The Role of Building Information Modeling in the Management and Operation of Existing Buildings

Heba Eid[1,*], Alaa Kadi[2], Hadi Kherbeic[3]

[1]Building Information Modeling and Management Master student ,Syrian Virtual University, Syria
[2]Lecturer, Syrian Virtual University, Syria
[3]Supervisor, Syrian Virtual University, Syria

Emails: heba_223179@svuonline.org; dr.ajkadi@ru.edu.com; Kherbeic@gmail.com

Abstract

This research aims to highlight the importance of Building Information Modeling (BIM) in improving the management and operation of existing buildings. The study illustrates that achieving integrated functional performance for buildings requires the adoption of modern technologies, especially in the operational phase of their lifecycle. Despite BIM being primarily used in the design and construction phases, its application in operation and maintenance remains limited due to certain challenges, such as information management. The research presents a case study of Homs Museum as a model of a facility that relies on traditional methods for its operation, where BIM was applied to enhance three operational aspects: the container (building modeling and space occupancy), the content (indexing and classifying artifacts), and the user (staff management and BIM adoption within the institution). The results showed that BIM significantly enhances operational information management with high flexibility, underscoring the necessity of its adoption in existing buildings. The research recommends increasing the reliance on BIM in the operational phase, supporting its use in existing buildings through training and providing data collection tools, and developing user-friendly software interfaces for project managers.

Keywords: Building Information Modeling (BIM); Facilities Management; Operation and Maintenance; Existing Buildings; Building Lifecycle

1. Introduction

Recently, the Architecture, Engineering, and Construction (AEC) industry is considered the most influential contributor to development all over the world [1].However, the importance of adopting modern technology appears to keep pace with The operational activities of facilities and their performance with quality and efficiency, especially existing facilities that rely on traditional means of operation. It appears that buildings Traditional management methods face significant challenges related to the lack of information and its organization, leading to increased costs and efforts required for operations and maintenance [2]. Those responsible for these facilities resist transitioning from traditional CAD systems to Building Information Modelling (BIM) due to the lack of research and practical applications demonstrating BIM's benefits, as well as concerns about the time and effort needed to switch to this system without understanding its potential advantages at this stage of the project lifecycle [3] [4]. This deficiency in information and reliance on traditional methods reduces the efficiency and sustainability of existing facilities, making it difficult for BIM professionals to focus on updating these facilities compared to working on new facilities managed with BIM [5]. This research aims to explore the impact of Building Information Modelling (BIM) on the operation of existing buildings. It seeks to answer the main question regarding the extent of BIM's effect on the operation of these buildings and addresses three sub-questions related to the current state of existing buildings, the challenges BIM implementation may face, and how to achieve practical effectiveness of BIM technology during the operational phase. The research hypothesis is that using BIM can improve the performance and sustainability of existing buildings and reduce the time and effort required for their operation. The research also aims to provide solutions for potential challenges and demonstrate BIM's effectiveness through a practical case study.

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

2. Literature Review

2.1 Current state of management and operation of existing buildings using traditional methods

The main Three Flaws That appears in using Traditional methods in operation phase are limited communication which is one of the main reasons for information and experience loss, also undocumented experience and knowledge due to poor communication and limiting this knowledge with only decision-making personnel which can cause a great loss of information and experiences. [6]. Lastly and more importantly, Scattered and unorganized information causing performance and operating inefficiency and making it difficult to manage and exchange information within team members. [2]

2.2 BIM benefits in operation phase and obstacles of its adoption in existing buildings

As an overview of BIM in construction, "it involves generating and managing digital representations of physical and functional characteristics of places, extending its utility across the entire building lifecycle, including cost management, construction management, project management, and facility operation." [7]. Regardless Of various definitions of BIM, it all pours in one that BIM help all AEC projects participants to collaborate in an intelligent environment to improve the projects efficiency, performance, and achieving the stockholder requirements. [8]. As [9] indicated that the importance of BIM comes from its richness of information that it Focuses on the information (data) rather than the 3D model which makes it about converting design into reality.

BIM proved its benefits according to [10] Such as clash detection, time-saving, improving the quality and reduced rework, increasing efficiency, improving collaboration, coordination and communication, creation and sharing information ability, improving visualization, reducing the number of requests for information and improvement of decision making. Also, [11] claimed that BIM Benefits Facility Management sector by enhancing information delivery methods therefore better information accuracy, Rather than increasing work orders efficiency in the terms of data access speed and identifying clashes and intersections.

As [12] concluded that adopting BIM might result in additional information sources, richer, more reliable information, improved information transmission efficiency, and a decreased risk of incorrect information interpretation. In addition, the researchers [13] affirmed, "BIM selects the right material, Design Optimization and Performance Simulation, Integration between systems, etc." also "After the construction is completed, BIM continues to be valuable for facility management."

As for the researchers [14] they concluded the benefits of BIM as follows: BIM enhances the collaboration Due to the richness of the information within the BIM Model also that it Reduces the financial risk, increase profitability and reduce change orders and disputes. Many barriers stands in the way of BIM Implementation like the low level of BIM awareness about BIM in the AEC industry, rather than resistance to change, and Lack of BIM technical experts in addition to time and cost required for switching to BIM. [15] [14]

Through several previous studies, researchers such as [16] conducted a study on a Building Information Modeling (BIM) framework suitable for sustainable operations management of existing buildings. The researcher proposed solutions to outcome challenges in this field through a case study, suggesting a general framework to facilitate the adaptation of building models to diverse operational needs and support BIM adoption in existing buildings. Additionally, [17] presented a BIM model for managing existing buildings through two case studies, affirming that basic BIM skills suffice to construct information models easily used by facility managers.

As concluded from previews Studies, throughout the life cycle of buildings, BIM can be utilized in several areas. In design, BIM assists in creating accurate 3D models to facilitate visualization and coordination among engineering disciplines [18], as well as analyzing building performance in terms of sustainability and energy efficiency. During construction, BIM can be used for planning schedules and managing sites more effectively, along with simulating the construction process to identify potential issues early on. In operations and maintenance, BIM enables efficient asset management and scheduling preventive maintenance based on available data, in addition to providing easy access to documents and drawings necessary for repairs and maintenance.

In addition, reviewed studies indicate that BIM still faces challenges and issues in its application for existing buildings, whether in data collection from these structures or in transitioning to non-traditional BIM systems. Moreover, by investigating the integration challenges and potential barriers faced by industry professionals it would provide practical guidance for successful implementation. [19]

Therefore, this research aims to underscore the importance of BIM for Existing buildings by applying a practical case study that highlights its effectiveness and benefits, making the effort to transition to a BIM system logical and worthwhile.

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

3. Research Methodology

In this study, several different research methodologies were employed to achieve the desired objectives:

The descriptive-analytical method involved analyzing and describing the current state of existing buildings in terms of their operation and maintenance using traditional methods. Details and processes currently used in managing these buildings were documented.

The experimental method consisted of conducting a case study through partial conversion of a specific building to Building Information Modeling (BIM) as an applied case study. Specific BIM tools were used within the operational framework to evaluate how adopting BIM could improve the operation and maintenance of the proposed building compared to traditional methods.

The comparative method involved comparing the sustainability and optimal operation of existing buildings between BIM-based management methods and traditional operational techniques. The focus was on analyzing performance and efficiency differences between the two approaches to provide comprehensive recommendations.

These methodologies were integrated comprehensively to gain a deep understanding of the challenges and opportunities associated with implementing BIM in managing existing buildings, aiming to provide a practical and sustainable framework for adopting this technology in this context.

Data was gathered through an interview conducted with the museum curator to understand the current operational status and processes of the museum. Questions were prepared in advance, the interview was conducted face-to-face with open-ended questions, and responses were recorded. Regarding the documentation of data and information, archaeological artifacts are received from excavation processes with records of their discovery locations and excavation logs. Subsequently, each artifact is documented with its number, measurements, material, source, and entry date into the museum. As for the distribution of artifacts, they are classified based on type, significance, and material to ensure proper storage and suitable display. Challenges exist in accessing data and coordinating artifacts for museum exhibitions, resulting in increased time and effort for maintenance and display. The museum staff lacks diverse specializations and efficiency in task distribution and communication, necessitating improvements in handling suitable operational systems for museum needs.

4. Data Analysis

Data analysis in the case study revealed several key operational axes for the museum, focusing on its core elements: container, content, and user. A plan was devised to transform the museum into a BIM system as follows:

Firstly, the building will be modeled using Revit based on existing CAD drawings, aiming to achieve spatial occupancy efficiency.

Secondly, a model and mechanism will be introduced for registering archaeological data using Revit software, facilitating effective and precise data management.

Thirdly, emphasis will be placed on workforce management and analyzing the museum's environment using the SWOT analysis tool, with the goal of proposing strategic alternatives that effectively integrate the BIM system within the museum's structural and organizational framework.

Spatial occupancy is a crucial aspect of operational processes, enabling the optimal utilization of facility spaces. In the case of the Homs Museum, the importance of spatial occupancy lies in improving the display areas and storage spaces, facilitating the effective sorting, distribution, and storage of artifacts. To study this aspect, Revit, one of Autodesk's leading Building Information Modeling (BIM) software, was used. Revit allows designers to automatically create 2D and 3D plans and provides tools for designing buildings and managing their information. The workflow included modeling the museum using existing CAD drawings, distributing and defining the functions and areas of the rooms, and creating schedules that detail these aspects. It also involved determining the spatial occupancy for the museum display and creating schedules showing each room's area and occupancy rate, as well as cataloging museum cabinets to track the number and specifications of artifacts.

Table 1: Rooms Area in the museum and its Occupation

Number	Level	Name	Occupancy	Area
1	ground floor	Hall	Exhibition	83 m^2
2	ground floor	Bio	Exhibition	70 m^2
3	ground floor	Storage Room	Storage	18 m^2
4	ground floor	Storage Room	Services	12 m^2
5	ground floor	Storage Room	Services	13 m^2

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

6	ground floor	Storage Room	Storage	13 m²
7	ground floor	Storage Room	Storage	18 m²
8	ground floor	Washroom	Services	6 m²
9	ground floor	WC	Services	2 m²
10	ground floor	WC	Services	2 m²
11	ground floor	Guard Room	Administrative	11 m²
12	ground floor	Hall	Exhibition	101 m²
13	ground floor	Bio	Exhibition	54 m²
14	ground floor	Garden	Services	113 m²
15	ground floor	Guard Room	Administrative	21 m²
16	ground floor	Reception	Administrative	113 m²
17	first floor	Laboratory	Services	18 m²
18	first floor	Kitchen	Services	12 m²
19	first floor	Museum Security Room	Administrative	33 m²
20	first floor	Manager's Office	Administrative	70 m²
21	first floor	Hall	Exhibition	103 m²
22	first floor	Bio	Exhibition	65 m²
23	first floor	Bio	Exhibition	70 m²
24	first floor	Hall	Exhibition	108 m²

The table reflects how spaces within the building are allocated to improve space management and optimize their use for displaying and storing artifacts, as well as managing museum operations effectively.

Table 2: Museum Spaces according to its availability for museum exhibition

Level	**Occupancy**	**Area**	**Museum Exhibition**	**Museum Exhibition Area (m²)**	**Museum Exhibition Percentage (%)**
Ground floor	Administrative	32 m²		0 m²	0.00%
Ground floor	Administrative	50 m²		0 m²	0.00%
Ground floor	Administrative	32 m²		0 m²	0.00%
Ground floor	Museum Exhibition	421 m²	✓	421 m²	37.00%
First floor	Administrative	102 m²		0 m²	0.00%
First floor	Administrative	102 m²		0 m²	0.00%
First floor	Private Museum Exhibition	346 m²	✓	346 m²	68.00%
Total		1127 m²		767 m²	68.00%

The previous table shows that the total available area for museum exhibitions is 767 square meters, which constitutes 68% of the building's area.

Table 3: Museum Cabinets Schedule

Museum Cabinets	
Description	**Count**
Cabinet with dimensions 65*65	7
Cabinet with dimensions 65*130	15
Cabinet with dimensions 65*250	9

These values and tables are utilized, as previously mentioned, in determining the available space for museum displays, designing and arranging exhibits, and distributing artifacts accordingly. Similarly, furniture can be distributed within any type of building by understanding available spaces, occupancy, and optimizing these areas effectively. This is done in a simplified manner, away from the complexities of specialized programs that require extensive time and effort to learn and integrate into facility systems.

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

Furthermore, collaboration with 3D modeling can leverage these resources to model museum exhibit paths and activities, providing a preview that facilitates and clarifies the exhibition route for visitors.

Figure 1. 3d perspective of Museum Modeled using Revit Showing Furniture and cabinet's distribution

For archaeological artifact records, libraries like Revit can be utilized or a custom library can be created based on the required level of detail for modeling artifacts. It is preferred that these models have low detail since the importance of artifact modeling relies on modeling the information and data of these artifacts.

The data field's specific to artifacts must be defined to facilitate communication with an external database such as Excel. These fields serve as historical databases for artifacts, including storage records, preservation dates, and data sheet indexing. Additional fields may include item weight, dimensions, display systems (hanging, floor-mounted, or in cabinets), photographs, preservation requirements, materials, and unique identifiers for each piece, among others.

Special parameters were created for artifacts using Shared Parameters, focusing on information such as their description, historical period, dimensions, acquisition date, and other parameters. Additionally, images of the artifacts were included. These Shared Parameters were then added to Project Parameters under the Data category, categorized as Generic models, through which the artifacts are modeled. Alternatively, artifacts can be modeled as Furniture. The required parameters were subsequently added based on each building's operational needs.

When creating a model for artifacts using Component - model in place and drawing them as Generic models, the added parameters appear on the side. These parameters can be filled with selected values for each parameter (text, number, image, material, etc.). Following this, a specific table for the Generic models category is created to display the data in a table format, as shown below.

Table 4: Archeological artifacts inventory Modeled in Revit

Inventory of Archaeological Artifacts									
Used for Museum Display	**Description of the Artifact**	**Thickness or Diameter**	**Width**	**Length**	**Material Type**	**Historical Period of the Artifact**	**Date of Entry**	**Ownership**	**Registration Number**
Yes	Rectangular tomb with missing cover, with scratches on the sides, and Roman inscriptions on both sides of the tomb	70	120	300	Stone	Roman	20/3/2013	Directorate of Antiquities, Palmyra	23

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

Yes	Circular clay jar covered with a piece of cloth	40	0	0	Clay	Ottoman	15/5/2007	Directorate of Antiquities, Homs	172
Yes	Stone tomb broken with side Roman engravings	90	150	320	Stone	Roman	2/4/2017	Directorate of Antiquities, Palmyra	99
Yes	Well-preserved stone tombstone of a Roman soldier	35	90	130	Stone	Roman	9/11/2010	Directorate of Antiquities, Palmyra	119
Yes	Stone tombstone of a young girl in good condition	40	115	80	Stone	Roman	18/12/2010	Directorate of Antiquities, Palmyra	123
No	Stone statue of a Roman king missing the head	90	100	220	Stone	Roman	26/5/2017	Directorate of Antiquities, Palmyra	

5. Discussion

The aim of implementing Building Information Modeling (BIM) in the museum case study was to enhance operational efficiency across its primary elements: containers, content, and users. With BIM, and comparing the results with previous studies on BIM implementation in existing buildings, significant advancements and improvements are revealed. The current study highlights enhancing spatial management, facilitating data administration, and improving operational processes through BIM. Unlike traditional methods relying on manual calculations and two-dimensional plans, BIM facilitates automatic and precise spatial analysis, ensuring optimal space utilization and effective distribution of museum elements in a three-dimensional model.

The study identifies several benefits associated with implementing BIM in existing buildings. Firstly, it enhances operational efficiency by enabling accurate spatial management and facilitating data administration. Secondly, BIM enhances collaboration among multidisciplinary teams and stakeholders, fostering better communication and coordination throughout project phases. Moreover, BIM facilitates heritage conservation through detailed documentation and preservation of archaeological artifacts within a digital environment. Lastly, BIM supports sustainable building practices by improving energy use and reducing material waste, contributing to environmental conservation efforts.

Despite its benefits, the adoption of BIM in existing buildings presents several challenges. Initial costs associated with software acquisition, training, and implementation can be prohibitive for some institutions. Moreover, integrating BIM with existing data systems and workflows may require substantial time and effort. Cultural resistance and organizational inertia can also hinder the adoption process, as stakeholders may be reluctant to depart from traditional methods. Furthermore, ensuring data interoperability and maintaining data integrity remain critical challenges, especially when dealing with diverse data formats and legacy systems.

6. Conclusions

- **Summary of Key Findings**

The study highlighted the importance of adopting BIM for existing buildings, especially during the operational phase, demonstrating its capability to address operational needs. It also discussed key challenges identified in previous studies and literature regarding BIM adoption at this project life stage. The case study applied showed that these challenges can be overcome through strategic planning and simple software tools integrated into the facility management system. The research concluded several points: BIM can significantly facilitate complex

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

operational processes like spatial analysis, furniture elements, information indexing, and task automation. Traditional methods face difficulties in coordinating operational data and managing operations due to limitations in information exchange via paper-based or 2D CAD systems. Overcoming these challenges requires a well-structured strategy to integrate BIM into the facility's framework and effectively train facility stakeholders for optimal operational processes and collaboration within the BIM framework.

- **Concluding Remarks**

Based on the research findings, recommendations were formulated to enhance operational practices in existing buildings using BIM. These include increasing BIM integration during the operational phase to replace traditional methods, establishing a comprehensive transition framework to aid facility managers in visualizing future operational realities post-BIM adoption, and promoting its implementation. Additionally, the study emphasizes managing facility information and data throughout the project lifecycle, advocating for the use of BIM due to its efficiency and flexibility. It also suggests providing user-friendly data collection tools like "scan to-bim" and conducting workshops and training courses to familiarize stakeholders with BIM systems, aiming to optimize operational efficiency and facilitate widespread adoption across diverse facility types. Moreover, developing BIM-enabled software for building operation and maintenance phases is recommended to streamline information management and enhance interaction among stakeholders.

References

[1] Ahmed Fahim Elgendi, Ashraf Elhendawi , Waleed Mahfouz M. A. Youssef, Abdul Salam Darwish, "The Vulnerability of the Construction Ergonomics to Covid-19 and Its Probability Impact in Combating the Virus," *International Journal of BIM and Engineering Science*, vol. 4(1), pp. 1-18, 2021.

[2] M A Hossain, J K W Yeoh, "BIM for existing buildings: potential opportunities and barriers," in IOP Conf. Series: Materials Science and Engineering 371, 2018.

[3] A. I. N. Elhendawi, "Methodology for BIM implementation in KSA in AEC industry," Edinburgh Napier University, UK, 2018.

[4] M. Y. Younes, "Achieving optimal lighting to improve the functional performance of the museum using computer simulation case study: Lattakia Museum in Syria," International Journal of BIM and Engineering Science, vol. 5(2), pp. 19-37, 2022.

[5] Joud Mohammad Shbeeb, Lama Adel Saoud, "Enhancing facility management for buildings using BIM (case study: model of a medical building)," International Journal of BIM and Engineering Science, vol. 7(2), pp. 8-24, 2023.

[6] Qiuchen Lu, Long Chen, Sanghoon Lee, Xiaojing Zhao, "Activity theory-based analysis of BIM implementation in building O &M and," Elsevier, 2018.

[7] Haretha Aljabr, Mohammed Ali, "Integration of Building Information Modeling and Project Management Process," International Journal of BIM and Engineering Science, vol. 8(1), pp. 8-17, 2024.

[8] Sonia Ahmed, Petr Dlask, Omar Selim, Ashraf Elhendawi, "BIM Performance Improvement Framework for Syrian AEC Companies," International Journal of BIM and Engineering Science, vol. 1(1), pp. 20-41, 2018.

[9] Ashraf Elhendawi, Andrew Smith, Emad Elbeltagi, "Methodology for BIM implementation in the Kingdom of Saudi Arabia," International Journal of BIM and Engineering Science, vol. 2(1), pp. 1-20, 2019.

[10] Martin Evans, Peter Farrell, Emad Elbeltagi, Ayman Mashali, Ashraf Elhendawi, "Influence of Partnering Agreements Associated with BIM Adoption on Stakeholder’s Behaviour in Construction Mega-Projects," International Journal of BIM and Engineering Science, vol. 3(1), pp. 1-17, 2020.

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024

[11] Rania Salman, Rana Maya, "Effects of Applying Bim on facility management for existing Buildings," International Journal of BIM and Engineering Science, vol. 7(1), pp. 72-86, 2023.

[12] Ayman Mashali, Ahmed El tantawi , "BIM-based stakeholder information exchange (IE) during the planning phase in smart construction megaprojects (SCMPs)," International Journal of BIM and Engineering Science, vol. 5(1), pp. 8-19, 2022.

[13] Fawaz Saleh, Ashraf Elhendawi, Abdul Salam Darwish, Peter Farrell, "A Framework for Leveraging the Incorporation of AI, BIM, and IoT to Achieve Smart Sustainable Cities," Journal of Intelligent Systems and Internet of Things, vol. 11(2), pp. 75-84, 2024.

[14] Ashraf Elhendawi, Hany Omar, Emad Elbeltagi , Andrew Smith, "Practical approach for paving the way to motivate BIM non-users to adopt BIM," International Journal of BIM and Engineering Science, vol. 2(2), pp. 1-22, 2019.

[15] Mohamed H. Shaban, Ashraf Elhendawi, "Building Information Modeling in Syria: Obstacles and Requirements for Implementation," *International Journal of BIM and Engineering Science,* vol. 1(1), pp. 42-64, 2018.

[16] J. M. Arthur, "A Building Information Management (BIM) framework and supporting case study for existing building operations, maintenance and sustainability," *Elsevier,* 2015.

[17] G.Carbonari, S. Stravoravdis, C. Gausden, "Building Information Model implementation for existing buildings for facilities management: a framework and two case studies," *WIT PRESS,* 2015.

[18] Lina Alshibly, Mohammad shaban, "Impact of BIM implementation in engineering projects in Syria," *International Journal of BIM and Engineering Science,* vol. 7(2), pp. 64-74, 2023.

[19] Fawaz Saleh, Ashraf Elhendawi, Abdul Salam Darwish, Peter Farrell, "An ICT-based Framework for Innovative Integration between BIM and Lean Practices Obtaining Smart Sustainable Cities," *Fusion: Practice and Applications (FPA),* vol. 14(2), pp. 68-75, 2024.

DOI: https://doi.org/10.54216/IJBES.080205
Received: October 18, 2023 Revised: January 17, 2024 Accepted: May 16, 2024