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Enhancing Facility Management through BIM 6D

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Abstract

BIM has been widely adopted by the construction sector, though Facility Management (FM) is still based on a variety of disparate FM systems. The operational phase requires comprehensive set of well-structured information regarding the building asset. Therefore, a BIM model filled with the multifarious information from the pre-use phase ought to be exploited through its integration with existing FM systems. This paper aims to appreciate the contribution of BIM in optimizing the processes conducted conventionally within the FM practice. The importance of sustained information flow for the efficient operational stage is a pre-requisite of the further discussion. The exploration of FM application areas for BIM-enabled processes is aimed to depict the potential of the BIM for FM concept. By elaborating on the existing challenges concerning the shift from traditional FM processes to new BIM-based approach the outstanding problems are realized. On these grounds advice is provided. The study focuses mainly on new investments, where information management must be sustained from the project inception until the current operational stage. The paper proves the potential of BIM for the optimization of FM practices, presenting a wide range of application areas followed by tangible benefits for the building performance across its life-cycle. Identified barriers are assumed to be mitigated by diligent implementation of provided recommendations. It is concluded that BIM-based FM processes have the potential to shed a new light not only on the FM sector itself but on the perception of the whole industry being based on the collaborative approach towards delivery of the intelligent facilities. Nevertheless, such results demand profound cultural changes within the construction sector, with the FM appreciation as a starting point.

Keywords: BIM-enabled processes, BIM 6D, Facility Management.

1. Introduction

Traditionally Facilities Management (FM) is recognized as a "non-core" part of the construction sector, focused mainly on supportive services with no real business value. Due to existing inefficiencies the FM importance is far from being appreciated [31].

FM constitutes for over 80% of the total project cost and hence its imperativeness ought to be acknowledged [6]. Conventionally the handover process takes up to several weeks for information to be collected and entered into FM systems [32]. The performance gap existing in FM practices unable to reap the benefits resulting from the efficient post-construction stage. Nonetheless, the FM sector is lagging behind construction and design with BIM implementation whilst the opportunities for leveraging this concept for the operational stage are compelling [14].

The paper starts with explanation of information logistics across the building asset life-cycle assumed to be a pre-requisite for further elaboration on the topic. FM application areas for BIM-enabled processes are presented afterwards. Subsequently, challenges and implications that hinder the potential of BIM for FM are depicted followed by recommendations for fully utilizing the discussed concept's benefits.

2. Logistics of information across the building asset life-cycle

Following [24], [22] sustained flow of information throughout a building life-cycle is crucial and should be deemed a primary objective for each construction endeavor from its beginning to the current operation stage. In

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this paper emphasis is put on building life-cycle rather than the construction project itself. Meaning that, the latter must be perceived as a holistic approach driven by the shift to final-product-oriented construction settings, aimed on procuring more efficient facilities.

2.1. *Importance of seamless information flow*

Maintainability of the asset refers to the business aspect of a construction investment and is oriented on attaining an optimum performance for the building across its life span [4]. Therefore, it is credible that strategic decisions concerning managing facilities must be made in advance as a pre-requisite for achieving expected business profitability afterwards. It cannot be denied that a significant upturn of business returns is in direct proportion to the increased efficiency of O&M processes [5]. The latter, in turn, is dependent upon the quality of information derived from the project delivery.

2.2. *Managing information efficiency*

Parsanezhad [24] sets out that information management in order to be efficient must be based on sustained collection, analysis and flow of information across the multidisciplinary environment throughout the life-cycle of the building asset. Such a holistic approach is defined by the buildingSMART alliance [3], as a "business process for generating and leveraging building data to design, construct and operate the building during its lifecycle". As it is argued Building Information Modeling (BIM) is not a new technology that has recently emerged on the market being forced by private vendors in order to replace current FM systems. Furthermore, it is a business process that encourages all stakeholders to be proactively engaged in the project delivery. Building Information Model (BIM model) is the output of this process which holds building data from its inception till the current operational phase. Data generated during the construction project delivery process is extracted from BIM model directly to non-proprietary International Foundation Class (IFC) file formats [22].

2.3. *Bridging the gap for sustained logistics of information*

Aforementioned arguments imply that in order to assure effective flow of information the consideration of construction project delivery as a process composed of the three main phases is essential. O&M stage ought to be treated, at least, equally to construction and design stages. Integrated approach to project delivery through BIM is a warrant of sustained flow of information. Developing awareness of above mentioned principles is a key to fully-realizing the benefits of implementing BIM. Since it is only matter of time until BIM becomes obligatory for all projects, BIM-resistant attitude will simply imply dip in the market share. The authors treat this knowledge as a pre-requisite for appreciating other application areas for BIM 6D and allowing further development of this yet fertile field.

3. Realizing the potential of BIM for FM

Having acknowledged that first and foremost BIM must be perceived as a shared knowledge platform for the building information that enhances decision-making during the asset life-cycle, subsequent application areas are to be depicted in this section. BIM 6D (sixth-dimensional Building Information Modeling) refers to the post-construction phase (O&M) of the building, however for many 6D stands for 'sustainability' mostly [24]. Indeed both definitions are correct since BIM 6D is primarily oriented to improve FM practices efficiency, which apparently overlaps with the life-cycle performance of the building, hence its sustainability.

3.1. *BIM in FM – application areas*

Fields of FM practices where BIM-based applications are successfully implemented are linked to the corresponding case studies presented in Table 1. All functionalities mentioned below are endorsed and further developed by the authors Becerik-Gerber et al. [4]; Love et al.[16]; Volk et al. [29].

Table 1. FM related BIM application areas identified in the real-life case studies

Application area \ Case study (ID nr)	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Mobile localization of building resources							▪		▪	▪
Digital asset with real-time data access	▪	▪	▪	▪	▪	▪	▪	▪	▪	▪
Space management		▪	▪							▪
Renovation/retrofit planning and feasibility studies	▪	▪								▪
Maintainability studies	▪	▪	▪							▪
Energy analysis and control		▪	▪							
Safety/emergency management		▪			▪					

Legend:

(1) Sabol [26]; (2) Aryaici, Onyenobi and Egbu [2]; (3) Neelapala and Lockheed [21]; (4) Codinhoto and Kiviniemi [5]; (5) Wang et al. [31]; (6) Orr et al. [22]; (7) Lin, Su and Chen [12]; (8) Su, Lee and Lin [27]; (9) Costin et al. [6]; (10) Fillingham, Malone and Gulliver [10].

There is no doubt that BIM 6D could bring revolutionary change for FM practices. Nonetheless, the authors believe that the full potential of BIM 6D can be realized only when currently available application areas are verified.

3.1.1. Mobile localization of building resources

Building components (equipment, materials etc.) must be located by the FM personnel on daily basis. Prompt reaction is critical for efficient problem detection and its resolution [4]. Conventionally when performing daily procedures FM personnel rely on a paper-based facility map and subjective judgment based on experience [9]. In many cases such approach is not effective enough (e.g. not readily visible places) or even worse - dangerous, since it might put others at stake (e.g. emergency). Nonetheless, productivity, safety and security could be optimized by the real-time resource location through integration of a BIM model and Radio Frequency Identification (RFID) technology [6]. Lin, Su and Chen [12] shed a new light on this matter by proposing even better value for money through the barcode-based system.

3.1.2. Digital asset with real-time data access

Following Paranezhad [24], “information” is a processed data, put in the relevant context. IFC files collect massive building data, whereas COBie spreadsheet selects only these adding value for O&M phase and structures them into context-based information. FM practitioners should be heading towards knowledge-based solutions, achieving subsequent step of this sequence. In order to satisfy this need Motawa and Almarshad [19] suggest knowledge-based system supporting O&M activities by enhancing BIM capabilities. Case-Based Reasoning (CBR) is a technique that enables the asset owners to learn from their past experience and hence avoid ineffective maintenance. The latter could be either preventive/predictive (planned) or reactive/corrective (repair). Though, reactive maintenance is more common and could be even four times more expensive than planned one for the same repair [14]. For efficient preparation of maintenance schedules for both preventive and corrective maintenance Motamendi, Hammad and Asen [18] come up with failure-cause detection patterns based on the knowledge-assisted and BIM-enabled visual analytics.

3.1.3. Space management

First and foremost, it is paramount for asset owners to understand the business operations taking place within the building asset. Such knowledge is a pre-requisite for adequate space classification, adjustment of space standards and eventually appropriate departmental allocations. The importance of BIM in this matter is undisputable since it enables space planners to exploit its visualization and coordination capabilities by streamlining the move process, forecast space requirements and facilitating space analysis [4].

3.1.4. Renovation/retrofit planning and feasibility

Depending upon the scale of the work and apparently contractual relationship, FM team quite often coordinates noncapital construction as well. BIM provides a profound basis for planning and feasibility studies with historical database of the existing building used as a reference for the cost estimation of the planned work. As the availability of a BIM model warrants a visual information to the designated structures then remodeling, refurbishment or demolishing should be performed seamlessly [29].

3.1.5. Maintainability studies

Maintainability is referred to in the first section of the paper, where the imperativeness of collaboration approach throughout the project delivery is highlighted. The BIM-enabled effective utilization of information is a warrant of sustained performance with a minimized upkeep costs during the building life span [24]. As suggested by Becerik et al. [4] BIM-based maintainability studies are concerned with the following areas: accessibility, sustainability of materials and preventive maintenance. BIM model enables FM staff to perform automated maintainability studies oriented towards operational stage assessment.

3.1.6. Energy analysis and control

UK Green Building Council [28] alarms that building operations account for around 40% of global energy consumption and 30% of carbon greenhouse gas emissions. Anton and Diaz [1] and Motawa and Carter [20] also agree upon the pivotal importance of building energy performance for procuring sustained investments. Though, also suggest that current energy consumption systems are not fully integrated due to the complexity of energy analysis and hence the need for a more efficient approach for energy simulation is stressed on. Motawa and Carter [20] come up with a sustainable BIM-based system that enables energy managers to perform complex energy evaluation efficiently by integrating energy-related information across the building asset life-cycle. Becerik-Gerber et al. [4] acknowledge the need for systems integrity.

3.1.7. Safety/emergency management

Cox and Terry [7] underline that within BIM, the critical and sensitive data is secured and accessible only for those who need it. This implies an improvement in safety, though it must be noted that such solution leaves also room for information abuse when being given an access to. Therefore, the asset owners must ensure that BIM-data protection systems are established. During emergencies FM personnel is foremost liable of mitigating life-threatening risks and facilitating the work for emergency units. In order to react promptly and adequately it is critical to have relevant data in place, organized in a logical and accessible way. Detailed information could be provided even before rescue units' arrival and hence professionals could develop a solution for a response and recovery more effectively. Wang et al. [30] create BIM-based emergency system that provides real-time two-way information flow, creating evacuation routes based on the user's location.

3.2. *Pursuing the competitive advantage*

There is no doubt that the full potential of BIM 6D has not been explored yet. Nonetheless, the authors believe that aforementioned application areas give enough reason to appreciate the importance of this emergent concept. The paper focuses on defining the most relevant technical benefits for enhancing FM practices, though it must be underlined that all conventional inefficiencies most often result in cost, time and quality deteriorations.

4. Fully utilizing BIM 6D capabilities

Despite BIM has already been utilized during design and construction stages [11], the previously discussed FM functionalities have not been widely applied yet. Apparently there are barriers and challenges responsible for the state of affairs, therefore remedies for them ought to be addressed.

4.1. *Problems encountered*

Authors collectively acknowledge the existence of challenges and implications that delay the BIM implementation in FM [4], [8], [14], [29], [30]. Based on the literature and practitioners' view the problems reported below are deemed most influential.

Table 2. Challenges and barriers of BIM 6D implementation process

Challenge/Barrier: Unclear roles and responsibilities regarding BIM model; Data requirements – level of development (LOD) needed; FMs role is underestimated; Lack of FMs input during the early stages of the project delivery process; Information exchange and transfer – interoperability concern; Lack of BIM knowledge/experience among the FM practitioners; Change-resistant attitude, lack of cases proving the positive business value.

4.2. *Action plan for leveraging BIM in FM*

The approach towards the fully employing BIM 6D potential envisaged in the paper is two-fold. Having elaborated on application areas that enhance FM practices, the key step is to plan and manage against known pitfalls that may hinder the sustainable manner of implementation process. Otherwise the expected benefits may not arise.

4.2.1. Plan and manage the implementation process

First and foremost, BIM potential must be actively managed for its full utilization. Therefore, in order to tackle the organization-wide uncertainty/reluctance towards innovation there should be a strategic implementation plan in place [16]. Becerik-Gerber et al. [4] suggest that leveraging the potential of BIM 6D requires a visionary owner who would lead the process from the early stages of the project delivery. Though, the authors do not fully agree since the support from the BIM manager could be a solution for the inexperienced owner too.

4.2.2. Collaborative approach towards Facilities Design

It is argued that the integration of the asset owner/end-user and facility manager has pivotal implications for O&M phase, provided that is made at the early stages of the project delivery [32]. Since the FM professionals are valuable source of information concerning end-users' expectations then their input in shaping the owner's requirements is beneficial for both sides [24]. The level of detail of the BIM model can be established effectively on the grounds of this relationship. The LOD (level of development) must reflect business needs and in many cases lower detail may be sufficient for FM team [13].

4.2.3. Standardize the format of information exchange and transfer

The BIM concept conveys certain principles that shape an attitude towards building asset life-cycle being strongly supported by technological advancements. The clue of BIM 6D is to integrate BIM model with existing FM software packages and hence assure a seamless flow of information with BIM model as a knowledge-based platform. Though, due to the magnitude of this change the relevant software applications are still being implemented in isolation, deepening the interoperability issue [30]. Diversity of private vendors trying to push their products on the market causes a great confusion within the industry and hence it is paramount for the BIM community to reinforce efforts on the development of nonproprietary methods. Additionally, as reported in the literature it is still unclear which facility data when and how ought to be transferred [30]. COBie as a simplified subset of IFC format was created to tackle these inefficiencies, though the practitioners still find some space for further improvements [17].

A cloud approach towards interoperability enhancement is a common topic in the literature, being deemed the right direction for future development. As proposed by Redmond et al. [25] the industry should focus on developing web-based BIM exchanges using the cloud platform incorporating both IFCs and SML (Simple Markup Language) files.

5. Conclusion

The authors aim to determine the extent to which BIM's utilization during operational stage is a warrant for more efficient and effective conduct of FM processes. This is achieved by presenting the application areas of BIM-enabled processes, bearing in mind the seamless information flow as a pre-requisite. Furthermore, existing challenges and barriers that hinder the successful employment and application of BIM 6D are identified and a solution in the form of an action plan is provided.

Understanding conventional FM practices allows establishing a performance gap, primarily attributed to inefficiencies in the information management across the building asset lifecycle and lack of collaborative attitude among actors within the industry. Furthermore, BIM as a collaborative process that facilitates the sustained logistics of information is introduced as viable way of bridging the gap identified earlier. Developing awareness of FM application areas for BIM-enabled processes is the first step towards appreciating BIM 6D potential.

By presenting explicit evidence of BIM applicability for FM practices the paper introduces researchers and foremost practitioners to the clear concept potential. Future work should focus on experimenting through larger number of case studies to ensure and verify the construction industry of the practical applicability and feasibility of implementing BIM 6D.

The main barriers that are difficult to be dealt with are cultural changes and interoperability issue. The latter one is continually being developed and hence it is believed that the technological advancements (e.g. cloud based applications) together with governmental efforts (e.g. the BIM development communities) are about to tackle it soon. Nevertheless, the authors claim that it is no longer lack of technological solutions that prevents the sector from implementing BIM-based revolution, it is the construction industry's inability to cooperate. However, the industry is continually evolving being led by BIM development hence the authors believe that all the aforementioned issues could be gradually diminished and eventually solved.

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