EVALUATING THE ABILITY OF BIM TO ENHANCE VALUE IN FACILITIES INFORMATION MANAGEMENT

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The concern towards information management in construction industry has been changed over the past decade with the introduction of Building Information Modelling (BIM). With this influence the Government Soft Landing Policy focuses on early end user engagement to enhance the in-use performance of buildings. Literature reveals number of advantages that BIM promises on enhancing the efficient management of buildings. However, many of these findings explain what BIM can do and only limited effort has been taken to reveal the mechanism to exploit those good practices. This knowledge gap has slowed down the adoption of BIM beyond government projects. The success of BIM is based on information it holds. Hence this paper attempts to investigate the value of construction information to the facilities management to understand optimum level of information to be handed over through BIM. Also, it further attempts to explain how BIM can be used as a vehicle to improve such value. 14 interviews were conducted among construction professionals to gather the value perception of information. The qualitative data were analysed through thematic analysis based on grounded theory. The information value matrix was developed to assist facilities managers on understanding information requirement and value of information.

Keywords: Building Information Modelling, facilities management, value of information

INTRODUCTION

Construction industry is forecasted to have a 70% economic growth by 2030 (HM Government 2013). Building Information Modelling (BIM) is one of the key concepts pioneered by the UK Government towards achieving this growth in construction sector. As a result, BIM is considered as a mandatory requirement in every centrally procured construction project (HM Government 2013). A growing interest for adopting BIM technologies within construction products and processes is visible (NBS 2015). The literature emphasise the fascinating contribution of BIM from design and construction to operation and maintenance stages of a built asset (Eadie *et al.,* 2013, Volk *et al.,* 2014, Giel and Issa 2016). BIM improves collaboration, visualization, waste reduction and many similar aspects engaged with process improvement (Eadie *et al.,* 2013).

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A frequent application of BIM in design and construction phases of product lifecycle can be identified (Becerik-Gerber *et al.* 2012) leaving facilities management isolated. Research on this matter noted that lack of experience in BIM as a key barrier for implementing BIM beyond design and construction (Eadie *et al.,* 2013, Giel and Issa 2016). However, this leads only to the reason for the problem. Yet, the question is still remains unanswered.

BIM can be explained based on its two main features of physical modelling of a 3D model and capability on capturing and storing information in text, numeric and graphical forms (Chen *et al.,* 2015). Importantly the information richness of BIM model is what makes it outstanding from any other 3D modelling tool (Demian and Walters 2014). It is capable of handling high volume of information at any given time, however it is necessary to understand the level of information which is economical for an organization.

Taking lead from the literature findings, this paper attempts to identify the barriers of adopting BIM in facilities management and also to cluster the information based on their perceived values. Having said that, the paper identifies information needs in facilities management as the starting point and then look forward to the mechanisms for value additions.

Facilities information management

Facilities Management (FM) is managing the complexities of a built facility to conduct a smooth functioning including its physical structure and support services (Kincaid 1994) to enhance the core business performance. The information used for FM purposes can be broadly categorise into 3 namely; construction information, business information and building operation information. In general, construction information refers to the information which are generated during design and construction of a facility (Craig and Sommerville 2006). However, construction information in FM's perspective is the information which are produced to building owner/facility manager by the project manager at the project handover (Clayton *et al.,* 1999) which includes the as-built information and exclude large amount of other construction information such as design variations, clash detections. Construction information are generated by number of project stakeholders who are having different level of interests and influence towards the project targets (see Figure 1). These information takes a complex flow due to the fragmented nature of the construction industry (Bouchlaghem *et al.,* 2004).

Types of facilities management information and their inbound complexities in terms of information flows are identified in Figure 1. Facilities management information needs are being fulfilled by 3 main types of information. Construction information which are generated at the design and construction stages of the building aims to educate facilities management team about the asset information, space allocations and maintenance requirements. It has a complex information flow due to multiple stakeholder involvement at construction stage. Comparatively the other two types of information used for facilities management have a direct flow as they are being generated during operation and maintenance of the building on which facilities manager have much control over. Business/market based information focuses on any information that supports to run the business smoothly such as functions carried out in the facility, expected occupancy rates and other business functional information which matters to the facility operations.

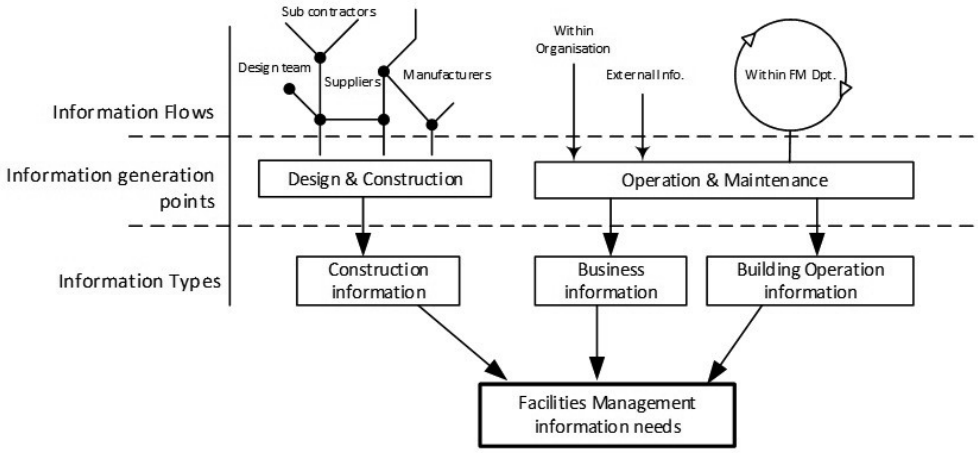

Figure 1: Facilities information flow

Usually, these information fed into the FM division from other departments in the organisation (Chotipanich 2004) and the right information at right time is the key to success at this point. Final set gathers information about the facility operation details such as energy consumption, maintenance records, facility operation staff information and such other information directly related to the building operations (Whitaker 1995). Whitaker (1995) further noted this is one of the responsibilities vested upon the facility manager and they are created within the FM division.

It is evident that information required for a smooth FM is scattered throughout the building life cycle. Although a must needed early engagement of a facilities manager is recommended in the theory, it is not common in the practice (Eastman 2011). Due to late involvement of a facility manager and complexities in construction information flows create several difficulties for facilities managers in acquiring construction information (Clayton *et al.,* 1999, Anderson *et al.,* 2012, Wang *et al.,* 2013). Therefore, most critical and frequent facility information management issues are based on construction information (Clayton *et al.,* 1999, Bröchner 2008).

On the other hand BIM is a process initiating building information management from early stages of a built facility has become a partial solution to the problems faced in design and construction in related to gathering information from number of stakeholders (Grilo and Jardim-Goncalves 2010). It carries a greater potential in information management during facilities management (Giel and Issa 2016). However, the potential benefits of BIM in facilities management is frequently gained through the information availability at the facility handover (Anderson *et al.,* 2012). Therefore it is necessary to identify facilities management information requirements at the early stages of a built facility. Due to the large number of information generated during design and construction and variety of needs in building operation and maintenance, it is necessary to accompany a filtering mechanism to recognise the information with an economical consideration. In this regard, identifying value of information is considered as an accepted concept to identify most important information (Neal and Strauss 2008).

Information value

The term 'value' is multifaceted and provides different meanings to different stakeholders. Simply it's the 'cost' over 'benefits', which represents the worth of the considered matter (Neal and Strauss 2008). The costs and benefits can be communicated in different ways. Repo (1986) explains a dual approach as "exchange

value" and "value in use". Exchange value refers to 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 the users which is not always in monetary terms.

However, the elements associated of each variable (objective or subjective) and the level of influence will differ based on the project. In construction, a balance of cost, quality and time is considered as a method to ascertain value (Best and De Valence 1999). Although the research is set in the Architecture, Construction, Engineering and Facilities Management (AEC/FM) setting, it is necessary to look for the features related to information to define the value of information beyond project's success.

Allocation of a monetary value to a piece of information is almost impractical (Gallagher 1974). Working on the cost benefit equation to capture the value of information, Gavirneni *et al.,* (1999) developed an equation based on case studies in supply chain information flow. They compare the monetary, performance and lead time improvements made through 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 of the methods being successful attempts due to the uniform nature of the manufacturing industry and its products. Conversely, this same reason makes them weaker to apply in construction industry. However, there are key points which can be taken forward to capture value of construction information for facility management.

One such fact which can be taken from manufacturing industry is that comparing the two situations of performing a task with and without information (Gavirneni *et al.,* 1999). Consequently, the improvements made through the situation when information is available quantify the value addition done through it. Value is something more "adjectival rather substantive" therefore, it should be found with along the considered object and interest (Perry 1914). On the other hand, Gallagher (1974) suggested 3 possible ways to measure the value of information. The first and the best way according to Gallagher is measuring the value after the information is being used and the consequences of the action are known. By obtaining the positive features of many value measurements the definition for the value of construction information for facilities management is defined as practical consequences result by information. Therefore, the value-in-use is considered as its concerns fit with the characteristics of facilities management information. As a result, this will attempt to understand the uses of information in FM.

RESEARCH METHOD

Literature review was undertaken to identify the facilities management information needs and also to establish the information value. A qualitative approach was adopted due to lack of available knowledge related to facilities information and its value. Accordingly, 14 semi structured interviews were conducted among construction industry professionals (5 facility managers, 2 estate managers, 2 contractors, 2 architects, surveyor, BIM manager and a CAFM service provider). Data was collected from different roles engaged in facilities information requirement identification process to have a holistic idea about the situation. However, priority was given to information demand side (5 facilities managers and 2 estate managers).The key purpose of these interviews was to identify the information requirements and flows (in and out) during the facilities management stage and further to explore how different stakeholders with different interests recognise 'value' of information. Data were analysed through coding (open coding, axial and selective

coding) and fed into the information value matrix. This matrix is in its development stage and needs to be tested for its usability and validity.

DATA COLLECTION AND ANALYSIS

The questionnaire focuses on three main themes, which can be clustered under 'current facilities information management practices and issues', 'information value' and capability of BIM in providing such value'.

The data were analysed thematically by adopting the systematic approach (open coding, axial coding and selective coding) coming under grounded theory research methodology. Interview transcripts were analysed for the first time with an open mind to identify the themes discussed by the interviewees. Then categories were made grouping similar themes together. At the second step (Axial Coding) properties and dimensions of categories were defined to have a more solid idea about the themes generating within data. This was done by going through the interview transcripts once more looking specifically towards the frequently raised points. Figure 2 illustrates the key findings generated through open and axial coding processes.

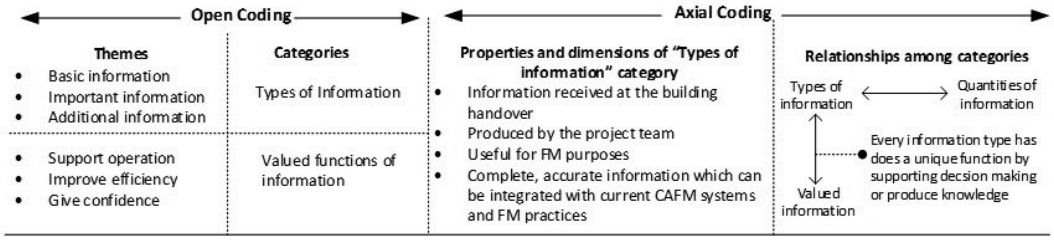

Figure 2: Open and Axial Coding

As shown in Figure 2, during Open Coding a category of "Types of Information" was developed based on the 3 similar themes generated within data. Accordingly, types of information consist of basic information which are highly necessary for building operation, decision making and compliance. During Axial Coding, properties and dimensions of this category were defined based on responses such as *"the lead contractor is liable to provide necessary documents in softcopies at the handover"* which was stated by a facilities manager. The given quotation emphasise a dimension of the "types of information" category through the code *"at the handover"* by limiting the amount of information falls under the category. A property of the category was derived from a surveyor's statement *"not all information is accurate most of the time"* which made the point that information should be accurate to perceive its value. Once the categories were formed their relationship with each other is considered during Axial Coding. For example, "types of information" was related with "quantity of information" as well as "uses of information". The final step of the analysis is Selective Coding which is dedicated to study the relationships among categories and to understand the concept developed within data. Accordingly, "information" was selected as the core category and its relationship to other categories was formed to explain the developed concept. The findings of data analysis were used to develop the Facilities Information Value Matrix (see Figure 3).

RESULTS AND DISCUSSION

A clear link between value and information is noted as a core result. In a broader perspective information is to be valuable in anyway and because of this understanding information users preferred to have more information having believed that value

increases with the amount of information on hand. This positive relationship between value and information has resulted asking for "all the information" about the built asset from the project team. However, information users have no clear idea about what information will be available in a complete BIM model with all the information or how to make use out of most of information. Although this is the preference of majority of facility managers none of them acquire such complete information pool to study its impact. This confirms that owners and facilities managers does not have adequate knowledge and experience to gain the benefits of BIM (Giel and Issa 2016).

The uses of information were identified base on the available information on site for facility management. This revealed that construction information is being used to answer two main questions. At the very beginning of the building operations, construction information assists to understand the facility including the background details, features and potential capabilities of a particular facility such as occupancy capacity, weatherproof qualities, heat load etc. Secondly it guides the user on how to operate the facility including the equipment handling, maintenance requirements and possible precautions to be taken for any failure. Facility managers value this contribution of the construction information and cluster information to gain value through different functions. Accordingly, construction information is clustered into 3 namely; basic information, important information and additional information. On the other hand, 3 value levels (Operation, Efficient and confidence) on construction information were identified through the interviews. The value levels were judged based on the functions fulfilled by construction information. As a result, Facilities information value matrix was develop by plotting the relationship between value functions and information along with the value perceived at each combination (Figure 3).

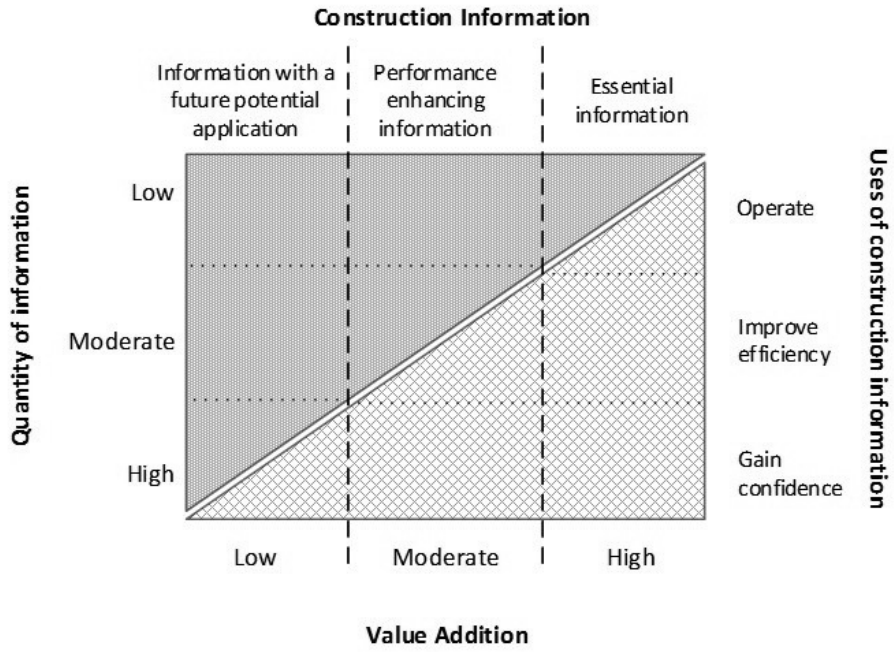

Figure 3: Facilities Information Value Matrix

Value matrix measures the uses of construction information (operate to confidence built up), types of information (essential to future potential), quality (low to high) and value addition of information (low to high). For example, the highest value addition of construction information is done through supporting the operations of a building to

the required standards. This use of information can be achieved by having essential set of information which includes drawings, safety manuals and other information which are necessary to gain approval and maintain compliance requirements. Value matrix graphically indicates this relationship showing the essential information which contains the least amount of information brings in the highest value addition. Accordingly, these information is used to operate, improve efficiency and also bring confidence to the information users by knowing the most critical facts about the building. Essential information are the minimum level of information required for facility management and this will ensure that services will be available and building is live for the business. However, this level is more towards adhering to the statutory requirements.

Stepping ahead from the minimum operational level, information has the capability to bring efficient performance. It is the second use of information on the value matrix. In order to perform FM tasks efficiently, it requires some important information along with the basic operational information. This additional set of performance enhancement information such as energy performance of the building, location of the assets will avoid extra time and effort spent on facilities management tasks. For example; if a technician can refer to the information and identify the type of bulb in the room which the maintenance request was made on, then he could take a suitable bulb and necessary equipment to fix it at one go rather physically examining for all these details and going back to stores to collect necessary equipment. Likewise, having performance enhancement information brings value through efficiency.

Finally, information gives confidence. Facility managers do prefer to have more information although they do not fully use them to sustain their businesses. They demand for this preference to gain confidence by knowing all information about the facility. To a certain level, availability of additional information directs to identify unrevealed applications of the information to the current system and to make them efficient. However, at the moment of request of these additional information they would not provide any efficiency or support the operational tasks but brings a psychological comfort by giving confidence of knowing.

After identifying the relationship between information and their uses, a hierarchy of preference was revealed. This is indicated through “Value addition” on value matrix. Value addition shades presents the worth of each use of information. On the other hand, information quantity on value matrix represents the quantity of information embedded on each type of construction information. Accordingly, “essential information” category has the least quantity of information while “future potential information” category carries the highest amount of information.

Among the uses of information, facilities managers retain most value by having building operated with a zero down time. They tend to make every possible effort to gather information which supports the operation. Next, they value the information which helps to improve the efficiency and finally the confidence. Therefore, value addition done through information match with diminishing marginal utility theory. On the other hand, it can be said that majority of the information in a fully complete BIM model is additional information which brings the least value addition by merely giving confidence to the users. Therefore it is important to filter the necessary information to capture more basic and important information which will ultimately create a highly valued information base.

In a nutshell, the preference to have all the information proven to be an inefficient choice. Identifying value of information through different functions brought into the decision that not every information is necessary specially when considered with the cost of information management (acquire, store, retrieve, update, use). Although the cost of information was not considered within this paper, it was evident that value decisions were made based on some kind of cost parameter although it was not in monetary terms at all times.

CONCLUSION AND RECOMMENDATIONS

Building Information Modelling (BIM) is an emerging topic in construction industry. It is worth the attention BIM has gained with the tremendous input it brings into the industry to move forward with the others and to be equipped to match with the digital economy dilemma under current circumstances. More importantly, BIM process does not limit itself to a specific task or a stage in the building but addresses the whole life cycle with a positive impact. Although current BIM practices are dominant in design and construction phases of a built asset, it was found that owners and facilities managers benefit the most out of BIM with its lifelong application (Eadie *et al.,* 2013). Contradictorily a reluctance in adopting BIM among facility managers is noted confirming the previous research findings (Giel and Issa 2016).

The key benefit of BIM for Facility Management (FM) is the opportunity of acquiring as-built information for building operation and maintenance. The long term application of BIM in FM highly depends on the information passed through BIM process. Therefore, it is necessary to identify facility management information requirements and communicate them to the project team beforehand. However, since information is always beneficial information users tempts to request for more information believing on the possible benefits they could bring. This unconscious decision may lead to information overloading, inaccurate information and missed opportunities to make optimum use of BIM by having a lighter BIM model.

Facilities information value matrix is in its conceptual phase, aims to provide a solution to this matter. Expanding its capabilities as a decision making tool, facilities value matrix has identified the expected value addition made at every option and the quantity of information represented by each information category in a hypothesised complete BIM project. With this facility managers can value their information systems by identifying the available information on their own systems and tracing them on the information categories in the value matrix. The result will guide the practitioners to make decisions on what information to be stored on BIM model for long term purposes and how to make use of available information. Also, use of this guiding tool will safeguard the client from losing essential information about the facility. Its application does not limit only to the information users but also brings knowledge to the information suppliers about the value addition done through their information in long term. This will promote accuracy and completeness of information handed over by the suppliers. In conclusion, value matrix promotes a decision making process based on the business opportunity created through facilities information and BIM rather gathering information based on the capabilities of information systems. However, the cost criterion should be considered to make informed decision on the information requirements and this will focus in future research.

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