ASSESSING THE BIM MATURITY IN A BIM INFANT INDUSTRY

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ABSTRACT

Building Information Modelling (BIM) is rapidly gaining acceptance of building industries internationally, and is likely to become the primary industry standard for AEC information exchange in near future. The built-in intelligence of BIM offers the highest potentials for adopting lean approaches for project delivery, and minimizing of risks and uncertainties; enabling highly sustainable procurement systems for the building industry. While it is accepted that BIM is in its infant stage in Sri Lanka and BIM technologies are rarely present, adoption of BIM has been identified to be timely. Use of inappropriate BIM adoption strategies would waste valuable resources and time. This will also hinder the industry acceptance of BIM. Development of reliable strategies requires information on current BIM maturity in order to identify the gaps. Wider gaps in a BIM infant industry give rise to the number of potential alternative BIM adoption strategies. Thus, a coherent assessment of current context is crucial to chose most suitable strategies. Bew-Richards BIM Maturity Model and Succar's BIM Maturity Stages were the widely referred models used to ascertain the BIM maturity of an industry or an organization. However, these were found to be less useful to assess a BIM infant industry. The study proposes framework comprising four components, viz. collaborative processes, enhanced skill, integrated information and automated systems, and knowledge management.

Keywords: *Building Information Modelling (BIM); BIM Adoption; BIM Maturity.*

1. INTRODUCTION

Building Information Modelling, or BIM as it is commonly referred to, is digital representation of physical and functional characteristics of a building creating a shared knowledge resource for information about it forming a reliable basis for decisions during its life cycle, from earliest conception to demolition (CPIC, 2011). The technological developments in BIM bring the construction to a new era. Contrast to the conventional ICT developments in the field of construction, BIM is based on a strong information schema which makes the building design fully machine readable. This enables automation of various design, construction management, quantity surveying and procurement processes; and minimizing of design and construction errors. Thus it offers the highest potentials for adopting lean approaches for project delivery, and minimizing of risks and uncertainties; enabling highly sustainable procurement systems for the building industry.

BIM has gained gradual popularity in United States and few European countries, especially in Finland (Khosrowshahi & Arayici, 2012), over the decade, while United Kingdom looked for a kick-start in BIM with the UK Cabinet Office announcing the Government's new Construction Strategy in mid 2011 (Poletayeva, 2011). The report announced the Government's intention to require collaborative BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016. Sri Lanka however, possessing a BIM infant industry (see Jayasena & Weddikkara, 2012), should be able to strategically adopt BIM if and when the requirement arises. In such and endeavour, the use of inappropriate BIM adoption strategies would waste valuable resources and time. This will also hinder the industry's acceptance of BIM. Development of reliable strategies requires information on current BIM maturity in order to identify the gaps. Wider gaps in a BIM infant industry give rise to the number of potential alternative BIM adoption strategies. Thus, a coherent assessment of current context is crucial to chose most suitable strategies. This paper presents a literature synthesis aimed to identify a suitable framework for assessing the BIM maturity in a BIM infant industry.

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2. BIM MATURITY

BIM maturity and developments have been widely discussed by various authors (e.g., Khosrowshahi & Arayici, 2012; Laakso & Kiviniemi, 2012; Owen *et al.,* 2010; Succar, 2009; Suermann & Issa, 2007; van Berlo, Beetz, Bos, Hendriks, & van Tongeren, 2012). Since BIM is a technique, its maturity in an industry shall be observed from its applications. For an assessment of the level of maturity, it is also essential to define the highest level of maturity.

Two maturity models, viz. Bew-Richards BIM maturity model and Stages of BIM maturity by Bilal Succar, have been used in discussing and ascertaining BIM maturity. It was observed that both models were developed by reviewing the natural maturity occurred and envisaged future of practical implementations of BIM and related techniques.

2.1. BEW-RICHARDS BIM MATURITY MODEL

The Bew-Richards BIM Maturity Model shown in Figure 1 is the most widely used maturity model to discuss the BIM maturity in an industry or an organization.

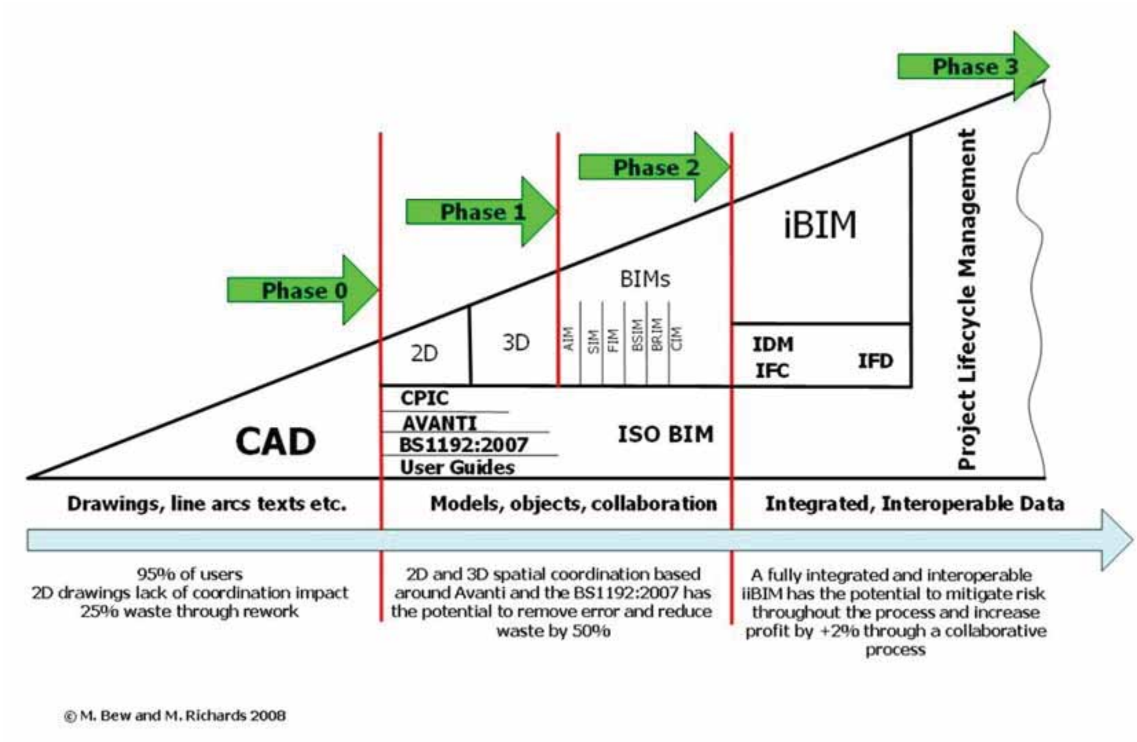

Figure 1: Bew-Richards BIM Maturity Model (Bew & Richards, 2008)

Bew-Richard model identifies basic CAD (Computer Aided Draughting) as "*Phase 0*", i.e. "*no BIM maturity*". At this phase, CAD is used as a replacement for conventional drawing board, representing information using lines and curves on a 2D plane. In these drawings no intelligence such as layering and blocks are expected. The model considers use of intelligence on basic CAD usage as the entry into early BIM maturity phase. A BIM infant industry will find itself in *Phase 0*, or at most at the entry of *Phase 1*. An industry which is already in *Phase 1* or higher shall not be considered as '*infant*'.

Phase 1 starts with introduction and application of best practices such as those introduced by CPIC and supported standards. BS1192:2007 "establishes the methodology for managing the production, distribution and quality of construction information, including that generated by CAD systems, using a disciplined process for collaboration and a specified naming policy. The standard is applicable to all parties involved in the preparation and use of such information throughout the design, construction, operation and deconstruction of projects and throughout the supply chain" (ICE, 2009, p. 1). This is well supported by the *Code of Procedure for the Construction Industry* established by CPIC. Through this, CPIC aims to provide practical guidance on the preparation of good production drawings, specifications and schedules of work and the methods used to co-ordinate the information contained within. AVANTI is also a CPIC initiative with the objective of helping to deliver improved project and business performance through the use of ICT to support collaborative working (CPIC, 2007). A BIM infant industry may directly apply those or use them as concepts and guides to make their own standards.

2.2. SUCCAR'S STAGES OF MATURITY

Another influencing BIM research and implementation framework has been proposed by Succar (2009). This has been widely referred and used by many works followed. He identifies three BIM maturity stages, and identifies Integrated Project Delivery (IPD) as the long-term goal after the third stage of BIM. Figure 2 presents the conceptual linear view of the maturity process.

The pre-BIM stage represents the conventional building practices, or the industry before the implementation of BIM. This stage includes both manual and computer based documents such as CAD drawings and spreadsheet schedules. Even 3D CAD is not considered as stage of maturity of BIM. Only object-based modelling and better is considered as BIM. Thus, Succar's model is comparatively stringent on the maturity level at the lower end.

Figure 2: BIM Maturity Stages – linear view by Succar (2009)

The pre-BIM stage would be characterized by 2D draughting, document-based linear workflows, asynchronous communication, and lack of interoperability (Khosrowshahi & Arayici, 2012). This stage may also include advance use of CAD such as 3D CAD. However, until and unless the modelling is object-based, it will not be considered as a BIM maturity phase.

The challenge a BIM infant industry like that of Sri Lanka would face is that the majority of organizations will not fall into any of BIM maturity level in either Bew-Richard or Succars models. Apparently, with their experience in the industry, authors are unaware of any organization falling into any BIM maturity level. In this context, a simple notion '*there is no maturity*' will not yield much help in terms of decision making on BIM adoption. On the other hand, it is questionable if such an industry should target first maturity level (*phase 1* or *stage 1* in above models) as the next step because there can be alternative roadmaps when well informed structural approach becomes possible. Therefore, an expanded framework for assessment is preferred. It should also be assured that the assessment framework enables comparison and contrasting of the current status with the ultimate BIM maturity level, so that it will help designing the BIM roadmap at industry or organization level.

2.3. INTEGRATED DESIGN AND DELIVERY SOLUTIONS

Reviewing the current applications and concepts of BIM, it was found that concept called *Integrated Design and Delivery Solutions* (IDDS) defines the ultimate maturity level of BIM. IDDS is one of the most comprehensive priority themes introduced by the International Council for Research and Innovation in Building and Construction (CIB). CIB describes, "*Integrated Design and Delivery Solutions use collaborative work processes and enhanced skills, with integrated data, information, and knowledge management to minimize structural and process inefficiencies and to enhance the value delivered during design, build, and operation, and across projects*" (Owen, 2009, p. 3).

IDDS is a holistic approach which effectively integrates people, processes and technology of the building industry. It is concept that has been developed on current technological advancement in the building industry fuelled by advancement of ICT, especially the BIM and related technologies, and novel processes like IPD. It aims to transform the construction sector through the rapid adoption of new processes, Building Information Modelling and automation technologies, using people with enhanced skills in more productive environments.

"*The development of IDDS is about radical and continuous improvement*" (Owen, 2009, p. 3). IDDS covers the current and future expectations thus becoming the ultimate mission of the building industry. It is a concept with a vision, and obviously a context that not yet has been achieved. In simple, IDDS is the BIM utopia, i.e. it is the perfect context that BIM can deliver best benefits. Thus, it is the ultimate maturity level of BIM implementation.

In 2010, Owen et al. (2010), with participation of BIM experts from around the world, reviewed the contemporary status of the building industry for its potentials to implement IDDS. They highlight the need to address improvements in terms of people, process and technology in parallel for better outcomes. IDDS is a holistic approach to get the maximum benefit of innovative technologies, especially BIM. They state that vital components are;

- Collaborative processes
- Enhanced skills
- Integrated information and automated systems, and
- Knowledge management

Classifying the BIM maturity status separately in each of these components will enable better comprehension on the status of a BIM infant industry. Since it is obvious that there are no actual BIM implementations in such an industry, the focus of assessment would be how strong its foundation is to implement BIM and reach IDDS stage in future.

3. BIM MATURITY ASSESSMENT FRAMEWORK

BIM maturity models are developed from observing the progression of industries which have already achieved certain BIM advancement. For a BIM infant industry, application of these BIM Maturity models to benchmark its maturity would reveal only little information. Absence of technology will allow higher flexibility for choices since decision is not influenced by the preference and learning curve of current users (as there is no one). This may also eliminate the requirement conventional maturity stages to be followed to reach the ultimate level. For the development of proposed maturity assessment framework, components of IDDS are used as the primary parameters. This assessment framework will allow well inform decisions on strategic BIM implementation. For example, an industry with better collaborations (non-BIM) has higher capacity to mature in BIM compare to a one with poor collaborations. A brief discussion on each four key elements of the framework follows.

3.1. COLLABORATIVE PROCESSES

Culture of distrust and litigation impedes collaboration in practice. Owen et al. (2010, p. 234) state that "in general, silo mentalities and cultures prevail and document-based information exchange across professions and throughout supply chains ensures that information and, particularly, any associated intelligence, coordination and agility is either corrupted or even lost. Thus decisions are frequently made autonomously without multidisciplinary participation, and in the absence of holistic or comprehensive and accurate knowledge. The use of an iteratively and incrementally developed design, pulled from an end user or client perspective, is virtually impossible within current structures, or at least rarely achieved." This description neatly explains the non-collaborative nature often found in the building industry. A paradigm shift is needed if the benefits of BIM to be achieved, or at least to prevent BIM implementation becoming a disaster. It should be noted that BIM relies heavily on power of computers to hold and process large amount of data which is shared among many project participants. Not like human brain, computers are less tolerant to erroneous and missing data and therefore would generate unexpected results if proper information is not provided on time by all participants.

Collaborative working in building industry has been encouraged for many decades. It is not a new concept even for a BIM infant industry. Prospects for collaborative procurement arrangements for Sri Lanka has previously being studied and has shown positive results than one could reason from the status quo (see Gunathilake & Jayasena, 2008). The study showed the change of attitudes and culture favourably to collaborative working once the context is purposefully changed. It showed collaborative working is hindered by procurement systems not supporting or promoting collaboration. Thus, mere observation of existence of collaborative processes will not offer full understanding; the framework should include an assessment of immediate potential for collaborative processes.

3.2. ENHANCED SKILLS

Integration skills are highlighted as important need. This does not refer to the skills of using BIM tools. It primarily refers to the abilities in parallel collaborative working. Owen et al. (2010) observed that in the contemporary building industry multi-tasking is rare and document based thinking is prevalent. A simplified example is Architectural drawings are awaited by the structural engineer to start structural design followed by HVAC engineer awaiting drawings from both for his design. In a multi-tasking setup, three designers would have worked in parallel, exchanging small portions of design developments by each of them in a collaborative work process.

The skill in using BIM tools relevant to the work performed by each professional or technical participant is also a necessity. The developments in the ICT industry and ventures of software developers have relieved most participants from knowing or becoming skilful in hardcore BIM technologies. Software tools are capable of processing and exchanging BIM data in background while providing user-friendly and familiar work interface for the user. A 3D graphical interface for Architects helps them to virtually model their imagination easily while the same model is shared with the Quantity Surveyor in 2D drawings and spreadsheet schedules for cost estimating. Thus, each participant is required to be skilful only in the tools used for his own performance. However, this does not relieve him from knowing what everybody else does in terms of delivery of the project, because that knowledge is crucial for collaborative working. A further limitation related to this is discussed in next subsection.

The skill in using relevant tools may offer further waivers. When CAD could not attract some of the professionals (for various reasons) when it started to become industry standard, it solved the problem by introducing a new technical layer of CAD draughtsmen to the industry. The same could be possible for BIM. Thus, multi-tasking will remain the primary skill enhancement required by the industry.

3.3. INTEGRATED INFORMATION AND AUTOMATED SYSTEMS

Owen *et al.* (2010) ascertained that integration is currently supported in BIM and associated tools. These are vendor specific and therefore tie only a small number of design and delivery tools; hence not capable of holistic integration. IFC standard offers interoperability but require individuals with special qualifications in each organization to ensure integrity of data exchange.

The future of integration sees that practitioners need not to understand the technology underneath but use tools to perform their respective tasks. An interoperability manager set up a framework for tools to seamlessly connect to each other to update the information required by any tool or process. Information integration should extend to the members of the value chain such as material suppliers and building operations (or facility management) teams. A study by van Berlo *et al.* (2012) has shown this is promising and authors believe this to be the highest practical proximity to true BIM as it has been conceptualized. Thus the ultimate level of assessment in terms of integration shall be set to van Berlo's model. An industry's ICT infrastructure shall be reviewed for its compliance to ultimate model.

In a BIM implementation, integration well supports and supported by automated systems. BIM and associated tools are regularly refined to improve their automation capabilities. In absence of BIM in a BIM infant industry, identical observations are not possible. However, other automated systems such as ERP (Enterprise Resource Planning) are positive signs of maturity.

3.4. KNOWLEDGE MANAGEMENT

Knowledge management (KM) has been popular research focus in recent years. Knowledge is thought to be the most strategically important resource for any company by many. Nevertheless, the fragmented, project-based and task-oriented nature of building construction work makes KM implementation difficult (Arayici *et al.,* 2011; Forcada, Fuertes, Gangolells, Casals, & Macarulla, 2013; Reginold, 2011). Knowledge management is currently at a poor state. "Codified knowledge within the typical firm exists within individual groups (discipline, trade, function) and is seldom shared with those in other domains or upstream or downstream partners in the name of 'competitive advantage'" (Owen *et al.,* 2010, p. 238).

Knowledge management is generally not conceived to be directly related to BIM. One may assume knowledge management systems to be another branch of development in the building industry. It was however found that mainstream BIM implementation literature expressly or impliedly highlights the importance of KM. The need primarily arise from BIM's lack of tolerance to erroneous or missing information. This demands project participants to provide timely and accurate information - a scenario which is easily perceived to be unrealistic. But, a proper KM system is capable of making it a reality. A proper system will not only harvest knowledge but also enable ongoing knowledge creation (Malhotra, 2004; Owen, 2009). It is important that KM system does not fail because its failure would also fail the whole BIM implementation.

Knowledge management does not show a strong position in Sri Lankan building industry (Senaratne & Sabesan, 2008) and it is unlikely to hold a good position in any BIM infant industry due to their lack of eagerness. This highlights the need of deeply assessing the KM maturity in a narrow spectrum. The primary measure would be to ascertain how well the current system (either purposeful or not) would map well with an appropriate automated system. Any current implementation of system would be considered as added maturity.

4. CONCLUSIONS

While implementation of BIM would probably pose numerous challenges, a BIM infant industry also benefits from option for wider number of potential alternative BIM adoption strategies. Thus, a coherent assessment of current context is crucial to chose most suitable strategies. The review of current knowledge showed that Bew-Richards BIM Maturity Model and Succar's BIM Maturity Stages Model alone were less useful to assess a BIM infant industry. A framework of assessment had to feature in depth assessment of a narrow scope of earliest BIM maturity or immediate potential maturity at zero maturity.

The Integrated Design and Delivery Systems (IDDS), was found to be the definition of ultimate maturity level of BIM. It is therefore considered to be the final destination in a strategic BIM roadmap. Using the primary parameters of IDDS, a BIM maturity assessment framework is proposed. The framework comprises of four components.

1. collaborative processes: assessment of immediate potential for collaborative processes
2. enhanced skill: assessment of current status and immediate potential for multi-tasking
3. integrated information and automated systems: assessment of existing automated systems (nonBIM) and compatibility of ICT infrastructure for BIM integration
4. knowledge management: assessment of compatibility of current KM systems with the expected BIM enabled systems

The framework offers a guide for holistic assessment of BIM maturity in a BIM infant industry. However, in-depth study within each of above four components will be required to develop proper assessment criteria and tools. The framework can embrace both Bew-Richards BIM Maturity Model and Succar's BIM Maturity Stages Model for assessment at higher level of maturity. Logical decomposition and synthesising of the model to divide the model elements to four components of the framework would be challenging. If carefully done, the assessment tool so developed will become a valuable tool for all BIM infant building industries around the world.

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