Automation in Construction 35 (2013) 208–216

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

From justification to evaluation: Building information modeling for asset owners

Peter E.D. Love [a,*], Ian Simpson [b], Andrew Hill [b], Craig Standing [c]

[a] Curtin University, GPO Box U1987, Perth, WA 6845, Australia
[b] CSi Global Services, Level 6, 83 Mount Street, North Sydney, NSW 2060, Australia
[c] School of Management, Faculty of Business and Law, Edith Cowan University, Joondalup, WA 6027, Australia

ARTICLE INFO

Article history:
Accepted 16 May 2013
Available online 15 June 2013

Keywords:
Asset
Building information modeling
Benefits
Costs
Evaluation

ABSTRACT

Building information modeling (BIM) is an emerging technology focused methodology that can be used to improve the performance and productivity of an asset's design, construction, operation and maintenance process. Typically the investment justification process for BIM has been based upon the utilization of the return on investment (ROI). This measure does not accurately reflect the 'real' costs and benefits that are associated with implementing BIM by an asset owner. With this in mind, a benefits evaluation framework that looks beyond ROI and takes into account the evolving nature of BIM by incorporating intangible benefits and indirect costs is presented and discussed. To acquire the wide range of benefits that BIM can offer asset owners, it is proffered that they should shift their mindsets away from justification using ROI to a process of evaluation that encompasses the appraisal of value and benefits' realization.

1. Introduction

> Not everything that can be counted counts and not everything that counts can be counted.
>
> [(Albert Einstein)]

For more than two decades the construction industry has been going through an intense period of introspection as a result of its poor performance and low productivity. In the 1990s numerous reports recommended actions that need to be undertaken to address the industry's prevailing problems [1,2]. In particular, Egan [2] identified the need to embrace lean concepts, standardization and pre-assembly methods as well as "new technology such as 3D object-orientated modeling and global positioning systems".

While such reports initiated a flurry of academic research, they failed to have a significant impact as the construction industry was, and to a large extent still is, reluctant to measure its performance [3]. According to Wolstenholme [4] the United Kingdom (UK) construction industry, for example, was sheltered by a strong economy prior to the global financial crisis (GFC) in 2008 and had an innate attitude that there was no need to embrace change. Since the commencement of the GFC, construction industries worldwide have been subjected to significant reductions in private and public sector investment. Hitherto, issues associated with poor project performance and productivity remains a pervasive problem. The Building Cost Information Service of the Royal Institute of Chartered Surveyors found that 48% of projects experience schedule overruns [5]. In the State of Massachusetts, in the United States (US), it has been reported that nearly 50% of all road and bridge construction projects are over budget and 33% were not completed on time [6]. In Australia, the Queensland Department of Main Roads reported that 10% of projects with a contract value greater than AU$1 m experienced an overrun of over 10% [7]. Blake Waldron found that less than 48% of Australian infrastructure projects surveyed were delivered on time, on budget and to the required quality [8]. A major factor that has contributed to overruns being experienced in construction projects has been the creation and transfer of poor quality information, which has manifested as errors, omissions and information redundancy [9,10]. In addressing this issue the methodology of Building Information Modeling (BIM), which generates and manages information throughout an assets entire life cycle utilizing data centric modeling has been advocated as an enabling platform to ameliorate an asset's delivery and performance [11–17]. Fundamentally, BIM improves coordination, enhances information accuracy, reduces waste, and enables better-informed decisions earlier than conventional methodologies that are used to create constructed assets.

Within the last ten years the literature has become replete with studies indicating that the application of BIM to asset delivery, at varying Levels of Development/Detail (LOD, which ranges from 100 mass modeling to 500 facilities management),[1] can provide a wide range of

* Corresponding author.
E-mail addresses: plove@iinet.net.au (P.E.D. Love), Ian.Simpson@csigs.com.au (I. Simpson), Andrew.Hill@csigs.com.au (A. Hill), c.standing@ecu.edu.au (C. Standing).

[1] For more details refer to http://www.fm.virginia.edu/fpc/ContractAdmin/ProfSvcs/BIMAIASample.pdf.

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http://dx.doi.org/10.1016/j.autcon.2013.05.008

benefits which include reduction in cost and schedule growth, rework, workflow cycle time, and errors in contract documents [15–19]. The LOD defines how much information is known about a model at given a time and increases in richness as an asset progresses throughout each project lifecycle phase. While the benefits of BIM have been widely espoused [11–17] and its adoption becoming an integral part of many government's strategies to derive better value for money (V*f*M) from their assets, many private sector clients as well as Architectural Engineering and Construction (AEC) firms are wary of the significant financial investment required to implement this new and emerging methodological and technological solution.

The return on investment (ROI) has been typically used to justify the investment in BIM [20–23], yet this measure does not accurately reflect the 'real' costs and benefits that can be associated with implementing such technology [24]. Many asset owners view the project appraisal process as a financial hurdle that has to be overcome and not as technique for evaluating the worth of technology [24]. If traditional financial measures, such as ROI, are used for justifying the adoption of technology, then the process of evaluation only serves the objective of management; often solely limited to financial management [24]. Should a decision to implement BIM based upon ROI be undertaken, then the objectives of supply chain participants who are involved with delivering an asset are neglected. Consequently, this may jeopardize their willingness to cooperate in realizing the full investment potential for the asset owner's business [24].

An evaluation approach for BIM that seeks to go beyond the traditional boundaries of financial evaluation is required [24–29]. Providing decision-makers with direct cost analysis, cash flow projections, and financial assessments ignores the indirect and intangible costs and benefits associated with implementing BIM. The role and scope of BIM investment decision-making are a complicated process, as its boundaries are continuously expanding. The change in boundaries is attributable to the emergence of new software solutions (increased scope, functionality, flexibility and interoperability) and organizational information system (IS) that can be used to support an asset owner's business. Hence, asset owners not only need to evaluate the technology, but also its impact on the future of the organization as well as the people that rely on to utilize the developed building information model, which will be used to manage, operate and maintain an asset over its life. Against this contextual backdrop, this paper examines issues associated with investment justification of BIM and propagates a framework that asset owners can use to realize its benefits and costs.

2. Evaluation and BIM

Evaluation is the process of "providing information designed to assist decision-making about the object being evaluated" [30]. In the context of IS evaluation, it is defined as "a process that places a different points in time or continuously, for searching for and making explicit, quantitatively or qualitatively all impacts of an IS project" [31]. Evaluation is an integral component of an organization's effective IS governance [32,33]. Information system's evaluation is a technique or a set of techniques that facilitates decision-making across an assets' life-cycle with the goal of achieving the best outcomes for an owner [33]. An evaluation can be undertaken prior to an investment in an IS or after the project is complete and includes predictive (ex-ante) and prescriptive evaluations (ex post). An ex-ante evaluation is used to calculate the feasibility, cost, and impact of an IS. Such evaluations may be used to inform investment decisions and obtain commitment to its implementation [34]. In contrast, prescriptive evaluations are conducted to access the performance of an IS. The rationale of the post-implementation review is to provide a comparison of *expected* and *actual* achievements, to learn how well resources have been used and to improve the use or selection and management of future IS investments [26,28,34].

Some of the most common predictive techniques used for evaluation by asset owners are Internal Rate of Return (IRR), Net Present Value (NPV) and ROI [25]. The underlying rationale of such methods is that the costs of an investment need to be related to the benefits that it seeks to realize. A problem with this balancing act is that costs tend to be incurred immediately, whereas benefits arise in the future [25]. Despite this inherent flaw with predictive techniques, the ROI has been widely used to assess the feasibility and cost of implementing BIM [16,20,21,34]. The ROI is a project's net output (cost savings and/or new revenue that results from a project less the total project costs) divided by the project's total inputs (total costs), which is expressed as a percentage. In the case of BIM, inputs are all of a project's costs such as hardware, software, external consultants, and training. Thus, if a BIM project has an ROI of 100% the cash benefits would be twice as great as the investment. In this instance, it would be reasonable to assume that investing in BIM would provide a significant return. However, an asset owner needs to consider a plethora of factors before making an investment decision to implement BIM, which include:

- assumptions underlying the cost of the project;
- assumptions underlying its potential benefits;
- the ability to measure and quantify costs and benefits;
- the risk that the developed model will not deliver what is required;
- the risk that the project will not be completed on time and on budget and will not deliver the expected benefits; and
- skills and expertise of consultants/contractors/subcontractors to deliver a fully integrated and functional model.

Accurately quantifying all of the benefits and associated costs that are attributable to implementing BIM is a challenging task when using the ROI. Pragmatically, hard (i.e. quantifiable) cost savings can be readily calculated, though the determination of indirect costs and intangible benefits arise from an imprecise process of deduction [25]. However, the improvements in productivity and potential revenue growth that can be obtained by an asset owner by utilizing a functional BIM, which has been developed to LOD 500 for operation and maintenance phases of an asset's life, are also difficult to estimate. An LOD 500 model represents the as constructed asset including as-built conditions and is configured to central data storage for integration into maintenance and operations systems. An example of the structure of an LOD 500 BIM deliverable for facilitates management can be seen in Fig. 1.

The quantification of intangible benefits such as strategic competitive advantage and customer and stakeholder satisfaction are insurmountable. The ROI analyses for BIM has tended to focus on determining potential cost savings and eschewed the intangible benefits that can be derived through its implementation such as site planning, site inductions, safety and usage analysis.

A survey by McGraw-Hill [23] revealed that 56% of respondents engaged in formal measurement of ROI for BIM on at least some portion of their infrastructure projects compared to 46% of BIM users in building projects [35]. A significant disparity exists with the ROI figures that have been propagated for BIM. For example, Ahzar et al. [18] ranged from 140% to 39,900% and Giel et al. [21] 16% to 1654%. Such figures appear to be overinflated and should be treated with a great deal skepticism, particularly as there is no standard approach for collecting and evaluating the data used to calculate ROI [36]. Moreover, such studies do not identify the LOD that was used to calculate the ROI. In addressing this issue, it has been suggested that six quantitative performance indicators should be used as tangible measures for ROI with regard to BIM [36]:

1. Quality control (rework reduction)
2. On-time completion (reduction in delay)
3. Overall cost (cost reduction)
4. Units (square feet/meters)/person hour
5. Dollars/unit (square feet/meters)/person hour
6. Safety (reduction in lost person-hours).

While the above performance indicators include key parameters that can be used to justify an investment decision to implement