BIM IMPLEMENTATION PLANS: A COMPARATIVE ANALYSIS

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To realise the benefits of BIM in construction management using (4D and 5D applications), it has to be implemented first. There are various BIM implementation plans to select from; with BIM features and guides, companies better understand BIM concepts and can easily choose a plan to apply in their operations. A literature review was conducted and 15 different definitions of BIM were encountered. Twelve different BIM implementation plans were found in publications by academics, software vendors and Architecture/Engineering/Construction (AEC) industry professionals. Those implementation plans were compared using a matrix which covers the complete building lifecycle. This research concludes that out of the 12 implementations plans, three were equipped with additional guides attached to their plans, simplifying project data collection; namely those by Autodesk, Penn State University and Indiana University. One implementation plan that scored very highly (based on 16 key issues identified from the three categories of stakeholders specified in this project) was the implementation plan proposed by a major software vendor. BIM is poised to solve many of the shortcomings reported in the construction industry. However, before realising the full potential of BIM in construction management, it needs to be systematically implemented.

Keywords: implementation plans, BIM, construction management.

INTRODUCTION

Eastman *et al.* (2011, 2008) and Hardin (2009) agreed that BIM use is growing in the AEC Industry. It is undoubtedly important in construction management, but needs to be implemented to reap its benefits. Currently there is no universal BIM implementation solution. Therefore, a question arises, how do you choose a good BIM implementation plan? It is important to first understand the nature and scope of BIM. It is characterised with many features; Isikdag and Zlatanova (2009) noted BIM as object oriented, equipped with spatial relationship between building elements, data rich with functional information about a building, and enabling automation of multi view generation. However, there is no standard universal implementation guide for

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Ahmad A. M; Demian P and Price A.D.F (2012) BIM implementation plans: A comparative analysis *In*: Smith, S.D (Ed) *Procs 28th Annual ARCOM Conference*, 3-5 September 2012, Edinburgh, UK, Association of Researchers in Construction Management, 33-42.

BIM; standards are being produced by different organisations for different purposes. Eastman *et al.* (2011) stated that the existence of various BIM implementation approaches can change existing working pattern of organisations to allow the implementation of new technology. Howard and Bjork (2008) stated that “many standards relevant to BIM exist but it was suggested that there is a lack of frameworks into which they could fit”. They were also of the view that BIM deployment standards are not compatible with all companies due to differences in organisational cultures, procedures, size, company goals and objectives. It is crucial before choosing any implementation plan, to have a good understanding of BIM; Aranda *et al.* (2007, 2008); Succar (2009) agree that BIM means different things to different people.

This research first identifies BIM features from the views of various stakeholders in the building industry. The methodology used in defining BIM and analysing BIM implementation plans is based on a literature review. The overarching aim of this paper is to compare BIM implementation plans; it is of great importance to understand BIM and plan for its implementation, due to the UK Government push to mandate the application of BIM in major public-sector building projects by 2016 and to realise its benefits. Arguably some experts view BIM as either an IT tool or a procedural process, while others views BIM as the combination of both technological tool and a comprehensive building process used in improving building procurement and envisioned to promote collaboration between professionals in the building industry. Eastman *et al.* (2011) agree with Hardin (2009) that BIM is defined by various experts and organisations differently. This paper identifies BIM features within 15 definitions from three categories: A) academic sources; B) software and hardware vendors; and C) AEC organisations. Table 1 was tabulated by identifying seven keywords from the 15 different definitions of BIM. These keywords appeared at least three times in all the 15 different definitions of BIM. The following keywords: "Information"; "modelling"; and "process" had appeared more than any other feature of BIM from the keywords mentioned in Table 1. Therefore, BIM for the purpose of this research can be defined as the process of using information technology for sharing, modelling, evaluation, collaboration, and management of a virtually building model within a building life cycle. BIM was also classified into three groups: building model (simulation, automation and presentation); building process (thinking, scheduling and organisation) and information management (preservation, sharing and organisation) within a building life cycle.

BIM Implementation Plans

Related Researches on BIM Implementation Plans

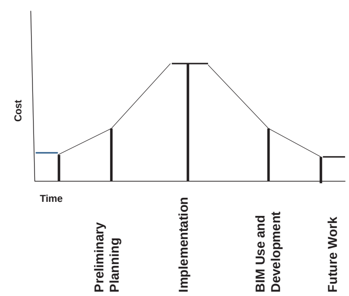
Stebbins (2009) considered BIM as a process rather than a piece of software. He clearly identified BIM as a business decision and the method of implementing BIM as a management decision. BIM implementation is strongly related to managerial aspects of professional practices; most industries have different working styles and cultures. AGC of America (2006) stated that “each project is unique, and the implementation of BIM should be tailored to the needs of the project”, therefore, standard implementation plans must be sensitive and can be tailored to the individual characteristics of each project. Fisher (2011) stated that a BIM plan: “defines scope of BIM implementation and information exchange; identifies the process flow for BIM tasks; and describes infrastructure needed for support”. He also noted that it provides a better understanding of goals, responsibilities attached to each personnel, teams, department, and management. BIM implementation plans also help to reduce unknown variables with competence to schedule and outline expected training and resources required for construction management.

Table 1: BIM features described by three different categories.

References	Information	Management	Modelling	Process	Technology	Analysis	Collaboration
A. BIM Definition by Academics							
1. Weygant (2011:vii)	x	x	x	x	x		x
2. Eastman *et al*. (2011)	x	x	x	x	x	x	
4. Hardin (2009:4)	x			x			
6. Smith and Tardiff (2009:xi)	x			x			
7. Howard and Bjork (2008)				x			
9. Sweet and Scheier (2008:375)	x		x		x		
B. BIM Definitions by Software Vendors							
12. Bentley (2011)	x	x	x	x	x	x	
13. Nemetschek`s Vectorworks (2010)	x		x	x	x	x	
14. Graphisoft (2002:5)	x		x	x	x	x	x
15. Autodesk (2002:1)	x	x	x	x	x	x	x
C. BIM Definitions by Architecture Engineering and Construction Industry and others							
16. BIM Journal (2011)	x			x			x
17. BuildingSmart (2008)	x	x					x
19. VTT (2006:25)	x	x		x			
20. AGC (2006)	x						
21. State of Ohio (2010)	x	x	x	x			x

Classification of BIM implementation Plans Levels

There are various methods of implementing BIM. The following methods were identified from literature: Top-down; bottom-up; slow and drawn out; using a selected team; using multiple teams; and implementing on a specific projects, all projects or the entire organisation. Jung and Joo (2010) described BIM implementation to be of three levels; industry, organisational and project levels. At the industry level, BIM standards are successfully developed, but the organisational and project level standards are different due to their formats, details and purpose, and are also related to managerial corporate strategy issues. Ashcraft and Sheldon (2008) noted that BIM adoption is divided into three groups of activities covering different scopes: Within an office: Selecting software; addressing IT issues; and training up and rolling out. Across the design team: Selecting software: addressing IT issues: and also legal and contractual issues. Across the project delivery team: Procedural scope (design, coordination, estimating, scheduling, submittal review, fabrication, agency review and facility management); and also legal and contractual issues. While the cost of BIM implementation is one of the major limitations of BIM adoption. There is no specific standardised amount designated to the cost of Implementation, nor a clear understanding of how to precisely estimate such cost. Hardin (2009) described that the cost of BIM implementation is higher when implementing; this involves the cost of training and software. In the life cycle cost of BIM implementation, the cost gradually reduces during the use and development phase. BIM users experiences lesser cost during the "future work" phase; perhaps training and (software and hardware purchasing) are the most expensive issues to think through when implementing BIM.



Figures 1: Cost of BIM implementation plans (Hardin, 2009).

Benefits of BIM in Construction Management

Weygant (2011); Autodesk (2002); Succar (2009); Hardin (2009); Aranda Mena *et al.* (2008); Eastman *et al.* (2008, 2011); AGC of America (2010) agreed that 4D and 5D modelling, helps clients and contractor to make inform decisions, by estimation, coordination and scheduling the construction process. The client can get a better scope and nature of the design and construction with BIM visualisation. Construction sequence can be visualised systematically, showing construction progress with time and cost implications attached. It also helps in synchronising the procurement of design and construction planning for early error detections. BIM is also used in managing existing facilities, by fully modelling and linking the structure to the virtual model. This way, energy consumption and operational faults can be detected from the model for management purposes. For example, the Sydney-Opera House is currently managed using a BIM model for facility management. It is also evident in literature that BIM is used more (higher percentage of use) on the construction compare to the design phase; perhaps BIM is effective in achieve quality and efficiency in construction management.

Barriers of BIM

Yan and Demian (2008) noted that people barrier seems to be the most challenging factor: companies have to provide time; human resources; and to training, forming a business case for BIM. Howard and Björk (2008:23) described the need of education, sharing, standards and legal issues to implement BIM, weygant (2011) and Eastman *et al.* (2008) agreed that legal issues are also barriers to implementation, Aranda Mena *et al.* (2008:14) suggested that due to the nature, size, relationship of private and public sectors involved, it will be difficult to assign a standard implementation plan for each firm to observe. Eastman *et al.* (2008) is on the view that there are both technological and sociological barriers to BIM implementation. Succar (2009:363); Aranda Mena *et al.* (2008); Eastman *et al.* (2008, 2011); AGC of America (2010); Howard and Bjork (2008) agreed that interoperability is a major issue of the use of BIM in the building industry. Succar (2009:363) defined interoperability as "the ability of two or more systems or components to exchange information and to use the information that has been exchanged.

RESEARCH METHODOLOGY

Literature review was used to define BIM: BIM implementations plans; levels of BIM implementation; identified best practices; barriers and benefits. About 20 high quality articles relating to BIM were selected for a comprehensive state of the art literature review. Research defined and compared BIM implementation plans from three stakeholder groups, academics; software vendors and professional AEC industry organisations. The objective was to find the common key factors used to deploy BIM. Comparability is defined by Kotabe and Helsen (2009), as the similarity and difference features of one research results to another. It is important to compare studies to illustrate the significance of choosing an implementation plan by identifying its features. BIM can be understood from a building life cycle point of view, therefore the BIM implementation plans (key factors) were categorised into pre-implementation, implementation and post-implementation. The comparison matrix was based on the criteria by Fisher (2011) who noted critical issues in adopting BIM execution Plan as: Goals; Participants; Level of detail; Infrastructures; Software platforms and Workflow. A total of sixteen key factors were identified, from which 14 were mentioned in at least 3 different implementation plans among the 13 plans. Two other key factors were identified by (Arayici *et al.* 2011; Messner *et al.* 2010) and Eastman *et al.* (2011) as vital issue of BIM implementation, there are: (specifying level of BIM implementation; and spreading BIM implementation from one team to others) respectively. Three of the 12 different implementation plans described from the three categories (stakeholders) in this paper, had additional data collection formatted documents, which are Indiana University, Penn State University and Autodesk.

COMPARISON SYNTHESIS

Table 2 shows categories of BIM implementation plans classified into three (A-C) and numbered (1-12): A. Software: Autodesk, (2010) [1]; and Dell, (2011) [2]. B. Academic: Eastman *et al.* (2011) [3]; Arayici *et al.* (2011) [4]; Hardin, (2009) [5]; Succar, (2009) [6]; (Penn State)-Messner *et al.* (2010) [7]; Indiana University [8]. C. AEC Industry and others: AGC of America, (2010) [9]; (BuildingSmart) - Lin *et al.* (2005) [10]; AIA, (2008) [9] [11]; and BIM Road Map, (2011) [12]. Table 2 was tabulated based on the 16 key issues identified within the 12 implementation plans cited by this paper. Each implementation plan that had one of the listed 16 key issues was ticked with an “x”. There is a 100 percent agreement with regards to ten key issues identified within the 12 implementation plans, and a gap on starting BIM implementation from a team and also spreading from a team to entire organisation.

Table 2: Comparison of BIM implementation plans from three different categories.

	Analysis of BIM Implementation plans numbered (1-12)												
	Pre-BIM Implementation Phase	1	2	3	4	5	6	7	8	9	10	11	12
1	Define BIM goals	x	x	x	x	x	x	x	x	x	x	x	x
2	Plan BIM uses	x	x	x	x	x	x	x	x	x	x	x	x
3	Start with a team			x						x			x
4	Leadership	x	x	x	x	x	x	x	x	x	x	x	x
5	Managerial support	x	x	x	x	x	x	x	x	x	x	x	x
6	Specify level of BIM implementation	x	x	x	x	x	x	x	x	x	x	x	
7	All stakeholder involvement	x	x				x	x	x				x
8	Identify current skill and list required skills	x	x	x	x	x	x	x	x	x	x	x	x
	BIM Implementation Phase												
9	Continuous training and development	x	x	x	x	x	x	x	x	x	x	x	x
10	Collaboration	x	x	x	x	x	x	x	x	x	x	x	x
11	Information exchange execution	x	x	x	x	x	x	x	x	x	x	x	x
12	Appropriate hardware and software	x	x	x	x	x	x	x	x	x	x	x	x
13	Conformity to standardisation	x	x	x	x	x	x	x	x	x	x	x	x
	Post BIM Implementation Phase												
14	Educational BIM awareness	x			x		x	x		x			
15	Spreading implementation from one team to the others	x		x									
16	Review performance	x					x	x					x

DISCUSSION OF FINDINGS

Table 1 was tabulated from 15 different definitions of BIM. There is an agreement in the features identified from the definitions that BIM is a technology, a process, an information management tool that allows (data storing and sharing). Table 2 shows agreement across the selected BIM implementation plans within the pre-implementation and the implementation phases. There is lack of agreement in two of the 16 keywords listed as: starting with a team; and spreading the implementation to other parts of a given industry. The advantage of starting with a team is that, it can easily be managed rather than starting with the entire professionals with an organisation. Obstacles encountered by a small team could be avoided by an entire organisation; saving project time and cost.

Literature shows that BIM usage has a higher percentage in construction compared to the entire design process; its applications are many and varied. Impact of BIM in Construction management can be categorised into three: 1.) Pre-construction-. It fosters the capability of making designs constructible, providing clash detections analysis, estimations, and other detailing such as BIM prefabrication modelling and information management for manufacturers specifications. 2.) Construction -

Autodesk (2002) described BIM in this phase to improve construction quality through 4D and 5D modelling. This involves time scheduling and information generation to make informed decisions. After analysing models in the pre-construction phase, the data can be used for organising and scheduling construction work progress with cost and time implications. This will eventually reduce errors and possible construction reworks. 3.) And management phase - the building life cycle includes inception, completion, and operational building management to demolition phases. Information for concurrent use of facility can be used to analyse the performance of a building for energy performance, utilisation analysis and their financial implications. The operational phase of a building is advised to always be linked to the first cost of a building, as the cost of running a building over some years could be more than the first time cost of a building. It is therefore important to analyse and compare the virtual analysis of a building performance to its real time performance. This can be used to improve the performance where it is deficient. The information on the performance of a building can also be used for managing the operation of a building.

BIM allows the architect and engineer time to collaborate within a project. Hardin (2009) stated that BIM "is mostly ineffective" in design-bid-build; this is one of the most traditional delivery methods that follow a linear sequence where the design precedes the construction, the ability of BIM to allow collaboration is hereby limited. Nevertheless, BIM can help with many other tasks such as quick financial quantification. BIM as a coordination tool for construction management works well with the design and build method; it is a combined service, with the full responsibility for design and construction, and could be architect or contractor lead. It allows BIM application to be fully explored and used to realise its benefits for construction management. However BIM has to be implemented before apprehending its benefits.

Olofsson *et al.* (2008) described that when using BIM in a building life cycle, the client is understood to achieve more benefits. Some of the most common barriers mentioned among the 3 stakeholders were the cost of training, software and hardware, perhaps when Implementing BIM organisations should be clear on the reality of their capabilities (Jason and Isikdag (2010:88). Implementation plans forms the basis for the use of BIM in practice, Jung and Joo (2010) stated that “it is important that the proposed framework be used as an evaluation criterion for practical implementation”. Messner *et al.* (2010) described key challenges of BIM implementation when developing an execution plan as defining appropriate purpose for the use of BIM, and information exchange. Indiana University (2009) and Autodesk (2010), have made recommendations to improve information exchange, they suggested one professional from each stakeholder group to form a team and agree a common naming and file format system, which makes each files easily identified to other professionals. Some parties tend not to share their process of achieving success with BIM (Howard and Björk 2008:26). It is important to start with the best team before spreading BIM implementation to other teams and projects, this will require smaller budgets, with ease in controlling difficulties when they arise; findings can easily be shared with the organisation at large and peer review for evidence based practice

Fisher (2011) highlighted six key issues for BIM adoption; this research identified 16 key issues adopted and modified from Fisher (2011) and as seen from the 12 different BIM implementation plans. Perhaps BIM can be implemented efficient and effectively following these 16 key issues identified in Table 2 as a primary guide for a general BIM implementation before the benefits of BIM can be realised.

Limitation of research

In Table 1, some of the keywords were not directly quoted from the various definitions of BIM, but indirectly described. For example; "information" category was considered as: data; database; characteristics; features; and documentation. In table 2, there are various others key issues that appeared in at least 3 different BIM implementation plans, but the selected key issues were based on Fisher (2011) description of important factors considered for BIM adoption.

CONCLUSIONS

BIM implementation standards are being produced by different organisation for different purposes consequently, according to Howard and Bjork (2008:274) “many standards relevant to BIM exist but it was suggested that there is a lack of a framework into which they could fit” they are also on the view that BIM deployment standard are not compatible with all companies due to difference in culture, organisational traditions, size and company goals and objectives. This makes the standards variable. Table 7 highlight horizontal black shadings showing BIM implementation plan gaps, most of them fail to acknowledge specific levels of implementation plans in their framework or guides. It is important that users know the exact guide to pick which suits their specific needs, implementation at a project level, might not necessary need the same criteria for implementation as at an organisational level, office level, or team level. Provision of multiple options can encourage BIM implementation. The top three implementation plans in this paper starts with the Autodesk plan, it has identified most key issues of implementing BIM, followed by BIM execution plan by Penn State University, with a similar plan from Indiana University. Apart from prescribing key issues to BIM implementation, all three plans have guides that can easily facilitate information collection from users and help provide the appropriate guide to implementation. Further research can be done with future emergence of more implementations plans. This research will further develop a framework for applying BIM in the design of flexible healthcare space.

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