Delivering Value with BIM: A Framework for Built Environment Practitioners

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Abstract

The built environment industry worldwide is facing significant external pressures such as increased competition, higher owner expectations, rapidly changing technology and skill shortages. Building Information Modelling (BIM) has been identified as a socio-technical system that can be used to improve team communication throughout the project life-cycle, produce better outcomes, reduce rework, lower risk, provide better predictability of outcomes and improve operation and maintenance of an asset, among other benefits. Within this context, proactively establishing quality improvement cycles based on standardised work processes and corresponding measures of effectiveness will ensure better project outcomes. These outcomes can be driven by continuously improving systems and active monitoring. This paper introduces a methodology for developing a whole-of-life asset management strategy for delivering value with BIM across the life-cycle of built assets. It also presents a framework to assess progress towards value-driven goals.

Keywords: BIM, value, whole-of-life, asset management, strategy

1. Introduction

The built environment industry has been facing significant external pressures worldwide such as increased competition, higher owner expectations, rapidly changing technology and skill shortages (Hampson, et al., 2014). Building Information Modelling (BIM) is "a digital process that encompasses all aspects, disciplines and systems of built assets within a single virtual model" (Sanchez, et al., 2015). It has been identified as a socio-technical system "that can be used to improve team communication throughout the project life-cycle, produce better outcomes, reduce rework, lower risk, provide better predictability of outcomes and improve operation and maintenance of an asset" (Sanchez, et al., 2014). There is a growing body of anecdotal evidence about benefits that can be achieved by implementing BIM (Gilligan & Kunz, 2007) and some firms are measuring some benefits (McGraw Hill Construction, 2014b; McGraw Hill Construction, 2014a). However, unclear business value and return on investment (ROI) are often identified as barriers for adoption (Barlish & Sullivan, 2012).

Identifying, monitoring and managing benefits throughout the life-cycle of a project or asset have been highlighted as a way to help achieve success during implementation of new technologies (Yates, et al., 2009). "By defining how each benefit will be measured and then providing evidence for the expected level of improvement that will result from the changes, rigorous and realistic business case and financial argument for the investment can be developed" (Ward, et al., 2007). Capturing and disseminating information to ensure intelligent decision making can also help reduce risk and deal with the large number of variables characteristic of construction projects (Roper & McLin, 2005).

Within this context, proactively establishing quality improvement cycles based on standardised work processes and corresponding measures of effectiveness can help ensure better project outcomes. Metrics play a critical role in driving this process (CURT, 2005). There is a great deal of literature on BIM adoption and benefits for specific applications, stakeholders and life-cycle phases (Bryde, et al., 2013; Arayici, et al., 2011; Migilinskas, et al., 2013; Eadie, et al., 2013; Azhar & Brown, 2009; Kasprzak & Dubler, 2012; Teichholz, 2013). However, there is a lack of comprehensive studies that focus on mapping and measuring the benefits of implementing BIM across the whole-of-life of built assets (Sanchez & Hampson, 2016). This paper introduces the research done to develop a framework to assess the actual benefits of implementing BIM throughout asset planning, delivery and management applicable to both buildings and infrastructure.

2. Methodology

This research was developed in Australia in consultation with national and international organisations encompassing client, designer, surveyor, contractor and facilities management organisations as well as industry organisation that represent thousands of individual organisations across the supply chain. The research aimed to:

(i) Define indicators to measure tangible and intangible benefits of BIM across a project's life-cycle in infrastructure and buildings; and
(ii) Pilot test a whole-of-life BIM value realisation framework on leading infrastructure and building case studies.

The research was informed by a thematic analysis of an extensive literature review covering over 400 academic and industry references. The framework was tested through expert consultation and three exemplar case studies in Australia that featured the use of BIM during design, construction and asset management. The expert consultation included 31 industry, government and research experts from across the supply chain with 10-30 years of experience in the field and roles related to BIM implementation and uptake at the organisational level.

It was important that the framework could be easily applied to both infrastructure assets and buildings. The research team studied a number of different approaches available to develop a strategy for measuring the value of information technology in construction. It was also consistently reviewed by a group of industry and academic experts from infrastructure and buildings, and at different levels of the supply chain. An introduction to the framework was also presented at the Australasian Regional Conference organised by the International Roads Federation (IRF) and Roads Australia in May 2015. This was done to obtain feedback from a wider audience and address common concerns of BIM guidelines being often directed only to buildings and architectural design. This research builds on Love, et al. (2014) who proposed the use of Benefit Realisation Management (BRM) by asset owners. However, the present work provides a different adaptation of the BRM method and extends it to be applicable to all built environment stakeholders across infrastructure and buildings. It was also modified to include the value of unplanned and flow-on benefits as later defined, as well as used to develop a step-by-step guide and an online interactive tool.

3. BIM Value Realisation Framework

The value of BIM is realised through its benefits for different stakeholders. Benefits arise because information technology systems such as BIM enable people to carry out tasks more efficiently and effectively. They do this by allowing and shaping new ways of working through the re-design of intra- and inter-organisational processes or facilitating new work practices (Peppard, et al., 2007). The Benefits Realisation Management (BRM) approach was originally developed in the 1980s and 1990s. This method offered a way of understanding the return on investment from information technologies and systems, and overcoming the limitations of traditional investment appraisal techniques. This aspect of project management has received increasing attention in the past few years (Breese, 2012). These practices have been shown to be associated to the creation of value (Martins Serra & Kunc, 2015) and been applied to a number of sectors and stakeholder groups (Bradley, 2010; Peppard, et al., 2007). However, tailoring this framework for specific organisations and sectors is an essential step towards optimising its value (NSW Government, 2014b). Love, et al. (2014) proposed the use of BRM and resource-based view (RBV) "to provide asset owners with the capability to realize its benefits". Although building on Love et al's idea, this research provides an alternative adaptation of the methodology to serve a larger audience and projects at different life-cycle phases. It was also used to develop a detailed step-by-step guide and online interactive tool to provide guidance for built environment practitioners on how to operationalise the overarching framework.

The framework (Figure 1) largely follows the traditional BRM structure and principles but acknowledges that value is realised not only through specifically identified end-benefits but also through unintended benefits. This has been addressed by including “flow-on” benefits. These are benefits that can be obtained once the end-benefit is achieved. While not being specific project goals with targets and associated milestones, they are included to account for the full value delivered by implementing BIM. The monitoring processes suggests the inclusion of other considerations such as project context and unexpected situations which may hinder the achievement of specific benefits. It additionally acknowledges the role of team and organisational capabilities in attaining value from implementing BIM. This broader view may enable more complete future benchmarks and better understanding of project-to-project different levels of implementation success. Finally, it proposes that enablers have associated risk which should be taken into consideration as they may bring “disbenefits”, these are non-value-adding outcomes which are counterproductive to the implementation goals.

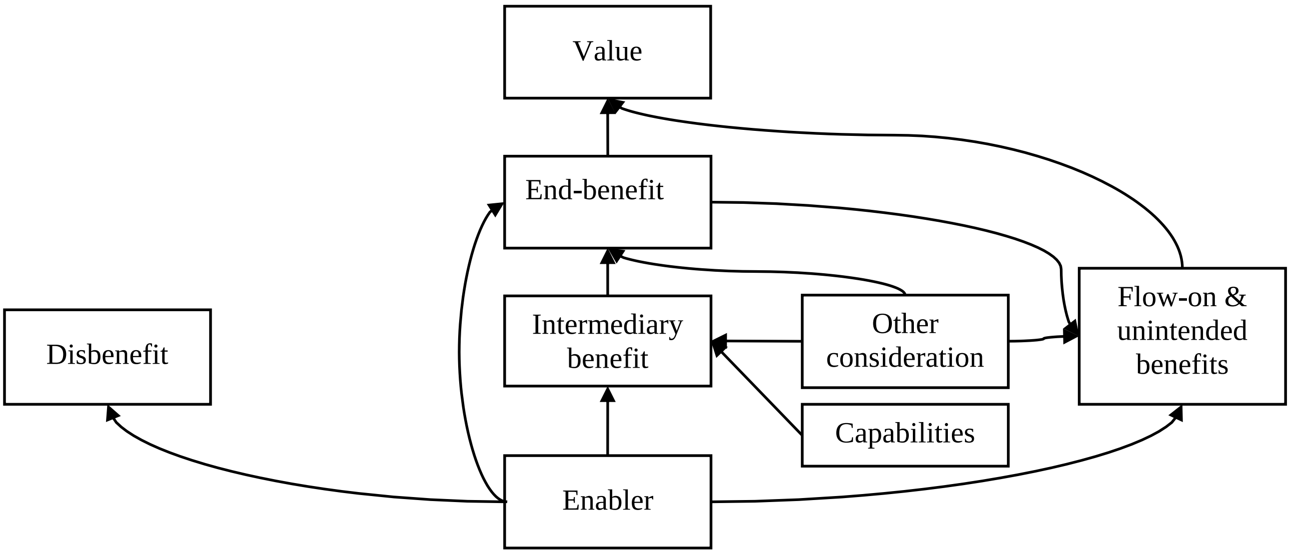
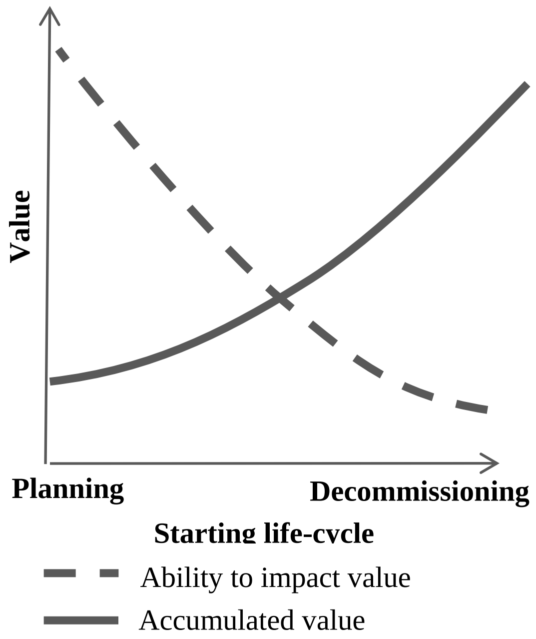


Figure 1 Framework principles

The BIM value realisation framework can be applied at any phase of the life-cycle of an asset and is meant to complement BIM implementation guidelines. The MacLeamy Curve (AIA, 2007) however applies to this process as well. This means that, as shown in Figure 2, the earlier changes and processes required to implement BIM are introduced, the larger impact they are likely to have on the outcomes of the project and realising its full value.



tionship

There is no single BIM software that covers all functionalities and processes. The value to each stakeholder is therefore delivered by identifying the specific benefits they aim to gain by implementing BIM-related tools and processes. This allows teams to have a clear understanding of the overall goals, select the path to these goals based on performance-driven objectives and establish a strategy to monitor their progress towards these goals. Thus, another key aspect of the framework is that it focuses on specific benefits driving the BIM implementation strategy and proposes specific asset and project management processes where this can be embedded.

3.1 Step-by-step Guide Summary

The detailed methodology and dictionaries were published in the book: *Delivering Value with BIM: A Whole-of-life Approach* (Sanchez, et al., 2016a). This section presents a brief summary of the main proposed steps.

Step 1 - Define end-benefits: end-benefits are the ultimate objectives. They are the value the team wants to have realised from implementing BIM – such as lower cost, improved safety and gaining competitive advantage. These are defined in a workshop environment with key stakeholders that include project manager, asset manager, designers, end-users and other relevant stakeholders. Including asset managers and end-users can help ensure a whole-of-life insight.

Step 2 - Define intermediary and flow-on benefits: these are the *story* behind each end-benefit and defined in the same workshop environment as the previous step. Intermediary benefits are those *expected* to occur between the implementation of early changes and the realisation of the end-benefits. Flow-on benefits are those that may be derived from achieving the end-benefit. There may also be unintended benefits arising from implementing specific enablers which may be identified at later stages.

Step 3 - Define enablers: enablers are processes and tools related to BIM uses and implementation. They help achieve the first intermediary benefit in the chain. A risk is associated to each enabler, and other considerations such as new skills requirements and cost need to be included in the assessment.

Step 4 - Assign metrics, targets and incentives: metrics provide the means to justifying investments made, comparing and ranking benefits, providing targets for success and benchmarking and monitoring progress towards goals. Assigning metrics to benefits is the basic requirement to provide effective accountability. Choosing as many metrics as possible related to the identified benefits may provide better insight into the success of the implementation strategy. Targets should be assigned to each metric and, if appropriate, financial incentives for exceeding targets.

Step 5 - Embed metrics and targets into progress report documentation and processes: this ensures accountability and provides a rich source of information based on which the group can make decisions and introduce changes in a timely manner in order to correct situations that may be hindering the achievement of the goals established in previous steps. Metrics, targets and incentives should be embedded in the project documentation including the regular progress report as well as the BIM model itself as appropriate. These should also include processes to record context information that may be used to understand different levels of success across different projects.

Step 6 - Workshop follow-up / feasibility and approval: this step is a reality check to evaluate what specific software solutions can be used as enablers to achieve the selected benefits most effectively. The associated cost, for example, will largely depend on the capabilities of the project team and previous experience with specific software packages as well as licences already purchased.

Step 7 - Progress review and correction initiatives: benefits require active monitoring and advancement towards targets related to benefits should be reported on and reviewed during project progress meetings.

Step 8 - Ongoing active learning: benefits are dynamic and will change as technology develops. Therefore, benefits, enablers and metrics dictionaries should be developed and regularly reviewed and updated.

Next steps: following the value realisation strategy, there are a number of considerations that will have to be addressed such as standards, protocols, BIM management roles, risk apportioning, skill development plans and system requirements. This methodology is proposed to be complementary to technical implementation guidelines and standards.

3.2 Dictionaries

BIM is not a single software package that teams can just buy and implement in isolation. It is a new way of working that commonly includes the use of a number of tools, processes and software solutions. One of the exemplar case studies carried out for this research project was based on the design and construction of the Perth Children's Hospital in Australia. This study identified 20 different BIM-related tools and processes that were associated with 26 different benefits (Sanchez, et al., 2015). The second case study was based on the design of the New Generation Rollingstock Maintenance Centre also in Australia and identified 17 tools and processes associated with 25 benefits (Utiome, et al., 2015). This can be overwhelming, especially for new users. To address this issue, the research team carried out an extensive literature review to develop a set of dictionaries.

The *Benefits Dictionary* includes 31 profiles of benefits that are currently achievable from implementing BIM. Benefit identification is a critical process in the BRM methodology "used to create a detailed plan of how those benefits are to be realised throughout the life-cycle of implementation and use of the new technology, process or system" (Sanchez, et al., 2016b). Benefits are defined as improvement on the status quo; as opposed to enablers which are those tools and processes used to achieve a benefit. This distinction is important because in many academic and industry publications enablers are often cited as benefits themselves. Clash detection is for example often mentioned as a benefit of using BIM. This however makes more difficult identifying appropriate metrics that can be used to monitor progress and create industry benchmarks. In this example clash detection is a tool/process; an element that cannot be measured in specific terms but just is or is not in use. The real benefit of clash detection is an improvement in the efficiency of the process of detecting clashes, brought by higher levels of automation and better communication and coordination; this in turn leads to fewer errors and lower cost. All of these are benefits that can be measured in different ways and specific levels can be targeted as success criteria.

Each profile provides a general description of each benefit and provides information about some interpretations that are specific to particular life-cycle phases. They also include a list of enablers that can help realise and maximise the value of BIM at different life-cycle phases, benefits that can flow-on from achieving the profiled benefit, main benefiting stakeholders, metrics that can be used to monitor the benefit and examples of projects where they have been achieved. The list was created based on a thematic analysis of the literature with input from the three exemplar case studies. It includes benefits at different scales that could be considered intermediary or end-benefits depending on the strategy chosen. This was done aiming to cater for progressive and incremental implementation strategies that may focus on different benefits at each step. This may be especially relevant to small and medium sized enterprises (SMEs) and cautious client organisations with limited resources.

The *Enablers Dictionary* contains information about 51 enablers grouped under two overarching categories and 28 sub-categories. The categories were developed using the Pennsylvania State University "BIM Execution Plan" (Penn State, 2011) as a starting point and further developing it based on input from industry experts. The two overarching categories are:

(i) Intrinsic/core: These are enablers that were considered to form the basis of BIM and maximise benefits from its use across different life-cycle phases. These included processes that were not standard practice in many countries yet but were considered an intrinsic part of BIM implementation strategies that aim to maximise its value for all stakeholders. Examples include "design authoring and data-rich accurate models", "early and effective stakeholder engagement" and "object libraries".

(ii) In Use: These are enablers which are either commonly used nowadays and/or that, although having had limited use in common practices, either are already growing in use or have the potential to do so in the near future and provide significant benefits. Examples include “3D laser scanning”, “automated clash detection”, “design reviews”, “GIS-BIM” and “digital fabrication”.

The *Metrics Dictionary* aims to provide a practical way of avoiding wasted efforts often seen in recording and tracking metrics which are being tracked elsewhere. The dictionary includes a comprehensive set of 43 metrics that were found to be practical and offer a set from which each project can select those that are most appropriate to their goals and needs. These metrics are mostly based on literature but also include indicators proposed by the authors based on professional experience, experts consulted and the three exemplar case studies. Metrics were categorised in four groups:

(i) People - serve to monitor benefits achieved through changes in behavioural patterns or that directly affect staff. Examples include “safety”, “meetings”, “stakeholder involvement” and “labour intensity”.
(ii) Processes - monitor benefits achieved through changes to general process improvement and generally aim to measure the efficiency of these processes. Examples include “time predictability”, “schedule conformance”, “cost of change”, and “latency”.
(iii) Procurement - monitor benefits achieved during or through procurement and asset management processes. Examples include “cost per unit”, “quality”, “program capacity” and “globalisation”.
(iv) Sustainability and future proofing - monitor benefits achieved in terms of better environmental sustainability outcomes and improved emergency management. Examples include “resource use and management”, “carbon emissions and footprint”, “emergency latency” and “emergency plan and response effectiveness”.

It should be noted that, although case study participants highlighted sustainability as one of the drivers to implement BIM, the research team found it particularly difficult to find literature about metrics that could be included in this category. This is proposed as a potential gap in the literature for future research.

A complete list of benefits, enablers and metrics can be found online on BIM Value (see section 3.3) or in Sanchez et al. (2016a).

3.3 BIM Value

The experts consulted to test the practicality to the framework suggested that one of the main barriers to adoption is fast and easy access to information about benefits, enablers and metrics. This led to the research team translating the dictionaries into an open access online interactive tool to step through the first four levels of the framework. This tool, BIM Value (http://bimvaluetool.natspec.org/), provides a tailored information delivery system. It guides the user through six steps where they select the stakeholder group and life-cycle phases they are interested in and the tool provides a set of benefits that apply to those two parameters. The user can then select those benefits they are interested in and the tool provides a new list of enablers and metrics which apply to the selected stakeholder group, life-cycle phase and benefits. In the final step, it produces a report with a summary of descriptions of the different benefits, enablers and metrics selected that also includes examples and references to follow upon. The tool also offers the possibility of accessing the dictionaries directly and provides links to other sites with

BIM-related videos and guidelines. In its first week and with close to no publicity, the tool had over 240 new users trying it out, mainly from the UK and Australia. Four months later, the tool has had over 4,000 views with a return rate in March 2016 of 49.3%. This is suggested to be a reflection of the industry's interest in accessing information about tangible and measurable benefits from implementing BIM.

3.4 Research Limitations

The methodology presented here, although based on an arguably proven approach such as BRM and submitted to a thorough review process with industry and academic experts has had a limited validation process. The framework was partially validated by the Sydney Opera House which was transitioning into a BIM-based asset management system. Feedback from this effort and the previously outlined consultation was used to finalise the framework into its present form. However, although originally planned, a more comprehensive validation process was not possible due to time and resources constrains. The research team will continue to work towards the validation of the complete process in the near future.

3.5 Future Research

Future research will aim to continue to develop and improve the BIM Value tool through new modules in order to increase its value to the industry. One of such modules is for example expected to form the basis for a world-first BIM benefits benchmarking system (BIM Value Benchmark). This new effort will also seek to understand how meta-data created from using the tool can be used to most benefit the industry.

4. Conclusions

This publication has introduced a methodology to identify and monitor benefits that will serve to realise and deliver value with BIM across the life-cycle of an asset to different stakeholders. This research was based on an extensive literature review, expert consultation and three exemplar case studies. An important aspect of the research was to collaborate with industry and government organisations across the supply chain to receive feedback on the practicality and completeness of the outcomes. This collaborative effort aimed to ensure that the outcomes of the research were most relevant to different industry stakeholder groups as well as complementary to outputs of other organisations active in this space. Outcomes of this research are expected to help achieve more informed value-driven assessment and continual improvement of the implementation of BIM across assets and life-cycle phases.

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