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Facilities Management Digitalisation Model: A Systematic Literature Review

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Abstract
Facility or facilities management (FM) helps ensure that the built environment is efficient, safe, comfortable, and sustainable. The goal of FM is to raise productivity and improve people's quality of life. FM involves working with a variety of service providers to ensure that buildings and associated facilities are well maintained. The role of the facility manager is becoming more prominent in a digitally enabled world. The recent pandemic has boosted the rate at which innovation is being embraced in most organisations. This research will look at the current trends in FM that are emerging as a result of digitalisation. The main objective of this research is to propose the FM digitalisation model, which might influence future FM practices. This systematic literature review is based on a search of articles across Scopus and Google Scholar using keywords such as "facilities management" and "digitisation". On July 6th, 2022, the searches yielded 614 articles, including 64 articles in Scopus, 113 articles in WoS, and 437 articles in Google Scholar. After screening, 29 Scopus articles, 93 WoS articles, and 398 Google Scholar articles were excluded. According to this study, the field of FM digitalisation is still in its early stages of development. The study also identifies FM digitalisation trends over the previous twelve years, establishing contextual knowledge. As a result, a conceptual model that focuses on sustainable FM digitalisation is proposed.
Keywords: Facilities Management, Digitalisation, Systematic Literature Review, Building Information Modelling, Internet of Thing

Introduction

The discipline of facility or facilities management (FM) focuses on supporting people. It helps ensure that the built environment is efficient, safe, comfortable, and sustainable. Integrating people, places, and processes within the built environment is the role of FM in an organisation. The goal of FM is to raise productivity in the core business while also improving people's quality of life (Alsayyari et al., 2019). Since FM is a sophisticated network of expertise that requires thorough coordination, many firms and property owners choose to outsource the responsibility to third-party companies (Ibrahim & Hassanain, 2022). In turn, the vendor collaborates with a variety of service providers to ensure that buildings and associated facilities, such as plumbing systems, mechanical and electrical systems, are well-maintained and work properly. Today, advanced technology in the built environment and FM is evolving and becoming more innovative (Li et al., 2019).

Trends in Facilities Management and Digitalisation

In addition to buildings becoming smarter year after year, there is greater pressure to invest in sustainability and digitalisation. This is linked to the health crisis that has hit the world, where epidemics and infectious diseases always surround human life (Ibn-Mohammed et al., 2021). Thus, in order to meet the expanding technological demands of the digital era, new regulations, demands for new building functions and layouts, contracts with suppliers, and performance management agreements are all required. In fact, the role of the facility manager is becoming more prominent. Furthermore, they are shifting from the operational level to the strategic level. Therefore, facility managers should see this situation as an opportunity to improve and support the organisation's strategic policy. All of this points toward the idea of realising the most value at the lowest price, or best value procurement.

Therefore, most FM organisations assume that soon there will be significant changes in FM practices. This situation demands a focus on the need to consider the influence of digitalisation when reviewing existing or new Service Level Agreements (SLAs).The world is rapidly becoming digitalised. While technology adoption has ordinarily been slow, the recent pandemic has boosted the rate at which innovation is being embraced in most organisations (Ashworth, 2020). New technologies have changed business models and forced organisations to rethink their operations. This is affecting all sectors of the economy, disrupting some while improving others. Interestingly, it appears that this pattern will continue to happen.

Similarly, FM digitalisation has evolved significantly. This revolution will continue to reshape FM organisations' operations, from maintenance to customer service (Lee et al., 2021). As a result, workplaces and service delivery are expected to become smarter and more efficient. Embracing innovations such as the use of drones for inspection of building facades, automated cleaning robots, and smart sensors are being facilitated to rapidly transform the built environment. Technologies including machine learning, artificial intelligence (AI), the Internet of Things (IoT), and sensors will undoubtedly define a new future for the FM industry (Ali et al., 2021). As a result, this research will look at the current trends in FM that are emerging as a result of digitalisation. These trends are then conceptualised in order to propose a FM Digitalisation Model.

Methods

The main objective of this research is to propose the FM digitalisation model, which might influence future FM practices. Thus, this systematic literature review is based on a search of articles across scientific databases such as Scopus, Web of Science, and Google scholar using

keywords such as “facilities management” and “digitisation”. These key concepts from the research protocol compose the search string together with Boolean operators AND/OR. The exact search string used is (“Facility management" OR "Facilities management") AND ("Digitalisation") OR ("Digitalization") OR ("Digitisation"). The primary search turned up an enormous number of articles. The articles that were searched were further filtered in a strict research protocol.

The research protocol uses specific exclusion and inclusion criteria in order to find the most pertinent and highly useful content. All the articles published between 2010 and 2022 reach saturation in terms of concept identification. In addition, this protocol only accepts common types of academic publication, such as journal articles, books, book chapters, and conference articles. Details of the research protocol are shown in Table 1.

The searches were conducted on July 6th, 2022, and the results were 614 articles, consisting of 64 articles in Scopus; 113 articles in WoS; and 437 articles in Google Scholar. Then, their titles and abstracts were screened and excluded if those titles didn't contain any of the keywords. After screening, 29 articles from Scopus; 93 articles from WoS; and 398 articles from Google Scholar were excluded.

Next, 96 articles from the chosen databases that were duplicates of one another were excluded, leaving 76 articles that were eligible for the following step. In addition, 21 articles were removed due to not being related to FM and digitalisation exclusively, and the idiom was other than English. As a result, 55 high-quality articles were included and selected for the systematic review. Details of the Prisma flow for FM Digitalisation are shown in Table 2.

Table 1
Research protocol.

ITEM	CONTENT
Aim / Key-objective	To identify theories of facilities management digitalisation in articles published between 2010–2022
Research Questions	What is the theories of facilities management digitalisation?
Search Methods (Electronic Databases)	Scopus; Web of Science & Google Scholar
Keywords	(("Facility management" OR "Facilities management") AND ("Digitalisation") OR ("Digitalization") OR ("Digitisation"))
Year of publication	2010–2022 inclusive
Type of publication	Articles, books, book chapters, conference papers.
Idiom	English
Exclusion criteria	• Not related to FM and digitalisation • Outside the defined period • Abstract not available for download • Not written in the defined idioms
Data extraction	Excel spreadsheets to track papers and status based on the protocol. One reviewer (author) to action.

Narrative Synthesis	Bibliometric Analysis:
	• Geographical location of authors.
	• Publications over time.
	• Publications’ distribution in journals.
	• Methodology applied.
	• Thematic Analysis:
	  • Analysis of selected publications: building type, research focus, people, process or IT research.
	  • Description of findings, outcomes and relationships.

Table 2
Prisma flow for FM Digitalisation.

IDENTIFICATION	*Record identified through SCOPUS database searching, (n =64)*	*Record identified through WOS database searching, (n = 113)*	*Record identified through Google Scholar database searching, (n = 437)*
SCREENING	*Records excluded after title and abstract screened, (n = 29) Records screened, (n =35)*	*Records excluded after title and abstract screened, (n = 93) Records screened, (n =20)*	*Records excluded after title and abstract screened, (n = 398) Records screened, (n =41)*
	Records excluded duplicates (n = 96) Records screened after duplicates removal (n = 76)		
ELIGIBILITY	*Records excluded (n = 21) due to:* • Not related to FM and digitalisation • Outside the defined period • Abstract not available for download • Not written in the defined idioms *Full-text articles assessed for eligibility (n = 55)*		
INCLUDED	*Studies included in systematic review (n = 55)*		

Results and Discussion

A quantitative approach to the description, evaluation, and monitoring of published research was used in bibliometric analysis. These methods establish a rigorous, systematic, and transparent review process that improves the quality of reviews. Figure 1 shows the distribution of publications by year included in this systematic review. It appears that publication on digitalisation in FM in particular began to develop in 2015. In 2021, the total number of publications was 25. So far, in the second quarter of 2022, there were records of 11 publications and expected will go beyond the current records.

Meanwhile, Figure 2 shows the detailed distribution of the publisher for each publication. The study further identified that over the span of the study period, Emerald Publishing Limited, Elsevier, and MDPI published a large number of articles on digitalisation in FM. Additionally, it shows a significant rise in the quantity of publications in the IEEE, IOP Publishing, and Springer journals.

Precisely, the publications of articles in peer-reviewed journals and conferences demonstrate that the Journal of Facilities under Emerald Publishing Limited is in the lead. The Journal of Facilities Management, published by Emerald Publishing Limited, the Journal of Building Engineering, published by Elsevier, and both Applied Sciences and Sustainability, published by MDPI, followed in that order. The detailed distribution of the articles within specific journals is demonstrated in Figure 3.

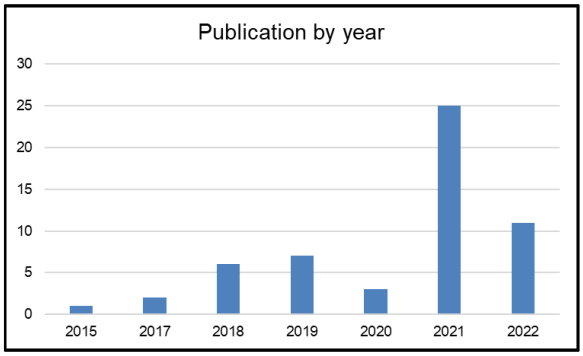

Figure 1. Distribution of publication on digitalisation in FM by year.

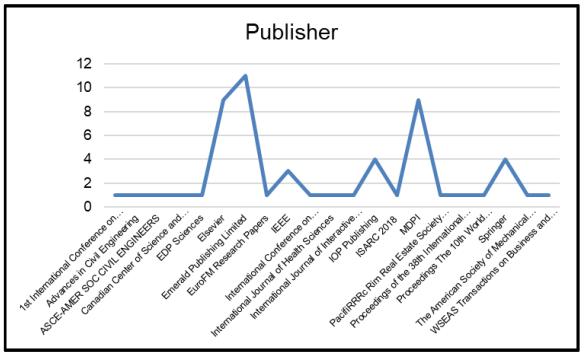

Figure 2. Distribution of publisher per publication.

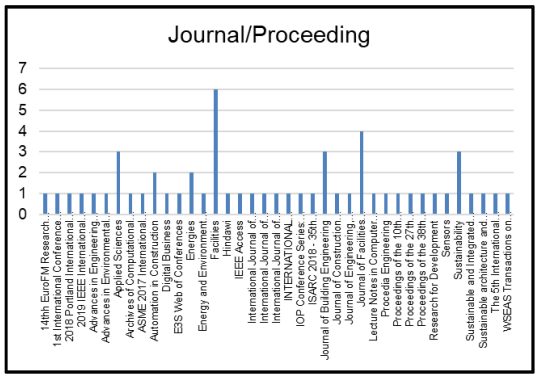

Figure 3. Distribution of Journals per publication.

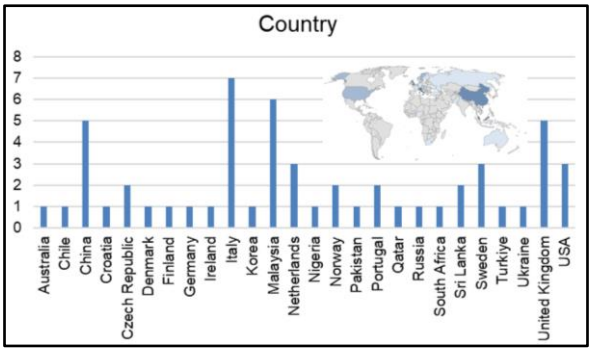

Figure 4. Distribution of authors country per publication.

The articles were then categorised in accordance with the publications' distribution of authors' countries in Figure 4. It reveals that authors from Italy are among the most widely published authors. Then, they were followed by authors from Malaysia, China, and the United Kingdom. Nevertheless, the USA, Sweden, and the Netherlands are likely to break the record. As a summary, Figure 4 provides us with the information that the majority of articles have been published in Western European nations. Additionally, the remaining nations demonstrated that there would likely be opportunities for future research on the topic in their regions as well.

Table 3
Classification of research themes.

Author(s)	BIM	H-BIM	BC	DT	COBiE	CFMDS	IoT	SOA	AI	ML	ST	BEM	CAFM	MEP	CRM	DCDE	KBE	IHS	SWT	VPBI	RCT	GIS	SC	IFM	UAVS	PSTs	AR	VR
(Babalola, Musa, Akinlolu, & Haupt, 2021)	X	X	X	X	X																							
(Pun, Choy, & Lam, 2018)						X																						
(Tang, Shelden, Eastman, Pishdad-Bozorgi, & Gao, 2019)	X						X	X																				
(Pinti, Codinhoto, & Bonelli, 2022)	X																											
(Orooje & Latifi, 2021)	X						X		X	X																		
(Muhammad & Mustapa, 2020)	X																											
(Hosamo et al., 2022)	X			X																								
(Jensen & Van Der Voordt, 2015)											X																	
(Khan & Ali, 2022)	X											X																
(Rudl, 2021)													X															
(Dwivedi et al., 2021)									X	X																		
(Di Filippo, Cotella, Guida, Molina, & Centarti, 2021)	X				X																	X						
(Hu, Tian, Li, & Zhang, 2018)	X													X														
(Ghadiminia, Mayouf, Cox, & Krasniewicz, 2022)	X														X													
(Liu, Chi, Osmani, & Demian, 2021)	X		X																				X					
(Matarneh, Danso-Amoako, Al-Bizri, Gaterell, & Matarneh, 2019)	X																											
(Asare, Liu, & Anumba, 2022)	X																											
(Mannino, Dejaco, & Re Cecconi, 2021)	X			X			X																					
(Ye, Yin, Tang, & Jiang, 2018)	X		X				X									X												
(Bergonzi, Colombo, Rossoni, & Furini, 2018)							X										X											

(Maki, Alshaikhli, Gunduz, Naji, & Abdulwahed, 2022)							X											X										
(Shaw et al., 2021)							X												X									
(Araszkiewicz, 2017)	X						X																					
(Atta & Talamo, 2020a)	X						X																					
(Ozturk, 2021)				X																X								
(Hou, Remøy, & Wu, 2021)		X		X																								
(Karki & Porras, 2021)							X				X																	
(Proskurin & Vorobeva, 2019)							X										X											
(Vigren, Kadefors, & Eriksson, 2022)							X										X											
(Kwok, Wong, Ge, & Xiangjian He, 2018)	X						X														X	X						
(Gunasekara, Sridarran, & Rajaratnam, 2022a)			X				X																					
(Lindkvist, Temeljotov Salaj, Collins, Bjørberg, & Haugen, 2021)							X																X					
(Casini, 2022)	X			X			X		X																	X	X	
(Atta & Talamo, 2020b)							X																X					
(Nataliia, Barzylovych, Zabolotna, Boiko, & Rybchych, 2021)							X																					
(Johannes et al., 2021)																								X				
(Jofré-briceño, Rivera, Atencio, & Herrera, 2021)	X																								X			
(Johannes, Voordijk, Wakkee, & Aranda-Mena, 2022)							X																					
(Saleh, Rased, Rijal, Ali, & Talmizi, 2021)																								X				
(Sivanuja & Sandanayake, 2022)							X																	X				
(Ali et al., 2021)							X																					

(Altohami, Haron, Ales@Alias, & Law, 2021)	X						X	X																			
(Lee et al., 2021)							X				X												X				
(Koch, Hansen, & Jacobsen, 2019)	X						X																				
(Petri, Kubicki, Rezgui, Guerriero, & Li, 2017)	X											X															
(Xu et al., 2020)												X													X		
(Tan, Loo, Zainon, Aziz, & Mohd Rahim, 2022)	X		X																								
(Sidani et al., 2021)	X																									X	
(Sidani et al., 2019)	X																										X
(Pavlík et al., 2021)							X										X										
(Bröchner, Haugen, & Lindkvist, 2019)							X				X																
(Matheri, Ngila, Njenga, Belaid, & Van Rensburg, 2019)							X				X	X															
(Wan Siti Hajar, Syahrul Nizam, & Nurshuhada, 2022)	X																X										
(Krämer & Besenyoi, 2018)	X						X																				
(Khudhair, Li, Ren, & Liu, 2021)	X						X																				

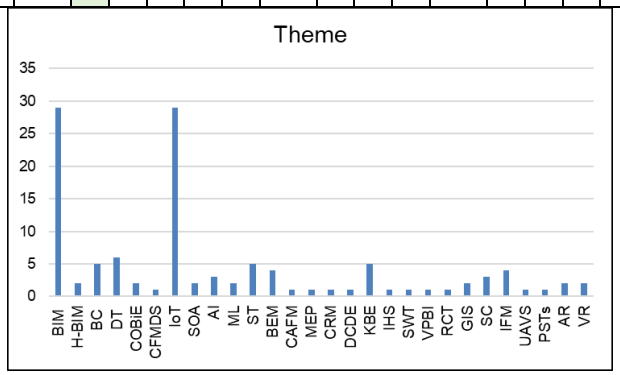

Figure 5. Distribution of themes per publication

The classification of FM digitalisation research themes is shown in Table 3 and Figure 5. As a result,, the primary determinants that contribute to the development of a sustainable model for FM digitalisation are described below.

Building Information Modelling (BIM) and the Internet of Things (IoT) - In first place, Building Information Modelling (BIM) and the Internet of Things (IoT) are the most researched themes. In the architecture, engineering, and construction (AEC) industries, BIM is the main foundation of digital transformation (Babalola et al., 2021). The IoT refers to a network of physical objects that are embedded with sensors, software, and other technologies. This function is required in order to connect to and exchange data with other devices and systems via the internet (Wong et al., 2018). The built environment is catching up with the digital revolution that has boosted productivity in virtually all economic sectors. The focus of BIM lies on exchange of documents, often through proprietary formats exchanged using the Industry Foundation Classes (IFC) and other tools such as CAD/CAM software (Werbrouck, Pauwels, Beetz, & Van Berlo, 2019). Following that, there is a growing interest in other areas of digitalisation that will be explained in the next section.

Blockchain (BC) - The Blockchain (BC) is a digital ledger where no service provider handles the data and all blocks are linked together to check and verify all transactions (Tavares et al., 2020). BC is also one of several technologies that appear to enable FM digitalisation. BC can be used to effectively share and protect data while improving interoperability and lowering costs. It can also be used to improve the procurement process. BC can provide efficient and secure record-keeping, which is beneficial for long-term records of FM activities (Gunasekara et al., 2022b).

Sustainability (ST) - Sustainability efforts are related to a firm's strategic positioning, reputation and experience, and hiring/employment policies, while profit margins are not higher in sustainable projects compared to traditional projects (De Paula, Arditi, & Melhado, 2017). Sustainability in FM is more than just reducing energy consumption, productivity increases, waste reduction during the operation and maintenance phases (Hodges, 2005). All FM supporting services must improve the FM customer's sustainability. As a result, the contribution of FM to the customer's sustainability must be measured in its own system. In response to these demands, the GEFMA (German Facility Management Association) working group "Sustainability in Facility Management" plans to publish a guideline on measuring and managing sustainability in FM processes (Pelzeter, 2013).

Knowledge Based Engineering (KBE) - FM inherits an understanding of how businesses operate as value-creating entities. This value is created through activities classified as core business and non-core business (Waheed & Fernie, 2009). A knowledge-based legitimisation that marks the transition from FM knowledge to an organisation-wide knowledge base. One of the most valuable assets of an FM organisation is the existing knowledge that is available to every staff member within the team. This knowledge has a positive impact on improving organisational performance (MohammadAli et al., 2018). Hence, digitalisation of FM can also be achieved by leveraging knowledge-based engineering (KBE), which increases the competitive advantage of FM organisations. KBE is an amalgamation of object-oriented programming, artificial intelligence (AI), and computer-aided design (CAD). KBE in FM introduces knowledge management (KM) in related engineering projects that have the potential to improve overall FM operational efficiency and effectiveness (Paul et al., 2014).

Integrated Facilities Management (IFM) – Additionally, the consolidation of FM efforts under a single, unified team is known as integrated facility management (IFM). This includes

contracts, vendor partnerships, space management, and real estate planning. IFM is one of many services that are gearing up to be digitised. The new technologies focus on providing better working opportunities for IFM and increasing profit for organisations. IFM improves FM practise by providing extensive underlying technical foundations, particularly standardised data models that allow information sharing between computer applications, automated workflow, increased workplace productivity, improved energy efficiency and streamlined compliance functions (Yu et al., 2000).

Building Energy Management (BEM) – The energy management team in most FM organisations uses the building management system (BMS) to store, integrate, and analyse data from multiple site sources, such as building specifications, environmental climate, and energy consumption. The energy management team will monitor the website, synchronously access data from various site sources and stages. They also execute building performance analysis and certification in accordance with the building code and building performance requirements. They also carry out building performance analysis and certification in accordance with building codes and performance requirements. The team will then provide feedback to the control layer and management. This will assist managers in making accurate and efficient decisions, such as those regarding energy management (Gerrish et al., 2017; Wang et al., 2019).

Computer Aided Facility Management (CAFM) – The main purpose of computer aided facility management (CAFM) is to create a centralised and comprehensive source of facility information. CAFM is a computerised network system that connects graphic and non-graphic information. At least 2D-CAD drawings of most major buildings in developed countries are available digitally. These drawings are frequently already linked to a CAFM-system database (Walder, 2006). Previous research has found that FM professionals are hesitant to use CAFM applications. However, the digitalisation boom is expected to transform this perception, considering its benefits for FM operations (Saengratwatchara & Elsworth, 2008).

Construction Operations Building Information Exchange (COBiE) - The idea of CAFM led to the development of the Construction Operations Building Information Exchange (COBiE). The central concept of COBiE is to incrementally collect and systematically store relevant information in digital form as it emerges in the project. The specification outlines procedures and data needs that make it easier to transfer certain data from the design and construction stages to the FM stage. The handover includes a large number of paper or e-paper documents. But extracting FM-relevant information from these documents is thought to be time-consuming (Babalola et al., 2021; Di Filippo et al., 2021).

A cloud-based fuzzy multi-criteria decision support system (CFMDS) – No doubt, procurement in facilities management is a critical process for identifying the best suppliers and contractors. It can improve resource allocation efficiency, equipment reliability, and facility conditions to reduce business risks and increase asset and building value. A cloud-based fuzzy multi-criteria decision support system (CFMDS) is proposed for integration with the procurement process. It would provide award analytics to find the best supplier and contractor. Based on the recommended outcomes, the procurement officer can then develop a follow-up plan (Pun et al., 2018).

Service-Oriented Architecture (SOA) - Service-Oriented Architecture (SOA) is a paradigm for organising and implementing distributed capabilities managed by multiple ownership domains. Each application includes a set of reusable services as well as a business process. SOA introduces numerous new challenges to organisations, posing significant risks to their operations (Blanco et al., 2007; Kang & Baik, 2010; Perrey & Lycett, 2003).

Artificial Intelligence (AI), Machine Learning (ML) and Digital Twin (DT) - The AEC industry has seen an increase in the adoption of digital twin (DT) technologies in general due to their potential to improve collaboration and information communication throughout the project lifecycle until the FM stages. The empirical evidence on such adoption in FM activities, however, is fragmented. By providing a real-time status of the building assets, DT technologies enable efficient and responsive planning and control of FM activities (Zhao et al., 2022). Furthermore, DT merges Artificial Intelligence (AI), Machine Learning (ML), and data analytics to create dynamic digital models that can learn and update the status of their physical counterparts from multiple sources (Hosamo et al., 2022; Wong et al., 2018; Zhang et al., 2022).

Intelligent Mechanical, Electrical and Plumbing (MEP) - BIM could be used to provide a comprehensive as-built building model containing Mechanical, Electrical and Plumbing (MEP) related information. Efforts should be made to broaden the scope of the proposed system's application. Increased demand for BIM-based OM management of the MEP system would stimulate system improvement (Hu et al., 2018).

Cybersecurity-Risk-Matrix (CRM) - The Cybersecurity-Risk-Matrix (CRM) framework encourages FM organisations to integrate cybersecurity into all aspects of their operations. BIM-FM can benefit from the development of process models to facilitate the accumulation of knowledge, skill sets, awareness, and culture required for cybersecurity implementation in FM (Ghadiminia, 2021; Parn & Edwards, 2019).

Decentralized Common Data Environment (DCDE) - The decentralisation of data and applications will enhance a more general adoption of Big Open BIM and is expected to lower the BIM threshold for smaller companies. This includes standardised data representations, role- or actor-based authorisation and authentication and the need for modular and extensible applications. It acts as an interface to a distributed Common Data Environment (DCDE) that also allows the generation of multi-models (Werbrouck et al., 2019).

Innovative Healthcare Solutions (IHS) - The COVID-19 pandemic has accelerated digital transformation in healthcare facilities utilising Innovative Healthcare Solutions (IHS). However, the successful evolution of IHS has revealed concerns about the digital distribution of medical information along the patient care pathway (Maki et al., 2022). Despite the challenges, AI, big data, distributed systems in healthcare facilities must be further driven to ensure on demand healthcare services, cost and process efficiency and immediate interaction with caregivers.

Semantic Web-based Technologies (SWT) - It has been demonstrated that using Semantic Web-based Technologies (SWT) to support digital FM activities can assist in the resolution of technical issues between disciplinary stakeholders. Despite this, there is no comprehensive

review that examines works with a particular emphasis on the FM domain. Since, SWTs have already been used by FM practitioners, and because their implementation is highly case-specific, developments must be designed to be flexible and user-oriented (Shaw et al., 2021).

Virtual-Physical Building Integration (VPBI) - In the built environment sector, virtual models have proven to be extremely useful and important. However, almost all of the potential of virtual models in FM has yet to be realised. With the advancement of digitalisation, there has been an increase in attempts to broaden the use of these models through the development of integration approaches and technologies. The coordination of Virtual-Physical Building Integration (VPBI) has the potential to improve FM operations in general. These may improve maintenance consistency, real-time progress monitoring and control of the construction process/built facility, tracking of changes and model updates, information exchange between the design office and real-time, as-built documentation, and sustainable practises (Akanmu et al., 2014).

Reality Capture Technology (RCT) - Creating time and cost-effective, accurate methods for surveying building stock and infrastructure, including the automated generation of an as-built model, has emerged as a significant concern in FM. The use of reality capture technology (RCT), such as photogrammetry or 3D laser scanning, is increasing the availability of reliable information about the current state or condition of a building or facility. The generated models are based on dense 3D Cartesian-based distance data sets derived from spatial data from the building. These data are then processed and transferred into a structure or object by specially designed software; however, using point cloud technology in FM has some limitations (Kwok et al., 2018).

Geographic Information System (GIS) - Geographic Information System (GIS) technologies have improved governments' ability to provide services to their citizens. GIS has become an integral part of many people's daily lives in many parts of the world, from facility mapping to inventory management, from land use analysis to trash collection routing. FM is looking for new technologies to address the challenges of large service areas, many distributed customers, and remotely distributed ageing facilities. As a result, FM integrated with emerging GIS technologies provides critical solutions to these challenges (Altadmory, 2013; Wong et al., 2018).

Smart Cities (SC) - Cities are non-organizations, which makes the identification of FM's core business vague and intangible. Smart city (SC) planning involves not only data optimization but also prominent FM governance structures. It seeks to overcome these limitations by considering the social value of the community and the relationship with the urban environment (Lindkvist et al., 2021).

Unmanned Aerial Vehicle System (UAVS) - The technical feasibility and efficacy of inspections with Unmanned Aerial Vehicle System (UAVS) shows that among the visual assets produced, digital photographs collected with the aircraft were more effective for the detection of pathologies when compared to other methods generated by digital photogrammetry software (Ruiz et al., 2021).

Pervasive Sensing Technologies (PSTs) - Many FM applications could benefit from Pervasive Sensing Technologies (PSTs), and one application could be supported by multiple PSTs. It has also been discovered that energy modelling and management are the most commonly referred to purposes in FM for adopting PSTs, while space management, while important, has received the least attention. There are five challenges identified: high investment in PSTs, data storage issues, a lack of proper data exchange protocols for data interoperability, a lack of mature data processing methods for data utilisation, and user privacy (Xu et al., 2020).

Augmented Reality (AR) - The construction industry is also seeing the use of augmented reality (AR) technology, which has the advantage of utilising existing 3D models and BIM data and is thus an active research area. However, most research has focused on either visualising information during the design phase, where architects and project stakeholders can share views; or on confirming the required information for construction management through visualisation during the construction phase. As a result, more research into the use of AR during the facility management (FM) phase is required (Chi et al., 2013; Chung et al., 2021).

Virtual Reality (VR) - Usability tests revealed that Virtual Reality (VR) have the potential to boost productivity in maintenance tasks. When compared to a legacy application, users with no training demonstrated a high level of engagement and performance when using a VRE interface. The potential reduction in user time and increase in engagement with a VR will eventually result in lower costs and higher quality (Carreira et al., 2018).

Conclusion

In conclusion, this study has provided important insight into the field of FM digitalisation. This study has contributed to knowledge by conducting a systematic review of relevant publications, establishing a baseline for future research. As a result, the study reveals that the field of FM digitalisation is still in its innovative stages. Furthermore, the study establishes contextual knowledge from the previous twelve years, identifying FM digitalisation trends. As a result, as explained in the previous section, a conceptual model that focuses on sustainable FM digitalisation, referred to as the Facilities Management Digitalisation Model (FMDM), is proposed, as illustrated in Figure 6 below. The FMDM represents a valuable contribution to the field of FM in the digitalisation era. The model has significant potential to improve existing policy, guide for future research, and improve FM practices.

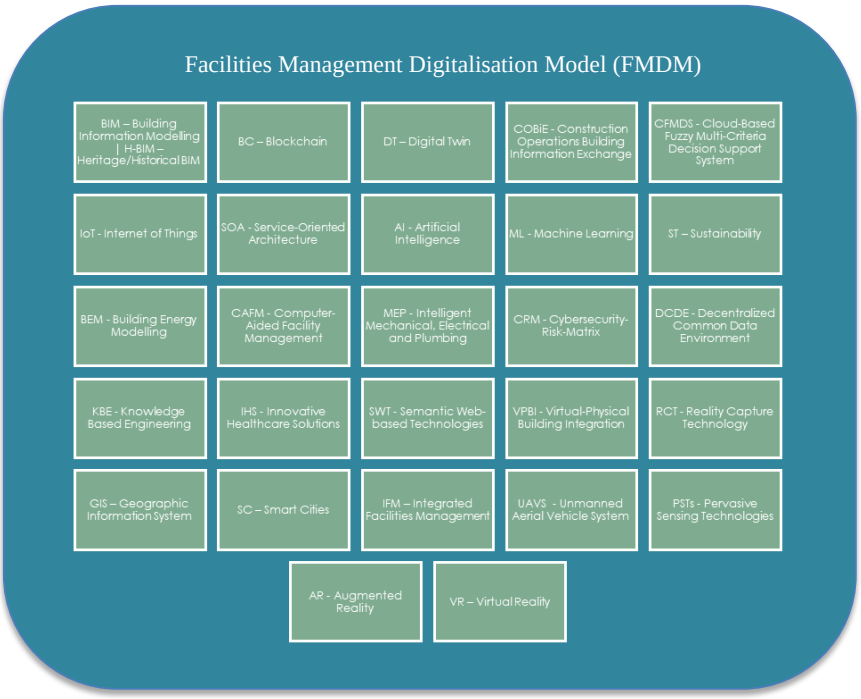

Figure 6. Facilities Management Digitalisation Model (FMDM)

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