google Blog, 12/21/2009 03:17:00 PM): “Open systems are competitive and dynamic. In an open system, a competitive advantage does not derive from locking in customers, but rather from understanding the
fast-moving system better than anyone else and using that knowledge to generate better, more innovative products. Open systems harness the intellect of the general population and spur businesses to compete, innovate, and win based on the merits of their products and not just the brilliance of their business tactics. All other things being equal, a 10 percent increase in share or a 10 percent increase in industry value should lead to the same outcome. But in our industry a 10 percent increase in industry value will yield a much bigger reward because it will stimulate economies of scale across the entire industry, increasing productivity and reducing costs for all competitors. As long as we contribute a steady stream of great products we will prosper along with the entire ecosystem. We may get a smaller piece, but it will come from a bigger pie.”

Open collaborative processes can optimally be accommodated by a virtual enterprise. A virtual enterprise (VE) is a partnering between non-competing companies who share forces using advanced ICT systems for the accomplishment of a specific goal without losing their autonomy. A number of companies can organise themselves in a temporary network based on the common importance in the business. The unique advantage of the VE is the possibility to collaborate closely using BIM despite the geographic dispersal. Next to periodic face-to-face meetings, the direct and more intensive collaboration contributes to accelerate the creation of interpersonal trust in teamwork. A VE reflects an equal collaboration through BIM. Although a certain participant holds the coordinating role, a complex hierarchy is not required. An attention should be given to build the trust that guarantees the „open book” philosophy and the ethics of collaboration regarding the sharing and integration of information.

Within a virtual enterprise, the interface management in the teamwork is essential especially with regards to the communication and decision-making. The research in InPro distinguishes the project team interface, client interface, and external interface; all of which are required for the BIM-wise collaboration. The project team interface integrates the information from all stakeholders and enables concurrent design and engineering processes. The client interface documents the collaborative processes, enables quick response decision, and estimates the consequences of the decisions. The external interface helps the wider group of stakeholders (e.g. local authorities) to interpret and evaluate the impacts of the project. The interface management also provides a systematic approach to decision-making. It clarifies which actor is to take a specific decision at a certain moment. The researcher in InPro develop the Smart Decision-Making Framework method, which is tailored for supporting the formulation of Key Performance Indicators (KPIs) and the evaluation of the alternative decisions against these KPIs. This framework can also be used in terms of change management.

Stimulating incentive and payment schemes are needed to encourage the stakeholders to release the full power of open collaborative processes based on BIM. Incentives based on a bonus-malus system will adjust the payment based on the delivered performance. In contrary to a closed value-chain (where an extra benefit for a stakeholder only means a loss for another stakeholder), such an incentive system stimulates the creation of real added values beyond the original expectations. As these real added values are created, the collaborating stakeholders can have a new share in the extra benefits. Linking incentives with KPIs in order to achieve the best performance requires the redefinition of the KPIs and quantifiable added values. Another issue is the return on investment of
BIM. The fee of the model manager and the investment in hardware, software, and training can be earned back through the higher efficiency of the process, e.g. no recurrent drafting, less labour cost, less independent drawings and documents, more accurate quality control, more efficient production and construction planning, and significantly reduced redesign and ad hoc modification costs.

BIM-wise collaboration is believed to be able to reduce the traditional project risks. BIM simplifies the risk management in a project through a more accurate estimation of cost, time, and quality. However, a new way of working often comes with uncertainties which can be seen as new types of risk by many stakeholders. Some examples of the „new“ risks are: the scarce availability of BIM experienced personnel for the formation of a highly qualified team, and the challenges to integrate the new expertise in the sustainable business strategy of the organisation.

The new business concept, collaborative processes, distribution of roles and responsibilities, and the use of new tools and techniques should be formalised and drafted in a contract. In general, the adoption of BIM requires contractual terms between the stakeholders that assure the intensive collaboration and open sharing of the relevant information.

Regardless of the selected type of contract form, particular contractual terms as follows should to be included in a BIM based project to facilitate open and neutral collaboration processes: 1) the agreement on modelling protocols, sharing and integration of open information and open technology – if possible by endorsing the internationally accepted open standards; 2) the workflows, level of authorisation, and access rights in a BIM based decision-making; 3) the intellectual property of the foreground and background information and knowledge; and 4) the legal status of the model. The possible legal status of the model is indicated by Ashcraft (2008). The model can serve as a co-contract document that is used between the contractual parties, but is not to be submitted to permit-issuing agencies. Otherwise, the model can become an inferential document which provides the visualisation of the design intent inferable from the contract documents. Another possibility is to use the model as accommodation document that can be used, but not to be relied upon, by the recipients. It should be taken into account that limiting reliance of the model will undermine the capability of BIM.

Depending to the selected contract form and procurement method, particular contractual terms should be considered as additional clauses to the contract, for instance: 1) the establishment of partnering and the legal entity of the enterprise; 2) the formal roles and responsibilities of the contractual parties; 3) the agreement on the payment features and schemes; and 4) the dispute resolution using BIM for a quicker and more precise retrieval system of errors, liabilities, and the circumstances.

Many of the legal issues related to collaboration are caused by duties and obligations that transcend boundaries. When assessing contractual frameworks, it is useful to compare how they address (or ignore) boundary issues (Ashcraft, 2008). Does working with BIM change the liability position of the stakeholders in the contract? In traditional contracting, the liability of each party is limited within the scope of its contract with the client. Working with BIM does not change the liability position in the contract. This is confirmed by the ConsensusDOCS (2008) of which one of the general principles states: “This Protocol Addendum does not effectuate or require a restructuring of contractual
relationships or shifting of risks between or among the project participants other than as specifically required per the Protocol Addendum and its attachments.”

Following the proposal for a business concept and BIM-oriented contractual terms, a strategy for a quick take-up of the BIM business concept in the European construction industry is presented in InPro research project. This take-up strategy consists of ways to: implement new BIM-oriented regulations on European and national level; raise the stakeholders’ awareness level of the new approach and benefits of BIM-wise collaboration; empower the professionals; create a leadership of BIM based projects, especially through the roles of the process manager, project manager, and model manager; develop a transition plan and a business re-engineering roadmap; and disseminate the state-of-the-art knowledge in science and practice. The take-up strategy intends to positively affect the organisational behaviour of key stakeholders by the development of sound business cases for the stakeholders representing diverse roles and professional domains. The early-design stage is crucial for a quick take-up. In this stage, when merely 1% of the project cost is used, the key decisions that commit 70% of the life-cycle cost of the building are taken (InPro, 2009). Moreover, this is the stage when open collaboration can effectively be set-up.

6. Concluding remarks

Building Information Modelling (BIM) has risen and has been acknowledged as a way to innovate the collaborative processes in a building project. BIM comprises an intelligent building model, a framework for open collaboration, and the required ICT systems, functionalities and standards. Despite the technological advancement, an industry-wide implementation of BIM in building and construction has not yet taken place. This paper began with an assumption that the business and legal barriers were the reasons behind it. In conclusion, this assumption has clearly been confirmed by the findings from the literature and field research.

Breaking through the business and legal barriers to improve the large-scale BIM implementation requires a radical change in the way the processes of a building project are organised. Instead of fragmented and subsequent project stages (each of which is domain-specific and dedicated to a phase in the building life-cycle), the whole life-cycle phases of a building should be addressed in each project decision stage from multidisciplinary domains involving all relevant stakeholders. The application of BIM to support an optimal cross-disciplinary and cross-phase collaboration opens up a new dimension in the roles and relationships between the stakeholders. In this respect, a conclusion can be drawn that the role of the process manager becomes even more significant. This paper shows that in a large and complex BIM based project, the process manager, project manager, and model manager are needed. Although some overlaps may exist, their roles are not substitutionary, but complementary. The process manager operates on the strategic inter-organisational level to shape the context and processes for collaboration; the project manager operates on the project level to lead a well-defined project with the mandate from the client towards the achievement of the objectives; and the model manager operates on the information level to coordinate the data sharing and integration. All of them and the other stakeholders similarly must exercise the ability for a BIM-wise collaboration.
This paper also concludes that breaking through the business and legal barriers of BIM requires a new business concept for partnering that imposes the open integration of ICT between the participating parties. Such a business concept can be accommodated in a virtual enterprise. Adequate interface management, incentive schemes, and risk management are needed to assure the openness, trust and equality in a BIM-wise collaboration. From the process management viewpoint, this paper highlights the important contractual terms for a BIM based project. Some of these contractual terms are generic and should be incorporated to any form of contract used in a BIM based project; some others are depending to the selected contract form and procurement method.

As a way forward, a follow-up joint effort by the process management experts, ICT experts and construction lawyers is strongly recommended for an in-depth investigation on how the new process and business approaches can be embedded in the existing standard forms of contract, or whether a new BIM-oriented form of contract should be developed. More applied research on BIM implementation in building projects is urgently needed to further develop a proof-of-concept. As a growing number of building projects with BIM have been carried out, the preliminary lessons-learned should be collected, analysed and utilised for the further development of the process, organisational and legal frameworks.
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