# The influence of managerial strategy on the implementation of BIM in facilities management: a case study

Saratu Terreno[1, *], Ruwini Edirisinghe[2], Chimay Anumba[3]
[1] Pennsylvania State University
[2] Royal Melbourne Institute of Technology
[3] University of Florida
[*]email: snt120@psu.edu

## Abstract

The implementation of Building Information Modeling (BIM) in lifecycle management can positively impact the performance of Facilities Management (FM) operations. However, the adoption of BIM in FM has been slow due to a lack of sufficient know-how in implementation. This study aims to explore the drivers and challenges for BIM adoption in FM in a showcase organization, with a particular emphasis on managerial strategy including the influence of policy. A case study that illustrates the journey of a tertiary institution, which is an early adopter of BIM, is presented. It details the interviews conducted with the upper and mid-level institutional representatives, and reviews of BIM-related documentation. Aspects of managerial approach are analyzed, including their motivation, organizational policy, choice of BIM uses and requirements, procurement planning, adoption strategies and technological impact. It was found that the top-down approach of managerial strategy has greatly influenced the sustainability and success of the BIM process downstream. The paper concludes with an evaluation of lessons learnt following an analysis of the recorded experiences. The documentation of these experiences will provide a needed source of information and lessons illuminating skill sets, decision styles and strategies for organizations planning to implement BIM in FM.

**Keywords:** Building Information Modelling, Facilities Management, Strategy, Policy.

## 1. Introduction

BIM is a major transformative influence with the potential to improve the efficiency of multiple FM processes (Becerik-Gerber et al. 2012, Teicholz, 2013, Eastman et al. 2011), with FM in turn having been shown to possess huge potential for enhancement of organisational and societal well-being (Amaratunga, 2000). Although the delivery of the value of BIM in construction has been focused on how to improve the product, the value of BIM in FM has instead been focused on how to prove the product. A gap in knowledge as expressed by facility managers in relation to BIM includes the need for more examples of demonstrated benefits of the integration, and increased abilities in the utilization of BIM deliverables (McGraw Hill, 2014). Kiviniemi & Codinhoto (2014) concluded that the integration of BIM and FM is hardly straightforward, with numerous missing links and intricacies. They advocated for an FM-BIM 'Champion/Expert' for the facilitation of a smoother transition; and observed that the main challenges in integration are more attributable to current work procedures and organisational structures. Munir & Jeffrey (2012) determined that the real value of a BIM asset can never be clear-cut owing to a collection of variables as evident in an organization's established disposition, amongst others.

Studies have illustrated the slow adoption of BIM in FM by owners (McGraw Hill, 2014; Kiviniemi & Codinhoto, 2014), and also highlighted the knowledge gap on the part of the FM professionals (Liu & Issa, 2013; Williams et al., 2014).

Thus, there is a need to address this hesitancy by providing real-life examples of implementation to fill in the learning gap. Studies examining the organisational dynamics of BIM adoption in FM are lacking, though this is an essential part of technology diffusion in practice. The aim of this study is to address the obvious knowledge gap by examining the organisational dynamics of BIM implementation in FM by an early adopter. It is part of a doctoral research project at the Pennsylvania State University that examines a wide range of organizations to uncover influential factors in the value delivery of BIM in FM.

## 1.1 BIM in FM infancy

It has been argued that BIM-enabled FM is able to solve many problems faced in traditional FM practice (Teicholz, 2013). The usefulness of digital modelling for asset management, particularly in operations and maintenance, has been widely explored in literature. For over half a decade, researchers (Eastman et al., 2011; Becerik-Gerber et al. 2012; Volk et al., 2014; Kassem et al. 2015; Yalcinkaya and Singh, 2015; Shen et al., 2016; Edirisinghe et al, 2016) have discussed value propositions and driving forces for BIM-enabled FM.

Value propositions for BIM-enabled FM have reported on operational efficiencies, productivity, quality of service improvements, and on organisational goals and mission aspects. Operational efficiencies are to be achieved through accurate FM data (Kassem et al., 2015), and increased efficiency in building commissioning (Eastman et al. 2011), work orders, and decision making (Yalcinkaya and Singh, 2015). Productivity improvements are realised through automated data population, real-time data access (Becerik-Gerber et al., 2012), and BIM serving as the single source of information (Edirisinghe et al, 2016) in contrast to the large number of software packages.

Studies have reported that FM accounts for up to 85% of lifecycle costs (Teicholz, 2004), and is five to seven times more costly than the initial investment (Lee et al., 2012). Regardless of the precise proportions (BIM Task Group, 2012), the on-going operation and maintenance costs of a building during its lifecycle far outweigh the cost of the initial investment. Even though the economic benefits over the lifecycle of a facility are evident, BIM adoption in FM is still in its infancy compared to its uptake in the architectural, engineering, and construction (AEC) phases.

Depending on the stage of implementation (Edirisinghe et al, 2017), many obstacles to making full use of BIM in FM exist, including process, technology (Eastman et al., 2011), and organisational barriers (Shen et al, 2016). BIM for FM is still relatively new, and thus market readiness and finding the right project for the organisation (Eastman et al., 2011) matters. It was recently argued that the decision to adopt BIM is related to organisational priority settings (Edirisinghe et al., 2016) during the technology initiation stage (Rogers, 1995). Challenges were particularly reported in setting organisational priorities for BIM, especially when the core business of the organisation is not asset management (Shen et al., 2016; Edirisinghe et al, 2016). Regardless, challenges exist in justifying the investment due to the benefits being largely intangible, and to the long payback period (Shen et al., 2016). FM personnel, as the final stakeholder group of the building lifecycle, are least involved in early decision making. A lack of technology readiness in organizations (Shen et al, 2016), high training costs and lengthy learning curves (Eastman et al., 2011; Kassem et al. 2015) are also significant. Technological barriers, such as unresolved interoperability between BIM and various FM technologies (Yalcinkaya and Singh, 2015; Kassem et al., 2015), availability of technology, and economic factors, are also challenges.

## 1.2 Organisational Dynamics

Strategic deployment of BIM is critical to realising the full potential use of the technology in a building's lifecycle while demonstrating its business value. The four core value concepts of FM (Jensen et al., 2013) were mapped to organisational value parameters as (Terreno et al, 2016) : (i) People: culture, satisfaction, and image; (ii) process: productivity, innovation, flexibility, reliability, adaptability, support, quality improvement, collaboration; (iii) economy: cost decrease, risk control, asset value, marketing improvement, financing potential; and (iv) surroundings: sustainability; economic, social, spatial.

Rogers (1995) argues that individual leader (decision makers and top management) characteristics reflect the level of support for innovation. These characteristics include the leaders' attitude to change. ‘Actor-centred institutionalism’ Scharpf (1997) posits the importance of the analysis of individual “actors” within the wider context of institutional influence. Thus, they combine the theories of rational choice institutionalism and structuralist perspectives (van Lieshout, 2008): “social phenomena are to be explained as the outcome of interactions among intentional actors… these interactions are structured, and the outcomes shaped, by the characteristics of the institutional settings within which they occur”.

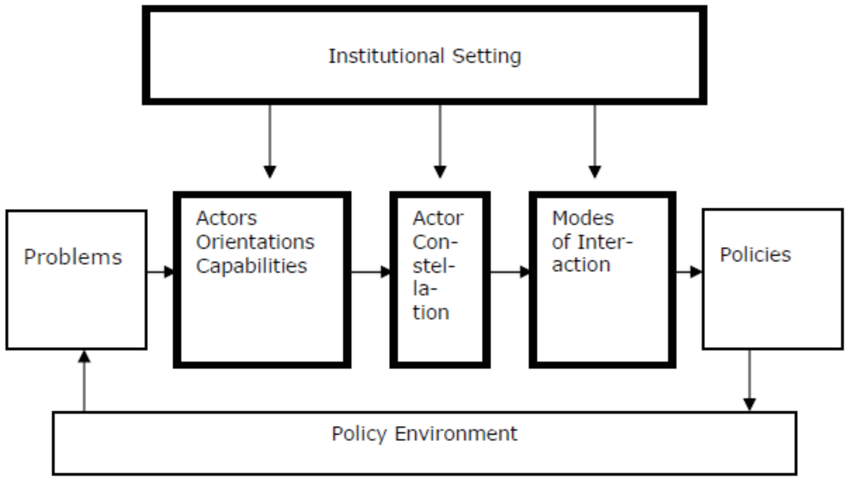


*Figure 1: the domain of interaction-oriented policy research (Source: Scharpf (1997)*

Through primary analysis of three case studies, Terreno et al (2016) explored how BIM can add value to FM in large owner-operator organisations – with a focus on tertiary institutions. The study postulated that the success of the implementation of BIM in FM depends on the managerial strategy, organisational culture, process and existing technological structure. Figure 1 (Scharpf, 1997) illustrates this further, showing how the policy environment introduces constraints on actors, and how the structure and influence of their institutional environment can either enable them to achieve their goals, or add further constraints.

## 1.3 Demonstrable real-world case studies

The absence of real-world case studies (Kassem et al. 2015; Edirisinghe et al, 2017) is another challenge while Kassem et al. (2015) also highlight the need for users to accept the technology in order for it to become more widespread. BIM-enabled facility management implementation process (Edirisinghe et al, 2017) grounded by innovation diffusion theory (Rogers, 1995) identified the knowledge gaps in BIM implementation in FM. Two technology adoption stages (Rogers, 1995) were considered in the gap analysis: (i) initiation stage - shared exemplars of early adopters' decision-making process; and (ii) implementation stage - shared knowledge base of case studies and real projects covering innovation maturity cycle (Rogers, 1995). Edirisinghe et al. (2017) highlighted the need for demonstrating real life examples of both stages to encourage wider-spread adoption.

Collaboration with "shared service peers" is important for future FM practice (CBRE&IFMA 2014). Literature also suggests that peers’ effect is a motivator for BIM adoption (Edirisinghe et al, (2016). Particularly, during the initiation stage, Edirisinghe et al, (2017) argue that the leadership and knowledge management is a critical factor. It is vital to demonstrate real life examples of early adopters about successful leadership strategies and knowledge management techniques as exemplars for wider spread of BIM adoption in FM. In this research vacuum, this paper reports a case study that illustrates the journey of a higher education institution which is an early adopter of BIM.

# 2. CASE STUDY

## 2.1 Institutional Background

The organization studied is the facilities department of a large tertiary institution, whose main campus alone comprises 956 buildings, with over 1,500 Full Time Employees (FTE). The organisation is semi-autonomous within the institutional structure, receiving partial funding from the state and capital funding from the institution, and also independent as an auxiliary business enterprise. The organization's design and construction department performs most of its minor renovation projects in-house, outsourcing most new build projects, with those costing $5m and above designated as BIM projects. Most external contracts are Design-Build, Construction Manager (CM) at Risk projects, allowing for the selection of CMs who are experienced with BIM, and thus greater collaboration with the external Architects who oversee BIM projects. Asset management is also performed internally by the organization's work control unit. Following their first BIM project in 2010, the institution was one of the first in the United States to develop a set of BIM Project Planning and Execution documentation comprising a guide, template and contract language. This has defined them as pacesetters in the construction industry in relation to BIM project implementation. The study analyses how their strategic focus can aid or constrain the actions of individuals, and its influence on the strategy of the department.

## 2.2 Methodology

The study focused on a tertiary institution because of the large asset holdings that these organizations typically have, in addition to being owner-operators of facilities. This organization was selected from within the small sample set of institutions implementing BIM because it was one of the first adopters and due to its rapid rise to leadership within the industry. The information sought within the study was collated from documentation provided by the institution, and those publicly available online. The key players in the initial move for BIM adoption were interviewed in order to establish the initial motivation and strategies put in place to move the initiative forward.

The document reviews provided insight on the background of projects, and information on procurement and the BIM planning process. The BIM suite of documents, including project databases, published papers and presentations, and other documents were studied to extract details relating to the study and BIM efforts.

The interviews highlighted the motivation of individuals and strategies that were included as the projects progressed. Seven participants who were part of the initial effort to implement BIM in project delivery were interviewed. They are spread between strategic and tactical levels of the facilities organization, and include the academic contributors to the effort:

- Upper Management: 3 respondents
- Middle Management: 2 respondents
- Academia: 3 respondents

The data was analysed by examining the history and progression of projects against the procurement, technical and relational strategies attached to each stage of learning. The personal motivational factors of each respondent were analysed, which resulted in 10 general categories of motivating factors. The range of interests were further grouped based on specialization /managerial level for further analysis. Strategies employed were broad and varied, with the most impactful selected for discussion. In studying the benefits and challenges, the responses were grouped based on the four categories of Management, People, Process and Technology for increased clarity and comparison to other related studies.

## 2.3 Summary of Responses

*Background*

Five of the respondents indicated that the initial seed for implementation came from academia, which had long been in discussions with a member of the organisation. Their partnership led to the sponsorship of three interns to form a group which would focus on the process of BIM execution in design and construction. One respondent saw an opportunity to reverse the equation whence BIM standards were being defined by vendors and service providers; and to take a lead in the industry. The organisation's strategy was to "begin with the end in mind", thus working backwards from the requirements for operations to include these within project execution. Following widespread interviews within the FM organization, the asset management unit was the low-hanging fruit. They responded positively based on their need for efficient organization and integration of information. The design services unit registered the greatest resistance, being comfortable with their use of CAD and the smaller sizes of their projects. A detailed list of asset submittal and information exchange requirements was developed and incorporated into the new BIM Execution Planning Guide for the institution.

*Table 1: Progression of BIM use in projects*

| | | | Projects | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| Type | Educational | Educational | Educational & Research | Medical | Athletic |
| Complexity | Low | High | High | High | High |
| Modelers | Interns | Interns & Contractors | Project Team | Project Team | Project Team |
| Collaboration | None | CM & Contractors | Project Team | Project Team | Project Team & FM |
| Contractual Requirements | None | Contractors | Project Team | Project Team | Project Team |
| FM data requirements | None | None | Yes | Yes | Yes |

A learning process followed the implementation of the first few projects. Table 1 details this gradual progression. The opportunities were taken as the projects presented themselves. They were all large, technologically complex buildings. Modelling and coordination of the structures initially began with the Academic Interns who had the skill, but by project 2, the contractors worked together with this group and developed their own modelling capabilities. By project 3, the selected team had enough skill that the academic interns were not involved. The list of participants and collaborators of design reviews has steadily expanded to include, in the latter phases, FM personnel; with project 5 involving maintenance technicians and supervisors in the virtual reality design review. Their involvement yielded a lot of constructive feedback from the maintenance standpoint, allowing for a lot of front-end savings ahead of building occupation. The team also learnt on the job, the importance of pushing the contractual (including data) requirements to much earlier in the process for more effective project delivery.

*Motivation*

Table 2 below summarizes the motivational factors as described by the interviewees. Most of the respondents alluded to a commitment to the academic cause, improved project delivery and derivation of value; and more efficient FM operations. Three of the respondents (spread across the 3 organizational categories) reported being inspired by a leader; further illustrating the effectiveness of the top-down approach. One participant highlighted the flexibility afforded him which equipped him with all the opportunities he needed to take the BIM vision to the next level. Interestingly, the participant to whom the initial seed is credited had a singular focus – the delivery of value to the projects through reduction of cost and improvement of quality

*Table 2: personal motivational factors of respondents*

| | | Industry Leadership | Organizational Culture | Academic Cause | Project Delivery Process | Project Value | Efficient Data Handoff | Waste Reduction | Efficient FM Operations | Visualization | Facilitator |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Upper Management | Respondent 1 | ✓ | ✓ | ✓ | ✓ | ✓ | | | ✓ | | |
| | Respondent 2 | | | ✓ | ✓ | | | | ✓ | | ✓ |
| | Respondent 3 | | | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Middle Management | Respondent 4 | | ✓ | ✓ | | | ✓ | ✓ | ✓ | | ✓ |
| | Respondent 5 | | | | | | | | ✓ | ✓ | |
| Academia | Respondent 6 | | | | | ✓ | | | | | |
| | Respondent 7 | | | ✓ | ✓ | | | ✓ | ✓ | | ✓ |
| | Respondent 8 | | | | ✓ | ✓ | | | | ✓ | |

*Strategies*

The BIM team realized they did not have the luxury of time, and so delved into BIM implementation headfirst – knowing that there would be mistakes and adjustments along the way. Some notable strategies are listed below:

- Partnering with academia and engaging skilled interns
- Incremental change beginning with observation of the results of 3D modelling and coordination on the first project, followed by systematic additions to capital project requirements over the years (Fig. 1).
- Structuring and communicating the desired project process, including backing it up with related contract language within the BIM document suite. The requirements are standard, yet customizable by project.
- Interviewing staff to uncover the low-hanging fruit of FM asset information requirements; included in the BIM Execution Planning Template.
- An internal benchmark for success is the focus on saving 45 minutes per day in operations – it is still being pursued following the fallout of vendor-coordinated discussions, which was yet another strategy for BIM/FM integration.
- The flexibility of the BIM Group as a fee-for-service entity provided the needed flexibility that enabled their leader to pursue the vision
- "Holding the hands" of contractors, designers and project managers by providing guidance and assurance to lead them step by step towards the eventual goal. A lot of negotiation, support and encouragement went into "sneaking the change by them". One participant observed: "we realized that we needed to find a win for somebody in order for them to play... define it and make it easy for them to get there".
- Developing a progressive workforce and culture that encourages innovation. A respondent observed how the change initiative came from bottom up and noted his own role as a "mere facilitator".

*Benefits & Challenges*

Most of the participants celebrated the buy-in from management and FM personnel; including the obvious motivation of contractors on the project teams (Table 3). In the early stages the contractors demonstrated a readiness to take on more risk, and to step in to fill in any gaps. By the third project, they reduced their bids in anticipation of increased collaboration and 3D coordination processes. The value of visualization and better integrated information both during project execution and submittals was noted. The organisation's clients were also better engaged during model reviews, as use of navigable 3D models brought the projects to life for them, thus eliciting more interactive conversation and useful suggestions. The modelling skills of the BIM Team was a positive addition to the new projects, as many participants noted; which helped in moving the BIM initiative forward. One main long-term benefit was having a member of the BIM team now embedded within the FM department. This was viewed as a unique and advantageous move. The interviewees noted the increased efficiency in project delivery, and the increased level of collaboration during project planning and execution. One of the participants mentioned the ease of extracting operations data directly from the model as advantageous, finding most of what was needed in one place.

*Table 3: Summary of the benefits and challenges of BIM implementation*

| | **Benefits** | **Challenges** |
|---|---|---|
| **Management** | Connection to Industry; Academia | Strategy |
| | Clear Contract Requirements | Value Proposition |
| | Flexibility of Operations | Funding |
| | External Image | Communication |
| | | |
| **People** | Skilled BIM Personnel | Organizational Culture |
| | Buy-In from FM; Management | BIM Staff Turnover |
| | Motivated BIM Teams | Modelling Skills |
| | BIM Staff embedded in FM | Project Team Resistance |
| | | PM BIM Skills |
| | | |
| **Process** | Value: information; visualization | Handover Coordination |
| | Efficiency: project delivery; FM | Model Use in FM |
| | Effectiveness: Engagement | Scope Definition |
| | Effectiveness: Requirements | Knowledge Capture |
| | Collaboration: Teams; FM | Schedule Delays |
| | | |
| **Technology** | Accessibility of Information | Interoperability |
| | Team Modelling Skills | |
| | External Influence on Industry | |

Table 3 also illustrates the main challenges to BIM implementation as observed by the study participants. Interoperability of technologies was a major concern, especially in the handoff to operations. The organisation's Computerized Maintenance Management System (CMMS), Maximo, is not integrated with Revit. Therefore, in order to import the operations data into Maximo, it would need to be exported out of Revit and converted to a compatible format. This involves several options such as the manual method of Extract, Transform & Load -ETL (Ibrahim et al., 2016), data hyperlinking (Parsanezhad & Dimyadi, 2013) or use of Application Program Interface (API) coupling or such as EcoDomus, FM: Interact, Data Warehouses etc. or proprietary middleware. The Construction Operations Building Information Exchange (COBie) standard faces similar issues in data exchange, itself needing many workarounds in order to exchange data customized to an organisation's standard (Terreno et al. 2019). The problems of interoperability in the industry are further discussed by Terreno et al. (2019), where they noted that the transition of BIM data from the construction phase into operations is not as automated as generally perceived, coining this phase "BIM in Transition". Six of the participants discussed the institution's early efforts to Maximo – which is an IBM product, with Autodesk's Revit – the 3D modelling software used by project teams. Discussions had been initiated with the two vendors, bringing them together to develop a plan for data integration and seamless information transfer. These talks failed, leaving a huge problem of interoperability. The organisation's management could do nothing about the situation, as the institution has used Maximo widely across many of its campuses, these involving thousands of buildings and millions of recorded and actively managed assets. Thus, the consensus amongst management was to continue with the manual workarounds, involving thousands of man-hours per project. The coordination of the handover of information from the closeout of projects still remains a huge challenge; yet the greatest challenge observed was the unwillingness to embrace change within the greater part of the organization.

One of the main problems talked about was the issue of staff turnover. At the time of the interviews, there was no longer a BIM Group in existence. All members had left the organization / department. There was no one left to lead the project coordination efforts; nor steer the organization towards achieving the latter goal of smooth operations and maintenance within FM. This was lamented by all the upper management participants and had been unexpected - thus there was no succession plan in place.

# 3. Discussion

The BIM journey began with an academic push. The partnership between the organisation and academia; including the organisation's flexible business capabilities served to provide the necessary funding and skills needed to move the vision forward. Many observed that this is a unique relationship which peers admired. The wider institutional culture of fostering academic partnership, and its supporting strategy of supporting organisational innovation have contributed to this initiative. The theory of rational choice played out, as the three main actors maximized these institutional benefits by using them to achieve the envisioned goals. The external policy constraints placed by the state requiring increased efficiencies aided the strategic initiative further by providing a business case for BIM. The absence of regulatory constraints or stipulations was seen as an opportunity by one respondent to define the "BIM environment" through legacy building and institutional leadership. Within the department however, resistance by many units to change stemmed from the opposing internal culture of 'social institutionalism' as described by Scott (2005) – "the way we do these things".

Two efforts stemmed from the BIM initiative – one outward for project delivery, and one internally for automation and integration in operations and maintenance. Though two successful guides (including a project execution template, contract addendum and asset list) were produced, only one initiative registered clear success. The project delivery documentation and implementation process earned accolades for the institution, firmly placing them as leaders in the implementation of BIM in FM. However, the second initiative – though admittedly long-term – is still in the process of achieving success. The institution still struggles with efficient handoff of submittals and asset data, though the requirements have been defined and complete; and the vision of having integrated information, visualization in operations and automated data transfer from project execution is still at bay. This is attributable to the failure of the collaboration between vendors, in spite of the commitment of top management and individual actors within the organisation. The resulting situation shows that where the theory of rational choice worked for the first initiative, it failed within the second based on the failure in the collaboration with the external players crucial to the interoperability of technologies (Yalcinkaya and Singh, 2015; Kassem et al., 2015). External policies requiring some level of collaboration would have aided this cause.

However progressive, the organizational culture has proven averse to major change; similar to the observations by Shen et al. (2016). Only one unit was open to the prospect of BIM implementation – more so due to their information management challenges. The values of majority of the personnel thus fall far from the institutional direction of innovation and change. Additional top-down strategies to cultivate these value parameters are needed to further demonstrate the value of BIM to the personnel, from whom (BIM) value will eventually be required. The difficulty of finding and keeping skilled BIM staff, and lack of a system for knowledge capture further put the organization into a rut following the departure and relocation of the whole BIM group. However, the move by one of the members to operations is viewed as advantageous and is anticipated as a potentially successful strategy.)

# 4. Conclusions

The exploration of the story of BIM adoption in a tertiary institution yielded a broad narrative of experiences derived from interviews with the personnel involved in the first initiative. Though the initial seed came from academia, and the push within the organization was essentially bottom-up, it was found that the top-down influence of senior management greatly motivated the personnel, with the funding and trust given provided the necessary enabling environment for the development of the BIM initiative. The resulting top-down strategies put in place by upper and middle management served to move the implementation forward. External policies are also important in fostering change and innovation, as the presence of these aided the first initiative; whilst their absence may have contributed to the failure of the second. The incremental advancement of change – evidenced in interactions with the project team, systematic formal requirements and the back-end strategy of beginning with the end in mind within the organization has registered positive results. More could have been done to improve mentoring and communication; including incentives to keep skilled BIM staff. Knowledge capture and succession planning are two elements to keep in mind to enable long-term continuity of the BIM initiative. The attention or inattention to these by management can greatly influence the sustainability and downstream success of BIM implementation. Beginning with the end in mind has proven to be a successful strategy, and the leveraging of a broader set of options to achieve interoperability, or at least laying the groundwork of intellectual property early on can give the FM initiative another opportunity. The study's limitations include the fact that the case study method was selected, which is not usually sufficient in representing the current state of the industry. However, this was necessary because the organization is an early adopter, and it was considered necessary to study their efforts to glean lessons learned. These can be studied and prove significant for other organisations considering the adoption of BIM in their facilities departments. The study serves as a baseline of documentation for other research efforts to build on. Future work will focus on the documentation of experiences of other early adopters of BIM to uncover patterns, trends and lessons following comparison, to yield a richer set of information.

# References


Becerik-Gerber, B., & Kensek, K. (2010). Building information modeling in architecture, engineering, and construction: emerging research directions and trends. Journal of professional issues in engineering education and practice, 136(3), 139-147.

BIM Task Group. The Government Soft Landings Policy (2012), (available online http://www.bimtaskgroup.org/wp-content/uploads/2013/02/The-Government-Soft-Landings-Policy-18022013.pdf [accessed December 2015])

CBRE & IFMA (2014). "2014 CBRE Facility Management Trend Report: Emerging Opportunities for Industry Leaders". http://www.cbre.us/services/ FMlink. (2004). "Facilities industry trends-survey results."

Eastman, C., Teicholz, P., Sacks, R., & Liston, K. (2011). BIM handbook: A guide to building information modeling for owners, managers, designers, engineers and contractors: John Wiley & Sons.

Edirisinghe, R., London, K. A., Kalutara, P., & Aranda-Mena, G. (2017). Building information modelling for facility management: are we there yet? *Engineering, Construction and Architectural Management, 24*(6), 1119-1154.

Edirisinghe R., London K. & Kalutara, P. (2016) An Investigation of BIM Adoption of Owners and Facility Managers in Australia: Institutional Case study, In the RICS annual construction and building research conference (COBRA 2015) Toronto, Canada, Sep 19-22.

Jensen, P. A., Sarasoja, A. L., Van der Voordt, D. J. M., & Coenen, C. (2013, May). How Can Facilities Management Add Value To Organisations As Well As To Society? In Proceedings of the 19th CIB World Building Congress 2013" Construction and Society", Brisbane, Australia, May 2013.

Kassem, M., Kelly, G., Dawood, N., Serginson, M., & Lockley, S. (2015). BIM in facilities management applications: a case study of a large university complex. Built Environment Project and Asset Management, 5(3), 261-277.

K. F. Ibrahim, F. H. Abanda, C. Vidalakis and G. Woods, "BIM for FM: Input versus Output Data," in Proc. of the 33rd CIB W78 Conference 2016, Oct. 31st – Nov. 2nd 2016, Brisbane, Australia, 2016. Rogers, E.M. (1995). Diffusion of innovations. Fourth edition. New York. Free Press.

Lee, S. K., An, H. K., & Yu, J. H. (2012). An Extension of the Technology Acceptance Model for BIM-based FM. In proceedings of the Construction Research Congress 2012@Construction Challenges in a Flat World (pp. 602-611). ASCE.

Liu, R., and R. R. A. Issa. "Issues in BIM for Facility Management from Industry Practitioners' Perspectives." *Computing in Civil Engineering* (2013). 2013. 411-418.

P. Parsanezhad and J. Dimyadi, "Effective facility management and operations via a BIM-based integrated information system," in CIB Facilities Management (CFM) 2014, Copenhagen, Denmark, 2013.

Scott, W. R. (2005). Institutional theory: Contributing to a theoretical research program. *Great minds in management: The process of theory development,* 37(2005), 460-484.

Shen, L., Edirisinghe, R., Yang, M. G. (2016) An Investigation of BIM Readiness of Owners and Facility Managers in Singapore: Institutional Case study, In Proceedings of CIB World Building Congress 2016, Tampere, Finland, May 30 - June 3

Teicholz, E. (2004). Bridging the AEC/FM technology gap. *Journal of Facilities Management*, 2.

Teicholz, P. (Ed.). (2013). BIM for facility managers. John Wiley & Sons.

Terreno, S., Anumba, C. J., & Dubler, C. (2016) BIM-Based Management of Building Operations. In Construction Research Congress (pp. 1855-1865).

Terreno, S., Asadi, S., & Anumba, C. (2019). An Exploration of Synergies between Lean Concepts and BIM in FM: A Review and Directions for Future Research. *Buildings, 9*(6), 147.

Van Lieshout, Harm (2008). "An actor-centered institutionalist approach to flexicurity: the example of vocational education and training."

Yalcinkaya, M., & Singh, V. (2015). Building Information Modeling (BIM) for Facilities Management–Literature Review and Future Needs Product Lifecycle Management for a Global Market (pp. 1-10): Springer Berlin Heidelberg