BIM FOR FACILITY MANAGEMENT: A REVIEW AND A CASE STUDY INVESTIGATING THE VALUE AND CHALLENGES

Graham Kelly, Michael Serginson & Steve Lockley
BIM Academy, Faculty of Engineering and Environment, Northumbria University, Newcastle, UK

Nashwan Dawood & Mohamad Kassem
Technology Futures Institute, Teesside University, Middlesbrough, UK

ABSTRACT: *For many years the issue of how to run buildings efficiently and effectively has posed a considerable challenge. This debate has had renewed significance since the emergence of Building Information Modelling (BIM) processes and the proposition that BIM information, captured during the facilities lifecycle, can help improve the efficiency of Facility Management (FM). Using this proposition as a starting point, the overarching aim of this paper is to investigate the value-adding potential of BIM and the challenges hindering its exploitation in FM. The literature review showed the BIM value adding potential stems from improvement to current manual processes of information handover. It also adds improvement to the accuracy of FM data and increases the efficiency of work orders execution, in terms of speed, to accessing data and locating interventions. It was also revealed that there is lack of real world case studies, especially in the case of existing buildings, despite new constructions representing a small percentage of the total building stock in a typical year. The case study was conducted on an existing asset composed of 32 non-residential buildings in Northumbria University's city campus. This was done to empirically investigate the value of BIM in a specific FM function (i.e. space management). The results provided evidence of the value of BIM in improving the efficiencies of FM work orders and the accuracy of geometric information records.*

KEYWORDS: *Building information modelling, facility management, computer-aided facility management,*

1. INTRODUCTION

The operational phase of a building is the main contributor to the building lifecycle cost. Estimates show that the lifecycle cost is five to seven times higher than the initial investment costs (Lee et al. 2012) and three times the construction cost (BIM Task Group 2013). There has been a tremendous economic and environmental need to manage both new and existing facilities in an efficient way. The industry has seen this debate renewed with the emergence of BIM, and the proposition that BIM data captured during the project lifecycle could improve the efficiencies of facility management functions. Facilities management (FM) is an umbrella term under which a wide range of property and user related functions are brought together for the benefit of the organization and its employees as a whole (Spedding and Holmes 1994). FM is holistic in nature, covering everything from real estate and financial management to maintenance and cleaning (Atkin and Brooks 2009). Governments around the world have recognised the inefficiencies affecting the construction industry in general, and have recommended and mandated the use of Building Information Modelling (BIM) as a strategy to addressing a declining productivity. Building Information Modelling (BIM) is the process of generating and managing information about a building during its entire lifecycle (BSI, 2010). For example, the UK Government has mandated BIM level 2 – Managed 3D environment held in separate discipline BIM models – on all public building projects from 2016, including the handover of digital data required for the operational phase (HM Government 2013) .

Tremendous research efforts have been devoted to address various aspects relating to the implementation of BIM in planning, design and construction processes. BIM for FM is an emerging area and there is still limited knowledge available on the subject. In addition, efforts investigating BIM applications in FM have mainly focused on new buildings despite new works making up only 1-2 % of the total building stock in a typical year. (Kincaid 2004). There are also lack of real world cases on BIM applications in FM (Becerik-Gerber et al. 2012). In this paper, a contribution to this gap is added by investigating the value and challenges of BIM in FM using an extensive literature review and a real world case study. The case study was conducted on 32 non-residential buildings in Northumbria University's city campus.

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2. CHALLENGES

There is an agreement about potential applications and benefits of BIM in FM, evidenced by the support of some pioneering FM organisations (Becerik-Gerber et al. 2012) and the vibrant research and development efforts addressing this area. The understanding of the challenges affecting BIM for FM applications is crucial at this stage.

One of the main challenges that is often discussed in workshops and reported in literature is the lack of processes in place for updating the designed model with as built information (Gu and London 2010). It is also unclear who is best placed to load data in and maintain the model (Becerik-Gerber et al. 2012). Facility managers have traditionally been included in the building lifecycle in a very limited way and at the late stage of facility handover to clients (Azhar 2011). Additionally, design decisions are not usually challenged for their impact on operational cost or maintenance (British Institute of Facilities Management 2012). As a result of these challenges, BIM data for FM is either lacking or inadequate. "*The FM field relies heavily on getting usable data from a BIM model to do anything meaningful with it. All too often, this data is not really there or is inaccurate, as the model has not been updated with any design changes made after the design phase and is therefore not an accurate model of the facility as it is built*" (Khemlani 2011). East proposes that facility maintenance contractors are paid to survey the existing building to capture as-built conditions and the owner should pay twice - once for the construction contractor to complete the documents at the end of construction - and again for the maintenance contractor survey (East and Brodt 2007).

The current FM industry cultural approach to adopting new processes and technologies is considered as a key challenge. The FM industry is quite rigid in its approach to new technology, and unless BIM for FM benefits are clearly proven, its uptake in the FM industry will continue to be low (Becerik-Gerber et al. 2012). Indeed, there is a lack of demand by clients for BIM models for FM (Australian Institute of Architects 2010) which is exacerbated by a general lack of collaboration between project stakeholders for modelling and model utilisation (Becerik-Gerber et al. 2012). The shortage of BIM skills and understanding in the FM industry hinders the adoption of BIM (BIM Task Group 2013).This is especially prominent because a BIM model for FM uses is considered an individual building asset, which requires continuous maintenance to remain valuable to the building itself and its owners (Becerik-Gerber et al. 2012).

Interoperability between BIM technologies and current FM technologies (e.g. CAFM – Computer Aided Facility Management) is still an issue in the handover of information and data to operation stage (Akcamete, Liu et al. 2011). Indeed, in existing buildings for example, FM legacy systems may be utilized for the next one or two decades. Unless the transfer of BIM data is automated, and the value of BIM is demonstrated, it is unlikely that facility managers can prove the business cases for using BIM in existing buildings. According to the British Institute of Facilities Management (2012) there is a need for open systems and standardised data libraries that can be utilised by any CAFM or asset management system. Without such non-proprietary format, facility owners and managers must enforce proprietary information systems or re-key information into a CAFM System. Owners and facility managers pay to have the data keyed into relevant FM systems (East and Brodt 2007). However, to date there is undefined fee structure for such an additional scope (Becerik-Gerber et al. 2012).

An information exchange specification called COBie (Construction Operations Building Information Exchange) was developed to provide a structure for the lifecycle capture and delivery of information needed by facility managers (East and Nisbet 2010). While there is an agreement that COBie is necessary for structuring data (Open BIM Network 2012), COBie "does not provide details on what information is to be provided, when and by whom" (East and Carrasquillo-Mangual, 2013, p.1). and there is still limited knowledge in the identification of such requirements. Only a brief summary of some non-geometric requirements was identified in recent studies (Becerik-Gerber et al. 2012). This challenge is best summarised by Teicholz (2013) who argues that *"Building information models delivered at project completion are a rich information source for FM, but not all of the information is valuable on a day to day basis within the broad range of an FM practice, where data retrieval, change management, and tracking costs and work activity are critical. Facility managers will need to detail and prioritise their information requirements".*

The lack of contractual and legal framework for the implementation of BIM in general (Eastman et al. 2011) and for BIM for FM in particular (Becerik-Gerber et al. 2012) is a significant area of challenges. For the foreseeable future, legal and liability requirements in the building industry will dictate that contracts between the parties be conveyed in the traditional written and two-dimensional graphical form (Reddy 2011). The first legal risk to determine is ownership of the BIM data and how to protect it through copyright and other laws (Azhar 2009).

Licensing agreements are a feasible option that allows limited use to another party while maintaining copyright and ultimate control (British Institute of Facilities Management 2012). However, this solution is challenged by the fact that there are difficulties with embedded data and 'whole of life' risk and audit (Australian Institute of Architects 2010). As a result, most contracts forms still require the handover of paper documents containing equipment lists, product data sheets, warranties, spare part lists, preventive maintenance schedules, and other information. This often leads to incomplete and inaccurate information that is difficult to access and utilise for the purpose of increasing FM efficiencies.

3. VALUE

Today most contracts require the handover of paper documents containing equipment lists, product data sheets, warranties, spare part lists, preventive maintenance schedules, etc. This information is essential to support the management of the facilities by the owner and property manager. The current process of information handover to FM phase is generally done manually. As a result, information handed over is often incomplete and inaccurate. The industry is spending millions of dollars, and thousands of man-hours recreating such information and working with inefficient workflows (Keady 2013). Of this $15.8 billion loss caused by interoperability inefficiencies, $10.6 billion are attributed to the owner/operator during the operations and maintenance phase of a building (Lee, An et al. 2012).

The improvement of handover processes is the among the main drivers for using BIM in FM (Gu, Singh et al. 2008). Despite current interoperability challenges, BIM data and information collected during the building lifecycle will reduce the cost and time required to collect and build FM systems (Teicholz 2013). For example, data regarding spaces, systems, finishes, etc. can be captured in digital format BIM models and do not require to be re-entered in downstream FM systems (Eastman et al. 2011). More importantly, the quality and reliability of data will improve, and in turn will result in increased workforce efficiencies (Teicholz 2013). According to Eastman et al. (2011) the utilisation of improved data quality is likely to improve further as more people become accustomed to working in a BIM environment. These benefits are summarised in a statement by the BIM Task Group (2013): *"BIM will provide a fully populated asset data set into CAFM systems and therefore reducing time wasted in obtaining and populating asset information enabling us to achieve optimum performance quicker, reduce running costs and refine target outcomes".*

The ability of extracting and analysing views from BIM models, specific to various needs and users, will provide information to make decisions and improve the delivery of facilities (Azhar 2011). There are also other benefits for FM, associated with the visualisation nature of BIM, compared to the two dimensional drawings (Akcamete, Liu et al. 2011). BIM visualisation provides accurate geometrical data that has never been possible before (CRC Construction Innovation, 2007). It enables the analysis of building proposals and the simulation and benchmark of building performance (Atkin and Brooks 2009). This is facilitated by the parametric nature and semantic richness of numerous types of relationships such as "is-contained-in", "is-related-to", "is-part- of", etc. that are very important in FM. Scenarios showing the benefits of BIM to FM interventions such as troubleshooting broken equipment and improving ergonomic and comfort conditions are described by Becerik-Gerber et al. (2012). Other important BIM in FM applications outlined in this study are in space management, emergency management, energy control and monitoring, and personnel training and development.

There are some proposals that adopting BIM in FM will facilitate the future involvement of facility mangers at a much earlier design stage to convey their input and influence the design and construction (Azhar 2009). Finally, the adoption of BIM in FM is expected to provide ways for managing knowledge about building operation which can be utilised in future designs (BIM Task Group 2013).

4. CASE STUDY

The research question posed at the start of this paper was to investigate the value and challenges of BIM in FM for new and existing assets. The value of BIM in FM for new assets has been explored in the literature review. However, there is also a need to explore how BIM can add value to existing buildings. A case study was collated and aimed to investigate the value of BIM in managing spaces selected as a specific FM function. The case study was conducted on Northumbria University's city campus, which is based in Newcastle upon Tyne (UK). It is made up of 32 non-residential buildings with a gross area of over 120,000 m² (Figure 1). The case study started in 2010, when the University commissioned five developers to produce building information models with a focus on improving the performance of space management. Working to a concise BIM Specification, the models were completed by the five developers in five weeks at a cost of approximately £ 0.33/m². Developers have used existing Estates Department's floor plans in DWG format, scans of the original elevations, sections in JPEG format, and space information in Excel databases. As the case study involves an existing asset, there are key challenges that the application of BIM for FM purposes should address. These are related to the strategic issues and the business case for migrating from the current FM processes to BIM-based FM processes. The case study involved personnel from the University's estates department who have taken part in detailed discussions investigating the value and challenges of BIM in managing the spaces of the existing university campus. The results are summarised into the following categories.

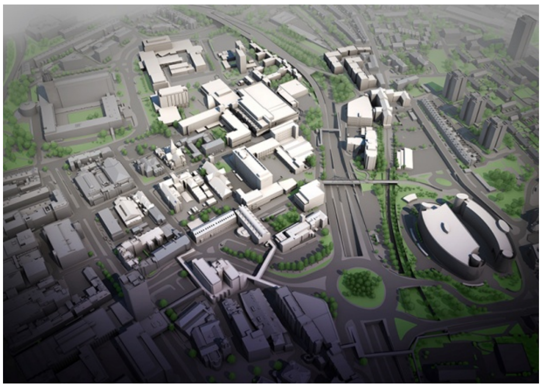


Fig. 1: Northumbria University's city campus

4.1 Workforce and process efficiencies

The efficiency of processes associated with managing spaces, such as updating geometric and non-geometric information, came immediately to the fore when the functionalities of BIM for FM were explored. The University currently updates its drawings and information in two separate environments (i.e. floor plan drawings in two-dimensional graphical representation - i.e. DWG format - and a database in MS Excel format). Both require manual update, creating duplication of workload. Photographs and scanned elevations and sections from the original drawing sheets are used to verify specific details. With regular changes in building utilisation occurring year round, this is a lengthy task requiring the full time attention of a CAD technician. Using BIM for FM the creation of geometric information and the inclusion of specific FM information allows automatic updating of required schedules; producing instant sections, elevations, three-dimensional visuals and renders, and generating drawing sheets from a single integrated environment. This provided efficiency gains that have not been possible to achieve with current processes and technologies utilised by the FM team (Figure 2). It was estimated that this would reduce the need for a full time CAD technician and provide cumulative savings from improved efficiencies in future work orders over the years. In addition, the BIM models' data richness provided additional information relating to statutory compliance such as integrated asbestos register, emergency equipment, escape routes, accessibility and essential maintenance. Detailed information on these components can be easily traced, updated and reported in schedules. An example that includes an area of asbestos, properties of the asbestos type, its exact location, date of removal and location of survey documentation can be displayed in real time (Figure 4). Moreover, the estate department staff identified that BIM for FM models, with the augmentation of available technology functionalities, to enable services such as room finding, fault reporting, development and refurbishment option generation, and assessment of building performance. Such services lead to reduction in response times, with detailed campus knowledge assigned to specific buildings, levels, rooms, etc. For example, with each request to replace a light bulb on the campus, the maintenance staff could check in real time the bulb type and manufacturer using the FM model before carrying out the task. Another example could be to check the paint colour code for a room where the wall finish has been damaged, thus saving staff time and material resources. The models have been used to trial option appraisal for redevelopment and refurbishment as phased plans, sections, elevations and 3D rendered views that could be quickly displayed and assessed (Figure 5). This provided time and costs associated with design and more accurate representations for strategic decision making from a management perspective.

4.2 Accuracy of records of geometric information

The creation of BIM models have revealed that some areas of buildings on the campus failed to line up when the two dimensional drawings and elevation scans were used as a basis to build the models (figure 5). This has called upon the estate department to order new surveys to verify the building layout. It was also agreed that once the FM team achieve the required BIM skills, the maintenance of geometric records will be accomplished in a more efficient way from both economic and quality perspective.

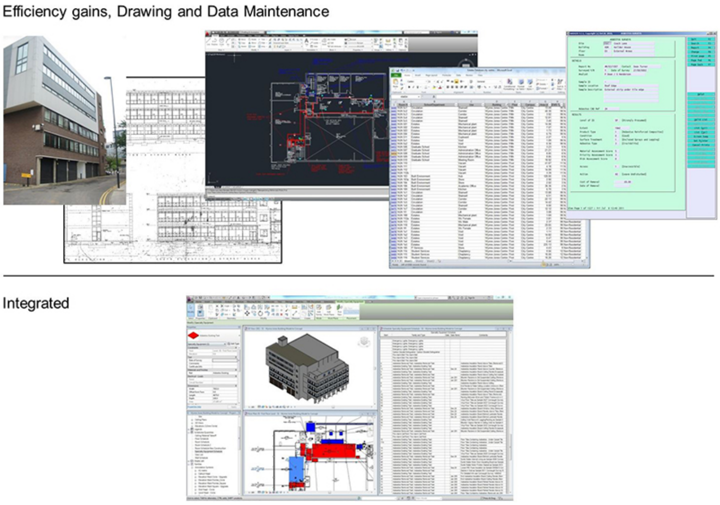


Fig. 2: Comparison of existing data maintenance processes with BIM processes

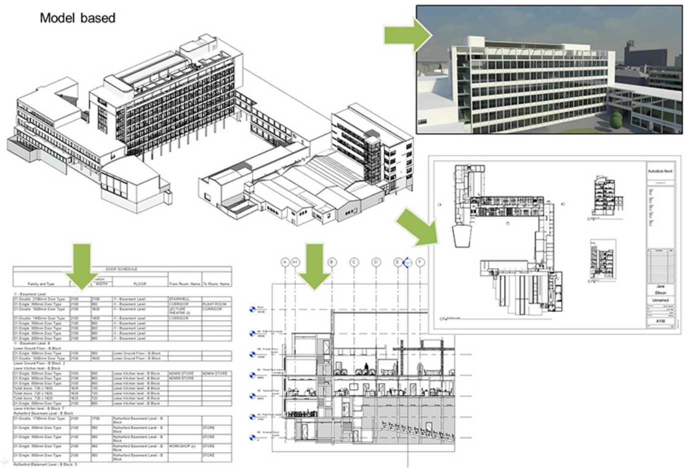
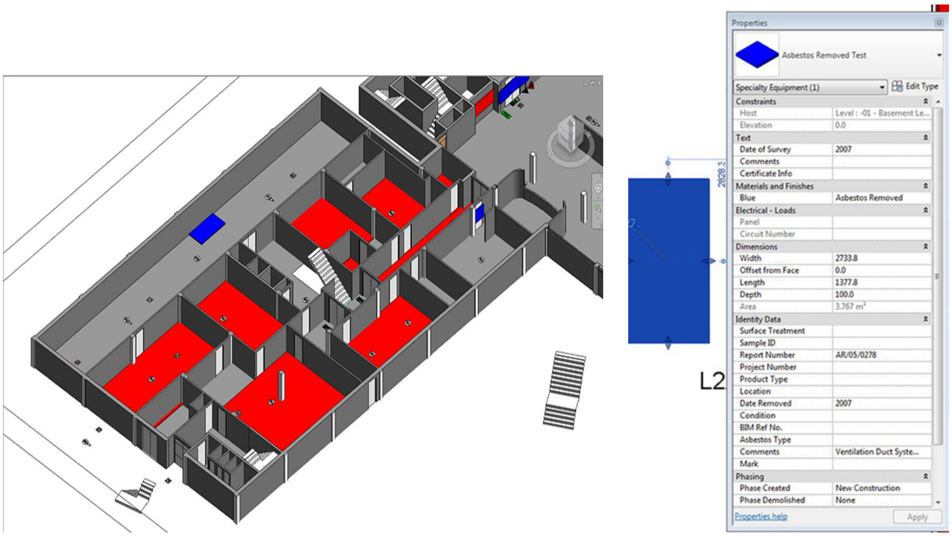


Fig. 3: Single BIM integrated database as a trusted source for information



Constraints	
Host	Level : -01 - Basement Le...
Elevation	0.0
Text	
Date of Survey	2007
Comments	
Certificate Info	
Materials and Finishes	
Blue	Asbestos Removed
Electrical - Loads	
Panel	
Circuit Number	
Dimensions	
Width	2733.8
Offset from Face	0.0
Length	1377.8
Depth	100.0
Area	3.767 m²
Identity Data	
Surface Treatment	
Sample ID	
Report Number	AR/05/0278
Project Number	
Product Type	
Location	
Date Removed	2007
Condition	
BIM Ref No.	
Asbestos Type	
Comments	Ventilation Duct Syste...
Mark	
Phasing	
Phase Created	New Construction
Phase Demolished	None

Fig. 4: 3D view of removed (blue) and existing (red) asbestos in building model

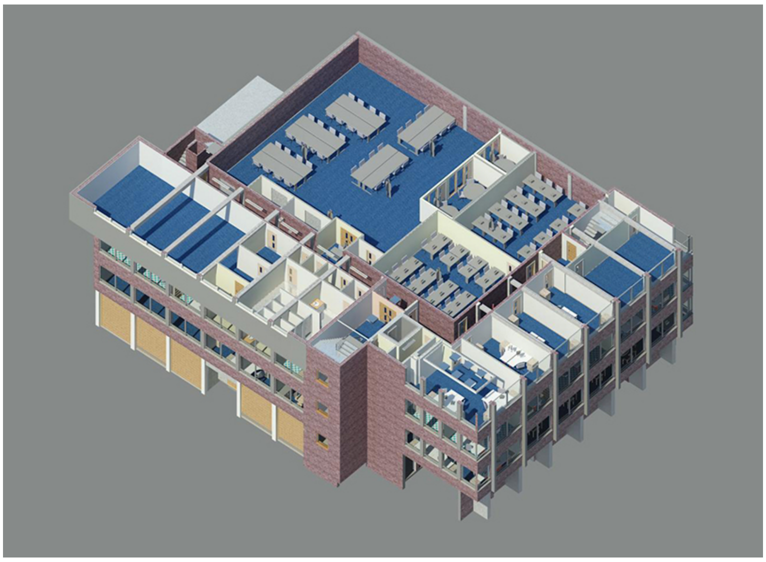


Fig. 5: Generation of design options for internal refurbishment

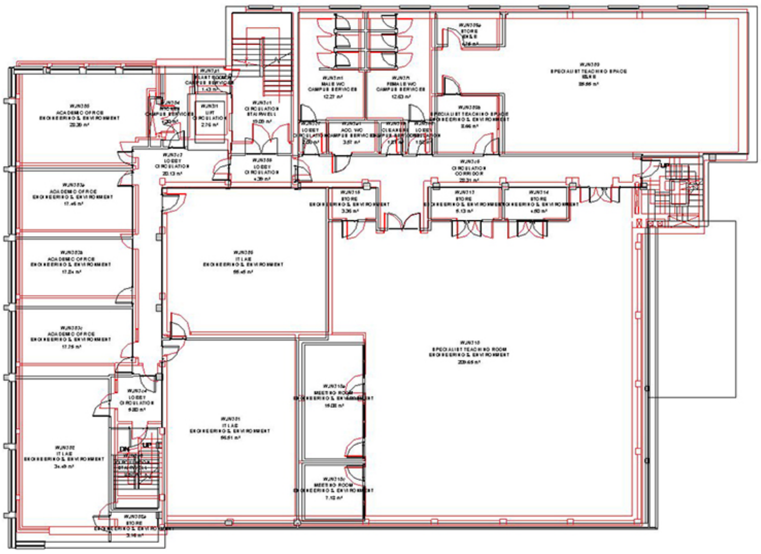


Fig. 6: Improved accuracy of building records when tested in BIM (Red: original, Black: updated)

4.3 Implementation challenge and maintenance of models

Once the previously illustrated scenarios have demonstrated the value of BIM in FM, discussions with the FM estates department have shifted to understand the challenges associated with migrating from current FM processes to BIM based processes. Several key challenges were revealed and are related to the implementation. There is a need to communicate and understand the benefits of BIM for FM such as the examples previously mentioned. However the FM team should have the skills to be in position of maintaining and controlling the BIM for FM models. A concise BIM for FM specification must be developed to define the information required to suit the particular requirements of the business and FM function. It was also acknowledged that there are still industry-wide challenges related to technologies and processes. FM teams wishing to implement BIM for FM in the immediate future should be willing to adapt to such challenges. For example, one of the major concerns was the limited compatibility between BIM technologies and FM technologies (e.g. CAFM, BAS, etc.) which can be exacerbated by the huge difference among the lifecycle of BIM technologies, FM technologies and buildings. The lifecycle of a BIM technology is typically 12 - 24 months, whereas the lifecycle of FM legacy systems vary between 10 - 20 years and building lifespan could be up to 100 years. This means that data standards and interoperability will remain critical for the adoption of BIM for FM technologies. Therefore, FM organisations wishing to implement BIM for FM in the immediate term should take a long term view (e.g. minimum 5 years) and be willing to work with different standards and information formats. It was also identified that due to the evolving nature of the BIM for FM field, and the differences in the lifespans of technologies, FM organisations must not fit their FM business processes to suit a particular technology which would otherwise result in a continuous effort of adaptation. However, FM organisations can presently attain the benefits of BIM for FM through the development of a tailored BIM specification and templates (e.g. information to be included, level of detail, object styles, line styles, units, export settings, etc.) that suit their particular business requirements. Examples of levels of development used in the case study are reported in figures 7 and 8 using the AIA LODs (AIA, 2012). Such specifications and template will also help to engage with the supply chain on future work on the university campus and enable compatibility with the organisation's FM procedures.

Fig. 7: a BIM model at AIA LOD 500 (left) and AIA LOD 100 (right)

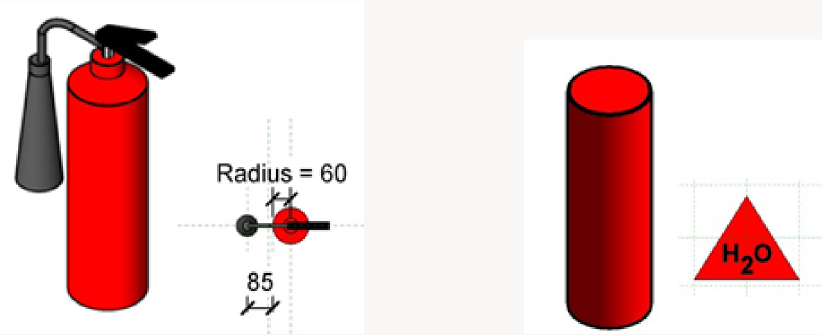


Fig. 8: Fire Extinguisher model at AIA LOD 500 (left) and AIA LOD 100 (right)

5. CONCLUSION

BIM applications have been thoroughly discussed and researched at planning, design and construction phases. BIM in FM application is still considered an emerging field. The understanding of the challenges and value-adding potential of BIM in FM is fundamental at this early stage. In this paper, such an investigation, utilising two research methods that build on each other – i.e. review of existing studies and a case study approach – was conducted. The findings from the literature review provided evidence that there is agreement about the value and potential of BIM in FM. It demonstrated that the value of BIM in FM stems mainly from:

- Improvement to the current manual processes of information handover; improvement to the accuracy of FM data
- Increase of the efficiency of work orders execution, in terms of speed, to accessing data and locating interventions. Such value is derived from the capability of BIM to provide a data-rich visual and integrated data environment.

However, there are challenges that are hindering the exploiting of BIM in FM. Four main challenges are:

- The lack of tangible benefits of BIM in FM despite agreement about the potential of BIM in FM
- The interoperability between BIM and FM technologies
- The lack of clear requirements for the implementation of BIM in FM
- The lack of clear roles, responsibilities, contract and liability framework.

Other challenges are related to the procedural and cultural mindset in the industry where FM managers are involved only at a very late phase in the project and models are not updated with as-built information. Another key finding is the lack of real-world case studies of BIM applications in FM. A real world case study of 32 non-residential buildings with a gross area of over 120,000 m² was presented with the following objectives in mind:

- Add a contribution as a real world case study;
- answer some of the challenges identified and in particular demonstrate the value of BIM in FM;
- Clarify the challenges associated with migrating to BIM-based FM;
- Reveal potential new challenges.

The results from the case study demonstrate with practical examples how BIM can add benefits to the workforce and process efficiencies and to the accuracy of records of geometric information. In addition to the challenges identified in previous literature, discussion with estate department experts conducted during the case study revealed a further challenge which is inherent in the significant differences of lifespans BIM technologies, FM technologies and buildings. This means that FM organisations must be prepared to work with different information and data standards in the mid and long terms instead of adapting their business processes to fit a specific technology. It is suggested that the development of a BIM for FM specification that suits the need of the organisation's FM processes is currently key to exploit the benefit of BIM-based FM and enable the organisation and its supply chain to work according to structured FM processes.

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