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ASSESSING KEY TECHNOLOGY FOR FACILITIES MANAGEMENT IN MALAYSIA

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ABSTRACT

The Facilities Management (FM) industry is seeing expansion and growth in Malaysia; nevertheless for the industry to elevate to a new level of success, it must overcome various technological barriers that have slowed its adoption of technology. The purpose of this research is to gain an understanding of the key technologies that the Malaysian market is prioritising and, consequently, to determine whether the industry is keeping pace with technological advancement. This study analysed the significance of ten (10) essential FM technologies and five (5) deployment FM areas with specific focus on real estate and commercial property sector in FM. The research employed purposive sampling to assemble an expert panel, and then used a questionnaire with a five-point Likert scale to conduct a Delphi study to evaluate the relative importance of each technology and implementation area. Each member of the expert panel was interviewed separately, and the survey was distributed to each of them. According to the findings, CMMS is identified as the technology with the most significant function as data and information management, and maintenance and operations management, whereas BAS is a significant technology for energy management. In conclusion, the research demonstrated that technology adoption in Malaysia is concentrated on legacy technology, hence emerging technology has not yet been considered due to factors such as untested use case, high risk on return on investment, the complexity of new technology and lack of organisational support. The implication of this study shows that adoption is still in its infancy stage; consequently, additional awareness, collaboration between academia and industry, investment in training, and prospects for industry efficiency and productivity are required. While the focus of the research is confined to real estate and commercial property, additional research can be conducted on other segments of the FM industry in Malaysia, including healthcare and education.

Keywords: Facilities Management, Technology Adoption, Facilities Management Digital Transformation, FM Malaysia, FM Technology

1. INTRODUCTION

FM is defined as "organizational function which integrates people, place and process within the built environment with the purpose of improving the quality of life of people and the productivity of the core business" and a "profession that encompasses multiple disciplines to ensure functionality, comfort, safety, and efficiency of the built environment by integrating people, place, process, and technology" (IFMA, 2017; ISO, 2015; IWFM, 2017). Facilities Management can be summarised as a function of guaranteeing a functional and efficient built environment to support the core business thus critical in ensuring a successful businesses and organizations. Despite its critical role, Shamser Ali & Tyagi (2020) mentioned that FM is a highly complex multidisciplinary industry with shrinking profit margin; hence technology can help to enhance business efficiency and productivity. To add, Atta & Talamo (2020) believed technology to have profound impact to the traditionally conceived FM processes that is currently driven by too many manual work.

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Despite the industry's positive growth in Malaysia, as reported by Kamaruzzaman et al. (2018), technology adoption topic has long been contentious in Malaysia. Prior to that, Ariff (2007) criticised that low adoption of technology will be one of the factors impacting the quality of services of FM in Malaysia and over the years keeping up with rapid changes of technology will be one of the challenges for FM in Malaysia as highlighted by Mohd Isa et al. (2016). There is no other option but to innovate as mentioned by Goyal & Pitt (2007), "innovate or get left behind". The industry has been long criticised for the lack of innovations. However, there are insufficient studies that indicate the actual adoption of FM technology in Malaysia. Understanding the key technologies is the starting point for a deeper comprehension of the level of adoption of FM in Malaysia. Hence, the aim of this research is to evaluate the key technologies deemed significant from a Malaysian market perspective.

2. LITERATURE REVIEW

2.1 Facilities Management in Malaysia

Kamaruzzaman & Ahmad Zawawi (2010) mentioned that FM is a good combination of management, business, and technological expertise that may be applicable to tactical, operational, and strategic decision-making processes and FM in Malaysia has evolved from outdated upkeeping and maintenance work into strategic roles since its inception. However, Zawawi et al. (2016) mentioned that compared to other parts of the world, FM in Malaysia is still nascent. Firdauz et al. (2015) highlighted that western countries and other developed Asian countries have begun a discussion to equip FM as a twenty-first century industry, however in Malaysia similar dialogue has yet to initiate. This has unwittingly impacted the quality of FM services and the image that FM in Malaysia seen as very traditional and lack of innovation. The lack of technology adoption for FM in Malaysia is quite apparent. Zawawi et al. (2016) mentioned that the workflows and processes for FM in Malaysia are still labour intensive. In contrast, Goyal & Pitt (2007) emphasized that process flow and workflow should be the fundamental for innovation for FM. In addition to that, Myeda & Pitt (2014) and Kamaruzzaman et al. (2018) emphasized technology competency as one of the required skills need to deliver a successful FM service. The shift from traditional work to a more strategic role is applauded, but for the industry to advance further, technological obstacles must be better understood starting with identifying the current technology adoption.

2.2 Technology Adoption in FM

Straub (2009) defined technology adoption as the behavioural change in which individual accept innovations to an extent it is integrated into appropriate context and Rogers (2003) mentioned its success depends on a lot of factors. Technology can provide powerful tools, competitive edge and improve FM services (Aziz et al., 2016) and FM should leverage on latest technology and reap its advantages (Teicholz, 2013). Ahmed et al. (2017) and Lavikka et al. (2017) added that the FM industry already recognised the potential positive effect of technologies although technology adoption will require a comprehensive framework to enable the shift of work and mindset. Rogers (2003) however was cautious about technology adoption, particularly over adoption, which occurs when a user adopts technologies that experts believe they should not. Consequently, successful technology adoption is also the result of identifying and selecting the appropriate technologies (Taherdoost, 2018).

2.3 Key Technology and Application Areas of FM

According to Goodhue & Thompson (1995), a high probability of successful technology adoption is a perfect match between the task and the technology. This research has therefore compiled five (5) operational areas and ten (10) technologies adopted from Teicholz, (2013) and Marocco & Garofolo (2021) for further analysis.

Table 1. Key Application Areas in FM

	Application Areas of FM	Detailed definitions
1	Information and Data Management	The location and monitoring of building components, the archiving of asset relevant data, and the sophisticated visualisation and interaction with facility data are all highlighted.
2	Maintenance and Operation	Work order management, maintenance decision-making processes, asset problem detection and inspection, and predictive maintenance are all tasks that are necessary for facilities to operate efficiently.

3	Energy Management	Keeping track of and analyse how much energy is used by buildings both in real-time and over a chosen time frame.
4	Asset Management	Significant and ongoing investment in repair and renewal of deteriorating components to safeguard a portfolio of facility assets against the ravages of time and keep it fit for present use.
5	Emergency Management	Natural catastrophes, such as tornadoes and earthquakes, as well as human-caused situations including fires, chemical spills, and failed assets.

Table 1 summarised the key implementation areas as adopted from Marocco & Garofolo (2021) while the key technologies are identified as adopted from Teicholz (2013) as below;

1. BIM – Building Information Modelling
2. GIS – Geographic Information Modelling
3. CMMS – Computerised Maintenance Management System
4. CAFM - Computer Aided Facility Management
5. AR – Augmented Reality
6. VR – Virtual Reality
7. IoT – Internet of Things
8. BEMS – Building Energy Management System
9. BAS – Building Automation System
10. BDA - Big Data Analytics

Building Information Modelling (BIM) overcomes the issue in collecting, processing, and modelling 'as-is' information of a building with more automated work (Wong et al., 2018). BIM is less laborious with scalable data retention and can also impact how space management, energy management and whole life cycle cost of assets for FM (Teicholz, 2013). Utilizing BIM in FM facilitates lifecycle data management and performance monitoring of FM activities, including building a preventive maintenance plan, commissioning, maintenance, and service, creating spaces, ensuring quality, handling emergencies, and deconstructing (Araszkiewicz, 2017; Chang et al., 2018; Gerrish et al., 2017; Motamedi et al., 2014; Wong et al., 2018).

Geographic Information System (GIS) supports many business processes and information systems for FM by understanding and visualising data to expose relationships and forms of maps, globes, reports, and charts (Wong et al., 2018). Facility managers could manage and analyse space across large areas, the spatial data can support various assessment and inspection tasks, the GPS-enabled tools can be used for asset inventories and building fire safety reviews, and they can also integrate with other technologies like BIM and CAFM (Sulaiman et al., 2021; Wong et al., 2018). Big Data Analytics (BDA) described as extracting value from large number of data (Gantz & Reinsel, 2011). Data gathered from various sources can assist FM to make valuable analysis, in maintenance pattern, costing, asset life cycle cost, energy management and in overall enhance FM processes (Ahmed et al., 2017; Araszkiewicz, 2017; Atta & Talamo, 2020; Konanahalli et al., 2018).

Systems such as Computer Aided Facilities Management (CAFM), Computerised Maintenance Management System (CMMS), Building Automation System (BAS), or Building Energy Management System (BEMS) have been around for a while and are utilised for FM purposes (Araszkiewicz, 2017). These technologies remove the needless, time-consuming, and redundant data collection effort and get rid of a task that doesn't offer value (Aziz et al., 2016). ISO defines Internet of Things (IoT) as "infrastructure of interconnected entities, people, systems, and information resources together with services which processes and reacts to information from the physical world and virtual world" (SO/IEC 20924:2018). IoT has become integral part of FM recently (Atta & Talamo, 2020).

Despite being completely unrelated concepts, BDA and IoT are strongly related function: in an FM setup, adding metres, sensors, systems, and devices that track the actual behaviour of assets, equipment, and components and connect with other systems is frequently necessary to implement IoT, which is essentially a technique to receive and deliver vast volumes of data (Konanahalli et al., 2018). Virtual Reality (VR) and Augmented Reality (AR) are technologies that used in combination with BIM. Digital modelling of building with AR and VR can be a powerful tool to interact with the facilities (Marocco & Garofolo, 2021). AR and VR can be implemented in simulating to fire escapes, to train safety maintenance routine or to emulate building changes (Konanahalli et al., 2018; Marocco & Garofolo, 2021; Sulaiman et al., 2021; Wong et al., 2018).

3. METHODOLOGY

3.1 Systematic Literature Review

Cooper (2017) mentioned that a systematic literature review is a rigorous and comprehensive method for identifying, evaluating, and synthesizing existing research on a specific topic or research question. An extensive review of journal was undertaken by adopting methodology by Wong et al., (2018), where an extensive scanning and review of existing literature was done according to ten (10) identified technology for FM and five (5) key implementation areas. For systematic reviews of certain themes of research, minimising subjectivity in selection of publications for research and analysis is a prime concern (Wong et al., 2018).

Hence the use of Scopus and Google scholar were utilized with keywords pertaining key areas 'information', 'data management', 'maintenance', 'operations', 'energy management', 'asset management' and 'energy management'. To add, additional keywords used, 'BIM', 'building information modelling', 'GIS', 'geographic information modelling', 'CMMS', 'computerised maintenance management system', 'CAFM', 'computer aided facility management', 'AR', 'augmented reality', 'VR', 'virtual reality', 'IoT', 'internet of things', 'BEMS', 'building energy management system', 'BAS', 'building automation system', 'BDA' and 'big data analytics'. Results of the findings were compiled in a crosswalk table as shown in Table 3.

Table 2. FM Key Technology

Author	Year	BIM	GIS	CMMS	CAFM	AR	VR	IoT	BEMS	BAS	BDA
Cardellino & Finch [1]	2006				*			*			
Atkin et al. [2]	2006							*			
Elmualim et.al [3]	2009			*	*					*	
Bainbridge & Finch [4]	2009				*						
Motamedi et al. [5]	2011	*		*				*			
Lai & Yik [6]	2012			*							
Teicholz [7]	2013	*	*	*		*	*	*	*	*	
Motamedi et al. [8]	2014	*		*							
Hua et al. [9]	2014		*								
Korpela et al. [10]	2015	*		*							
Mohanta & Das [11]	2016	*			*						
Gheisari & Irizarry [12]	2016	*				*	*				
Domingues et al. [13]	2016									*	
Araszkiewicz [14]	2017	*		*	*			*	*	*	*
Ebbesen & Bonke [15]	2017		*	*	*						
Suprabhas & Dib [16]	2017	*						*			
Gerrish et al. [17]	2017	*				*	*				
Ahmed et al. [18]	2017							*			*
Atkin & Bildsten [19]	2017	*						*			*
Bentley [20]	2018										*
Konanahalli et al. [21]	2018			*				*			*
Chang et al. [22]	2018	*						*			
Wong et al. [23]	2018	*	*	*		*	*	*			
Carreira et al. [24]	2018	*	*	*	*	*	*				
Matarneh et al. [25]	2019	*								*	
Bröchner et al. [26]	2019	*									
Christiansen [27]	2020			*							
Aziz et al. [28]	2020	*									
Marinakis [29]	2020	*						*			
Atta & Talamo [30]	2020							*			*
Marocco & Garofolo [31]	2021	*						*			
J. Y. Lee et al. [32]	2021	*	*			*	*				
Total	32	19	6	12	7	6	6	14	2	5	6

A compilation of publications was summarised in view of key technology being discussed by the scholars as per Table 2. A total of 32 publications were compiled with BIM were widely discussed by scholars from 2006 to 2021. The time based given was year 2006 until 2021 since FM technology is a new concept and technology obsolescence is about three to five years (Mellal, 2020) thus 15 years span is considerably logical. A further analysis of areas of implementation are discussed in the following.

Table 3. Crosswalk of Technology and Implementation Area

	Tech	Data Management	Maintenance and Operation	Energy Management	Asset Management	Emergency Management
1	BIM	[5], [7], [8], [10], [12], [14], [16], [17], [19], [22], [23], [24], [25], [26], [28], [31], [32]	[7], [8], [10], [12], [16], [17], [22], [23], [24], [25], [26], [28], [31]	[7], [12], [16], [17], [22], [24], [25], [28], [29], [31]	[7], [8], [10], [14], [22], [23], [24], [25], [28]	[5], [7], [17], [31]
2	GIS	[7], [15], [23], [24], [32]	[9], [15], [23]	[7], [9], [23]	[23]	NA
3	CMMS	[5], [6], [7], [8], [10], [11], [14], [15], [23], [24]	[5], [6], [7], [8], [10], [11], [14], [15], [21], [23], [24]	[7], [24]	[8], [10], [11]	[27]
4	CAFM	[1], [3], [4], [7], [11], [14], [15], [24]	[1], [3], [4], [11], [14], [15], [24], [25]	[3], [4], [24]	[3], [4], [11]	[4]
5	AR	[12], [17], [23], [24], [32]	[7], [12], [17]	NA	[24]	[17]
6	VR	[12], [17], [23], [24], [32]	[7], [12], [17]	NA	[24]	[17]
7	IoT	[2], [16], [19], [21], [22], [30], [31]	[2], [14], [16], [18], [21], [22], [23], [30], [31]	[2], [14], [16], [18], [21], [22], [23], [29], [31]	[1], [2], [7], [14], [22], [23]	[5], [14], [23], [31]
8	BEMS	[14]	NA	[14]	NA	NA
9	BAS	[3], [13], [14]	[3], [13]	[3], [13], [14], [25]	[3]	[7]
10	BDA	[18], [19], [20], [21], [30]	[14], [18], [20], [21], [30]	[14], [18], [20], [21]	[21]	[21]

*NA – Not Available

Table 3 summarises the findings with the use of a crosswalk table of FM implementation areas and technologies. In addition to other technologies that have been the focus of this research, BIM and Data and Information Management were extensively discussed by scholars. The crosswalk analysis adopted from Teicholz (2013) has enabled this study to filter the pertinent technology and implementation areas. Eight (8) technologies and implementation areas that were not included in Table 3 were also omitted from the expert panel's discussion, namely BEMS for Maintenance and Operation Management, GIS for Emergency Management, CMMS for Energy Management, AR for Energy Management, VR for Energy Management, BEMS for Asset Management, BEMS for Emergency Management, and BAS for Emergency Management. This information served as the foundation for the expert panel's Delphi session.

3.2 Expert Panels

The research is quantitative in nature with a positivism perspective, which believes that only knowledge based on observed facts can be true (Easterby-Smith et al., 2008). Linstone et al. (2002) mentioned that the Delphi approach selected for this research is a method that can foster consensus in novel domains and to be conducted using various tools including survey and interview which was adopted for this research. The choice of expert panel and their level of competency can determine the outcome of a Delphi survey as mentioned by A. P. C. Chan et al. (2001). Hence a purposive sampling is being adopted for selection of expert panels. Skulmoski et al. (2007) mentioned that two important criteria for expert panels are knowledge and experience, and willingness to participate. The experts must be a Certified Facilities Manager Level 5 by Malaysia's Construction Industry Development Board (CIDB) and should have more than 10 years' experience in facilities management with addition experience in technology adoption in real estate and commercial property. The scope of industry selected is real estate and property as it covers around 30% of the FM industry (Moore et al., 2004). This segment of FM is highly represented, so the effects of the study will be evident. It was also noted that each sector or segment of the FM industry may prioritise technology differently.

There are no specific rules on number of expert panels for Delphi analysis, however as mentioned by Skulmoski et al. (2007) since the group is homogenous in nature, 10 to 15 panels shall be sufficient, hence 15 expert panel were invited for the interview session and 10 accepted. The expert panels were interviewed individually or in person and provided with a questionnaire survey containing the technologies and implementation areas from Table 3, and they ranked them on a Likert scale ranging from 1 - Less Significant to 5 - Most Significant. All the data collected were served as the basis for the research that will identify essential FM technologies and implementation areas.

3.3 Statistical tools for data analysis

The data gathered from the expert panel was analysed using statistical methods, and comparisons between the expert groups were made. The first statistical techniques are the mean score (M) and standard deviation (SD); the second is the Cronbach's alpha reliability test; the third is the Kendall's coefficient for concordance; and the fourth is the test for inter-rater agreement (IRA). The mean score, SD, and Relative Importance Index (RII) were used to rank the 10 technologies. When two or more factors have the same mean value, the ranking considers both the mean and the standard deviation of the factors and consequently, factors with lower SD will be given a higher position (Tsai et al., 2014).

3.4 Kendall's Coefficient of Concordance and IRA

The Kendall's coefficient of concordance, which ranges from 0 (perfect disagreement) to 1 (perfect agreement), was used to assess the degree and reliability of consensus among survey participants (D. W. M. Chan & Chan, 2012). The ordinal level of measurement with more than 2 raters should apply Kendall's coefficient (Gisev et al., 2013). Suppose that object i is given the rank $r_{i,j}$ by rater number j, where there are in total n objects and m raters. Then the total rank given to object i is;

$$R_i = \sum_{j=1}^{m} r_{i,j}$$

And the mean value of these total ranks is,

$$\bar{R} = \frac{1}{n}\sum_{i=1}^{n} R_i$$

The sum of squared deviations, S is defined as,

$$S = \sum_{i=1}^{n} (R_i - \bar{R})^2$$

And then Kendall's W is defined as,

$$W = \frac{12S}{m^2(n^3 - n)}$$

3.5 Significance of the factors

The level of agreement between the two rounds of the Delphi survey was investigated in this study, and the results were validated, using the IRA statistics and significance level grading. The 42 criteria that were identified during the second round of the Delphi survey were utilised as the basis for the data used and evaluated in this section. More so, the study applied the scale interval grading method used by to determine the significance of each factor (Li et al., 2013) as follows:

"Not important" ($M < 1.5$),
"Slightly important" ($1.51 \leq M \leq 2.5$),

"Moderately important" ($2.51 \leq M \leq 3.5$),
"Important" ($3.51 \leq M \leq 4.5$) and
"Very important" ($M \geq 4.51$)

RII is also used to analyse the relative importance of each factor. RII is calculated using below equations.

$$RII = \frac{\sum r}{(k)(m)}$$

Where r is the total ratings given by expert panels, while *k* is the number of factors and *m* is the number of respondents. The IRA is being analyse for each element with equations;

$$IRA\ (P_{i)} = \frac{1}{m(m-1)}\left(\sum_{j=1}^{k}(r_{i,j})^2 - m\right)$$

The interpretation for the IRA statistics (Lebreton & Senter, 2008) are:

0.00–0.30 "lack of agreement,"
0.31–0.50 "weak agreement,"
0.51–0.70 "moderate agreement,"
0.71–0.90 "strong agreement" and
0.91–1.00 "very strong agreement."

Where *r* is the total ratings given by expert panels, while *k* is the number of factors and *m* is the number of respondents.

4. RESULTS AND DISCUSSION

4.1 Data Analysis

From Table 4, ten (10) experts were selected and 60% of them are facility manager. 70% of the experts hold master's degree. The experts have minimum 10 years' experience with 30% having more than 20 years. All the experts are certified Level 5 CIDB FM. The experts also have at least 6 years' experience in FM technology and involved in real estate and commercial property. A combination of experienced and skilled experts is a priority for this study. The study focused on real estate and commercial property to form a homogenous opinion.

Table 4. Demographic of Expert Panel

Demographics Background	Frequency	Percentage (%)
Role		
Facility Manager	6	60
FM Consultant	2	20
Technical Manager	2	20
Education Level		
Bachelor's degree	7	70
Master's degree	3	30
Certification		
Certified CIDB FM Level 5	10	100
FM Experience		
10 – 15 years	5	50
16 - 20	2	20
More than 20 years	3	30
Industry		
Real Estate & Commercial	10	100
Years of experience in FM technology		
6 – 10 years	7	70
11 – 15 years	1	10
More than 15 years	2	20

The two-round Delphi surveys shows consensus among the expert panels, and there are no significant changes from both round of questionnaires. The α-value for the first round and second round of Delphi survey was 0.938, which is greater than the 0.7 and data is considered reliable. Furthermore, a Shapiro-Wilk test of normality for both rounds of the Delphi surveys reveals that non-parametric tests are necessary for the analysis of the gathered data due to the data's non-normal distribution ($p<0.05$).

Additionally, thirteen (13) factors are considered very important by the expert panels. The top 5 very important factors are, A3 - CMMS for Data Management, B3 - CMMS for Maintenance and Operations, C7 - BAS for Energy Management, C8 - BEMS for Energy Management, D3 - CMMS for Asset Management, C6 - IoT for Energy Management, B8 - BAS for Maintenance and Operations, and A9 - BAS for Data Management. A3 - CMMS for Data Management, B3 - CMMS for Maintenance and C7 - Operations and BAS for Energy Management has Mean Value of 5.000 and RII=1.000, which means the expert panels agreed on its significant importance. While B6 – VR for Maintenance and Operations least important with RII = 0.500 and M=2.500. The variance for mean score between the highest-ranking factor (M = 5.000) and the least important (M = 2.500) is 2.500. It is worthy to note that 32 factors from overall 44 factors are graded RII >0.7 and M>3.5, thus considered significant.

Among the factors ranked highest by expert panels, CMMS and BAS tied at 23% as the most important technology. CMMS is considered very important for Data Management, Operations and Maintenance and Asset Management. While BAS considered very important for Energy Management, Maintenance and Operations and Data Management. An emerging technology, BDA also seen very important for FM is areas such as Asset Management and Data Management.

Table 5. Round 1 Delphi

Code	Tech	RII	Mean	SD	Rank	P_i score	IRA	Significance Grade
A- Information and Data Management								
A1	BIM	0.760	3.80	1.033	23	0.200	lack of agreement	Important
A2	GIS	0.660	3.30	0.949	29	0.222	lack of agreement	Moderately important
A3	CMMS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
A4	CAFM	0.860	4.30	0.823	14	0.311	weak agreement	Important
A5	AR	0.560	2.80	0.919	31	0.311	weak agreement	Moderately important
A6	VR	0.540	2.70	0.823	33	0.311	weak agreement	Moderately important
A7	IoT	0.880	4.40	0.516	11	0.467	weak agreement	Important
A8	BEMS	0.900	4.50	0.527	8	0.444	weak agreement	Very important
A9	BAS	0.940	4.70	0.483	5	0.533	moderate agreement	Very important
A10	BDA	0.900	4.50	0.850	10	0.489	weak agreement	Very important
B- Maintenance and Operation								
B1	BIM	0.800	4.00	1.054	21	0.222	lack of agreement	Important
B2	GIS	0.680	3.40	0.966	28	0.222	lack of agreement	Moderately important
B3	CMMS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
B4	CAFM	0.840	4.20	1.135	18	0.356	weak agreement	Important
B5	AR	0.540	2.70	0.949	32	0.222	lack of agreement	Moderately important
B6	VR	0.500	2.50	0.707	36	0.400	weak agreement	Moderately important
B7	IoT	0.860	4.30	0.675	13	0.356	weak agreement	Important
B8	BAS	0.940	4.70	0.675	4	0.622	moderate agreement	Very important
B9	BDA	0.820	4.10	1.287	19	0.356	weak agreement	Important
C- Energy Management								
C1	BIM	0.740	3.70	1.160	25	0.356	weak agreement	Important
C2	GIS	0.700	3.50	1.179	26	0.222	lack of agreement	Important
C3	CAFM	0.840	4.20	1.033	17	0.289	lack of agreement	Important
C4	AR	0.560	2.80	1.033	30	0.289	lack of agreement	Moderately important
C5	VR	0.540	2.70	0.949	35	0.356	weak agreement	Moderately important
C6	IoT	0.960	4.80	0.422	3	0.644	moderate agreement	Very important
C7	BAS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
C8	BEMS	0.980	4.90	0.316	2	0.800	strong agreement	Very important
C9	BDA	0.840	4.20	1.135	16	0.356	weak agreement	Important
D- Asset Management								
D1	BIM	0.780	3.90	1.197	22	0.222	lack of agreement	Important
D2	GIS	0.740	3.70	1.059	24	0.267	lack of agreement	Important
D3	CMMS	0.980	4.90	0.316	2	0.800	strong agreement	Very important
D4	CAFM	0.860	4.30	0.823	12	0.311	weak agreement	Important

D5	AR	0.640	3.20	1.033	30	0.200	lack of agreement	Moderately important
D6	VR	0.540	2.70	0.675	34	0.356	weak agreement	Moderately important
D7	IoT	0.800	4.00	0.943	20	0.289	lack of agreement	Important
D8	BAS	0.800	4.00	1.054	21	0.222	lack of agreement	Important
D9	BDA	0.900	4.50	0.972	7	0.489	weak agreement	Very important
E- Emergency Management								
E1	BIM	0.900	4.50	0.707	6	0.400	weak agreement	Very important
E2	CMMS	0.840	4.20	0.919	15	0.356	weak agreement	Important
E3	CAFM	0.800	4.00	1.054	21	0.222	lack of agreement	Important
E4	AR	0.680	3.40	1.075	27	0.289	lack of agreement	Moderately important
E5	VR	0.640	3.20	1.033	30	0.200	lack of agreement	Moderately important
E6	IoT	0.900	4.50	0.707	9	0.400	weak agreement	Very important
E7	BDA	0.740	3.70	1.059	24	0.222	lack of agreement	Important

Cronbach's Alpha (α)	0.938
Number of Respondents (n)	10
Kendall's Coefficient Concordance (W)	0.518
Chi – Square (X^2)	222.587
Degree of Freedom (df)	43
Significance Level (p)	0.000

Table 6. Round 2 Delphi

Code	Tech	RII	Mean	SD	Rank	P_i score	IRA	Significance Grade
A- Information and Data Management								
A1	BIM	0.760	3.80	1.033	23	0.200	lack of agreement	Important
A2	GIS	0.660	3.30	0.949	29	0.222	lack of agreement	Moderately important
A3	CMMS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
A4	CAFM	0.860	4.30	0.823	14	0.311	weak agreement	Important
A5	AR	0.560	2.80	0.919	31	0.311	weak agreement	Moderately important
A6	VR	0.540	2.70	0.823	33	0.311	weak agreement	Moderately important
A7	IoT	0.880	4.40	0.516	11	0.467	weak agreement	Important
A8	BEMS	0.900	4.50	0.527	8	0.444	weak agreement	Very important
A9	BAS	0.940	4.70	0.483	5	0.533	moderate agreement	Very important
A10	BDA	0.900	4.50	0.850	10	0.489	weak agreement	Very important
B- Maintenance and Operation								
B1	BIM	0.800	4.00	1.054	21	0.222	lack of agreement	Important
B2	GIS	0.680	3.40	0.966	28	0.222	lack of agreement	Moderately important
B3	CMMS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
B4	CAFM	0.840	4.20	1.135	18	0.356	weak agreement	Important
B5	AR	0.540	2.70	0.949	32	0.222	lack of agreement	Moderately important
B6	VR	0.500	2.50	0.707	36	0.400	weak agreement	Moderately important
B7	IoT	0.860	4.30	0.675	13	0.356	weak agreement	Important
B8	BAS	0.940	4.70	0.675	4	0.622	moderate agreement	Very important
B9	BDA	0.820	4.10	1.287	19	0.356	weak agreement	Important
C- Energy Management								
C1	BIM	0.740	3.70	1.160	25	0.356	weak agreement	Important
C2	GIS	0.700	3.50	1.179	26	0.222	lack of agreement	Important
C3	CAFM	0.840	4.20	1.033	17	0.289	lack of agreement	Important
C4	AR	0.560	2.80	1.033	30	0.289	lack of agreement	Moderately important
C5	VR	0.540	2.70	0.949	35	0.356	weak agreement	Moderately important
C6	IoT	0.960	4.80	0.422	3	0.644	moderate agreement	Very important
C7	BAS	1.000	5.00	0.000	1	1.000	very strong agreement	Very important
C8	BEMS	0.980	4.90	0.316	2	0.800	strong agreement	Very important
C9	BDA	0.840	4.20	1.135	16	0.356	weak agreement	Important
D- Asset Management								
D1	BIM	0.780	3.90	1.197	22	0.222	lack of agreement	Important
D2	GIS	0.740	3.70	1.059	24	0.267	lack of agreement	Important
D3	CMMS	0.980	4.90	0.316	2	0.800	strong agreement	Very important
D4	CAFM	0.860	4.30	0.823	12	0.311	weak agreement	Important

D5	AR	0.640	3.20	1.033	30	0.200	lack of agreement	Moderately important
D6	VR	0.540	2.70	0.675	34	0.356	weak agreement	Moderately important
D7	IoT	0.800	4.00	0.943	20	0.289	lack of agreement	Important
D8	BAS	0.800	4.00	1.054	21	0.222	lack of agreement	Important
D9	BDA	0.900	4.50	0.972	7	0.489	weak agreement	Very important
E- Emergency Management								
E1	BIM	0.900	4.50	0.707	6	0.400	weak agreement	Very important
E2	CMMS	0.840	4.20	0.919	15	0.356	weak agreement	Important
E3	CAFM	0.800	4.00	1.054	21	0.222	lack of agreement	Important
E4	AR	0.680	3.40	1.075	27	0.289	lack of agreement	Moderately important
E5	VR	0.640	3.20	1.033	30	0.200	lack of agreement	Moderately important
E6	IoT	0.900	4.50	0.707	9	0.400	weak agreement	Very important
E7	BDA	0.740	3.70	1.059	24	0.222	lack of agreement	Important

Cronbach's Alpha (α)	0.938
Number of Respondents (n)	10
Kendall's Coefficient Concordance (W)	0.518
Chi – Square (X^2)	222.587
Degree of Freedom (df)	43
Significance Level (p)	0.000

Based on the Kendall's Coefficient for Concordance, analysis shows W= 0.518, this illustrates that the expert panels moderately agreed on overall factors. The significance level (p) = 0.000 means a strong consensus achieved among the expert panel. The expert panels are very strong in agreement that A3, B3 and C7 are playing very important part for FM. The expert panels are extremely in agreement for these 3 factors with IRA = 1.000. The other factors that have strong agreement among expert panels are C8 and D3. While C6, B8 and A9 although considered very important, received moderate agreement among the expert panel. Moreover, the rest of the factors that are categorised as very important received weak agreement among the expert panels, and they consist of E1, D9, A8, E6, and A10.

Table 7. Summary of Result

Code	Technology	FM Areas	Rank	Significance	IRA
A3	CMMS	Information and Data Management	1	Very important	very strong agreement
B3	CMMS	Maintenance and Operation	1	Very important	very strong agreement
C7	BAS	Energy Management	1	Very important	very strong agreement
C8	BEMS	Energy Management	2	Very important	strong agreement
D3	CMMS	Asset Management	2	Very important	strong agreement
C6	IoT	Energy Management	3	Very important	moderate agreement
B8	BAS	Maintenance and Operation	4	Very important	moderate agreement
A9	BAS	Information and Data Management	5	Very important	moderate agreement
E1	BIM	Emergency Management	6	Very important	weak agreement
D9	BDA	Asset Management	7	Very important	weak agreement
A8	BEMS	Information and Data Management	8	Very important	weak agreement
E6	IoT	Emergency Management	9	Very important	weak agreement
A10	BDA	Information and Data Management	10	Very important	weak agreement
A7	IoT	Information and Data Management	11	Important	weak agreement
D4	CAFM	Asset Management	12	Important	weak agreement
B7	IoT	Maintenance and Operation	13	Important	weak agreement
A4	CAFM	Information and Data Management	14	Important	weak agreement
E2	CMMS	Emergency Management	15	Important	weak agreement
C9	BDA	Energy Management	16	Important	weak agreement
C3	CAFM	Energy Management	17	Important	lack of agreement
B4	CAFM	Maintenance and Operation	18	Important	weak agreement
B9	BDA	Maintenance and Operation	19	Important	weak agreement
D7	IoT	Asset Management	20	Important	lack of agreement
B1	BIM	Maintenance and Operation	21	Important	lack of agreement
D8	BAS	Asset Management	21	Important	lack of agreement
E3	CAFM	Emergency Management	21	Important	lack of agreement

D1	BIM	Asset Management	22	Important	lack of agreement
A1	BIM	Information and Data Management	23	Important	lack of agreement
D2	GIS	Asset Management	24	Important	lack of agreement
E7	BDA	Emergency Management	24	Important	lack of agreement
C1	BIM	Energy Management	25	Important	weak agreement
C2	GIS	Energy Management	26	Important	lack of agreement
E4	AR	Emergency Management	27	Moderately important	lack of agreement
B2	GIS	Maintenance and Operation	28	Moderately important	lack of agreement
A2	GIS	Information and Data Management	29	Moderately important	lack of agreement
C4	AR	Energy Management	30	Moderately important	lack of agreement
D5	AR	Asset Management	30	Moderately important	lack of agreement
E5	VR	Emergency Management	30	Moderately important	lack of agreement
A5	AR	Information and Data Management	31	Moderately important	weak agreement
B5	AR	Maintenance and Operation	32	Moderately important	lack of agreement
A6	VR	Information and Data Management	33	Moderately important	weak agreement
D6	VR	Asset Management	34	Moderately important	weak agreement
C5	VR	Energy Management	35	Moderately important	weak agreement
B6	VR	Maintenance and Operation	36	Moderately important	weak agreement

4.2 Discussion

Table 7 provided a comprehensive summary of the research's findings. The study utilised existing literature and performed a cross-analysis of forty four (44) factors between ten (10) technologies and five (5) implementation areas in FM. The expert panel subsequently in consensus, confirmed two (2) highly significant technologies, CMMS and BAS for FM in real estate and commercial property. CMMS is considered critical for Information and Data Management and Maintenance & Operation, while BAS is considered critical for Energy Management. The selection of two well-known legacy technologies demonstrates a fundamental understanding of workflow and process automation in FM, which is consistent with the scholar's suggestion as mentioned by Goyal & Pitt (2007). This shall also include the role of CMMS for maintenance and operation, which predominantly automates these processes. In addition, it is notable to observe the increasing significance of data and information management, which reflects the industry's shift towards data-driven operations. Since FM produced huge data from operations and processes, it is only logical to harness on the massive data to improve decision making, analysing life cycle of assets or even predicting the maintenance work (Ahmed et al., 2017). Similarly, BAS is considered significant because energy management is driven by data collection and analysis.

The research also revealed that well-known emerging technologies such as BIM and IoT did not rank among the most significant technology. The experts opined that the emerging technologies are still in conceptual stages or research mode, and it will take significant time to be useful for FM since it does not have successful use case yet in Malaysia. Hence continuous awareness and educating the practitioners is significant to expose facility managers with successful emerging technology use case and understanding of its usefulness. Collaboration between the industry and academic institutions is likely the best way to overcome this obstacle. Despite this, Atkin & Bildsten (2017) criticised the dearth of current research in the field of technology for FM on the grounds that researchers were discussing lagging indicators for technology or speculative technology without representing the actual situation. As demonstrated by this research, BIM has lately dominated FM discussions; however, the research indicated that BIM's disruptive innovation nature has yet to have an effect on practitioners.

In addition to that, the experts appear concerned on the risk associated with adopting new technology. It was stated that for organizations only take a bottom-line approach, thus prioritizing return on investment (ROI) is necessary to obtain support from the top management for new technology investment. Therefore, without a concrete plan or extensive knowledge and support from top management, it is unlikely that organization would take any technological risks. The lack of fail-safe framework for any new technology has prevented facility managers from taking risks with new technology. To add, facility managers also worry about the complexity of new technology and that in contrast will significantly increase their team workload while testing the individual limits to new technology. This is consistent with Taherdoost's (2018) views on Diffusion of Innovation (DOI) by Rogers (2003) and Technology Acceptance Model (TAM) by Davis (1985), which emphasised sociological and psychological approaches for users to accept new innovations. The discussion elaborated on three fundamental cognitive behaviours: attitude, social norm, and intention, all of which should be voluntary, and usage voluntariness would be a key criterion for the acceptance and adoption of new technologies.

5. CONCLUSION

This study began by examining the most important FM technology in Malaysia and whether the industry is keeping up with technological advancements in order to address the most pressing issue regarding the adoption of technology in FM. Prior to the research, there was small number of discussion and citations on the subject; however, the results demonstrated that the theories presented by scholars over the years are now supported by evidence. Clearly, the FM industry in Malaysia is still in its infancy and has fallen behind the technological curve. The reasons for the industry's predilection for older technology and utter disregard for emerging innovations have been clearly explained. Despite the lower profit margins and technological advancements, the FM sector remains sceptical to invest in new technology that could significantly benefit their organisations and the entire industry due to factors such as lack of awareness, lack of support from organizations and the risk of low acceptance for technology and therefore become the reason of adoption failure. The study's findings could very well serve as the basis for a framework research for the adoption of FM technology in Malaysia.

In order to provide a comprehensive assessment of the current state of technology adoption in Malaysia, future study could also involve facility managers and analyse the level of technology adoption for two (2) key technologies among them, as determined by experts. In addition to that, for future research a similar study could be deliver, but with a different segment of FM in Malaysia, such as healthcare and education, and integrate the perspectives from all segments, thereby presenting a holistic view of technology adoption FM in Malaysia. The detailed assessment of technology adoption in Malaysia's FM industry can provide researchers, industry practitioners, and other relevant stakeholders with important insights. This study shows the sector's massive hurdles and emphasises the necessity for greater research in this area. A thorough strategy to evaluate technology adoption could reveal valuable insights that might facilitate future research and industry decisions.

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