BIM IN DIFFERENT METHODS OF PROJECT DELIVERY

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ABSTRACT

This paper particularly addresses the topics of "legal and regulatory aspects of Building Information Modelling (BIM)" by reporting actual discussions in The Netherlands on the appropriateness of four project delivery methods to be applied for BIM based projects, i.e. traditional Design-Bid-Build, Dutch Building Team, Design-and-Build, and Integrated Project Delivery (IPD). BIM has become very important in a complex project that requires multidisciplinary collaboration. However, in many projects, BIM is still viewed as an ICT tool only, and hitherto BIM is to be decided when the project reaches an operational level. Such a viewpoint can undermine the effectiveness of BIM to support an effective collaboration. Therefore, considering the most appropriate project delivery method to assure an open and integrated collaboration is crucial since the project initiation stage.
The main part of this paper covers a desk research to review several project delivery methods. The analysis focuses on how the use of BIM in a project affects the division of tasks and the formal agreements on the roles and working processes between the parties involved. Following the theoretical analysis, this paper makes a reflection on the recent BIM based projects in The Netherlands refer to the best practices presented during the national BIM competition in 2010. Recommendations are then given to improve the existing practice, among which the standardisation of general contract conditions for a BIM based project is strongly advised to avoid 'reinventing the wheel' in each new project.

Keywords: BIM, project delivery method, collaboration, best practice, The Netherlands.

1. INTRODUCTION

The development and implementation of Building Information Modelling (BIM) is growing at a very fast pace. Various organisations and literature use different definitions of BIM, yet it is widely accepted that BIM comprises both modelling technologies and model-based collaborative processes. TNO Team Building ICT (2010) summarises the ongoing discussions and defines BIM as:

- a three-dimensional virtual model of the building which contains multidisciplinary information;
- the ICT tools and standards for sharing and integrating of information in the model;
- the collaborative processes which represent the life-cycle activities in a virtual building project.

Many people in the building industry across the globe believe that BIM is among the most important innovations in practice since Computer-Aided Design and Drafting (CADD) in 1970s (Chadwick 2010). Although the CADD technology has evolved over the years, CADD drawings have remained two-dimensional, making the whole CAD format not that far removed from traditional hand-drawing. BIM is not just the cutting-edge 3-D technology or the photorealistic renderings, BIM has not only picked up where CADD left off, but it has also enhanced the collaborative elements of the design, production, construction, and utilization processes. The trend began in the early 1990s – and ever since then, BIM has become increasingly sophisticated. During the design phase, the architect composes a BIM model based on the request from the project owner. While working together with the architect, the other designers and technical specialists add their information to the BIM model. BIM has been proven very useful for the collaborative work by the designing parties. Using BIM, multiple layers of information can be contained in one centralised model and specific details can be generated from the model. This means a better consistency of the information and a higher efficiency compared to the traditional CADD based way of working in which each discipline produces a set of technical drawings which accordingly need to be cross-checked with the drawings of others.

Despite the increasing technological readiness, large-scale utilisation of BIM in the building industry is hampered by uncertainties regarding the legal and business aspects (Kent Holland 2010; McAdam 2010; Sebastian 2010; Greenwood et al. 2010; Ashcraft 2008; InPro 2009a & 2009b). Conflict of interests among the project stakeholders and regulatory constraints cannot be ignored. However, in many projects, BIM is still viewed as an ICT tool only, and hitherto BIM is to be decided when the project reaches an operational level. Such a viewpoint can undermine the effectiveness of BIM to support the project collaboration. Besides, many existing project delivery methods have not sufficiently addressed the key issues of integrated collaboration with BIM support. In addition to this, in contrary to the rather generic character of the technology, the local influences at the project level are still strong, for instance contractual legislations strongly differ between countries. Therefore, considering the most appropriate project delivery method in relation to the contract type to assure an open and integrated collaboration is crucial since the project initiation stage.

This paper particularly addresses the topics of “legal and regulatory aspects of Building Information Modelling (BIM)” by reporting actual discussions in The Netherlands on the appropriateness of four project delivery methods for a BIM based project, namely: traditional Design-Bid-Build, Dutch Building Team, Design-and-Build, and Integrated Project Delivery (IPD). The main part of this paper covers a desk research to review the selected methods. Following the theoretical analysis, a reflection on some recent practice in the Netherlands is made refer to the BIM based building projects nominated for a national BIM competition in 2010.

2. BRIEF OVERVIEW OF THE BUSINESS AND LEGAL ISSUES OF BIM

The concept of BIM was introduced with the vision towards an open and integrated collaborative process in the building project. Many argue that the use of BIM in a building project will bring important added values if information is shared and managed openly. This will result in economic benefits, such as significant reduction of failure cost by preventing and eliminating design errors by the integration of information from different disciplines since the early-design stage in a virtual building model.

Despite the existence of a common belief in the economic benefits of BIM, the practitioners are still confronted by several issues that are less supportive for the business strategy to implement BIM, i.e. the lack of immediate benefits of BIM for the stakeholders; and the changing roles, responsibilities and payment arrangements. For many designers and engineers, the immediate benefits of BIM are not proportional to the investment in the new technology at the operational level (Sebastian 2010). 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. Furthermore, collaborating BIM-wise leads to a shift of activities from the later stages to the early-design stage. 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. In the current practice, 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. For the contractors, one of the main concerns is how to get an early involvement in the design and engineering stages. 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 in agreement with the subcontractors and suppliers.

Next to the business issues, the legal aspects very much affect the success of BIM implementation in building projects. In this paper, the legal aspects of BIM are categorised in two types: 1) the general legal aspects concerning the law and regulations on information and communication; and 2) the project-specific aspects concerning the project delivery method and contractual arrangement for a project. The general aspects regard the protocols of information exchange and information management between and among the parties involved in a project. These issues are relevant before the start of the project, during the project, and after the delivery of the project. In most countries, including the Netherlands, the existing regulations have not yet been designed to address the authenticity and legal status of information supplied in BIM, structure and format of information, safe-keeping and archiving of information, and way of communication when BIM is used (Chao-Duivis 2009). This issue regards the general legal framework on information in the country, and it is outside the scope of this paper. The project-specific aspects regarding project delivery is within the scope of this paper and will be further described in the following sections.

3. REVIEW OF SEVERAL PROJECT DELIVERY METHODS IN RELATION TO THE USE OF BIM

This paper distinguishes a project delivery method from a collaboration model and a contract type. Almost all building projects nowadays are carried out by a number of parties together. When the project owner decides to involve project partners, the model of collaboration relationship needs to be selected, i.e. a traditional client-contractor relationship, an alliance, a comakership, or a project-based partnering like Public-Private Partnership. After the collaboration model has been decided, a project delivery method applies to establish the project organisation. Widely known project delivery methods are Design-Bid-Build (which is also known as 'traditional') and Design-and-Build (including the variants, which extend to maintenance, financing, and operation). In a project that involves a public client, a public tender usually applies within the selected project delivery method. Following the tender process, the winning parties will be awarded a contract. In the contracting process, the agreements between the project owner and the parties involved are formulated in a project contract that is usually based on a standard contract model (JCT 2007; Bruggeman et al. 2008).

In The Netherlands, there is an ongoing discussion on four project delivery methods in relation to BIM based projects, i.e. 1) the traditional Design-Bid-Build; 2) the Dutch Building Team; 3) the Design-and-Build, and 4) the Integrated Project Delivery (IPD). It is commonly believed that the use of BIM in the project affect changes in the division of tasks and the formal agreement on the roles and working processes between the parties involved (Sebastian 2011).

3.1. BIM use in traditional Design-Bid-Build project delivery method

Design-Bid-Build is widely known and most often used in building projects across the world. This method is characterised by the clear separation of responsibilities of designing and constructing. After project definition stage, the project owner hires an architect to generate the building design. The design is then further developed and detailed by the architect together with technical designers, who also generate the technical specifications of the building. Based on the detailed design and technical specifications, the project owner organises a tender process to select a contractor. The tenderers submit their offers that show the proposed price to construct the building. In most tenders, the lowest price bidder will be awarded a contract. Most project owners choose the Design-Bid-Build method because they can exercise a full authority over the design and construction processes. A professional client organisation with much experience and technical knowledge is likely able to define the detailed design criteria and technical requirements of the building. Another important reason to choose this method is that the project owner has full liberty to select a trusted architect based on subjective preferences such as architectural style and design approach.

In Design-Bid-Build method, designing and constructing are considered as two separate activities which take place in two sequential phases and are carried out by two different parties. Due to this division, the integration of the building life-cycle information through BIM and in the BIM model can only be done to a limited extent. The contract award that follows the tender is commonly the moment when the BIM model is transferred from of the architect to the contractor. Two most important issues which must be dealt with properly are: 1) the necessary measures and agreements to prevent or minimise the loss of information during the conversion between the different BIM systems of the architect and the contractor, and 2) the clarity of the intellectual rights of the model and its parts. The latest also implies the division of responsibilities and liabilities if mistakes are found in the model of its parts. This should be included in the additional legal clause in the contract.

Although the design parties have developed a complete BIM model before the tender, until present, no project is known to use the full BIM model as the sole or main tender document that replaces the traditional drawings, details, and specifications. The first reason behind this is there are still discussions about the legal status of the BIM model, i.e. whether any right can be derived from the information in the model. The second reason is there is still no consensus on how the information in the BIM model can be fully assessed and interpreted. Even with the advanced development of open ICT standards at present, a full interoperability between different software applications cannot be guaranteed.

3.2. BIM use in Dutch Building Team project delivery method

The Dutch Building Team method can be considered as an extended version of the traditional Design-Bid-Build method. This method is especially known in the Netherlands as it is based on the Model Building Team Agreement 1992 (Bruggeman et al. 2008). This method is different from alliance or partnering. The purpose of this method is to involve the contractor during the design stage. The contractor is expected to contribute the knowledge about construction techniques and logistics as well as about actual cost calculation. During the design stage, the contractor only holds an advisory role to the project owner and the design team. The design team, consisting of the architect and technical designers, develops the designs, details and technical specifications for tendering. The project owner then organises a tender to select the contractor who will construct the building.

Under strict conditions of fairness and transparency, the contractor who has been involved in the design stage may also join the tender. The transparency about which knowledge the advising contractor has gained during the design phase (the pre-tender knowledge) must be guaranteed. The pre-tender knowledge may never become a privilege during a public tender procedure. When BIM is used, special attention must be given to the agreement of access rights to specific BIM knowledge with regards to the confidentiality of certain pre-tender knowledge.

3.3. BIM use in Design-and-Build project delivery method

Design-and-Build (including its extended variants (i.e. design-build-maintain (DBM), design-build-finance-maintain (DBFM), and design-build-finance-maintain-operate (DBFMO)) has a basis concept that is the project owner establishes a contract with a single party (a contractor or a consortium) which is fully responsible for both designing and constructing the project. In the case that the contract is signed with the main contractor, this contractor then hires an architect and other specialists. In the case that the contract is signed with a consortium, the contractor and the other parties together are joined as partners in the consortium. Another characteristic of this method is the tender based on functional programme of requirements, instead of the detailed design and technical specifications. The candidate contractors (or consortiums) submit offers, which include the proposed design solution next to the price for design, construction, and the other activities such as financing, maintenance, and operation if applicable depending on the scope of the tender.

Design-and-Build becomes more and more popular for large and complex projects where function, performance and efficiency are prioritised above the owner’s subjective preference to a certain architectural design style. The project owner gives the freedom to the winning tenderer to generate the design, which meets the given functional requirements. Since the same tenderer is also responsible for constructing (sometimes also for maintaining and operating the building), the project owner can be assured that the design is efficient to construct, to maintain and to operate. This is most advantageous for many project owners which posses much knowledge in how the building and facilities should function to accommodate the owner organisation’s daily business activities, but possess little technical knowledge in how a building should be designed and constructed. Design-and-Build is also advantageous for innovative contractors, which are able to propose the most optimal design based on their knowledge and experience in construction techniques and processes. Within a Design-and-Build tender, the offers are evaluated based on the price for construction as well as the quality/performance of the proposed design, instead of solely based on the lowest price for constructing the owner's predefined design. In Design-and-Build, the traditional borders between tasks and occupational groups become blurred since architects, consulting firms, contractors, subcontractors, and suppliers all together stand on the supply side while the project owner remains on the demand side. Such configuration puts the architect, engineer and contractor in a very different position that influences not only their roles, but also their responsibilities, tasks and communication with the client, the users, the team and other stakeholders (Sebastian 2011).

How does the use of BIM affect the contractual relationship? On the one hand, collaborative working using BIM does not necessarily change the liability position in the contract and the division of risks, nor does it obligate an alliance contract (ConsensusDOCS 2008; Chao-Duivis 2009). On the other hand, implications in terms of tender requirements regarding BIM should be anticipated. In Design-and-Build tender, BIM can be considered as: 1) a means to be used in developing, realising, and operating the real building; or 2) a product to be delivered next to the real building.

Conform to the principle that the project owner only defines the functional and performance requirements for the building; the contractor (or the consortium, which includes the architect, contractor and other parties) has the freedom in the way and the means for developing and realising the building. When BIM is considered simply as a means, in theory, the project owner cannot enforce the use of BIM and does not have to pay for the cost of BIM development. In such a situation in a number of projects, BIM is used based on the initiative of the main contractor (or another party that leads the consortium). Next to the advantage of using BIM for coordination, BIM brings added values for the main contractor which is responsible for the total project throughout different project phases. The advantage of BIM increases in a long-term contract, which includes maintenance and operation of the building. The agreement on the BIM system to be set-up, the working procedures to be followed, and the standards to be used will entirely be decided by the consortium members. Without the agreement on the use of a neutral or open BIM, the main contractor or the leading party in the consortium may require the other parties to use the BIM approach most familiar to it. The consortium agreement should address the cost incurred at each consortium member in order to comply with the required BIM approach.

When the BIM model (a virtual building model) is considered as a product to be delivered next to the real building, the project owners ought to establish the programme of requirements for the virtual building including the ICT requirements for BIM development, next to the programme of requirements for the real (physical) building. In this way, the project owner can ask for certain BIM systems and modelling structures, which are the most suitable for its organisation and purposes, for instance: the use of the BIM model for portfolio management across different projects or the use after the Design-and-Build contract period ends. There should also be clear tender evaluation criteria and formal procedures to assess the virtual building and the real building.

When evaluating the tenders, the project owner needs to assess the resources (and the respective price) to be dedicated for realising the real building and those dedicated for developing the BIM systems and model. The distinction between the cost for the real building and the cost for BIM should be transparent. Only by doing so, the project owner can objectively evaluate the price-quality ratio of the products. The cost for BIM development is supposedly lowest for the contractors with the most knowledge and experience in BIM.

3.4. BIM use in Integrated Project Delivery (IPD)

A rather new concept called Integrated Project Delivery (IPD) was coined to facilitate the collaborative processes using BIM (AIA California Council 2007 & 2010; CRC Construction Innovation 2009). In recent years, several IPD projects have been realised, among others in the USA. The unique characteristic of IPD is that the three key parties in a building project –the project owner, the architect, and the contractor– are bound together in a single IPD contract, starting from the initiation or the very-early phase of the project.

The main purposes of the IPD method can be summarised as:

- to optimise the integrated collaborative processes supported by BIM;
- to involve the contractor as an equal partner since the initiation of the project;
- to define and validate the project goals together by the three key parties;
- to make major decisions based on consensus by the three key parties;
- to avoid time and cost consuming claim processes by no-claim agreement between the key parties;
- to promote trust in the collaboration through an open-book project accounting system and a transparent division of profits and risks according to the formula agreed beforehand.

IPD is developed to encourage and to facilitate an open and integrated collaboration throughout the whole building project with the support of BIM. During the implementation of IPD in recent projects, among others as described by AIA California Council (2010), several challenges have been identified. First, despite the use of open standards for BIM and continuing improvements, certain interoperability problems remain unsolved due to the shortcomings of the ICT standards and software applications. Second, many negotiations and much legal advice are needed to establish an IPD contract. At a time when neither the building programme nor the conceptual design is developed, the three key parties (the project owner, the architect and the contractor) must sign a binding contract with a no-claim clause. In certain situations the key parties decide to deviate from a full IPD to a modified Project Alliance contract to limit individual risks and to allow limited claims.

Up to now, there is neither legal tendering framework nor standardised formal working procedure for IPD method. Many government organisations are restrained to implement IPD due to the obligation to hold public tenders involving multiple candidates, in contrary to detailed negotiations with limited number of parties prior to an IPD contract. Moreover, the public tenders are evaluated against strictly-defined price-related criteria conform to the project owner's programme of requirements or design specifications. According to IPD, these elements are yet to be developed by the key parties after the contract is signed.

4. REFLECTION ON BIM BEST PRACTICES IN THE NETHERLANDS

In the following, several BIM based projects in the Netherlands are described and the performance of multidisciplinary collaboration in relation to the selected project delivery method is analysed. In March 2010, Bouwend Nederland –the professional association of Dutch construction companies– together with TNO –the Dutch research institute of applied sciences– organised a competition titled "How Smart is Your BIM?", in conjunction to the national exhibition of Buildings and ICT. Companies from the Dutch construction sector demonstrated their BIM models and processes which were implemented in real projects. The main goal of the competition was to assess the practical achievements of using BIM in practice. By doing so, it was expected that the real added values and shortcomings of BIM would become evident as the lessons learned for the ongoing innovations in the construction sector (Bouwend Nederland 2011).

The nominated projects were evaluated by an expert jury consisting of an academic scientist (Prof. Dr. Bauke de Vries from Eindhoven Technical University), an applied-research scientist (Mr. Peter Bonsma, MSc. from TNO), and an experienced BIM consultant (Mr. Hans Hendriks from DeBIMSpecialist). The comprehensive evaluation criteria were used, covering 1) the performance of collaboration using BIM; 2) the richness and the effective reuse of information in the BIM model; and 3) the appropriate applications of open ICT standards, tools, and software. These criteria were based on the main aspects of the BIM performance measurement tools used in The Netherlands and in the USA (Sebastian and Van Berlo 2010; Succar 2010).

Based on the result of the preliminary selection round, 5 BIM based projects submitted by 7 different companies were nominated as finalists. These represent a variety of project types and disciplines. The submitting participants were 5 architectural firms, 1 MEP engineering firm, and 1 contractor. The finalist projects included 3 housing projects and 2 public building projects.

4.1. BIM use in housing projects

There are three BIM based housing projects nominated as finalists. All of them were carried out through the traditional project delivery.

The first project was a residential building in Wassenaar, submitted by Martijn Verbeek, an architect from Naaldwijk. Although the scale of the house was rather small, energy sustainability was prioritized in the design requirements. Next to the purpose of an effective communication with the project owners and other project participants, BIM was used for energy simulations and analyses during the design. Much attention was also given to effectively use of BIM for the technical detailing. The second project was a public housing project in Aalten, submitted by ZEEP (an architectural firm from Amersfoort formerly known as Poolen Architecten) and VECCINS 3D (an MEP engineering firm from Wezep). The building complex accommodated appartments for elderly people with care facilities. The architect and the MEP engineer extensively used BIM during the conceptual and technical design processes, and attempted to achieve a high efficiency in the collaborative working processes. The IFC open standard and certain BIM tools –including a centralised BIM model server– were deployed. The MEP engineer also used standardised building service components stored in a BIM object library.

In these projects (the housing projects in Wassenaar and in Aalten), BIM was initiated by the architect, who then asked the structural engineer and the MEP engineer also to work with BIM. Each party made an agreement with the project owner on the design and engineering fees including the required effort to setup and develop BIM. The architects and engineers were paid based on the working hours on the project. Although there was no objective financial evaluation on these projects, all project stakeholders basically agreed that the extra investment paid by the project owner for BIM and integrated design process in the early phase would be compensated by the saving in the later phase. Redesigns and ad hoc modifications due to the design errors resulted from the unsynchronised information from different disciplines would not occur as all information was integrated and validated in the BIM model. The contractor was not yet involved during the development of BIM in the design and engineering phases.

The third BIM based housing project was submitted by Bouwbedrijf Flipse (a contractor from Koudekerke) and WTS Architecten (an architectural firm from Vlissingen). This project was located in Koudekerke and resulted from an initiative of a group of SMEs in the local building sector to apply an integrated design approach based on supply-chain integration. The main goal was to minimize design errors and the respective ad hoc repair work during the construction through the improved communication and coordination. BIM was, therefore, developed together by these different parties. This was clearly demonstrated in the completeness of the BIM model, i.e. the inclusion of information from architectural, structural, and MEP disciplines. The IFC open standard was partly used for integration of information generated by different software applications. The project stakeholders previously worked together in other projects. The project owner was a project developer, which was also the main contractor. Each party put effort and resources in the BIM implementation. Such an informal teamwork commitment based on trust was unique considering that these parties still used the traditional contractual agreement. Based on this positive experience, they intended to establish a kind of partnering agreement or a project-based comakership. This could be successful among a small number of parties with strong trust-based relationship and as long as the private project owner directly involves both in initiating the project (e.g. as a project developer) and in carrying out the project (e.g. as a contractor).

4.2. BIM use in public building projects

Two of the five nominated BIM based projects were medium and large-scaled public buildings, i.e. a school and a hospital.

The BIM based school building project in Veenendaal was submitted by BuildingInfoArchitects (an architectural firm from The Hague) in cooperation with ZEEP (an architectural firm from Amersfoort formerly known as Poolen Architecten). The building comprised 13,500 sqm floor area. While ZEEP as the main architect developed the design, BuildingInfoArchitects was in charge of developing the BIM model. The structural engineer was then involved to integrate the structural design in the BIM model. In addition to the use for 3D visualisation to support the communication with the project owner and end-users, the BIM model was also useful to calculate the floor area and building volume for repetitive validations of the user functional requirements during the design process. Much information necessary to apply for a building permit was derived directly from the BIM model. For the agreement on the collaboration within the project, the so-called “Living Building Concept” was adopted. This concept promoted a more flexible agreement between the project owner and the other project stakeholders in case of design modifications conform to the changing user requirements (Ridder 2006). The concept aimed at providing the project owner with a maximum flexibility in the project plan to anticipate the changing user requirements. In this sense, the project owner could partly influence the execution of the project depending on the need for change, instead of (totally) hand over the project to the contractor after the tender. BIM was very useful as the architect and contractor worked closely together. However, the project suffered several setbacks as it appeared to be difficult to fit the Living Building Concept into the existing project delivery and legal frameworks. Much time was spent to examine possible combinations of Design-and-Build and the Dutch Building Team methods. As a result of the uncertainties, the initial architect and the contractor withdrew and the process was restarted. The contractual agreement was finally settled with a project developer, which was also the contractor for this project. BIM was then implemented by the architects under commissioning of the new project developer / contractor.

The other public building project nominated was the BIM based hospital building project in Amersfoort, submitted by AtelierPRO (an architectural firm from The Hague). The project comprised a large-scaled hospital building complex covering 113,000 sqm floor area. The building complex included various facilities, such as emergency rooms, operation rooms, laboratories, hospital bedrooms, a policlinic, utility rooms and a parking garage. The BIM implementation in this project was characterised by the close collaboration between the architect and the contractor in developing the BIM model for use throughout different project phases. Well-structured and formalised working procedures, which were established in the early phase, contributed in the high consistency of the modelling process and the model. The BIM model was used for 3D visualisation, cost calculation, and generation of technical details, specifications and bill of materials. The project was basically carried out based on the traditional Design-Bid-Build method. The design process was carried out by the architect together with the structural engineer and MEP engineer. When BIM was implemented, the integration between architectural and structural designs occurred within the same architectural firm which had an in-house structural design department. Subsequently, the information from the other firms, i.e. the specialist structural engineer and the MEP engineer, was added to the BIM model. Other than a common traditional project delivery method, during the developed design phase and prior to the tender for the construction work, the contractor became involved based on a special agreement which resembled the Dutch Building Team method. The involvement of the contractor during the design process and the collaboration between the architect and the contractor resulted in a solution for reusing the BIM model for the subsequent construction phase.

Based on the assessment of the submitted BIM models and the presentations by the nominees, the jury decided the winner of the competition, which was the public housing project in Aalten submitted by ZEEP (Bouwend Nederland 2011). The project and the involved participants were highly regarded for the appropriate use of BIM technologies to support open design collaboration. This underlined the added value of BIM, not only as a model containing rich information, but more importantly as a new possibility for different disciplines using different tools to integrate their information and working processes.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. Conclusions

The best practices in The Netherlands, which are analysed in this paper, show that BIM is useful for various project types: residential and public buildings, small and large-scaled projects, privately or (semi) publicly owned facilities, projects by SMEs and by large companies. Based on the analysis of literature and real practice, this paper concludes that BIM can be used in combination with any project delivery method. However, the effectiveness of BIM to support an integrated collaboration depends to the framework of each method and the scope and duration of the contract. The impact of BIM is the greatest when used in a complex project where the project stakeholders collaborate in an open and integrated way during a long time through the building life-cycle.

Although any project delivery method can be applied for a BIM based project, there are different challenges to the effectiveness of BIM according to the selected method. The separation between design and construction activities and responsible parties in the traditional Design-Bid-Build method hampers the integration of building life-cycle information in BIM. In the Dutch Building Team method, the open integration of knowledge in BIM is very difficult due to the requirement to 'protect' certain knowledge to allow a fair tender process to take place despite the contractor has been involved in the design process. In the Design-and-Build method, the project owner is supposed to establish a functional programme of requirements and hand over the execution of design, construction, etc. to the contractor. This means that after the tender, the project owner cannot actively involve in the project in design and construction. Consequently, a total integration of the knowledge from all parties from both the demand side and the supply side is less obvious. IPD foresees the signing of the contract between the project owner, the architect and the contractor before the detailed project plan and the design are created. This method is difficult to apply in a public tender which should be opened to large number of candidates and should be evaluated based on the price of the project.

Certain aspects of the project remain unchanged despite the use of BIM. The design –whether or not it is made and presented in a BIM model– remains the responsibility of professional and certified designers (architects and specialist designers), especially for the issue of a building permit. The construction work –whether or not it is carried out with BIM support– remains the responsibility of the contractor, especially regarding the construction techniques, safety and health during the construction process. Therefore, the division of risks between the project stakeholders, according to the selected project delivery method and contract model, is not changed by BIM. Nevertheless, as the information on the product (the building) and the processes (the way the building is to be realised) is integrated in one model, using BIM the project stakeholders can clarify the risks attached to each product or process component. Using BIM, hidden risks can be uncovered much earlier than in the traditional process. This will allow the stakeholders to anticipate the risks and to timely agree on necessary measures.

5.2. Recommendations

Since the existing project delivery methods were developed before the BIM era, and since the BIM based method (such as IPD) may not be suitable to the local tendering regulations in different countries, the project stakeholders should discover new possibilities for optimal achievements. Certain lessons can be learned from the best practices discussed in this paper, i.e. a project-based comakership, a more flexible Design-and-Build method refer to the dynamic life-cycle contract, and a partial application of the Dutch Building Team method. The existing contract models are not the barriers for BIM implementation. However, in order to avoid the effort of making a new formulation at the establishment of each project contract, it is highly recommended to develop and standardise a set of general contract conditions regarding a BIM project. An example of how some legal issues related to BIM can be addressed in the regulation can be found in the BIM Addendum which is widely used in the USA (ConsensusDOCS 2008). The existing national BIM guidelines, for instance in the USA, Finland and Australia (NIBS 2007; Senate Properties 2007; CRC Construction Innovation 2009) should be enriched by such general contract conditions. To a certain extent, this should also become an international standard, for instance through the BIM Handbook by BuildingSMART (2010).

Future research should focus on analysing real experience based on primary source of information, such as surveys and interviews with the project stakeholders. As more and more BIM based projects are carried out, cross-case analysis and comparison between the real practice and the theoretical concept will become essential to determine the most effective strategy to apply BIM for a certain typology of building projects.

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