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Decoding BIM Challenges in Facility Management Areas: A Stakeholders' Perspective

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Abstract: The adoption of building information modeling (BIM) in the operational and maintenance phase remains limited, with many buildings still managed through paper-based processes. While BIM has the potential to optimize various facility management (FM) areas—such as energy performance, security, administration, and space management—most studies only provide global analyses of adoption barriers. This study aims to identify and analyze area-specific barriers to BIM adoption in FM, highlighting the need for tailored integration strategies rather than a one-size-fits-all approach. By taking a novel approach, it investigates these barriers and demonstrates that BIM implementation cannot be uniformly applied across all FM areas. The methodology involves a multi-step process: first, a literature review is conducted to identify generic barriers to BIM implementation. Subsequently, FM areas are classified to provide a structured framework for analysis. Based on this classification, an interview structure is developed to gather expert insights on area-specific barriers. The research proposes that barriers should be assessed based on their impact. While contextual barriers or knowledge areas may be addressed through a global approach, ensuring BIM adoption across all areas requires consideration of specific characteristics. This approach will ultimately facilitate broader implementation in every domain.

Keywords: facility management; BIM; information; barriers; construction; stakeholders

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1. Introduction

The widespread adoption of BIM for FM in both existing and new buildings faces significant challenges, impeding its successful implementation [1–6]. Using BIM technologies in building FM presents significant advantages in a phase constituting 80% of a building's life cycle costs, including enhanced efficiency and preventive maintenance [7]. Digital twins developed through BIM technologies enhance operational efficiency through real-time monitoring, predictive maintenance, and resource optimization, reducing energy waste and costs [8,9]. They support carbon reduction and energy efficiency by simulating usage patterns, monitoring emissions, and aligning operations with global standards like LEED or BREEAM [10,11]. These tools also bolster climate resilience, enabling simulations and adaptive strategies by providing insights into life cycle assessments and circular economy practices [12,13].

1.1. BIM Tools for FM

Nowadays, there is a wide range of digital solutions available to facilitate the management of building facilities. Notably, the computerized maintenance management system (CMMS) is employed to oversee and log the technical attributes of the building and its equipment [14,15] and enterprise resource planning (ERP) tools support key activities such as manufacturing and logistics, finance and accounting, sales, and human resources [16]. Additionally, another category of tools known as building management systems (BMSs) have a role in controlling and storing data sourced from Internet of Things (IoT) systems [17,18]. FM data come from monitoring facilities or IoT systems that provide information about the status of each asset at a given time and historical trends based on stored and available data [19]. BIM management allows all of these solutions to be combined into a single platform and keeping track of all FM actions, such as repairs, upgrades, and replacements [20,21]. In addition, while conventional in situ interventions provide a singular point-in-time assessment of building assets, they often fall short in offering a comprehensive understanding of primary maintenance issues and uncovering the root causes of persistent malfunctions. In this context, the integration of IoT data analyses and digital twins facilitates a holistic view of the building's condition. Such analysis including BIM technologies helps enhance various aspects of FM, including comfort optimization, efficient energy management, and bolstering security and safety measures [22–24].

1.2. BIM Adoption Challenges for FM

However, the adoption of BIM in the operations and maintenance phase faces diverse challenges, including cultural, economic, legal, and technical factors, as well as aspects related to organizational work practices, training availability, and established habits within companies [25,26]. Many researchers have explored the obstacles hindering BIM adoption, identifying numerous barriers that significantly contribute to the limited implementation of BIM during the operational phase, despite its wide range of potential benefits. S. Liu, in their in-depth analysis of the construction industry, identified key challenges to BIM implementation, including the absence of clear national regulations in each country, high initial costs of tools, lack of skills among professionals, organizational issues, and regulatory concerns related to data ownership [27]. Based on research conducted by S. Durdyev on BIM adoption in operations, the most common obstacles are the high cost of software, lack of employee training, data ownership concerns, and the absence of regulatory promotion and incentives from governments [7]. In France, E. Hochscheid also identified very similar obstacles to those mentioned by S. Durdyev and S. Liu: software-associated costs, lack of national standards and actor training, technical issues with tool interoperability, organizational problems, and, ultimately, cultural factors related to architects and their attachment to traditional methods [28]. Consequently, the obstacles hindering BIM adoption are numerous and similar across various countries and professions within the construction industry. Furthermore, numerous studies have indicated that BIM technologies face comparable implementation challenges on a global scale in different countries [29]. A key barrier to implementing BIM in the operations and maintenance phase today is the lack of skills. This deficiency plays a central role in the challenges highlighted in BIM maturity publications [30,31]. However, market barriers also appear as an important obstacle since they suggest that European countries have a long history of innovation based on science but suffer from a poor understanding of markets that prevents them from capturing the full commercial potential of their innovations [32]. The financial barriers related to the cost of implementation, the lack of public investment, and the high price of tools will also affect the adoption of a new technology. Finally, there is the context it is going to affect as well the implementation of any innovative process, including the kind of sector [33].

Furthermore, facility managers are often underrepresented in barometers, and BIM usage for operations and maintenance remains low compared to its widespread application in the design or the construction phase [3,34,35]. Surveys among architectural, engineering, and construction (AEC) professionals indicate a lack of recognition and perceived benefits in FM, with a focus on time and cost reductions during design and construction phases rather than the potential benefits of BIM in building management [36]. Overall, there is a need for increased awareness and understanding of BIM applications in operations and maintenance. Consequently, while BIM has the potential to improve the management of these areas, few studies have employed qualitative methods to explore the barriers to its implementation or have examined these challenges across individual FM areas simultaneously.

1.3. Paper's Layout

This study employs an innovative approach by analyzing the discourse of FM stakeholders to identify both specific and shared obstacles to BIM adoption across various interconnected FM areas. This paper is structured as follows: Section 2 delineates the methodology utilized in this study, providing a comprehensive overview of the qualitative approach and the data mining techniques employed to analyze the barriers to BIM adoption. Section 3 presents the key findings, elucidating the specific challenges encountered by facility managers in different FM domains. Section 4 discusses the implications of these findings, emphasizing the necessity for tailored solutions to effectively address the identified barriers. Finally, Section 5 concludes the paper with recommendations for future research directions and practical applications within the field of facility management. The conclusion highlights that overcoming BIM implementation obstacles requires a thorough understanding of the unique barriers within each FM area, addressing both societal and technological factors and tailoring solutions to meet the specific needs of each domain.

2. Research Methodology

Interviews are a widely utilized tool for data collection, especially in the construction field, where they effectively support qualitative research. Interviews are ideal for this type of qualitative questioning study because they allow for in-depth exploration. Unlike surveys, interviews provide detailed insights and allow for follow-up questions, making it easier to uncover nuanced, context-specific challenges [36]. In this study, interviews were conducted to assess and validate the findings of a preceding literature review (Figure 1), which facilitated the identification of the most recurrent BIM barriers observed in similar research studies and allowed for an analysis of what occurs when these barriers are examined separately across different FM areas. To better understand the informational obstacles faced by the professionals during the operations and maintenance phase, interviews were carried out with experts in FM and BIM. This analysis is based in a qualitative research interview, a form of discussion in which the interviewer elicits information from participants regarding personal opinions about a specific topics, usually considered to be a purposeful conversation [37]. An analysis of these interviews was conducted using text mining, as outlined in Figure 1, which presents the phases of the text mining process, along with the literature review, to categorize the BIM barriers affecting different FM areas. Afterwards, each area of facility management was assessed individually in order to measure the impact of the aforementioned barriers.

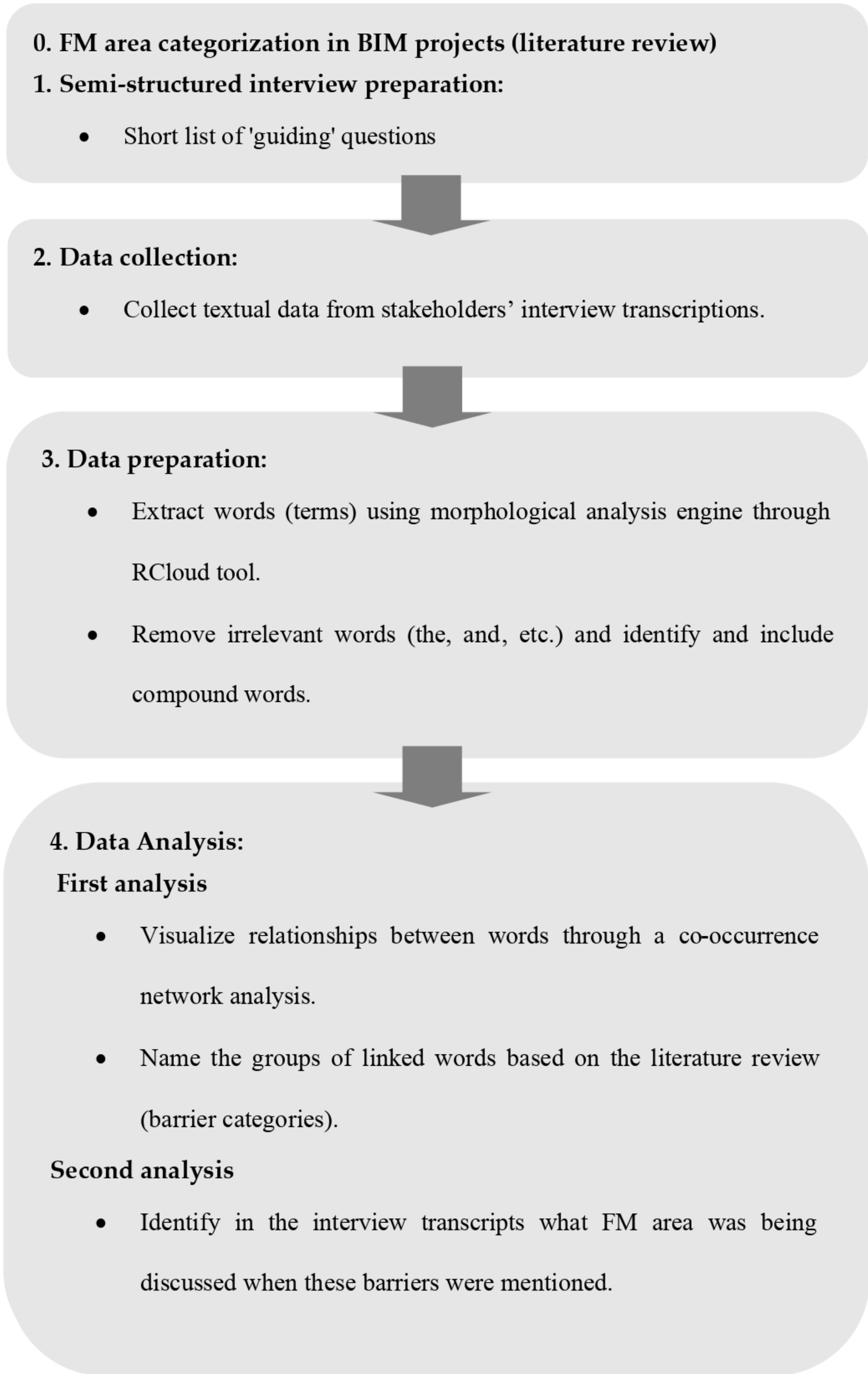

Figure 1. Research methodology including text mining approach.

2.1. FM Area Categorization in BIM Projects

In the operations and maintenance phase, BIM technologies demonstrate applicability in enhancing space management, streamlining maintenance processes, optimizing energy usage, facilitating cost-effective renovations and upgrades, and refining life cycle management [38–41]. The literature review further identified a similar categorization established by the International Facility Management Association [42], including: better management of space, simplified maintenance, efficient use of energy, cost-effective renovations and upgrades, and better life cycle management. Furthermore, a list of indicators based on facility managers' perceptions on building performance assessment highlighted that the most important areas would be: safety and assets working properly, health and comfort, space functionality, and energy performance [43]. Consequently, the exploration of these categories sheds light on the technological prerequisites necessary for successful BIM integration. Besides these categories, administrative management and urban management are also commonly taken into consideration within FM tasks in BIM projects [44,45]. Administrative management is at the heart of BIM projects during FM because centralizing and storing data also facilitate the gathering of contractual documents, procedures, technical files, etc. Centralization of documents is related to collaborative platforms providing a cloud that allows storage of all project documentation and most of the literature on this topic focuses on how to connect the digital model with this documentation [46,47]. On the other hand, the integration of BIM with GIS allows connection of the building to its neighborhood, its sensors, and its infrastructures, supporting the development of green and smart planning of neighborhoods and cities [48].

Through an extensive literature review, the study identifies several key focus areas, including energy performance, space management, security, technical maintenance, health and comfort, administration, urban management—also referred to in the BIM context as city information management (CIM)—and safety. To ensure the robustness of this categorization, it was systematically validated by all interviewers at the beginning of the interview process, confirming its relevance and consistency with expert insights.

2.2. Semi-Structured Interview

Semi-structured questions were used since they allow for in-depth responses about people's experiences, perceptions, opinions, and knowledge [37]. The main methods for conducting semi-structured interviews include face-to-face conversation, email, video conference, and telephone. The choice of the used methods was based on the availability of the stakeholders and their location. In this study two approaches were used: face-to-face interviews and video conference interviews for all ten (10) participants. The semi-structured interviews followed Patton's general interview guidelines anticipating the analysis and for designing the evaluation data collection to facilitate the study of the results [49].

Consequently, the interview guideline was structured into two main sections: one addressing the overall adoption of BIM in FM and its associated barriers, and the other focusing on the specific FM areas where BIM could be applied, including energy performance, space management, security, technical maintenance, health and comfort, administration, CIM, and safety. This approach allowed participants to discuss both the general obstacles to BIM adoption in FM and the challenges specific to individual areas, reflecting the novel, area-specific approach of this paper. The face-to-face interview process began with an introduction from the interviewer to set the context and clarify the study's objectives.

2.3. Data Collection

In qualitative research, depth of understanding takes precedence over sample size, particularly when the study focuses on a specialized field like BIM in FM. The ten participants in this study were selected for their expertise and represent a diverse range of FM areas (Table 1). The responses from experts, spanning two countries (France and Spain), showed significant convergence, with many recurring themes identified across diverse roles and FM areas. This repetition of insights indicates that data saturation was achieved, validating the reliability of the findings.

Table 1. Details of participants.

Descriptive Data of Interviewees					
FM Expert ID	E.1	E.2	E.3	E.4	E.5
Role	Director of building engineering and FM in an energy service company	Director of a consultancy company for facility management	Director of development of a BIM collaborative platform for FM	Project manager of building management in a multinational company	Developer of a BIM collaborative platform specialized in data management
Nationality	French	French	French	French	French
FM Expert ID	E.6	E.7	E.8	E.9	E.10
Role	Head of digital transformation in an FM company	BIM consultant in a BIM consultancy firm and associate professor	Director of facility management company	Public building facility manager specialized in prevention and security	Asset manager in a new technologies consultancy firm
Nationality	Spanish	Spanish	Spanish	Spanish	Spanish

Participants were selected through a systematic process that was part of a larger research project aimed at analyzing stakeholders' interests throughout various phases of the construction process, which included case studies conducted in France and Spain [50,51]. Specifically, in the FM phase, a diverse range of participants was sought, including facility managers, BIM specialists, technical experts, and developers, to capture various perspectives on BIM adoption. Networking efforts were made to connect with professionals through industry associations and academic institutions. In instances of limited direct contacts, snowball sampling was used where initial participants recommended additional experts within their networks, further expanding the pool of qualified candidates [52]. Ultimately, 10 participants were selected based on their expertise and willingness to contribute, prioritizing depth of understanding for rich qualitative data.

Furthermore, the use of robust qualitative methods, including semi-structured interviews and text mining, ensured comprehensive analysis. Comparable studies in the field have similarly used small but focused samples to generate meaningful and actionable insights [53–55].

The first part of the interview was focused on the background information of the participants and their knowledge on projects using BIM technologies for FM. This step was essential to understand the professional profiles of the stakeholders and to verify whether the interviewees had the required experience to support the data. In addition, all the interviewees had prior involvement in BIM projects and were in the 30–40 years of age range.

The second part of the interview focused on participants' daily work routines and the challenges they face in adopting BIM across different FM areas, including energy performance, space management, security, technical maintenance, health and comfort, administration, urban management (CIM), and safety. These FM areas were identified based on the findings from the previous literature review.

Starting with open-ended questions allowed participants to identify and develop their ideas and thus obtain a general idea of what the interview might entail, while creating an encouraging and friendly environment. However, the order of topics as indicated in the guideline was not strictly followed. In fact, in a semi-structured interview, participants have the freedom to contribute without strictly following the guide. This step aimed to delve deeper into understanding the specific obstacles that impact various areas of facility management.

2.4. Data Preparation

Data mining methods such as correspondence analysis and co-occurrence network analysis facilitate the visualization of relationships between words and the extent to which respondents expressed their problems and barriers concerning the implementation of BIM in the different FM areas. The choice of two-mode (bipartite) co-occurrence network analysis was made for its systematic ability to identify the most pertinent words in this context [56,57].

Words were extracted from the text, and their frequencies were calculated using the n-gram package in RCloud Studio [58]. This R package constructs n-grams, which are ordered sequences of n "words" derived from the existing text [59]. Additionally, a morphological analysis engine available in R was employed, and during this process, stopwords such as "be", "in", "the", "we", and "other" were excluded to enhance the significance of the analysis. From the list of extracted words, those with identical or similar meanings were grouped into the same category, each assigned a code (a single word chosen from that category). For example, "utilize", "employ", and "use" were combined and labeled as "use" while "cost" and "price" were grouped under "cost". The same procedure was applied with singular and plural words, and if both were present in the text, they were grouped under the singular term. Codes appearing in less than 2% of all responses were eliminated due to low information content. Only the most relevant codes, referred to as "words", were selected to create a numerical matrix for analysis, enhancing the interpretability of visualized results from data mining.

2.5. Data Analysis

The initial step of analyzing the transcribed interviews involved generating a co-occurrence network diagram using the R language [60,61]. This diagram was constructed to assess the most frequently repeated words and their associations with the barriers to BIM adoption in the context of facilities management (FM). Following this, a text mining approach was employed to further analyze the transcription of the interviews, classify these barriers, and gain a deeper understanding of the underlying reasons for these obstacles in each FM area.

3. Results

3.1. Main BIM Barriers Affecting FM Identified

3.1.1. First Analysis

This analysis identified four distinct types of barriers: knowledge barriers, organizational barriers, market barriers, and financial barriers (Figure 2). However, the initial analysis, through the examination of word co-occurrence networks, did not uncover any external or contextual barriers.

3.1.2. Second Analysis

The literature review established that the fundamental obstacles to any implementation of new information technologies and BIM are mainly the following: knowledge barriers, market barriers, financial barriers, regulation barriers, and external/contextual barriers. Nevertheless, our first analysis showed that the text mining approach just identified in these interviews knowledge barriers, market barriers, financial barriers, and regulation barriers. The goal was to ascertain whether FM experts' discussions highlighted the existence of all these barriers and identify the specific FM areas that were affected.

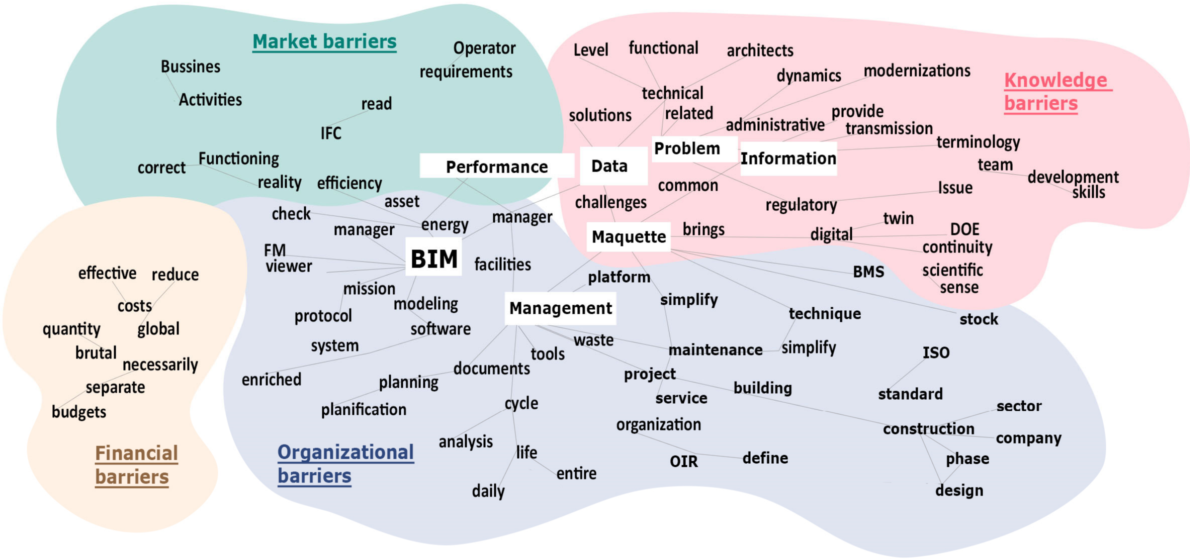

Figure 2. Co-occurrence network analysis from interview re-transcriptions.

The barriers have been categorized into subgroups based on the framework outlined in the literature review. Most of these barriers were also developed by M. Hosseini in the study of the BIM adoption barriers in Australian companies [62] or by C. Chan in terms of the barriers of implementing BIM in the construction industry in Hong Kong [63] but they have also been included in many other studies as shown in the following table. Upon examining the key obstacles discussed in each interview, the category of contextual barriers has been added to the analysis. The results of the interviews reveal that the primary factor contributing to the lack of implementation are the knowledge barriers, followed by the organizational barriers and the market barriers (Table 2).

Table 2. Barriers affecting BIM Implementation in FM.

Barriers Affecting BIM Implementation		Number of Interviews Addressing This Barrier	
Knowledge barriers	Lack of skills [62–67]	6	16
	Lack of experience and feedback [62,65,66,68,69]	3	
	Lack of data quality [66,70,71]	7	
Market barriers	Multiple non-interoperable existing tools [7,62,63,70]	7	8
	High cost of tools [62,63,72]	1	
Organizational barriers	Lack of FM requirements during design phase [65,71]	5	9
	Lack of procedures, methodologies, and readiness [62,66,67,69–71,73]	4	
Financial barriers	Lack of investment of the client and companies [62,63,65,67]	4	4
Contextual barriers	Gap between IT and society [25,31,33,74,75]	5	5

However, it is worth noting that organizational barriers linked to interoperability hold significant importance as well. This was previously illustrated in Figure 1, which showed the influence of these two types of barriers on the central themes of most discussions.

These barriers are closely associated with terms such as "data", "model", "information", "management", and "BIM". Surprisingly, financial barriers do not hold the same level of significance. The co-occurrence network analysis indicates that discussions related to financial barriers appear sporadically and remain somewhat detached from the broader discourse. This is notable despite their proximity to conversations revolving around organizational and market barriers.

3.2. Main BIM Barriers by FM Area

The next step in this study is to analyze the barriers to BIM implementation across different FM areas. Table 2 provides a summary of these barriers, categorized into four groups: knowledge, market, organizational, and financial. Table 3 uses this classification to further analyze the barriers by FM area. The FM areas examined include environment and energy performance, technical maintenance, administration, and city information management. Feedback from interview participants (E1 to E10) forms the basis of this analysis, offering a clear view of the specific challenges within each domain. This table will be analyzed in the subsequent sections, highlighting how barriers differ across areas and emphasizing the need for tailored solutions to address the unique requirements of each FM function.

Table 3. Barriers affecting BIM Implementation in FM by area.

Environment and Energy Performance		**E.1**	**E.2**	**E.3**	**E.4**	**E.5**	**E.6**	**E.7**	**E.8**	**E.9**	**E.10**	**Quantity**
Knowledge barriers	Lack of skills	■				■						9
	Lack of experience and feedback		■									
	Lack of data quality	■	■			■	■	■			■	
Market barriers	Multiple non-interoperable existing tools	■	■	■								3
	High cost of tools											
Organizational barriers	Lack of FM requirements during design phase											0
	Lack of procedures, methodologies, and readiness											
Financial barriers	Lack of investment of the client and companies											0
Contextual barriers	Gap between IT and society	■	■	■	■		■		■	■		7
Technical Maintenance		**E.1**	**E.2**	**E.3**	**E.4**	**E.5**	**E.6**	**E.7**	**E.8**	**E.9**	**E.10**	**Quantity**
Knowledge barriers	Lack of skills		■			■		■		■	■	12
	Lack of experience and feedback		■									
	Lack of data quality			■		■	■	■	■		■	
Market barriers	Multiple non-interoperable existing tools	■				■	■	■	■	■	■	10
	High cost of tools	■				■					■	
Organizational barriers	Lack of FM requirements during design phase			■		■	■	■	■		■	10
	Lack of procedures, methodologies, and readiness	■		■			■				■	
Financial barriers	Lack of investment of the client and companies	■	■						■		■	4
Contextual barriers	Gap between IT and society	■	■	■	■		■		■	■		7
Administration		**E.1**	**E.2**	**E.3**	**E.4**	**E.5**	**E.6**	**E.7**	**E.8**	**E.9**	**E.10**	**Quantity**
Knowledge barriers	Lack of skills			■								6
	Lack of experience and feedback											
	Lack of data quality			■			■	■	■		■	
Market barriers	Multiple non-interoperable existing tools			■				■	■			3
	High cost of tools											

Table 3. *Cont.*

Environment and Energy Performance		**E.1**	**E.2**	**E.3**	**E.4**	**E.5**	**E.6**	**E.7**	**E.8**	**E.9**	**E.10**	**Quantity**
Organizational barriers	Lack of FM requirements during design phase											2
	Lack of procedures, methodologies, and readiness								■		■	
Financial barriers	Lack of investment of the client and companies								■			1
Contextual barriers	Gap between IT and society	■	■	■	■		■		■	■		7
City Information Management (CIM)		**E.1**	**E.2**	**E.3**	**E.4**	**E.5**	**E.6**	**E.7**	**E.8**	**E.9**	**E.10**	**Quantity**
Knowledge barriers	Lack of skills	■				■						9
	Lack of experience and feedback		■	■	■	■	■			■		
	Lack of data quality							■				
Market barriers	Multiple non-interoperable existing tools	■						■			■	3
	High cost of tools											
Organizational barriers	Lack of FM requirements during design phase											0
	Lack of procedures, methodologies, and readiness											
Financial barriers	Lack of investment of the client and companies											0
Contextual barriers	Gap between IT and society	■	■	■	■		■		■	■		7

3.2.1. Environment and Energy Performance

The environment and energy performance area was mainly addressed during the interviews concerning knowledge barriers. The use cases considered by the practitioners in the environment and energy performance area focus on optimizing energy consumption through real-time monitoring and analysis of building systems [76,77]. They also include assessing and improving environmental impacts by simulating operational scenarios to enhance sustainability and ensure compliance with environmental certifications and standards, such as sustainable materials, life cycle analysis, and waste management [78,79]. Specifically, data quality was one of the main topics during the discussions about environment and energy performance. The respondents complained about the database they obtain after the construction of the building and how they cannot rely on it: "*I have thousands and thousands of assets, and I have no guarantee that the data or the geometry is true*" (E.7—Interview with BIM a consultant in a BIM consultancy firm and associate professor) or "*the problem is that the information we get it is not really consistent with the operating expectations*" (E.3—Interview with the director of development of a BIM collaborative platform for FM).

These barriers significantly affect the domain of environmental and energy performance. The absence of a reliable building database acts as a major impediment to conducting various analyses, such as life cycle assessments and evaluations related to the circular economy [76].

During the analysis of interviews, occasionally, the lack of skills was solely related to a specific domain: "*For energy management with the model, I have no idea how it works, and I find it difficult to envision*" (E.2—Interview with the director of a consultancy company for Facility Management). In these situations, the barrier of knowledge is due to the lack of skills as well as the absence of experience and feedback from other projects.

3.2.2. Technical Maintenance

Technical maintenance emerged as the FM area most affected by implementation barriers, which is consistent with it being the most developed. As a result, this area generated significantly more feedback during the interviews, covering all categories of barriers. The addressed use cases primarily focused on asset management, supported by the integration of IoT systems, and on preventive and predictive maintenance [15]. These maintenance strategies rely on the extensive data provided by digital twins, which are created through BIM in FM, to monitor asset performance, detect anomalies, or optimize maintenance schedules [80].

Stakeholders emphasized that technical maintenance is particularly impacted by organizational barriers. Organizational barriers are classified into three main categories: lack of established procedures and methodologies, absence of FM requirements during the design phase, and the high cost of tools [81]. The lack of standardized procedures has a compounding effect on skill development, as respondents reported feeling unprepared and often needing to develop their own methodologies to navigate these challenges: "*There are many ways to do it, we do it here with a 3 level hierarchy*: *Installation, utilization subgroup and then equipment*" (E.6—Interview with the head of digital transformation in an FM company), "*Depending on the client, the methodology varies, in some cases the model is intended to be integrated into the maintenance, but in others it is only partially integrated*" (E.3—Interview with the director of development of a BIM collaborative platform for FM), "*I don't know how BIM can allow me to optimize all this and what is the procedure*" (E.9—Interview with a public building facility manager specialized in prevention and security), "*the day will come when we will all agree on the data dictionary and how to call things. The ISO standard for the time, it defines the structure of data, but it does not define the information*" (E.10—Interview with an asset manager in a new technologies consultancy firm).

The late arrival of facility managers to the project and the lack of discussion during the design and construction phase were addressed in several interviews, however, participants only related this problem to the informational barriers this caused in technical maintenance. The facility managers' technical needs are not considered by designers: "*the models have been conceived for construction and are intended to be used for the facility, so they do not have the data in the form and quantity that we would like them to have*" (E.8—Interview with a director of a facility management company), "*it is necessary to anticipate the operating needs in the design specifications*" (E.2—Interview with the director of a consultancy company for facility management), "*Another problem is that the Facility Manager comes in late. I guess it's a classic in the whole world, he shows up too late, and he wants to set the requirements*" (E.7—Interview with a BIM consultant in a BIM consultancy firm and associate professor).

Stakeholders also denounce a lack of skills and knowledge regarding BIM tools: "*We need to assist maintenance teams; this will enable them to have more versatile technicians, even if they are not necessarily aware of everything, as long as they are well-trained*" (E.2—Interview with the director of a consultancy company for facility management), "The main issue is also that teams are not trained in BIM usage" (E.10—Interview with an asset manager in a new technologies consultancy firm), "We need someone responsible for updating the BIM model" (E.7—Interview with a BIM consultant in a BIM consultancy firm and associate professor).

Some of the practitioners were concerned about the prices of the tools and the economic difficulties in implementing them: "And today it's expensive, I think the professional federation of the building industry has measured the price of BIM implementation and it's expensive" (E.5—Interview with a developer of a BIM collaborative platform specialized in data management).

During the phases prior to the operations and maintenance phase, the implementation of BIM is less questioned from an economic perspective because the return on investment is more easily measured in the short term. However, operations and maintenance are a very long-term project and the return on investment is much more difficult to measure and ensure: "*. . . as FM is not a big project in which there is an important budget dedicated to it* etc., *it costs more to implement BIM, it is an investment that is difficult to justify to the client*" (E.10—Interview with an asset manager in a new technologies consultancy firm) or "*the clients do not have the capacity to provide the means to implement BIM, and it is not a priority for them either*" (E.2—Interview with the director of a consultancy company for facility management). However, many publications address the return on investment for the design and construction phases ensuring time saving advantages and improvement in the decision making process [82–84]. The financial barriers most of the time are linked to the high cost of the tools, however, while the price of tools it is a barrier imposed by the market, the lack of means and investment comes as a budget decision from the client or the contractors. Some clients who could afford these tools do not consider them useful enough or see them as a waste of money. Some of the interviewed practitioners claimed that the main problem is the lack of budgets taking into account the whole life cycle of the building: "*This will have expensive consequences because here (in France) we still do not work in global cost of the building*" (E.1—Interview with the director of building engineering and FM in an energy service company) or "*We should think: Maybe this will cost me more this year but in 5 years I will save money, but this concept in Spain costs a little bit*" (E.3—Interview with the director of development of a BIM collaborative platform for FM). Even if the FM phase is the longest and most expensive part of the project [7], the advantages linked to BIM implementation in FM are not yet widely accepted in the construction field. Despite the widespread recognition of BIM's benefits in FM, there is still a financial barrier on the part of clients to invest in developing digital capabilities [85]. The interviews reveal that client hesitation to invest impedes the implementation of these tools, despite their utility.

3.2.3. Administration

The use cases considered for the administration area primarily focused on documentation and record management, as BIM serves as a centralized digital repository that facilitates the structured storage, efficient retrieval, and systematic management of as-built documentation, contracts, warranties, and compliance records, ensuring data integrity and accessibility and contributing on the service planning of a building [86,87]. Regarding to the administration area, respondents also referred to the idea of avoiding the repetition of information in several tools because ultimately this generates inconsistencies between the data stored in each tool: "*We are of the opinion that the less synchronization required, the better. In other words, the information should be where it belongs without repetition (. . .) It is a mess, and we have to do some archaeological research to find out what information they have and where*" (E.10—Interview with an asset manager in a new technologies consultancy firm). This repetition of data with errors is inconsistent with the idea that BIM is a technology that aims to improve the reliability of data. Data reliability has been a major issue since the arrival of BIM in the construction industry even though there are multiple standards that aim to ensure the quality of data in BIM projects.

Another important obstacle identified in the interviews is the lack of interoperable tools: "*A big disadvantage of the FM platforms is to be able to work on IFC files, these platforms were designed, and this is basically a mistake on the part of the developers, to work only with native files*" (E.7—Interview with BIM consultant in a BIM consultancy firm and associate professor). Interoperability is a very important topic in BIM projects during all phases of the project. International Foundation Class (IFC) is the format that enables interoperability in BIM projects and, as Laakso states, its development is part of the research on information technology standardization [88]. The International Alliance for Interoperability (IAI) has faced many challenges in developing such an ambitious interoperability standard with few resources. The development of IFCs also had to confront some hindrances such as slow market adoption or low usage in actual construction projects so far [89]. In the phase of operations and maintenance, problems with interoperability can disrupt the flow of information between different stages. If the BIM format is not compatible with the platform, it can prevent the administration area from fully accessing the entirety of the project's information.

3.2.4. City Information Management (CIM)

The use cases for urban management in CIM and FM focused on integrating building-level BIM data with urban infrastructure and neighborhood information. This integration enhances the management of the building by providing access to relevant data on services such as transportation, climate, utilities, or land use, thereby facilitating informed decision making [90–92]. The problems in the implementation of CIM according to the participants include the lack of experience and feedback: "*For the CIM, I am less sensitive because we are used to working on the scale of the building and I have never worked on a urban larger scale with cartography*" (E.2—Interview with the director of a consultancy company for facility management) *or "for the CIM in facility management, currently, honestly, is very absent in our projects and we don't have any feedback on that*" (E.6—Interview with the head of digital transformation in an FM company). Most of the participants agree that CIM is not part of the current reality of construction projects even if it is more and more frequently requested by clients. Most publications describe the advantages of the communication between GIS and BIM tools since it allows the connection of BIM buildings in smart cities' grids. Nevertheless, there are currently difficulties concerning the interoperability of the tools due to the different structures of the databases [91,93,94].

The difficulties of implementation of GIS together with BIM are much more present in building projects since the space of design is not adapted to the territory scale, however, infrastructure projects and design tools in BIM have proven that merging these technologies is still possible [95,96].

3.2.5. Space Management, Health and Comfort, and Security and Safety

BIM enhances FM through its applications in space management, health and comfort, and security and safety since it provides real-time data on space utilization and occupancy, enabling efficient space allocation and layout optimization to meet organizational needs [97–99]. Additionally, BIM integrates environmental data, such as air quality and lighting, allowing facility managers to monitor and improve indoor conditions for occupant health and comfort [100–102]. Furthermore, BIM supports security management by incorporating building data into emergency response and access control systems, thereby improving safety protocols and ensuring regulatory compliance [103,104].

However, space management, health and comfort, and security and safety received less attention during the interviews. For instance, in terms of the security and safety category, no respondent mentioned it when discussing implementation barriers. Furthermore, some even proposed that the facilities management category was unrelated to BIM.

In addition, the interviews reveal that these stakeholders consider existing tools sufficient for managing space, health and comfort, and security. In the area of health and safety, facility managers failed to perceive the potential advantages of BIM, despite recent research highlighting its benefits through integrated use [105,106]. During the interviews, the respondents stated: "*Today the tools to manage comfort already exist [...] what can the BIM model bring in addition to all these tools?*" (E.2—Interview with the director of a consultancy company for facility management), "*For space management we already have a tool in place for that*" (E.4—Interview with a project manager of building management in a multinational company), *or "Managing the space is something almost everyone already does to some extent (without BIM)*" (E.8—Interview with a director of a facility management company). Even though, during the interviews, the need for connecting all the existing tools in these FM areas was observed, only a viewer role was required rather than functioning as a source of information: "*You have to understand that in no way BIM replaces operating tools, it just puts the point together and makes information accessible in a more visual way*" (E.6—Interview with the head of digital transformation in an FM company).

Some actors try to justify why the existing tools are sufficient to develop their work and the introduction of BIM does not bring many benefits. The fear of change due to the introduction of BIM has already been identified in the thesis of H. Gless [107] who explains that actors are afraid of the negative changes that BIM could bring, the loss of autonomy, or the loss of power, especially for architects. This fear is present in all phases and causes informational ruptures between them when the actors of the next phase do not feel ready to recover the digital model of the building and stop the BIM process.

3.2.6. Contextual Barriers: The Gap Between IT and Society

Contextual barriers represent an additional category that impacts all areas of FM simultaneously. When addressing the identified barrier related to the gap between IT development and society, the interviewed professionals referred to all FM areas collectively. This highlighted its cross-cutting nature and its influence on multiple domains at the same time. For this reason, the gap between technological advancements and societal development has been analyzed separately. The first interview addressed this obstacle at the beginning: "*The disconnection between the development of IT and society is evident in many projects, where people claim they are doing BIM, but in reality, they are doing very little of it*" (E.1—Interview with the director of building engineering and FM in an energy service company).

Besides the barriers to implementation that have been previously analyzed, some participants were resistant to adopting BIM, driven by the unrealistic marketing, publicity, or conferences they have attended: "*In BIM many things sound a bit like science fiction, at least from what I see in my environment*" (E.8—Interview with a director of a facility management company), "*Some consultants are selling something unrealistic; they are selling the moon because for them the moon is accessible but for the rest is not accessible*" (E.2—Interview with the director of a consultancy company for facility management), *or "Today, in the field of facility management, everyone is talking about uses such as virtual reality,* etc.*, but at the end of the day, many of them are not yet applied and it is still difficult to implement them*" (E.1—Interview with the director of building engineering and FM in an energy service company).

The interviewed practitioners claim there is an existing gap between reality and BIM marketing. In the professional world of BIM today, it is difficult to discern at conferences and in the professional press what corresponds to the reality of the profession and what is mere prospecting or even imagination, as is the case, for example, of some professional conferences or advertisements. It is necessary that developers do not exceed the expectations set by their advertisements [108]. In many cases, this gap is also tied to unrealistic expectations that are not met [109]. In the same way, some researchers demand that BIM education in architectural and engineering schools should not be detached from the realistic context of building projects and that students should work with information of real-world cases [110].

Besides the above barriers, the gap between technology and society was a concern that emerged repeatedly during these interviews. Technology is evolving rapidly, and it is difficult for stakeholders to imagine the future needs of facility managers in terms of information and tools in the next 10 to 20 years: "*in terms of administrative data, do we really know today what will be the use tomorrow and what we will need?*" (E.2—Interview with the director of a consultancy company for facility management).

The introduction of new information technologies in the field of construction is also related to the transformation of society during the information age [111] and yet, most of the time, information technology evolves faster. The professionals interviewed warn about the speed of technological development and the gap this produces with society and the reality of the building site.

Society evolves, but sometimes technologies develop faster than society and a gap appears between the two, as was the case with Google Glass. D. Corpellet explains that, in 2015, Google was forced to withdraw connected glasses from the market because users felt spied upon [112]. In this case, the anthropological filter held back technological advances, but this is not always the case, and engineers and developers of new software also have a responsibility for the social impact of their tools, as E. Sadin explains in his book on the siliconization of the world [113].

Facility managers do not currently know what their future needs will be or what new operating tools will be developed, and this translates into a great uncertainty about what they need to ask of the executing companies in order to achieve high-performance management in 20 years' time. At the same time, they warn that BIM in operations and maintenance is currently not widespread and will take time to become widespread.

This topic also impacts simulations with the digital model. For example, it is now known which properties are necessary for air quality analysis or circular economy analysis; but perhaps there are aspects that are not currently considered that will be needed in analyses in the future. Several issues such as artificial intelligence, sustainable buildings, or the Internet of Things are the core of the future of operations and maintenance [114]. However, it is difficult to currently measure the impact of these transformations and the technology that will accompany them in a few years.

4. Discussion

The interview results indicated that a lack of skills impacts nearly all FM areas. This skills gap in the FM sector is often associated with its traditionally rigid cultural approach to adopting new technologies [71,115]. The lack of BIM skills in FM is linked to the academic background of architecture and engineering schools, which still face difficulties in integrating BIM into their courses. The main problem is that this technology is simply seen as a new tool and not as a complete change in methodologies, due to the introduction of informational tasks in the construction process, which has an impact on professions [116,117]. Furthermore, the way data from digital twins are utilized really depends on the specific area within FM, as each domain has distinct requirements and objectives. Therefore, having comprehensive training and knowledge about the specific areas of FM also appears crucial for effectively leveraging digital twins and other technologies in practice.

Furthermore, regarding knowledge barriers, in operations and maintenance, the quality of the data is also important to perform corrective maintenance actions that consider the reality of the building [118] or to provide the client with strategic asset management [119]. The problems related to the recovery of useful and reliable data for operations and maintenance are also related to the centralization of tools that proposes the operations and maintenance in BIM. This working methodology requires dialogue with all FM tools or at least finding gateways or connectors between them such as those proposed by Y. Jin for maintenance in virtual reality [120]. In this context, interoperability is a major issue, even though Revit is one of the most used pieces of software in architectural agencies, design offices, and construction companies in both France and Spain [28,121]. Public policies on BIM currently defend open-source formats, and in France the Plan de Transition Numérique du Bâtiment, currently Plan BIM 2022, has developed tools and working methodologies to promote exchanges in IFC [122–125]. These policies emerge facing monopolies that try to impose software that is very expensive, limiting access by small companies which do not have sufficient resources to purchase these licenses. Additionally, open formats allow for the integration of more tools from different FM areas, enabling greater flexibility and fostering collaboration across various technologies.

Interoperability is ultimately a technological, organizational, and even economic problem that is very difficult to address. However, the development of tools or digital models that are not interoperable causes the loss of data or even the entire database in BIM projects. Furthermore, the price of some BIM software can exclude small companies from the "BIM market", a situation already identified by A. Dainty in the Anglo-Saxon context [126]. During the operations and maintenance of the assets, the introduction of BIM becomes expensive because of the price of software, the training and upgrading of skills of maintainers, and the creation of a BIM group that can allow the updating of models during possible renovations or interventions by maintainers. In addition, the entire ISO standard also encourages the use of open-source formats and advocates interoperability between all tools. This aspect becomes especially important in the operations and maintenance phase when, theoretically, the operators are supposed to receive a compiled IFC model of the building. However, this is not always the case, as the use of IFC remains problematic, as highlighted by the interviews with various actors in the operations and maintenance phase. Additionally, each area may require different functions and tool development, and attempting to address interoperability as a whole may not have the most effective impact. Tailored approaches for each specific area could be more beneficial in overcoming these challenges.

Moreover, the survey participants revealed difficulties in accessing BIM standards and "best practices". However, this result contrast with the high number of norms and standards published in recent years. Standards are defined by ISO 19650, and they group together the information requirements necessary to ensure information continuity throughout the project. As far as data structuring is concerned, ISO 19650 imposes the ISO 12000 classification which is very similar to the uniclass or omniclass classifications. At the same time, these requirements are very useful for asset managers to understand what they can ask for in BIM projects [127]. Consequently, a gap exists between the current norms and stakeholders' perceptions [128]. It is also possible that some stakeholders have not had access to the ISO, that the standards do not address specific area-related issues, or that their status as non-legally binding standards reduces their perceived importance among industry professionals.

The results also identified a gap between actors and between phases which could be influenced by the training in engineering and architecture schools. The concepts of life cycles and the operations and maintenance of buildings are very rarely included during training courses in architecture schools [129]. As a result, two worlds have developed, before and after delivery of the building. The actors between the design and construction phases speak the same language and use similar tools, but this is not the case during the operations and maintenance phase where actors face gaps in vocabulary, tools, skills, and uses. In this context, G. Kelly explains that the gaps between these phases is also related to the different temporalities of construction projects and those of operations and maintenance [130].

5. Conclusions

This study investigates the barriers to adopting BIM in FM, employing a novel approach that addresses the diversity within FM areas. The findings emphasize that BIM implementation in FM is not uniform; tailored strategies are necessary to address the specific needs of each domain. The research revealed several pervasive challenges across

FM areas, including the lack of BIM skills and the exclusion of FM requirements during the design phase. These issues highlight a systemic gap between the design/construction and operations/maintenance phases, further exacerbated by insufficient integration of FM concepts into academic curricula and professional training programs. Broader systemic challenges also hinder BIM adoption. Unrealistic marketing claims have created skepticism among FM professionals, while the rapid pace of technological advancements has outpaced societal readiness, leading to uncertainty about future needs and tools.

This study contributes both practically and theoretically to the understanding of BIM adoption in FM. From a practical perspective, the findings emphasize the importance of tailoring BIM implementation strategies to the specific needs of diverse FM areas, providing actionable insights for professionals and policymakers. The study also highlights critical barriers by FM area, offering a roadmap for targeted interventions to improve BIM integration in operations and maintenance. Theoretically, this research enriches the existing literature by adopting an area-specific approach to BIM in FM, moving beyond generalized analyses to reveal nuanced insights into the adoption process.

The findings also highlight area-specific barriers, demonstrating the need for distinct strategies to overcome these challenges in different FM domains:

- Poor data quality in the environmental and energy performance area restricts the ability to conduct life cycle assessments and implement effective energy optimization strategies, making it a major obstacle for facility managers.
- The absence of standardized procedures and the late involvement of facility managers in early project stages hinder the effective adoption of BIM in technical maintenance, creating organizational challenges that complicate workflows and integration.
- Interoperability issues and inconsistent data across platforms undermine the reliability and efficiency of administrative processes, preventing seamless management and reducing the perceived value of BIM in the administration area.
- In city information management, limited experience and feedback on the integration of BIM with GIS technologies create barriers restricting its potential for urban-scale applications and smart city development.
- In areas such as space management, health and comfort, and safety and security, traditional tools are still perceived as sufficient. BIM's value in these domains is often underestimated, as its primary perceived benefit is enhanced visualization rather than deeper integration into workflows. Greater awareness and research of BIM's potential in these areas are needed.

From a global perspective, the most significant changes to facilitate BIM adoption should focus on modifying educational programs to better integrate FM concepts and BIM technologies, ensuring that future professionals are equipped to bridge the gap between the design/construction and operations/maintenance phases. Moreover, addressing the issue of unrealistic marketing is vital to set clear and achievable expectations among stakeholders. Complementing these global reforms, the study underscores the importance of an area-specific approach to BIM integration. Each area is highly specialized, with distinct tools and challenges, requiring tailored analyses.

This study provides practitioners with a framework to analyze each FM area from two perspectives: the overarching barriers to BIM adoption and the specific challenges unique to their domain. Barriers should be assessed based on their impact, and while contextual barriers or knowledge areas can be addressed through a global approach, ensuring BIM adoption across all areas requires consideration of specific characteristics. By recognizing and addressing the distinct barriers faced by each FM area, stakeholders can implement targeted strategies that align, for example, with specific data or interoperability requirements. The particularity of this approach lies in recognizing that, in a world inundated with vast amounts of data, we often overlook the importance of in-depth and tailored analysis, which prioritizes a more human-centric perspective. This ultimately facilitates broader and more effective implementation across all FM domains.

While this study provides valuable insights, it has some limitations. The research focuses exclusively on practitioners in France and Spain, which may narrow the cultural and regulatory contexts of the results. Future research should broaden the scope by incorporating more diverse geographic regions and a more balanced participant pool. Longitudinal studies could further explore the progression of BIM adoption over time within each FM area and assess the effectiveness of targeted interventions. Moreover, future research could examine the potential of emerging technologies, such as artificial intelligence, to address challenges in FM areas like administration and CIM, particularly in enhancing database management.

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