Rethinking the project development process through use of BIM

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RETHINKING THE PROJECT DEVELOPMENT PROCESS THROUGH USE OF BIM

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ABSTRACT

Building Information Modelling (BIM) is a process whereby digital representation of the physical and functional characteristics of a facility are built, analysed, documented and assessed virtually, then revised iteratively until the optimal model is obtained. The virtual BIM model is not only a graphical design but a process to generate and manage building data. All project participants can use BIM as a real simulation of the actual project. However, in regard to the linear, uncoordinated and highly variable traditional processes, there is ambiguity how BIM can be consistently utilised during whole project life cycle and whether traditional processes are able to fully benefit from BIM.

This study did a literature review and identified that BIM is greatly effective in all aspects of a construction project life cycle and overcomes many of the problems found within the traditional process management by providing an object oriented, parametric and visual representation of the product. It was also found collaborative delivery methods such as IPD and DB are more appropriate for BIM based projects. Nevertheless, in order to effectively use the BIM, it is required to rethink the way in which projects are delivered.

KEYWORDS

BIM, communication, coordination, productivity, planning, digital data storage, information management, project control, integrated project delivery.

INTRODUCTION

A set of teams from various disciplines are employed to deliver and operate a building project and information is a crucial factor for them (Vanlande et al., 2008). Project team members traditionally access the required data via reports, blueprints, work schedules and periodic meetings whereas providing and presenting the information in this way is time consuming and

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needs human effort. Traditional methods also fall short in accurately monitoring life cycle of building projects.

IT systems have been developing to help project participants access more accurate and updated information. These systems cover all disciplines and are utilised to determine and document the contributions of each project member (Fisher & Kunz, 2004). The most well-known and functional IT product presently is Building Information Modelling. BIM is not just a 3D virtual representation of building, but is a process by which a digital representation of the physical and functional characteristics of a facility are built, analysed, documented, and assessed virtually, then revised iteratively until the optimal model is obtained (NIBS, 2007). BIM consists of a significant information packages for the management of building life cycle such as cost estimation, scheduling, clash controls and energy analysis. Therefore, the designer, contractor and facility manager and all other players can use BIM as a real simulation of the actual project from earliest stage. However, there is ambiguity about how BIM can be consistently used during whole project life cycle and whether traditional processes in building projects are able to fully benefit from BIM. This research aims at rethinking the current life cycle of a building project through implementation of Building Information Modelling. Section 1 investigates BIM development process and its impact on traditional life cycle of building projects. Section 2 analyses the most appropriate delivery methods for development of BIM based projects.

WHAT IS BIM?

There is no definite definition of BIM but there are many ways of interpreting what BIM is. Aranda-Mena et al. (2008) found that for some BIM is a software application and for others is a process for designing and documenting building information. Also some other people consider BIM as a whole new approach to practice and advance the profession which requires the implementation of new policies, contracts and relationships amongst project stakeholders. The latter interpretation has been chosen for this paper. In other words, BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle; defined as existing from earliest conception to demolition (NIBS, 2007). This definition of BIM contains adequate life cycle building information and does not refer only to one group of stakeholders, thus it is used as the underlying definition and purpose of BIM for this research.

BIM is a process for managing the information produced during the life cycle of an asset (NBS, 2013). However, the use of BIM was limited to architects but now is moving toward other phases and to all disciplines across the architecture, structure, MEP, and construction industry (IBC, 2011). BIM is not just a tool or a solution (BIFM, 2012), but rather value-creating collaboration, underpinned by 3D models and intelligent structured data (BIM Industry Working Group, 2011). Variable digital models or an integrated model contain all the information about project, which is built by project participants and support the interchange of data among them. In addition to planning and design phase, the BIM method consists of cost management, construction management, project management and facility operation (IBC, 2011).

BIM AS PROJECT DEVELOPMENT PROCESS IN A BUILDING LIFE CYCLE

In an increasingly competitive market and with pressure from clients and internal organisations to increase the return on investment (ROI) in projects, state of the art technological aids have emerged in order to minimise project costs, increase project control and amplify the construction industry's productivity (Dainty et al., 2006; Eastman et al., 2008). In today's construction, investing on modern technologies is the prerequisite to improve competiveness and economic status. Hence, BIM is being rapidly embraced by the construction industry to reduce cost, time and enhance quality (Ku & Taiebot, 2011). In fact, BIM is not just a tool or a solution (BIFM, 2012) but requires new processes and new channels of communication (Teicholz, 2013). However, due to misguided efforts and lack of guideline, the results have not been satisfactory as yet (Koskela & Kazi 2003; Tatari et al., 2007; Fischer & Kunz, 2004). As a result, construction industry in terms of level of technological adaptation has lagged behind other industries such as manufacturing.

Figure 1 shows cost of any design change during the project lifetime increases whilst the ability to impact functional capabilities decreases. BIM does not necessarily minimise the work load but forces a lot of decisions to be made in the early design phase where the cost and risk of change is lower. This indicates the need for specified expertise to be included in the project at earlier stages. In processes similar to line 4, a large part of tasks have to be carried out during the schematic design and design development. The traditional design process contrary to preferred BIM approach has the highest workload when the construction documentation is made and in this point changes cannot be made without considerable negative impact on the costs. Detailing also which usually was performed in the construction design phase now has to be carried out earlier.

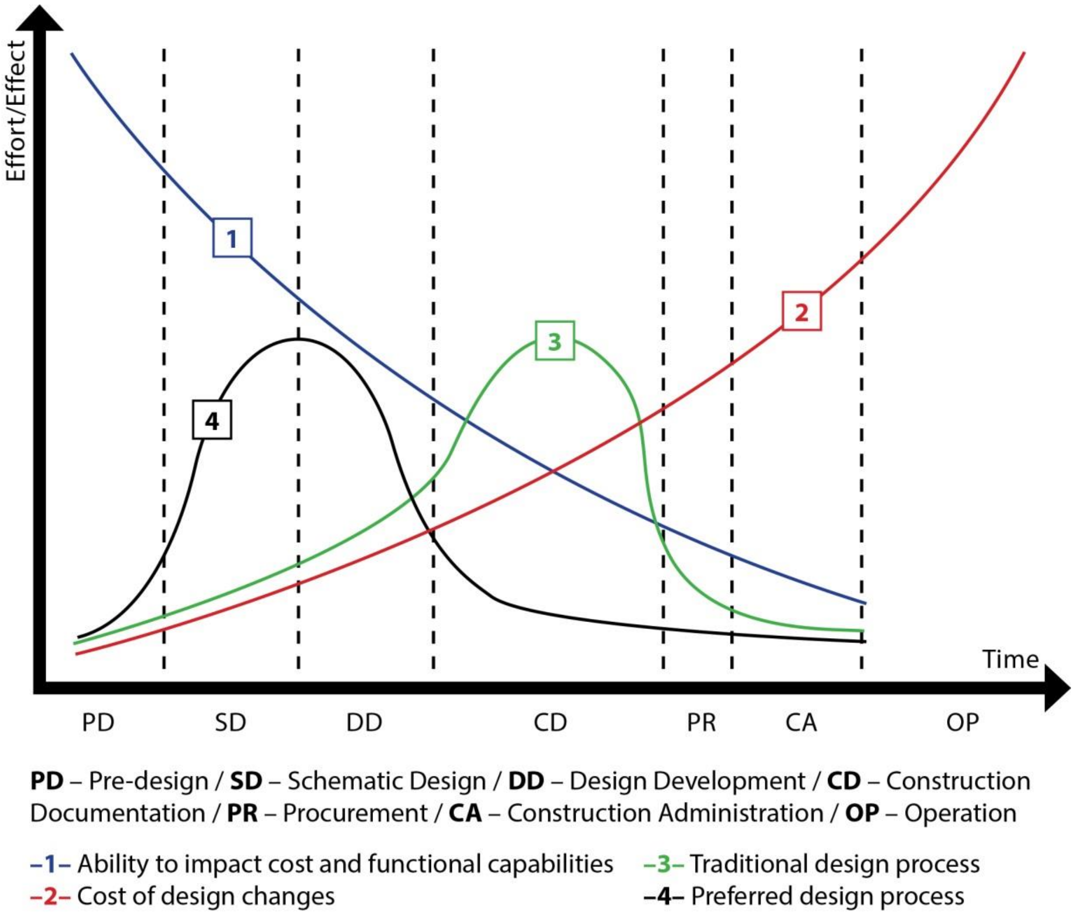

Figure 1. Added value, cost of changes and current compensation distribution for design services (CURT, 2004):

In other words, during the design phase, the use of BIM can maximise its impact on the project since it has the highest ability to influence cost. The design team and other project participants can collaboratively come up with efficient ideas and identify solutions for problematic issues before they become high cost impact. For instance, the design and technical teams can test their design ideas including energy analysis prior to construction. The construction manager can provide the constructability, sequencing, value and engineering reports and the client can visually reconsider the design based on the requirements. It is also of great value to start 3D coordination between parties on site.

Furthermore, BIM process greatly benefits from concurrent engineering (CE) management principles. The purpose of CE is to modify the sequential waterfall model (figure 2) into an iterative and integrated design mode (figure 3). This technique involves all parties to detect errors at earlier stages where cost of changes still is low. BIM by means of CE has adopted the concept of iterative and collaborative processes. CE is also very similar to collaborative project delivery processes such as design-build (DB) and integrated project delivery (IPD) within the industry where all parties are integrated in the design development whereas some other contractual agreements like design-bid-build (DBB) are based on the waterfall model.

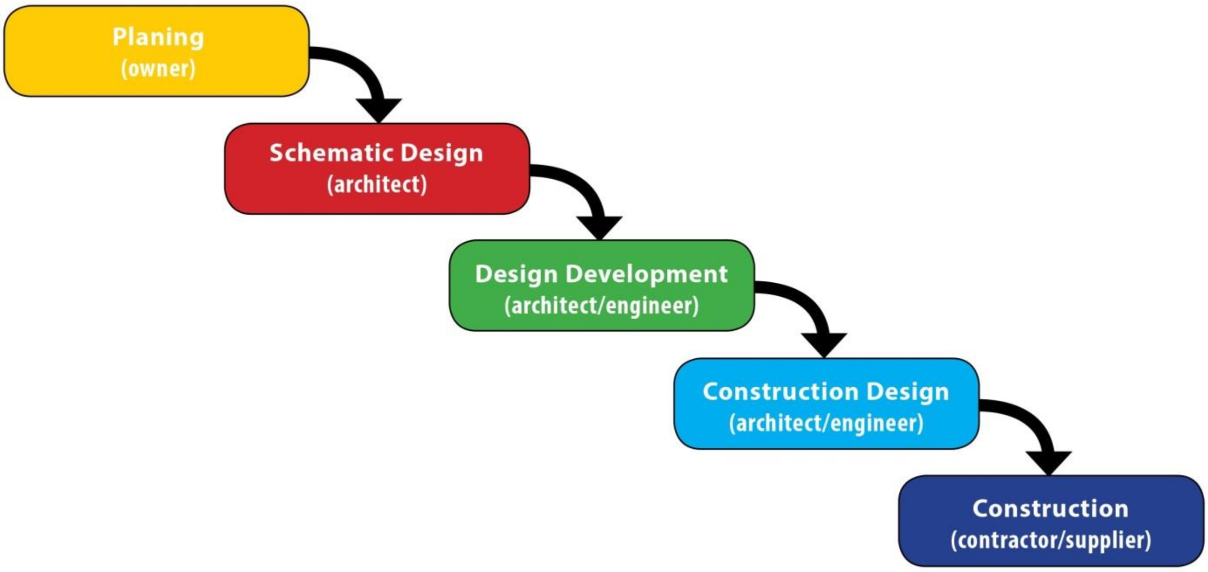

Figure 2. Waterfall model (VO, 2007)

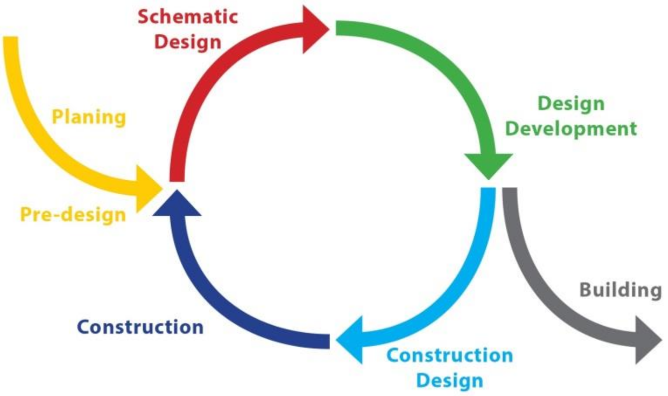

Figure 3. Iterative process (VO, 2007)

Overall, BIM aims to foster optimal collaborations between project stakeholders through the life cycle of a facility to insert, extract, update or modify information (NIBS, 2007). By using BIM, project participants can have the potential of coming closer to start an accurate and multi-disciplinary collaboration. BIM's major objective therefore is development of a new and modern process in order to have more time and cost effective production process and facility management by means of software options.

Other changes caused by BIM implementation in building life cycle are explained below. It was found that division of BIM's impacts on traditional distinct phases is difficult as all BIM processes can be started in design phase and either they continue or their consequences remain.

Visualisation and its impact on communication, collaboration and planning: Building Information Modelling is an efficient visualisation tool which provides a three dimensional virtual representation of the building. The ability to visualise gives a better understanding of what the final product may look like. In addition, virtual mock-ups facilitate decision making process on the aesthetics and the functionality of the space. This ability in BIM greatly improves communication and collaboration amongst the project members whereas traditionally the primary causes of the construction's poor performance was due to ineffective communication practices (Dainty et al., 2006; Emmerson, 1962). The efficiency of business process depends on the quality of communication and improvement in the communication can reduce failure (Thomas et al., 1998). Moreover, effective communication by use of BIM in early stages positively influences the quality (Brow, 2001; Barret & Baldry, 2009).

Visualisation promotes planning and sequencing the construction components. All components of building and tasks in model can be checked and planned prior to construction which leads to better collaboration, reduced need for on-site inventories and minimised costs (Eastman et al., 2008). In addition, BIM is able to follow up the actual construction status by regularly updating the installation dates of structures and systems to the model (Karppinen et al., 2012).

Visualisation capability in BIM compared to physical mock up is cost and time effective. However, traditional, physical mock up may still be required since sometimes curtain components of the building need to go through a series of physical tests. Therefore, virtual mock-ups could become a good standard to initiate the modelling and control the quality and constructability of design. In addition, an actual mock-up may be necessary after the virtual mock-up was approved.

3D Coordination and its Impact on Workflow and Productivity: the coordination efforts of construction manager and specialty contractors prior to construction through BIM implementation correspond with reduction of design errors and better understanding of the project. As a result, number of requests for information (RFI) and change orders during the construction are reduced which improves workflow and productivity (Love et al., 2010; Azhar et al., 2008).

Waste throughout construction resource flow is omnipresent that makes the operations inefficient although much of them are avoidable (Teo & Loosemore, 2001; Vrijhoef &

Koskela, 2000). A meta-analysis of wasted time in construction was conducted by Horman and Kenley (2005), where the authors reported that over the last 30 years, almost 49.6% of time was wasted during construction in non-value adding activities. There are other similar studies around the world, which have reported sub-optimal performance of construction projects in terms of productivity and efficiency (Teicholz et al., 2001; Ramaswamy & Kalindi, 2009). BIM is able to minimise these wasteful processes and increase labourer productivity by coordinating the activities on sit.

If the architect only provides 2D drawings, the construction manager should convert the 2D drawings to 3D intelligent models. Involved specialty contractors can coordinate their work immediately after the 3D model is generated to ensure that any same space interference (hard clash) or clearance clash (soft clash) conflicts are resolved.

Digital Data Storage and its Impact on Data Recapture: the loss of data in traditional paper based processes is another challenging issue. BIM Collaborative environment mitigates this risk by storing all information digitally and making the data easy readable to all participants. Thus, while a traditional process fails in recapturing all information, BIM stores the data accurately during the whole building life cycle (Eastman et al., 2008).

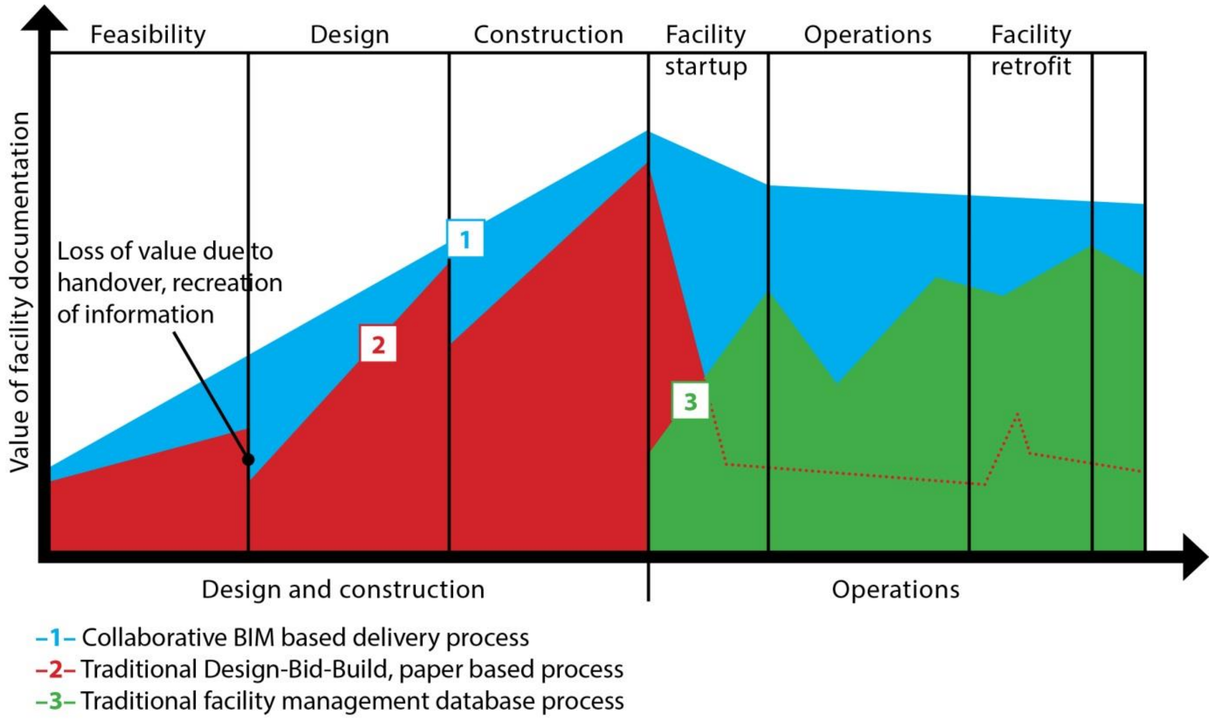

Figure 4. Data integrity (Eastman et al., 2008): Graphic presentation of the data losses during the lifetime of a building in a traditional paper-based process vs. a collaborative BIM based delivery process.

Time Estimation and its Impact on Project Planning and Monitoring: the schedule of the anticipated construction progress can be integrated into a building information model which is often called 4D BIM. It involves the scheduling and sequencing of the components and tasks in order to plan and monitor the construction progress. In other words, this method graphically visualises the project schedule and enables the users to simulate the site and construction activities at any point in time. This type of simulation provides considerable insight into the project and facilitates early detection of planning errors. Thus, instead of realising planning mistakes later on in the construction phase and having to resolve problems on site which can be very costly, mistakes can be eliminated in the design phase. Moreover, time estimation can be utilised to optimise the logistical aspects. Various alternative solutions of executing the construction can be simulated and weighted against each other to find the most beneficial solution (Eastman et al., 2008).

There are two common scheduling methods that can be used to create 4D Building Information Models, namely (1) critical path method (CPM) and (2) line of balance (Kenley & Seppänen, 2010). In critical path method, needed time for accomplishment of each task is assigned and then each task is linked to another task as either predecessors or successors. Based on the dependency and duration of the tasks, the longest path is defined as the most critical path. In this method, if defined tasks are not accomplished within anticipated duration, the total duration of the project will be further pushed out. CPM is widely used technique that keeps the project within schedule.

Line of balance technique utilises location as the basis for scheduling. It is appropriate for iterative tasks to improve the labourer productivity. In this technique, task durations are based on number of people available on site and the sequence of the location. The method focuses on the locations being completed by crew before the other crew moves in. As a result, number of mobilisations and resources can be minimised. Moreover, productivity of the trade can be revised to reach the pre-defined schedule. In general, line of balance is a proper scheduling technique to plan and monitor iterative activities during construction progress.

The planning by means of BIM during the construction and hand over stages improves space coordination and site utilisation. Some BIM software tools such as SMARTBOARD can incorporate site components to the model in order to facilitate space management and utilisation. As an example, all traffic access routes, site work progress and location of equipment can be depicted in the model as part of the logistic plan.

4D BIM can as well be used as a proactive method to improve the monitoring and planning the site safety. In other words, safety plans such as temporary structures (rails, fences, etc.) and related activities can be visually modelled. Subsequently, this contributes to better monitoring the carried out precautions on job site.

Furthermore, number of field data acquisition systems such as Radio Frequency Identification (RFID) has been developed to make the construction manager able to track the work progress (Wang, 2008). RFID can be linked to the 4D BIM to show inventories are in the right location at required time. Specifically, RFID can be tagged to the trades' protective hats to control the manpower and their position based on the project schedule. Therefore, the daily activities of crews will be monitored to find whether the crew's productivity and manpower are sufficient for planned schedule.

Cost Estimation (5D) and its Impact on Project Control: with cost estimation, often called 5D, the objects in a 3D design can be linked to price lists for different materials. The price lists are mainly based on volume cost of materials, but can also include labourer and equipment costs for more detailed cost estimates. This enables BIM users to generate accurate and reliable cost estimates by automatic quantity take off from the building model, receive a faster cost feedback on changes in design phase and better understand the financial implications of design decisions. Materials and construction solutions can therefore be evaluated from an economical perspective (Eastman et al., 2008; Sabol, 2008). The cost estimation capability is of value for both the contractor and the client. It can be used as a foundation early on in the project for the contractor to control costs and optimise the quality requirements based on the budget.

Two main elements of cost estimate are quantity take-off and pricing. Quantities from a Building Information Model can be extracted to a cost database or an excel file. Cost estimation requires an expertise to analyse the components of a material and the way they can be installed. Cost estimator can finally find the unit price consisting of the unit material cost, unit labourer cost, overhead cost and profit. The unit labourer cost is driven by the mobilisation and installation durations and the labourer wage. Also, the unit material cost is the sum of the material costs used for an activity per unit. Once the unit price is identified, the cost of the entire activity can be attained by multiplication of the total quantity extracted from BIM and unit price. Generally, quantity extraction by means of BIM technology is greatly facilitated particularly if the design team collaboratively provides the required data to estimator.

Accurate Information and its Impact on Prefabrication: prefabrication is a cost and time effective method by which construction quality can greatly improve. One of the major prerequisites for this method is accurate design and erection information. Prefabrication can benefit from BIM to obtain information with high level of accuracy through integration of 3D visual to each component with specifications, erection sequence and so forth. However, the related challenge to adapt BIM in prefabricated structures might be the interoperability of BIM with software used by fabricators.

Some of the prominent uses of BIM in prefabrication are design, production and erection of curtain wall systems, steel connections and piping systems. Curtain wall systems are divided into two categories, namely, penalised or stick system. In stick system, components are assembled on site while penalised system comes prefabricated with all components including insulation, glazing and framing. Walls, rooms and generally houses with all roughed mechanical, electrical, plumbing (MEP) components can be virtually designed and erected through use of BIM. Pipe manufacturer also can use BIM to determine piping locations, length and sizes prior to erection stage. This allows in-wall drops including hot, cold, drain/vent, vacuum, etc. to be prefabricated in a controlled environment with readily available equipment which would yield to more efficient, higher quality, and less costly products. In steel structures, BIM helps timely modification of design to eliminate or reduce use of beam penetrations on site. BIM technology is able to co-ordinate these penetration by determining their exact locations and prefabricating them offsite. Prefabricated beam penetrations save tremendous time, money and effort compared to onsite beam penetrations. However, particularly in complex projects, few beam penetrations are inventible due to MEP conflicts. Overall, integration of BIM and prefabrication method enhances the information exchange of the products between project members and significantly it is used to virtually coordinate the location and routing of the products.

Record Model and its Impact on Information Management: the problem of having accurate as-built information from the construction process has existed in the construction industry for a long period. The majority of building information traditionally has been stored as paper documents, supplied to facility managers after a building was in operation, sometimes months after handover (Teicholz, 2013). As a result, much valuable data associated with the design, construction and operation of a facility is lost during the building life span (NRC, 1983). Construction Innovation (2005a) claimed that 80% of the FM managers' time is devoted to find information of the building that they managed. NIST report states that an inordinate amount of time is spent on locating and verifying specific facility and project information from previous activities (Gallaher et al., 2004). Hence, collecting essential FM information at the end of a new built or refurbishment project is expensive as most of the information has to be recreated. For new projects it can take up to three years to generate as-built information after the financial close out of a project (East, 2013a).

Record Building Information Model is given to the owner at the end of the project. The model includes important information in terms of manufacturer specifications and maintenance instructions for building and installation components. Each object in the model can include links to operation, maintenance and warranty information (Eastman et al., 2008). Centralised database helps the facility managers to find information easier. Different analyses as well can be made to examine whether the building and its systems work properly (Eastman et al., 2008). One concrete example is the use of simulation results as a first guess when balancing the air conditioning system. Moreover, record model is used to manage security and safety information such as emergency lighting, emergency power, egress, fire extinguishers, fire alarm, smoke detector and sprinkler systems.

Record model can have a major impact on information management of construction projects and building life cycle but it requires that BIM is truly used to store all the information related to the project (Grilo & Jardim-Goncalves, 2010; Palos, 2012). Nonetheless, the interoperability of the record model with various applications could potentially be a challenge (Tulke et al., 2008). Furthermore, the owner needs to be willing to allocate funding to train employees, update and maintain the record Building Information Model. An accurate record model that contains the scope of the project and the needs of the facilities department can help the owner to manage and maintain the building. This can leave a long lasting positive impression of the construction manager to the owner of the project.

DELIVERY METHOD FOR BIM

The architecture, engineering and construction (AEC) industries have traditionally assimilated fragmented approaches when it comes to project procurement. Current dominant project delivery processes are primarily dependent on paper-based modes of communication. However, the AEC industries have not completely ignored the incorporation of technology into the project delivery process; many of the activities associated with the delivery process are now performed and delivered faster via the use of software and web-based technologies. In the following subsections, the Design-Bid-Build, Design-Build and Integrated Project Delivery methods will be analysed as a basis from which to develop the transitional program proposed as an aid to begin incorporating BIM concepts into their project delivery practices.

Design-Bid-Build

The Design-Bid-Build is a common delivery method within both public and private sector. In the first stage of DBB model, the client contracts with separate entities for each of the design and construction disciplines. Client chooses an architect who determines requirements for the building and creates the schematic design. Structural and building service engineers then will be involved to assist in design of structural, HVAC, piping and plumbing components. The end product of this stage is set of drawings and specifications which should be sufficient for construction bidding phase. The client and/or architect then make an award based on the best value to the owner, which is often the lowest bid from responsible and responsive bidder.

There are many advantages and disadvantages associated with the Design-Bid-Build project delivery method. In this method, client is able to receive competitive bids and thus in theory constructs the project at the lowest possible cost. Another benefit for the client is design team only seeks for client's interests and is impartial. On the other hand, the design team develops drawings based on pre-defined conditions and constraints which to some extent differ from the actual site conditions encountered by the contractor. The contractor does not have any impact during the design phase, thus the contractor's knowledge of constructability, material availability, value engineering and so forth in a very limited way can be incorporated into the project execution. Participants won't put extra efforts in order to deliver the project since often division of economic benefits and incentives are not part of agreement. The architect and other participants may be reluctant to share their models due to risks, liability concerns, unauthorised reuse of intellectual properties, and misinterpretation of the information.

In general, if the designer generates a 3D parametric model, design-Bid-Build method eliminates the benefits could be gained by having the construction input during design phase when the ability to influence the cost is the highest. As a result, problems, which stem from design defects, materialise during construction stage and lead to overhead costs, time delays and increased tension among the project teams. Furthermore, in collaborative environment, processes of mutual information sharing and distribution through BIM contribute to several beneficial aspects (Fisher & Kunz, 2004) while parties in the DBB model are not willing to share information. Last, division of economic benefits of BIM in-between the different disciplines is another challenge that this method is not able to address.

Design-Build (DB)

Regarding the Design-Build Institute of America's (2014) report, number of DB contracts has been continuously on upward trend since 1985. Under this system, the owner contracts with a DB team, which can be a joint venture of a contractor and a designer, a contractor with a designer as a sub-consultant, a designer-led team with a contractor as a subcontracted entity, or a single firm capable of performing both design and construction. Unlike to DBB, the primary benefit for the client is the simplicity of having one party responsible for the design and construction of the project (Sanvido & Konchar, 1999). As a result, projects are often carried out faster with fewer disputes. The DB team submits the design to client according to a set of preliminary descriptions including client's requirements and estimated cost and time. After approval by the client, the DB team can begin the construction in order to reduce the project lead time.

In DB model, all design modifications can be made in early stage of the process. Consequently, amount of money and time needed to apply changes during project life cycle are reduced. Most importantly, the intimate collaboration of the designer and the builder enables the usage of BIM as an effective process immediately after the project initiation. However, in this method, it is difficult for client to obtain comparable competitive bids from different DB teams and subsequently the method is not suited for projects that require a complex and elaborative design for aesthetical and technical purposes. In addition, since the designer and builder work together, quality control assurance is limited and cost could become a priority over quality.

Integrated Project Delivery

Integrated Project Delivery (IPD) needs a multiparty agreement between design and construction team. The purpose of this contract is to optimise project results and increase value to the owner by reducing waste and maximising the efficiency in all phases of design, fabrication and construction. In IPD, all of the partners are committed to a pre-determined system which can be BIM.

The owner should assemble the prime players into a contracted team at early inception and feasibility stages according to the presumed need of knowledge and expertise. The entire team members have the same objectives and continue their collaboration until project handover time. This results in reduction of documentation time and improvement of cost control and budget management.

However, there is a challenge about how to manage the team and have the full benefit from all of the participants. Trust is an essential factor in this method since IPD engages many participants in a collaborative agreement. Also, all costs ideally should be fully open-book in nature and all incentive and goal achievement compensation are agreed to by the team and incorporated in the contracts in advance. Overall, obtaining an optimal collaborative process needs a transparent process, value-based decision making, shared risk and reward, open information sharing, and utilisation of full technological capabilities and support.

Process Delivery Method for BIM?

The literature showed a need for better integration of project teams and collaboration between all parties. It is also required to have a new way of dealing with information and moving from the document paradigm to the Project Integrated Database paradigm. The information analysed pointed in the direction that BIM could be the tool that allows better integration of teams and information. Accordingly, the design-build, IPD and other forms of collaborative delivery methods enable better opportunities for the client to benefit from BIM adoption particularly because all prime players are involved from the earliest practical moment, the design mostly is performed in-house (Eastman et al., 2008) and entire project team is equally (or similarly) incentivised to achieve the same set of goals (CMAA, 2012). However, it is still needed to find alternative BIM based approaches to deliver a facility that creates a win-win situation for all stakeholders (Becerik-Gerber & Rice, 2010) and addresses all found challenges in existing methods.

CONCLUSION

Traditional development process in building projects is inefficient and faced many challenges. The future of building projects lies in the use of technology and BIM is expected to build this future. The introduction of BIM into life cycle of building projects requires fundamental changes in traditional project development processes. Most importantly, BIM aims to focus the bulk of workload in early design phase when cost of any change is lower and use the CE concept to modify sequential waterfall model into an integrated design model. In general, BIM is able to revolutionise traditional development process in order to have more time and cost effective processes during building life cycle.

As a digital representation, BIM provides a virtual view of the objects in the building with physical geometry (2D or 3D) and other functional parameters such as materials and spatial relationship. This model incorporates both physical and functional information stored in the BIM objects. This ability increases the design quality, facilitates decision making on the aesthetics and the functionality of the space, enables planning and sequencing the construction components and improves communication and collaboration. 3D coordination of activities prior to construction reduces design errors, gives the better understanding to participants, increases the labourer productivity and minimises inefficient processes on site. Furthermore, design, production and erection of components in prefabricated structures can be carried out in a controlled environment since BIM is able to virtually coordinate the location and routing of the products.

BIM also has the capability to incorporate project schedule (4D) and component price (5D) to the building model. 4D BIM simulates the construction process, visualises the sequence of construction, and reveals potential problems on the site and opportunities for improvements. 5D BIM generates accurate and reliable cost estimates in order to control costs and optimise the quality requirements regarding the client's budget.

Record Building Information Model acts as a centralised database and contains information related to building and installation components. It helps the facility managers to find information easier, analyse the system efficiency and avoid any loss of data. Moreover, record model is used to manage security and safety information. After the completion of the building model, all the information can be generated by users for fabricating, analysing, project scheduling (4D BIM), cost estimating (5D BIM), and eventually, for facilities management during operation phase.

BIM requires enhanced integration of project teams and collaboration between all parties. Hence, regarding delivery methods, collaborative approaches such as IPD and DB compared to linear methods like DBB are more able to optimise BIM based projects. The intimate collaboration of the prime players in earliest stage is highly compatible with BIM capabilities. Further, collaborative methods can resolved the problems such as division of incentives gained by BIM between stakeholders and lack of contractor’s knowledge in design phase by their early involvement. However, there are still some challenges relevant to management of project teams, having competitive bids and meeting client's needs that imply a need for development of new methods and clear guidelines to create a win-win situation for all stakeholders.

BIM is not just a temporary trend, but it can revolutionise the current process of building development. The research findings indicate a need for more detailed understanding of BIM's impact on business process of all disciplines within the industry during the project life cycle. Currently, the author has undertaken another research using expert opinion survey to collect detailed qualitative information regarding how BIM has changed the business process and organisational structure of construction firms.

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