Development of a BIMAsset Maturity Model

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Abstract

This paper presents a BIMAsset Maturity Model (BAMM) which demonstrates how asset owners can appraise the maturity of their organisations in relation to their capability of realising Building Information Modelling (BIM) business value in Asset Management (AM). The study aims to develop and enhance the understanding of asset owners in relation to techniques of appraising key business processes that help derive BIM business value during asset operations. The study utilises a qualitative multi-case study strategy to develop a maturity model that is specific to the domains of BIM, AM and value realisation management. Also, this study adopts an inductive approach using semi-structured interviews to collect data. Furthermore, an expert panel in the form of a focus group is utilised to validate the BAMM. This study finds that the ability of asset owners to derive BIM business value during asset operations has maturity implications in relation to certain key business processes. Furthermore, the study reveals that business value can be derived by the asset owner if organisational processes such as BIM strategy, contract management, lifecycle management, maintenance management, work-order management and value realisation management are effectively executed and continuously improved to an advanced stage of maturity. An important contribution of the paper is that it presents a novel approach for evaluating owner-operator organisations using the BAMM from two perspectives; AM business processes (BIM strategy, contract management, lifecycle management, maintenance management, work-order management and value realisation management); and BIM governance dimensions (people, process and technology).

Keywords: BIM, BIMAsset, AM, Value realisation, Maturity.

1.0 Introduction

Building Information Modelling (BIM) is one of the recent disruptors of the Architecture, Engineering and Construction (AEC) industry (Aranda-Mena, Crawford, Chevez, & Froese, 2009). Asset owners are faced with BIM implementation challenges and maturity models are tools meant to simplify those processes. Generally, maturity models assume that organisational change or process development is achieved in distinct stages whilst capturing capability maturity at particular periods as well as positioning an organisation in line with defined best practices and providing the right solutions for change (Blommerde & Lynch, 2016). BIM in this study is defined as '*a set of interacting policies, processes and technologies producing a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle*' (Succar, Sher, & Aranda-Mena, 2007). The use of BIM enables asset managers to perform these activities and have the ability to generate more reliable information for their daily work (Wijekoon, Manewa, Ross, & Marsh, 2016). Patrick, Munir & Jeffrey (2012) define a BIMAsset as '*the combination of BIM technologies together with the updated facility information, models, associated links and references in an interoperable structure to be handed over to clients at the point of practical completion or at the point of sale*'. A BIMAsset is developed through the integration of accurate data of a facility over its entire lifecycle. This study adopts the term 'BIMAsset' in developing a maturity model that focuses on the domains of BIM, Asset Management (AM) and value.

Research to date has focused on BIM-based maturity models that mostly address the design and construction phases (Bew & Richards, 2008; Succar, 2010; Liang, Lu, Rowlinson, & Zhang, 2016) and there is a lack of maturity models that are specific to AM, BIM and value realisation management. There is a need to develop the understanding of asset owners in terms of the capability of their organisations in implementing BIM in AM because the benefits realised by asset owners from BIM in the operations and use phase has been marginal due to the lack of organisational synergy between people, processes and systems (Bosch, Volker, & Koutamanis, 2015). Hence, the rationale for this study.

This paper is part of a study aimed at investigating the business value of BIM in AM. The study develops the BIMAsset Maturity Model (BAMM) with the aim of providing a tool that will assist asset managers in appraising organisational maturity of BIM-based AM processes in relation to the tendency of realising BIM business value. In this paper, the BAMM is presented and its constituent elements are reviewed including its application.

1.1 Maturity Models in the AEC Industry

Maturity models originate from the software industry which are aimed at increasing productivity and reducing defects through continuous improvement of organisational practices. Generally, most maturity models are based on the Capability Maturity Model (CMM), which was developed in response to poor project performance (SEI, 1994; SEI, 2006; Blommerde & Lynch, 2016). A maturity model facilitates the easy distinction between mature and immature processes in terms of an organisational approach to business processes (Sarshar *et al.*, 2000). The maturity levels indicate a scale for evaluating the capability of individual processes in an organisation. This indication helps an organisation to establish self-knowledge of its current process maturity and support continuous improvement. Despite the large number of maturity models available in literature, their objectives are highly similar.

Researchers have proposed a number of maturity models that are applicable to the AEC industry. One is the Structured Process Improvement for Construction Enterprises (SPICE) model (Sarshar *et al.*, 2000). The SPICE model presents various levels of maturity as enablers to help construction companies to improve their processes. Another is Construction Supply Chain Management (CSCM), which focuses on the management of information, costs and workflows in a construction project (Vaidyanathan and Howell, 2007). The CSCM aims to remove inefficiencies and improve operational excellence in the construction supply chain. Similarly, the Portfolio Programme and Project Management Maturity Model (P3M3) is a framework that organisations can use to assess current performance, enhance efficiency, improve project success and achieve value for money from project and programme procurements (OGC, 2010). Furthermore, Kwak & Ibbs (2002) present a Project Management Process

Maturity $(PM)^2$ Model, which aims to integrate project management maturity models, processes and practices in order to improve effectiveness. However, the above maturity models are too generic and are not specific to BIM nor AM.

The National Institute of Building Sciences (NIBS) proposes an Innovation Capability Maturity Model (I-CMM) that is aimed at improving planning, design, construction, operation and maintenance processes using a well-established building information model (McCuen, 2008). The I-CMM determines the maturity of a building information model against a set of criteria, of which there are ten maturity levels and eleven areas of interest (NIBS, 2007). Similarly, Succar (2010) proposes a BIM Maturity Index (BIMMI), which includes defined levels that signify the evolutionary development of BIM governance dimensions at the organisational level. The BIMMI is based on the CMM and has five stages; Ad-hoc, Defined, Managed, Integrated and Optimised. Although the above maturity models are specific to BIM, they lack applicability in relation to AM and value realisation management processes. Hence, the need to develop a maturity model that addresses BIM on one hand and AM processes on the other and in appraising both from the perspective of value realisation for the asset owner.

2.0 Methodology and Research Questions

2.1 Research Question

This study aims to provide a model that will aid asset managers in evaluating organisational maturity in relation to BIM business value in an AM system. The paper seeks to provide a theoretical rationale for the development of a framework that is focused on organisational maturity in relation to BIM, AM and value realisation management. The study aims to address the following research question:

- How can an asset manager appraise organisational maturity in relation to BIM business value realisation during asset operations?

2.2 Research Methods

The study utilises a multi-case study strategy to investigate real-life phenomenon in relation to key business processes that drive BIM business value in AM (Yin, 2003). This study is conducted in two phases; literature review and case study. The literature review phase helped in the identification of significant BIM governance factors such as people, process and technology. Furthermore, the case study helped to identify key business processes such as BIM strategy, contract management, lifecycle management, maintenance management, work-order management and value realisation management. These factors were used as key elements for analysis during model development. Semi-structured interviews are utilised to collect data from the case studies. A total of four case studies were investigated, with one interview conducted for each case. However, this paper focuses on the presentation of the BAMM. The results of the case studies will be reported in future work. The methodological process is shown in Figure 1.

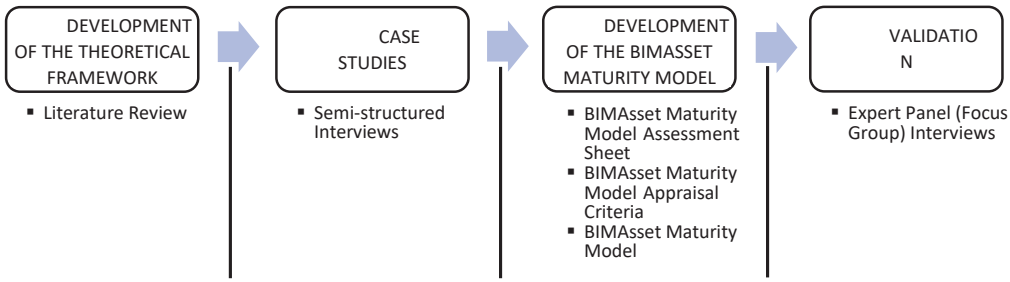

Figure 1: Methodological process

Furthermore, an expert panel in the form of a focus group interview was conducted to validate the BAMM. The criteria utilised in assessing the model's validity are: fruitfulness, prudence, quantification, scope, progressiveness, internal consistency and external consistency (Proctor & Capaldi, 2006). Data analysis from the focus group shows that 100%, 83%, 83%, 67%, 100%, 100% and 67% agree that the BAMM satisfies the above validation criteria respectively.

2.3 BIMAsset Maturity Model (BAMM) Appraisal Criteria

This study presents the BAMM tool for assessing maturity in owner-operator organisations. A number of studies have utilised a similar approach in developing maturity models (SEI, 1994; Sarshar, et al., 2000; SEI, 2006; Succar, 2010). This study utilises the five stages of BIM maturity as proposed in the BIMMI (Succar, 2010). They are, Ad-hoc, Defined, Managed, Integrated, and Optimised, which are allocated a scale of 1 – 5 points. Furthermore, the BAMM tool takes into perspective aspects of BIM governance within organisations. Hence, People, Process and Technology are added to the model and are given equal weightings (Bosch *et al.*, 2015; Prodan, Prodan & Purcarea, 2015; Alreshidi, Mourshed & Rezgui, 2017). In the context of the BAMM tool, the BIM governance dimensions are referred to as functional drivers. Furthermore, from the case study interviews, the vital BIM-based business processes in relation to value realisation in AM are referred to as activity systems. These two elements are established as the main focus of analysis. The key activity systems are BIM strategy, contract management, lifecycle management, maintenance management, work-order management and value realisation management. The BAMM appraisal criteria are described in Appendix A (via https://drive.google.com/file/d/1NFSbVfrnThWBIgohi-znN4XXjaOU8Cyw/view?usp=sharing) and the assessment sheet is shown in Figure 2. The total score from this sheet (Figure 2) qualifies the maturity level of the organisation in Figure 3.

ORGANISATIONAL MATURITY ASSESSMENT SHEET								
S/ NO	DESCRIPTION		COMPANY NAME					
			1	2	3	4	5	
1	BIM STRATEGY							
	A. People							
	B. Process							
	C. Technology							
2	CONTRACT MANAGEMENT							
	A. People							
	B. Process							
	C. Technology							
3	LIFECYCLE MANAGEMENT							
	A. People							
	B. Process							
	C. Technology							
4	MAINTENANCE MANAGEMENT							
	A. People							
	B. Process							
	C. Technology							
5	WORK-ORDER MANAGEMENT							
	A. People							
	B. Process							
	C. Technology							
6	VALUE REALISATION MANAGEMENT							
	A. People							
	B. Process							
	C. Technology							
	TOTAL SCORE		NUMERICAL VALUE					

Figure 2: BAMM Assessment Sheet

2.3.1 Activity Systems and Functional Drivers

From the case study interviews, the activity systems are acknowledged to have a vital impact on business processes performed by asset managers in order to be able to derive BIM business value. The scoring of each activity system from the dimensions of people, process and technology considered the following organisational measures in developing the BAMM appraisal criteria (Appendix A):

- BIM Strategy: Organisational BIM approaches; change management; performance management; stakeholder management; organisational policy for utilising BIM-based processes; and definition of specific organisational needs from BIM processes.
- Contract Management: Performance monitoring; invoice tracking; checking compliance; and tendering.
- Lifecycle Management: Organisational BIM standards covering asset development stages; data integration across asset development phases; process standardisation; technological capability; and human inclusion.
- Maintenance Management: Organisational culture of utilising BIM in reactive, preventive, predictive, proactive and passive maintenance-based practices.
- Work-order Management: Organisational task management protocols; process standardisation and workflows; identification of user characteristics; definition of individual and organisational data needs; automated cost estimates and invoicing; and supply chain integration.
- Value Realisation Management: Formulation of organisational performance targets; establishment of value measurement techniques; definition and monitoring of KPIs; change management strategies; and stakeholder management strategies.

In addition, the scoring of each functional driver from the perspective of each activity system considered the following organisational measures in developing the BAMM appraisal criteria:

- People: Organisational strategy; BIM implementation strategy; collaboration; staffing; training; and business process capability of every activity system.
- Process: BIM standards; organisational BIM objectives; defined roles; effective use of data; supply chain integration; asset lifecycle integration; and value realisation management of every activity system.
- Technology: BIM systems; IT Systems; AM Systems; FM systems; organisational systems architecture; interoperability; data integrity; and data accessibility of every activity system.

The BAMM appraisal criteria is shown in Appendix A.

3.0 BIMAsset Maturity Model (BAMM)

The understanding of organisational maturity is crucial for asset owners to be able to realise BIM business value. Hence, the premise for the development of the BAMM. This is because the more organisations are aware of the maturity of key business processes the greater tendency they have in improving business process capability (Harmon, 2004). The BAMM would enable an owner-operator organisation to determine its strengths and weakness within key BIM-based AM business processes. Furthermore, in order for an organisation to move through the levels of maturity, an organisational culture of continuous improvement should be established. The BAMM consists of five sequential tiers of maturity that demonstrate the development of an organisation in relation to its potential to realise BIM business value (Figure 3). The BAMM appraisal assessment sheet (Figure 2) and criteria (Appendix A) is developed to assess organisational BIM capability in six business activity systems in relation to three functional drivers. The score is aggregated on the assessment sheet and summarised to indicate the maturity level of the organisation.

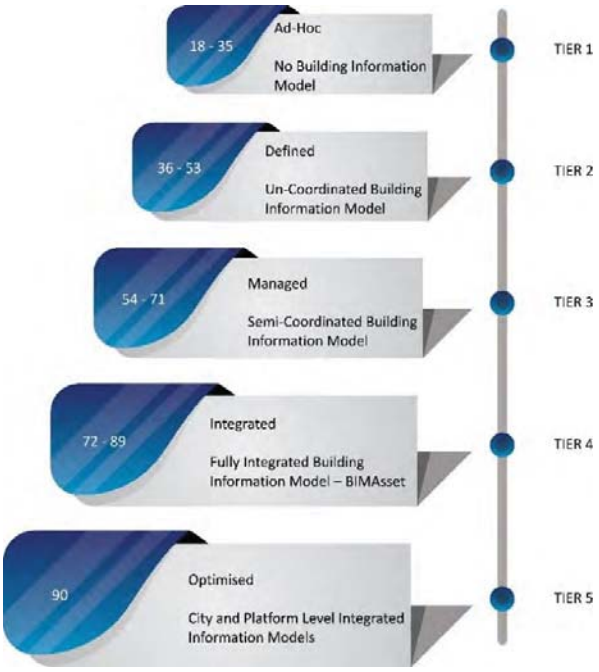

Figure 3: BIMAsset Maturity Model (BAMM)

3.1 Tier 1 – Ad-Hoc

NO BUILDING INFORMATION MODEL

The overall characteristic of this level is that there are ad-hoc BIM-based processes within the organisation. Documentation is in variants of 3D, 2D electronic or paper-based formats with no specific requirements for information models. Also, no COBie information is delivered from the design and construction stages.

3.2 Tier 2 – Defined

UNCOORDINATED BUILDING INFORMATION MODEL

The general organisational trait of this tier is having un-coordinated building information models delivered at the end of design and construction phases. Documentation may lack organisational-level standards for requirements and use within BIM-based AM processes.

3.3 Tier 3 – Managed

SEMI-COORDINATED BUILDING INFORMATION MODEL

The common organisational attribute of this stage is the existence of semi-coordinated building information models. COBie-level information requirements are defined and the delivery process is arbitrary. Here, it is common that the owner-operator organisation lacks a robust strategy for EIR documentation.

3.4 Tier 4 – Integrated

FULLY INTEGRATED BUILDING INFORMATION MODEL – BIMAsset

The main organisational feature of this phase is the existence of fully integrated building information models with access to real-time data at the building or facility level. Here, the organisation

is BIM Level 2 compliant in relation to the UK BIM strategy (BSI, 2014). The BIM-based AM system operates with smooth interoperability and AM information is searchable for analysis. Here, the asset owner possesses a robust strategy for EIR documentation. At this stage of maturity, the constantly updated virtual model (BIMAsset) will have an intrinsic value in its own right.

3.5 Tier 5 – Optimised

CITY AND PLATFORM LEVEL INTEGRATED INFORMATION MODELS

The general organisational characteristic of this level is the management of activities at the multi-facility system level, including fully integrated systems combining general access with city level information. Here, the organisation is BIM Level 3 (Digital Build Britain) compliant in relation to the UK BIM strategy (BSI, 2014; HM Government, 2015). The BIM-based AM system operates with smooth interoperability including the availability of asset information at the multi-facility or city level.

4.0 Discussion and Conclusion

The purpose of this paper is to establish the BAMM and demonstrate how it can be used for maturity appraisal for asset owners in relation to BIM business value realisation. The literature review establishes the need for a maturity model that is specific to the domains of BIM, AM and value realisation management. The study reveals that the BAMM can be used to guide organisational appraisal in relation to activity systems and functional drivers. The substantive model enables the asset manager to determine the strength and weakness of business processes and to continuously improve on weaker areas in order to achieve higher maturity and increase the potential of realising BIM business value. This appraisal technique helps serve as a reference point for analysis by an owner-operator organisation when applying value realisation practices in asset operations in order to realise BIM business value. Each maturity level contains focus areas and characteristics of organisational development. The BAMM provides a basis for: (a) assessing various aspects of value realisation management within the organisation; (b) identifying organisational areas where there is room for improvement; (c) demonstrating relationships between all variables and their relationship to BIM business value; and (d) a methodology that is logical and transparent for organisational appraisal in relation to value realisation management of BIM-based processes in AM.

An original contribution of this study is the provision of a maturity model that helps guide asset owners in organisation appraisal in relation to BIM business value. By this, the study answers the research question of how utilise the BAMM for organisational appraisal. Furthermore, as discussed in the literature review, there are a number of maturity models that are applicable to the AEC industry but none is specific to the domains of BIM, AM and value realisation. Thus, a gap in knowledge that the proposed framework in this study fills.

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