Enhancing the Value of Facilities Information Management (FIM) through BIM integration

Purpose: Building Information Modelling (BIM) provides a robust platform for information management in built environment facilities. However, one of the consequences of the limited application of BIM in facilities information management (FIM) is that the potential value gain through the integration of as-built information during the operations management process has had limited exploration in current practice. This paper attempts to explore the potential impact of BIM to enhance the value of Facilities Information Management.

Design/methodology/approach: A detailed literature review was undertaken to identify BIM application in a construction context, and to develop a framework to investigate the value of information. An interpretative approach was adopted for data collection and analysis. 14 semi-structured interviews were conducted with construction industry professionals to identify how value of FIM can be enhanced through BIM integration. The interview data were analysed using open and selective coding.

Findings: The findings confirm that information exchange between the construction and facilities management phases of a project are important in terms of efficient and effective maintenance of a facility as well as optimising the design task. With these promising benefits, BIM is an efficient mechanism to facilitate construction information exchange. However, there is an uncertainty over the optimum level of information that ought to be on a BIM model for facilities management purposes. The relationship between different aspects of value is a starting point to filter the required information for each individual project. In contrast, limited awareness of value of information exchange and the potential of BIM enabled FIM during construction is noted.

Research limitations/implications: The information exchange considered within this investigation was limited to two key phases of the facility lifecycle, namely construction and facilities management (in-use).

Practical implications: The findings bring insight into an unseen aspect of facilities management information needs that should be given priority in upcoming BIM developments. Also, it draws attention to how value is concerned in a daily basis beyond monetary terms.

Originality/value: The investigation of value enhancement through BIM integration in particular to facilities information management and ongoing research with new value dimensions.

Keywords: Building Information Modelling, Construction, Facility Information Management, Information Value

Article Classification: Research Paper

01. Introduction

Building Information Modelling (BIM) has significant potential to bring positive impact to the sustainable delivery of construction project goals (Poirier, Sheryl, and Forgues, 2015). It provides a robust platform to exchange, reuse and update asset information, which is an essential requirement for a successful through-life management of a facility. BIM integrates several project dimensions such as time, cost, quality and environment into a single platform through an intelligent multi-dimensional model. It has recently become more popular within the UK construction industry. Having analysed, through life adoption of BIM within the UK construction projects, Eadie et al (2013) reveal 55% of construction organisations adopt BIM during design and construction phases, however only 9% during the Facilities Management (FM) phase.

Although the application of BIM is dominant in design and construction phases, it is a promising process to improve through-life performance of a built asset (Codinhoto *et al.*, 2013). Frequent adoption of BIM in early stages of construction facilities has been identified to give proven benefits, such as effective coordination, visualization of the end product and early detection of clashes (Azhar, 2011). There are limited case studies to reveal the benefits of BIM beyond design and construction phases (Innovation, 2007; Arayici *et al.*, 2012; Patacas *et al.*, 2015). On the other hand, construction clients are more concerned about the end products (tangible deliverables), rather than the long term operational and maintenance requirements (Becerik-Gerber *et al.*, 2012).

The success of building maintenance and operations (facilities management) depends on robust information management practices (NBS, 2015). The data that flows (in – out) during the lifecycle of a construction facility is high in volume, complex, and more frequent. The UK Government have been set clear targets to implement BIM Level 2 for all publicly procured projects by 2016. This promotes the collaboration between project stakeholders to enhance the through-life project performance.

There are growing number of extant research papers explaining the benefits of implementing BIM in the FM tasks (Pittet *et al.*, 2014; Giel and Issa, 2016) and the execution of BIM standards in construction (Howard and Björk, 2008). In a way, the current focus is mostly on “what” could be achieved through BIM in FM. However, limited effort has been given on “how” to achieve the BIM advantage in FM. Having identified this gap in the existing knowledge, this paper aims to review the perceived value of information used during FM and the potential of BIM to enhance the value of Facilities Information Management (FIM). The term information management encompasses information, technologies, strategies and systems. However, the facilities information management (FIM) considered within this paper is limited to the information management requirements during the facilities management phase of a built facility.

02. Facilities Information Management in construction projects

Literature reveals construction as a heterogeneous and enormously complex industry. The industry produces one-off products, many of which have longer lifecycles. Supply chain integration has been identified as one of prominent considerations for effective delivery of construction products and processes. The project stakeholders have different levels of interests and influence towards the project goals. Therefore, the information flows of construction project are enormously complex, scattered and multi-dimensional.

On the other hand, Facilities Management (FM) is the integration of processes within an organisation to maintain and develop the agreed services that support and improve the effectiveness of its primary activities (European Standard EN 15221.1, 2007). The FM process focuses on managing the complexities of a built facility to smooth the functioning of its physical structure and support services to enhance the core business performance (Kincaid, 1994). The information flows during FM stage is significant to achieve such targets. In a typical construction project, information exchange is frequent and the information providers/users range from design team, builders, suppliers, regulatory bodies, funders, end users etc. Involvement of these roles on information exchange depends on the selected procurement route and the conditions of the contract (RIBA POW, 2013). Therefore, information flows and the timing of them varies and is crucial to operate a facility with minimum disruptions. Having identified such variables, Information considered within this paper is been narrowed down to as-built information of projects procured through a design and build arrangement. Also, it determines the 'information value' in terms of fit for purpose rather than monitory value due to several reasons such as lack of experience in whole life application of BIM, unmeasured and indirect contribution of as-built information to facilities management and poor consideration of facilities management needs at the early stages of construction. However, it is visible that a successful Facilities Information Management clearly considers the 'type of information' (WHAT), 'timing of them' (WHEN), 'uses/functions' (WHY), 'flows' (HOW) and the 'users and providers' (WHO). Therefor it is vital to have a complete understanding beforehand, without being specific to the area of study.

3.1 Types of information - (WHAT)

Based on existing knowledge, information which is used to complete FM functions comes in three main domains, namely 'Construction information', 'Business information' and 'Facility operation information'. Construction information refers to the information which is generated and in-use during the design and construction phases of a facility (Craig and Sommerville, 2006). Facilities Managers identify construction information as the one which is exchanged between project manager and the owner/facility manager specifically to particular assets at the project handover stage (Clayton et al., 1999). For example, asset information, space allocations and maintenance schedules etc.

Business or market driven information support running the business, while maintaining the competitive advantage. For example, functional requirements related to the space being used, expected occupancy and other business functional information that influence facility operations are considered within this category. Usually, such information is fed into the FM system internally or externally (Chotipanich, 2004). The need is to have the right information at the right time to prosper the business.

Facility operational information refers to the information which is directly related to the operation and maintenance of the facility in current and future environments. Examples of such information are energy consumption, maintenance records, facility operation staff information etc. (Whitaker, 1995). Whitaker (1995) further noted the need of a proactive role of facility managers towards managing the operational information efficiently and productively.

3.2 Timing of information (WHEN)

Information needed for FM is generated and released in different phases of a project life cycle. For example, client information requirements are produced at preliminary stages of the facility, and they are continuously amended and improved during the design and construction stages. Although such information is generated during the inception phase; it may be released to the facilities manager along with the physical output of the project. Subsequently, asset operation and maintenance information such as post occupancy evaluations, breakdown records, energy consumption, etc. are added continuously during the FM phase. Information flows during the facility operations and maintenance stages include details of the built asset as well as the business operations. This continues up to the disposal of the facility at the end of its economic, physical or functional lifecycles, including information related to refurbishment or end of use.

3.3 Uses/Functions (WHY)

As mentioned above different types of information feeds into facilities management systems at different times. A variety of information is gathered to serve the multiple needs of FM. Information from the early stages of a facility up to the construction phase is used to learn about the building and its nature, spatial plan, etc. On the other hand, business operations related information such as occupancy rate, business functional needs and market information are gathered to perform daily FM activities to support the current business and secure the future potential business opportunities. This information assists to maintain a flexible built environment, capable of adapting to changing business needs. Moreover, operational and maintenance information are used to upkeep a sustainable built environment.

3.4 Users and Providers (WHO)

The FM related information flows from a variety of sources. Construction information is provided by supply chain/stakeholders who are in the project team ranging from clients/end-users, architects, engineers, service providers and manufacturers. Similarly, business operations information flows into the FM division from various departments within the organisation such as finance, marketing and administration as well as from external sources such as government, funders, standardization bodies and competitors. Operations and maintenance information are mostly generated within the FM division. The users of FM information vary amongst different professional roles, and the level of the detail of the information used varies with the user and the project objectives.

3.5 Flows (HOW)

Business and facility operation information maintain a direct flow, as they are generated during the operation and maintenance of the facility on which FM have much more control over them. However, the construction information flows vary with the type of procurement arrangement. For example, in a design and build procurement approach, the responsibility of information handover is vested with the main contractor/architect creating a more centralized approach. In traditional procurement method (i.e. design- bid-build) it consists of a complex array of information flows due to the engagement of a number of parties and dispersed involvement in the construction phase.

Having studied what, when, why, who and how questions it is evident that information required for a continuous FM is scattered throughout the facility life cycle. Although an early engagement of a FM is recommended in theory, it is not frequent and visible in current practice (Eastman, 2011). The late involvement of facility managers in construction projects and the complexities in information flows create multiple difficulties for facilities managers when absorbing appropriate construction information (Clayton et al., 1999; Anderson et al., 2012; Wang et al., 2013). Hence, the information exchange between construction and FM stages is not coordinated. Literature further confirms that the root cause for most of the FIM issues are due to drawbacks arising from information generated and handed-over from the construction phase (Clayton et al., 1999; Bröchner, 2008). Therefore, it is necessary to study the value of construction information for facilities management to understand the value of BIM in facilities information management (FIM). This is the way forward as BIM has the full capacity to carry information necessary for FM from construction stage.

03. Information Value

The term 'value' is multifaceted, providing different meanings to different stakeholders. Simply it is the 'cost' over 'benefits', which represent the ultimate worth of the considered matter (Neal and Strauss, 2008). The costs and benefits can be communicated in different ways. Repo (1986) explained a dual approach as "exchange value" and "value in use". Exchange value refers to the market value of information when it is regarded as a product or service. On the other hand, value-in-use refers to the benefits of information to its users which include both subjective and objective perspectives.

However, the elements associated with each variable (objective or subjective) and the level of influence differ based on the project type, nature etc. In construction, a balance of cost, quality and time is considered as a reasonable method to ascertain value (Best and De Valence, 1999). Although this paper mainly focuses on the Architecture, Construction, Engineering and Facilities Management (AEC/FM) context, it is necessary to consider the features related to information to define the value of information beyond project success.

Allocation of a monetary value to a piece of information is not always practical (Gallagher, 1974). From a case study analysis, Gavirneni et al (1999) developed an equation to measure the value in supply chain information flow. The equation is integrated with the monetary, performance and lead time improvements made through the availability of information. Similarly, by elaborating factors considered as benefits in value equation, Neal and Strauss (2008) introduced a measurement tool to capture the brand value. Both methods have been considered successful due to the structured nature of the manufacturing industry/products. On the other hand, what is measured in quantitative (monetary) methods as "value" of information is a single use of information and have always left with a question mark on what it is meant by "value". However, key facts which could be taken forward to determine the value of information in FM are considered.

Literature suggest several mechanisms to determine the value of information. The method which is popular in manufacturing industry compares two situations of performing a task with and without information (Gavirneni et al., 1999). However, value is something more "adjectival rather substantive", therefore, it should be considered along with object and interest (Perry, 1914). Moreover, Gallagher (1974) suggested three possible ways to measure the value of information. Among these three methods, measuring the value after the information is used and the consequences of the action are known as the best method to determine the value of information. Having considered such characteristics of value of information, this paper adopts "the combination of needs fulfilled by construction information towards achieving the FM functions" as the value of information. Thus, the value-in-use is considered as its concerns fit with the characteristics of FM information, which assists to understand the uses of information within FM. This paper argues how current construction practices evaluate the value of information and how recent IT led information management mechanisms influence on enhancing such values.

04. Building Information Modelling in AECO Environments

BIM is identified as one of "emerging approaches to design, construction, and facilities management, in which a digital representation of the building process is used to facilitate the information exchange and interoperability in a digital format" (Eastman, 2011). In a construction context, it appears as an AECO (Architectural, Engineering, Construction and Operations) digital modelling process (McGraw-Hill, 2009; Succar 2009). BIM is also introduced as a technology based process, which aims to enhance the performance of a built asset with through-life considerations (Love et al., 2013). In the context of facilities management, it holds more credit as a process, however there is an ongoing debate on whether BIM is a mere "process" or a "tool/technique" (British Institute of Facilities Management, 2012). Literature explains a variety of definitions for BIM in AECO environments. Having recognised the holistic nature of construction, this paper considers BIM as "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle" (Penttila, 2006). BIM is considered one of the mechanisms which assists project stakeholders on informed decision making and apposite coordination by providing correct information at the right time which may lead towards waste reduction (Love et al., 2013). However, limited attention has been paid to identify the whole life benefits of BIM in AECO environments.

There is evidence to confirm that the project stakeholders are under pressure to adopt BIM within their project execution plans (Barlish and Sullivan, 2012). On the other hand, Love et al (2013) explain BIM as a complication as it continues expanding from software to Asset Information Management (AIM). However, BIM should not be treated as mere technology, adopted during design and construction stages of any construction asset. Attention should be extended to identify the through-life application and the organisational-wide implications of BIM when it comes to AIM. The need is to consider both FM and asset information in the early stages of the project life cycle (at least the design phase) to facilitate a continuous FM. However, there is no clear evidence on what type of FM information should be integrated with the BIM model, how to include such information, and the value attached to such information within the existing construction/AIM practices. Therefore, a clear gap in the existing knowledge is identified.

FM deals with an enormous amount of asset information; including acquiring, updating and analysing of such information (Wang et al., 2013). BIM, as a platform evolving from the early stages of a building, is a perfect solution for FM data management. BIM allows communication with FM needs in the early stages of the projects (British Institute of Facilities Management, 2012). The positive contribution of adopting BIM in FIM is identified as a significant value addition (Gu and London, 2010). Eadie et al. (2013) explain that facilities managers and clients benefit the most out of BIM implementation. Becerik-Gerber et al (2012) argue that considerable effort should be given to define client's FM needs at the project briefing stage. However, the majority of the BIM enabled projects are reluctant to handover the complete 3D model and Construction Operations Building Information Exchange (COBie) datasets at the commissioning stage of such built assets and this prevents BIM adoption in FM (Eadie et al., 2013).

COBie and IFC (Industry Foundation Classes) are the most popular standard formats for data exchange within BIM environment. In terms of FM, COBie is seen as a neutral spreadsheet format which allows data exchange in a structured manner for commissioning, operation and maintenance of an asset (British Standards Institute, 2012). IFC is another common language for information sharing (Abanda et al., 2015), which provides a standard form of data sharing between construction, operations and maintenance stages of a built asset (International Standard Organisation, 2013). IFC does not provide clear details on what information should be claimed to perform any specific task under a given scope (East et al., 2013). It is a format to store data to promote interoperability of information. Limited understanding of the appropriate information requirement for continuous FM, and the level of details of these information, are identified as the two key factors for limited implementation of BIM within FM (Parsanezhad and Dimyadi, 2014). This evidenced the need for robust mechanisms to acquire necessary information for FM. Correct identification of the value that attaches to facilities information is a main-stream mechanism to filter necessary information (Zhao et al., 2008).

05. Research Methodology

A preliminary literature review was undertaken to identify the existing knowledge gap and to formulate the research question. At the second stage, a snowballing approach was adopted to carryout interviews to study the context and main themes, which are "value of information", "facilities management" and "application of BIM in FM functions".

The research disqualifies the pure quantitative approach due to the lack of established knowledge on BIM in FM and value of facilities information (Bosch *et al.*, 2015). Therefore, priority was given to adopt the interpretative approach to mine the data in detail. Fourteen (14) semi-structured interviews were conducted among construction industry professionals who were engaged in facilities information demand and supply processes. These interviews were aimed at identifying FM information needs, value of facilities information and further to explain how such values can be enhanced through BIM integration. The collected data was analysed through open and selective coding and structured through NVivo 11.

06. Data Collection and Analysis

Snowball sampling method was used to select the suitable participants for the interviews. This sampling method provides the opportunity to gather data from an appropriate population under the theory of those members with a special relevance are familiar with each other in the population (Penrod *et al.*, 2003).

The process of FIM consist of several phases (i.e. information requirement identification, communication of these information requirements to project stakeholders, handover and use/reuse of information). Also, the information flows are complicated as it flows to and from different parties. In this regard, the interview sample was selected to cover both information supply and demand/user sides. Altogether 14 semi structured interviews were conducted with 5 Facilities Managers (FM1-5), 2 Estate Managers (EM 1-2), 2 Contractors (C1-2), 2 Architects (A1-2), 1 Building Surveyor (BS), 1 BIM Manager (BM) and a CAFM Service Provider (SP). All the interviewees have more than 7 years of professional experience. Priority was given to collecting data from information users (5 facility managers, 2 estate managers, 1 BIM manager and 1 CAFM service provider) due to the limited application of BIM within FM. Data collection continued until data saturation was obtained.

The interview questionnaire was designed and piloted for its clarity and readability. Having noted the comments given in the pilot run, a few amendments were made into the interview questionnaire. The questionnaire consisted of open ended and multiple-choice questions, and they were structured into four main sections. The first section was aimed at identifying the generic information of interviewees such as industry experience, type of organisation, roles and responsibilities etc.to prequalify the candidates and to identify any patterns based on the background of the respondent. The second section was targeted at identifying current FIM practices (including BIM and non BIM environments), while the third section considered the fit for purpose of such information in achieving FM functions. The final section of the interview questionnaire was used to determine the value considerations of such information in achieving FM tasks, and further to study how BIM enhances the value of FIM. Each interview lasted between 40min to 1hour and probe questions were considered where appropriate. All interviews were recorded using a digital recorder and transcribed for analysis.

The purpose of qualitative data analysis is to break the data into smaller components to describe what the data is referring to, and to identify the concepts and their relationships (Dey, 1993). For this purpose, coding is an accepted initial data analysis tool in qualitative analysis (Berg, 2007). Qualitative coding involves defining the meaning of data and tagging them with an abstract name (Charmaz, 2006). A wide range of tools have been introduced for this purpose such as conceptual analysis, thematic analysis (Vaismoradi et al., 2013), pattern coding, cross case analysis (Yin, 2014), open, axial and selective coding (Corbin and Strauss, 2008). Having analysed the merits and demerits of each method, the open, axial and selective coding were adopted within this investigation as it takes a step by step coding process to identify the emerging theories.

Identification of information requirements was considered as one of the mandatory requirements to adopt BIM and for continuous facilities information management. The results explain that the influence (standards, technology, policies etc), quality (accuracy, usability, availability, completeness, format etc), sources (external, internal etc), types (essential, performance enhance, future potential use) of information were key considerations of facilities information management requirements. To ensure a better use of BIM in FIM, these considerations should be taken into account in advance. Any advancement in these areas would be a positive contribution to promote whole-lifecycle BIM practices. The nodes generated through interview analysis are illustrated in Figure 1.

Nodes

Name	Sources	References
Facility information requirement	0	0
Influences on information requirement	0	0
software requirements and features	4	4
Standards, guidelines and regulations	4	5
Quality of information	0	0
Accuracy	4	6
Completeness	4	6
Format	5	7
Sources of information	2	3
Types	0	0
Enhance performance	3	4
Essential tasks	4	10
Future potentials	4	5

Figure 1: Key considerations of facilities information management

The interview findings further helped to understand the different viewpoints of information users (Client, Facilities Managers, Estate Managers, Building Surveyors, BIM Manager etc) and the providers (Contractors, sub-contractors etc) on current FIM practices. The information users claim *"we get a mix of information….not all information is accurate a lot of the time"* (BS, FM3); *"the lead contractor is accountable to provide necessary documents in soft formats at the handover"* (EM1). The information users expect that the providers will provide a complete set of valid information at the handover stage. However, information providers believe "the *client needs to specify his information needs… communicate the format they prefer. In most cases this won't happen*" (C1, C2 and CAFM). This clearly evidenced the information mismatch between users and providers. Moreover, BM noted "…*in terms of the kind of information and the taking of that through to an FM situation, the information has got to be structured properly and be available at the right sort of depth of information and level of detail to allow that to be done".* There should be a simple and flexible structure that should determine the information requirement, uses, providers etc.. However, the current FIM practices are more towards capturing every possible information of the asset without considering their fit for purpose. Supportively, FM4 noted *"we need everything about the building….We have to keep all the information, if not it's not worth to have a BIM system. The problem is how we are going to use this information realistically and that's why CAFM system is there. If fire alarms are fixed in 2005 we can expect all the sprinklers and smoke detectors to fail by 2010…. We know if all went in the same time they will fail at the same time. That's me making a decision based on information. We need the information so we can use that to make knowledgeable decisions".* This has not become a problem so far as FM does not get all the information expected at the handover. The findings further explained that most of the information is dispersed in current FIM, and the users and providers intend to identify the uses and types of information rather than its value contribution to FIM. Therefore, a clear gap in the value of FIM is noted, and the same set of transcripts were analysed to identify the fit for purpose of construction information (see Figure 2).

Fit for purpose of information	0	0
Uses	0	0
Confidence	1	2
Improve	2	2
Information Management	2	2
Operate	2	3
Users	3	5
Value	0	0
Certanity	2	2
Economical benifits	3	5
Performance	4	4

Figure 2: Fit for purpose of the construction information in achieving FM functions

The fit for purpose of as-built information in achieving FM tasks is a mandatory concern in FIM. The interviewees noted that fit for purpose depends on the uses and the value of information. They further explained that the “uses of information” covers multiple layers, including building-up confidence, improving and managing the process, operating the facility and helping to identify the main users of this information. However, they highlighted “*value is given least priority in current FIM practice”* as construction itself is complex, so the number of stakeholders have different interests and influences on the project goals and the value itself is difficult to define. They identified “value of information” as a multifaceted construct and the handover phase information (as-built information) are used to ensure the certainty, performance and/or commercial attributes of products/processes during its facility management phase. As a result, the value of facilities information is further considered to fall into three main categories, namely “certainty value”, “performance value” and/or “commercial value”. Certainty value of information ensures the perfect knowledge that has total security from error. The information, which helps to enhance the performances of product/process during its FM stage is considered under “performance value” (eg. improving efficiency, productivity and reducing waste etc) and the commercial value of information used to analyse market behaviour in terms of strengths, weaknesses, opportunities and threats.

Axial coding confirms that the “value” is a function of “types” and “uses” of information. Therefore, when determining the value of information in a construction context, it is necessary to consider the type and the use/purpose of this information along with the project objectives. In construction, the project success is measured in time, cost and quality criteria, and most of the successful projects have considered at least two of them, although it is rare for time, cost and quality to be equal in either importance or impact. The business case would identify which criteria are most important and which would constitute the highest risk. This will impact in setting the project objectives. Similarly, the uses of construction information and the way they value it within the FM context also vary from project to project.

Having analysed the interview findings, the value of information was integrated in to the current FIM (see Figure 3). The model considered three main considerations of information (i.e value, types and uses), however the priority of each consideration ranged from project settings to wider organisational settings. For example, information certainty is a high value concern in project environments, however commercial value brings more competitive advantages in organisational environments. The area covered by each triangle demonstrates the FM information needs in both project and organisational environments and the magnitude of each triangle varies with the project/organisational objectives and goals. However, this needs to be tested in a real case scenario to identify how different projects determine value, and how those values vary in BIM and non-BIM environments.

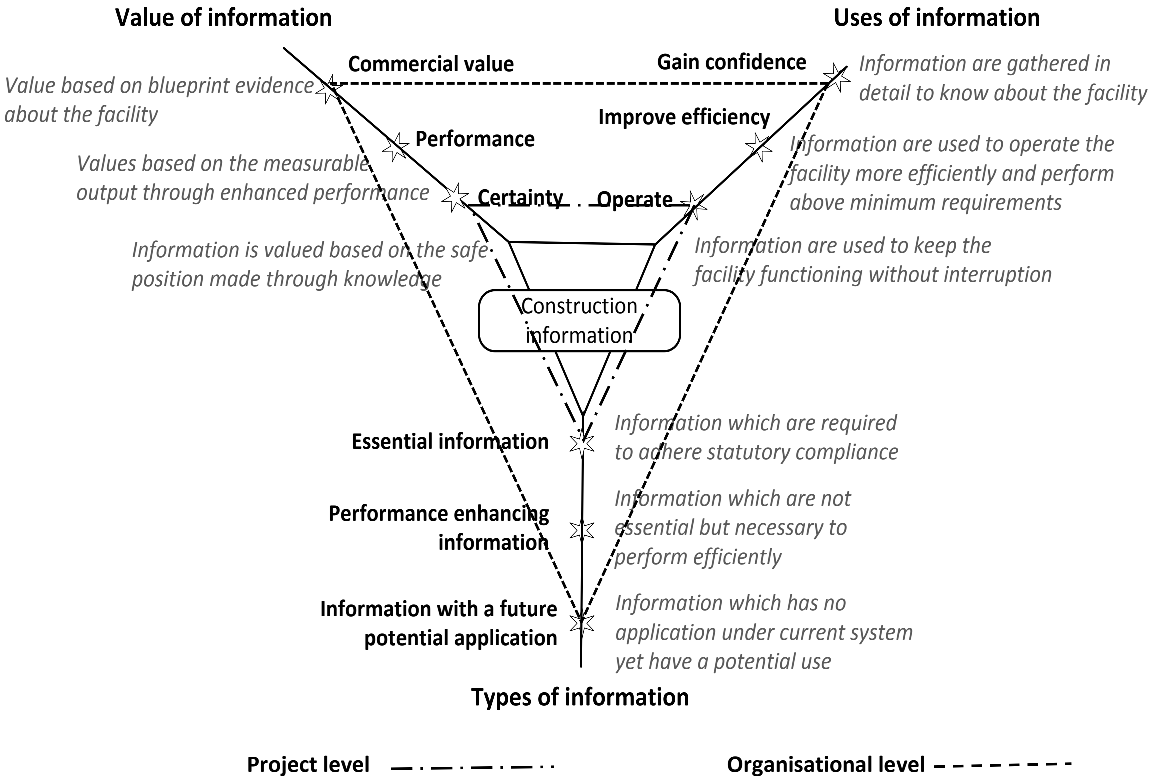

Figure 3: Value of construction information in FIM

6.1 Types of information

Information users categorise construction information into three main categories, namely "essential", "performance-enhanced" and "future potential" information. Essential Information refers to information that is highly necessary in getting legal approvals and operating the facility. For example, as-built drawings, operational and safety manuals, statutory compliances etc. Supportively, one interviewee stated "*if the technician knows the type of lock on the door, referring to the room number which the service request was made then he will save lot of time on going up and down'.* Performance Enhancing Information refers to the set of construction information used to perform FM tasks effectively and efficiently. This information guarantees the higher order functions/performance of the facility. For example; heat load calculations, durability and sustainable features of components/asset. The set of information which supports future decision making or simply *"nice to know"* information (as mentioned by FM2 and BS) is referred under "Information for future potential application". The information considered within this category does not have any immediate implication but points to future potential adaptations that will prevent the facility from future obsolescence. For example, FM2 noted, "*If you take a pre-1995 building, the first thing you ask now is what the asbestos content is. We have to do a visual inspection. You never know what legislations are going to change and what is going to be important in the future. You may not use 30% of the information today but that may be the important 30%".*

6.2 Uses of information

The construction information is reviewed concerning their fit for purpose of achieving FM functions. Facilities managers prefer to have essential information as it helps the operation of the building at the beginning until the technical staff get used to the features of the facility. This is considered as the basic yet most important use of as-built information. The information gathered here is used to understand the operations of the building with minimum disruptions including maintenance requirements, equipment handling, and possible precautions to be taken at any failure. The secondary functions aim at performing FM functions efficiently. Performance enhancement information tends to avoid time/money spend on physical inspection and costly consultancy surveys to collect necessary details about the built asset. Therefore, another application of as-built information is to use available information to make process improvements. At this point, a simple comparison between the types of information and its uses reveals that both are heading in the same direction (which is identified as value). Thirdly, information is used to retain knowledge and ultimately gain confidence by in-depth knowledge of the facility. This is merely a subjective use of information; hence, no practical application is visible. In other words, information users prefer more information although they have no expected application but merely to gain a psychological satisfaction of being risk/doubt free.

6.3 Value of information

The term "value" within the paper refers to the needs fulfilled by construction information in achieving the FM functions. The most valued fulfillment of information is its ability to create secure environments in both project and organisational levels. For example, when employees are informed about the characteristics, procedures and risks they are more likely to be familiarised with the workplace and the work they do. On the other hand, information contributing to enhancing the product performance, and as a result creating value, is categorised under "performance value" category. As noted by FM2 "*performance enhancement information is valuable through the use of the efficiency it brings in but.. it is preferred to gather information with potential application as it brings value through giving confidence about an unpredictable future".* The visible contribution of information such as time and cost savings, avoidable risks by being informed and support on decision making is also considered as a value addition of construction information. If any information provides good market value with a high competitive advantage, such information is structured under a commercial value category. Potential benefits could be gained through information in the property market at the reselling stage or being accredited for best practice can be given as examples for "commercial value". Within the construction context, information acts an important role as visible proof providing evidence to past activities.

6.4 Value gain through BIM integration

Frequent application of BIM in design and construction stages of a construction project, and its limited application during FM stage is identified. As a result, the information management during FM is challenging, and has been identified as a significantly time and cost consuming process. The UK Government's soft landing, which was initiated through the Construction Strategy 2025 is an attempt to provide a solution to some extent by pushing forward the involvement of the construction team further down in the facility life-cycle. However, the practitioners identify the information diffusion as one of the significant reasons for making FIM somewhat complex. They suggest BIM as an ideal solution to integrate the required information into a single model, which makes FM information management easier than the traditional FIM. However, industry is lacking such strategies for BIM adoption during FM stage, and use firewalls around information models in an adversarial way.

A complete BIM model provides a set of multiple information, which can be used in visualisation, energy modelling, simulations, lifecycle costing and also to predict the performance of the facility during its FM phase. However, FM1 states, "*BIM is still quite new in terms of industry awareness and the standards are only just starting to come through (eg. PAS1192-3) so that you've got to catch it very early and you've got to have a lot of clarity very early to make sure that everybody who's worked on the project is putting the right stuff in the right format and the right structure at the right time to ensure a continuous FM"*.

BIM models usually allow assignment of information into different groups/variables, which will help to minimise the information redundancies. In fact, storing bulk information is costly for the owner, but the BIM process provides the possibility to filter the necessary information based on information value determined by the project stakeholders with the Employer Information Requirement. Moreover, BM explains, *"BIM has a greater ability to rapidly generate revision and to work through optioneering and scenarios which may highly benefit in whole life cost considerations of a facility"*. By contrary, FM3 noted that "*there's a big caveat around that because what we find is that where the project has been delivered and, where there are agreed structures and protocols around how the model would be functioned, then it is considerably more efficient. Where something goes wrong with that there are times when working with BIM can be less efficient because the model has to be reworked to get the information of the right format and work with the data so BIM doesn't guarantee greater efficiency*".

In summary, BIM is a process of initiating information management from the early stages of a built facility. This has become a partial solution to the problems faced during the design and construction stages in relation to gathering information from multiple stakeholders (Grilo and Jardim-Goncalves, 2010). It holds a greater potential in information management during FM (Giel and Issa, 2016). However, the potential benefits of BIM in FM are frequently gained through the information availability at the facility handover (Anderson et al., 2012). Therefore, it is necessary to identify FM information requirements at the early stages of the built facility. Due to the large number of information generated during design and construction, and the variety of needs in facility operation and maintenance, it is required to establish a robust information exchange. In this regard, the assessment of the value of information helps the users to identify their information requirement for FIM.

07. Results and Discussion

The UK Government's contribution towards adoption of BIM in construction businesses is showing continuous growth over the past decade. Although it is mandatory to adopt BIM Level 2 in all publicly procured construction projects from 2016 onwards, its adoption is still dominant in the design and construction stages (Eadie et al., 2013; Love et al., 2013; Volk et al., 2014). With this influence, BIM is still recognised as mere technology used during design and construction stages, and has only limited knowledge and experience on its impact on the future of the organisation as an information tool for operation and maintenance of built asset over its life cycle (Love et al., 2013).

How BIM enhances value in FIM is BIM facilitates initial data for , and information enhances the potentials of FM (Becerik-Gerber et al., 2012). Therefore, the success of BIM in FM depends on the information carried through BIM into FM. This has become a good reason to motivate the early engagement of facilities managers. In contrast, the late involvement of the facilities manager has restricted the opportunity of communicating FM information needs at the early stages of design and construction. Due to this reason, the facilities manager has to deal with the issues related to incomplete or inaccurate information handover. Communicating FM requirements at the early stages will accumulate operations and maintenance needs and enable the application of BIM in FM. Moreover, it is not only beneficial for information users but also for information providers as this communication cycle clears-out the client's requirement which is always a problematic situation from the information suppliers' perspective. Therefore, promoting an early engagement of the facilities manager is beneficial to the client as well as for the entire project team.

Having analysed the demand side of information (users), it was noted that facilities managers should have a complete knowledge about the project and also clear awareness on deciding which information needs to be fed into the BIM platform for long term use. Although BIM is technically capable of handling high volumes of information, it is important to understand the value of information especially at the early adoption stage. With the common view of information as something that is always valued, information users tend to demand "all the information" which refers to much but says nothing. On the other hand, demanding "all the information" is not helpful for information suppliers to understand the client requirement nor benefits to the facilities manager. This has been the most common reason to hold back BIM from FM in recent studies since no single person is completely aware of the exact applications of information exchange through BIM in FM. However, when identifying the role of construction information, it was clear that each type of information has specific uses as well as a unique value created through the availability and use of information. Yet, there is no structured frame for the types of information, its application and value based on the project objectives.

The model introduced here guides the users on expected value addition through BIM while deciding what information should be asked from whom, when and why. This creates a win-win solution by informing the information requirements with their potential uses and value addition to the project team since it is helpful to provide robust information at the handover as well as to have a clear understanding over client requirements.

08. Conclusion

The Construction sector should focus on “product-service delivery” rather than looking at the products and services separately. The limited awareness of BIM and its wider potentials by the client and facilities managers is the main barrier for adoption of BIM within FM (Giel and Issa, 2016). The initial motivation to adopt BIM in FM is highly depend on the quality of information passed through the BIM processes. Considering the fact that having information is always useful, facilities managers tend to request all possible information about the built asset. Information suppliers conclude the reason for this as information users’ poor understanding about the required information. Therefore, it is necessary to understand the specific uses of information to cooperate with high tech information society. If not, BIM would be misused as another type of software that replaces the maintenance documents storeroom.

The most common scenario related to handover information in non-BIM environments is either the complete absence of as-built information or having incomplete information which has little use. On the other hand, the issue in a BIM environment is having a complex set of as-built information, yet not using most of it after a considerable investment on BIM process. The role of the proposed information model is to serve as a guiding tool by achieving the balance between FM information requirement and the value of information. More importantly, it is influential in mapping the work of FM and information with an organization’s objectives to make a blueprint of value created through information. In conclusion, from the information users’ perspective, the model could be used to understand the information requirements in FM and what uses are to be obtained out of available information to create value. From the information suppliers’ side, it provides a clear understanding of the client information requirements, thereby leading to quality improvements in handover information.

Alongside the above-mentioned approach to establishing a model to ascertain the value of information, uptake of BIM in FM contexts is crucial to the overall success of FIM. However, at present, there is a paucity of coherent and robust evidential trial of what the value of BIM implementation is to FIM. As a result, current justification of BIM adoption is mostly based on perceived savings of through-life costs and value, rather than on what has actually being saved. Therefore, further research on establishing the quantum of savings (in terms financial, waste, processes etc.) that can be accumulated from BIM implementation, will be of outmost importance.

09. References

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