BIM: FM for Healthcare: Lost in Transition

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Abstract

The context of delivery for in-house facilities management (FM) is one of insufficient resources, namely financial, people and time, to develop strategic solutions that improve FM service delivery models; whilst managing a complex data landscape of hybrid digital and analogue data. Digitalisation of the FM model with automated data capture, productive workflows and integrated data systems is a viable alternative to current FM delivery models. A systematic literature review and comparative thematic analysis of BIM implementation for facility management was used to identify progress, stagnation and new research directions. The results indicate a research gap where delivery of a methodology for BIM: FM implementation based on building typologies i.e. education, public, healthcare etc. is required to evolve the BIM paradigm and engage with BIM for FM. Currently, BIM for FM implementation relies on individual organisations to move the model forward without support for a complex data information modelling solution.

Keywords: Building Information management, Facility management, Healthcare, digitalisation, Information Modelling.

1. Introduction

Facilities management teams ensure maintenance of the physical infrastructure, deliver operational space and reduce health and safety risks for users, to achieve organisational aims. For organisations with large estates, another aspect of the role is the management of energy consumption and reducing energy usage to deliver sustainable solutions. Automated data capture, energy consumption and integration of the building management system (BMS) data with FM data and a BIM model makes data available for analytics which would then allow decision-making about energy issues with strategic solutions, to be based on historic data. Facility management is a data intensive service, liaising with specialist contractors and internal technicians to deliver a built environment that meets organisational needs and complies with relevant statutory and regulatory requirements including sustainability targets.

The potential for BIM: FM is a virtual 3D model with attached data that synchronises using bi-directional data flow between FM specialist software and BIM, this is known as a digital twin of the physical building (Ismagilova et al., 2019). The digital twin for FM is a 3D model that mirrors the physical model where proposed changes to the built fabric of a building may be analysed and used for solution testing before procurement, and for remodelling and problem solutions. This 3D digital model identifies asset location and the complex data held on assets, warranties, manufacturer, model delivers accessible data. Data can be automatically collected and communicated using devices known as the 'Internet of Things' (IoT); which together with the digital twin links data streams and has the potential to automatically schedule maintenance activities. This would release technicians from mundane tasks such as meter readings, which can be easily achieved through the application of technology and ensuring the use of technical specialists to deliver innovative and creative solutions, not suited to machine learning or artificial intelligence.

The low adoption rates for BIM: FM implementation are due to the complexity of the BIM paradigm, a lack of BIM & FM expertise among construction professionals and a decided lack of support in the form of guidance and standards (Bosch et al., 2015; Ilter et al., 2015; Love et al., 2014; Pärn et al., 2017; Tan et al., 2018). UK BIM for design and construction stages are delivered through a national strategy using British Standards, PAS 1192 1-6 series, guidance documents and support organisations in the UK. January 2019, the UK has published new international BIM standards BS EN ISO19650-0:2019 (Transition guidance on BS EN ISO19650); BS EN ISO 19650-1:2019 (Concepts and principles) & BS EN ISO 19650-2:2019 (Delivery phase of Assets), with chapters for specific countries. These new BS EN ISO's replace BS1192:2007 and PAS1192-2 in the UK suite of BIM documentation; PAS1192-3, 4, 5 & 6 remain valid until 2020 (cdbb, 2019). The concurrent development of a national standard and guidance enabling BIM information management for BIM: FM for existing estate, which integrates BS EN ISO 19650:2019 series and ISO 41001:2018, has not yet been realised, leaving BIM: FM waiting for support, they are lost in transition between their many hybrid systems to a BIM: FM solution.

At the same time the USA implemented a different strategy for BIM implementation without the use of standards, based on a model of commercial market stimulus. Singapore has used a hybrid solution for standards as a city nation, with required submission for planning as BIM models and the use of AIM models for OPEX activities. Implementation solutions for data integration between BIM: FM and FM software, bi-directional data flows and the level of data granularity are essential to maximise the benefits of BIM: FM implementation (Becerik-gerber et al., 2012; Carbonari et al., 2018; Patacas et al., 2016; Sacks et al., 2018). Overall, this represents the interoperability needs for a BIM: FM methodology and BIM implementation will resolve the existing inefficiencies of siloed data, isolated data and keeping data up to date. Currently, in the UK there is not a proposed strategic solution to integrate BIM: FM which has new buildings coming on stream and existing estate, within the BIM paradigm. FM professionals do not have the expertise, time, financial or support from the UK government in the form of standards & guidance to deliver the complexity that is BIM: FM.

This systematic review considers the status of BIM for facility management implementation for existing and new buildings in research based on articles between 2014 and 2018 (inclusive). Comparative thematic analysis relates the themes from the reviewed articles to themes identified in Volk, Stengel & Schultmann, (2014) article, which has a very high citation rate. The next section describes the methodology and how articles were selected and excluded using Systematic Literature

Review Specification Protocol (SLRSP) detailed in Table 1, followed by results and discussion that report the bibliometric assessment of articles and thematic comparative analysis of articles selected for review.

2. Material and methods

This systematic review is an evaluation of the status of BIM: FM implementation from 2014-2018; it offers a transparent, accessible overview that is rigorous, with a transparent methodology and the research is reproducible (Denyer et al., 2009). The occurrence of bias is reduced using a systematic review when compared to other types of review and the use of a checklist delivers transparency (Petticrew et al., 2006).

Table 1: Systematic Literature Review Specification Protocol (SLRSP)
(adapted from Schardt et al. (2007))

Criteria for Inclusion of Articles in the review	
Study population/participants and conditions of interest	Facility management teams, population is worldwide
Interventions	Papers about BIM implementation within FM departments between 2014 – 2018
Comparisons	Thematic comparative analysis with an article by Volk et al. (2014)
Outcomes of interest	Similarities and differences of outcomes
Setting	Organisations with existing estate, hospitals
Study method	Any method
Language	Written in English
Criteria for Exclusion of articles in the review	
References	Dated
Technology	Very specific about technology for BIM
Software	Specific about file types
Conference Papers	Excluded for reasons of uncertain reliability
Publication	Date range 2014 – 2018 inclusive
Search Methods	
Electronic Databases	Web of Science, Scopus, Science Direct
Other search methods	Checking references in papers, and snowballing.
Methods of Review	
Reviewers	One reviewer of journals, primary author.
Quality assessment	Based on checklist derived from social science research and medical research, critical appraisal skills programme (CASP)
Data Extraction	Excel spreadsheets to track papers and status based on the specification protocol. One reviewer (author) to action.
Narrative Synthesis	Carried out using the framework below: Bibliometric Analysis: 1. Geographical location of authors 2. Articles over time 3. Article distribution in Journals 4. Method uses 5. Methodological use 6. Research themes Thematic Analysis: 1. Thematic analysis of selected journal papers 2. Develop a preliminary synthesis of findings 3. Explore methods, findings, outcomes and relationships 4. Compare and contrast selected articles with themes identified in Volk et al. (2014).

The papers selected and reviewed are published journals with a peer review system about BIM: FM implementation for BIM: FM legacy estate. The specification protocol for inclusion of papers in the review is based on PICOS (Population, Intervention, Comparison, Outcome, Setting and study method) and detailed in the specification protocol as shown in Table 1.

The search terms and Boolean operators used include BIM, Building Information Model*, facilit* management. The breakdown of the papers collected is detailed in Figure 1, and exclusion and inclusion criteria applied using the Systematic Literature Review Specification Protocol (SLRSP) in Table 1. Initially 942 articles were identified, a total of 876 articles were excluded. The analytical stage reviewed 31 journal articles using the SLRSP shown in Table 1.

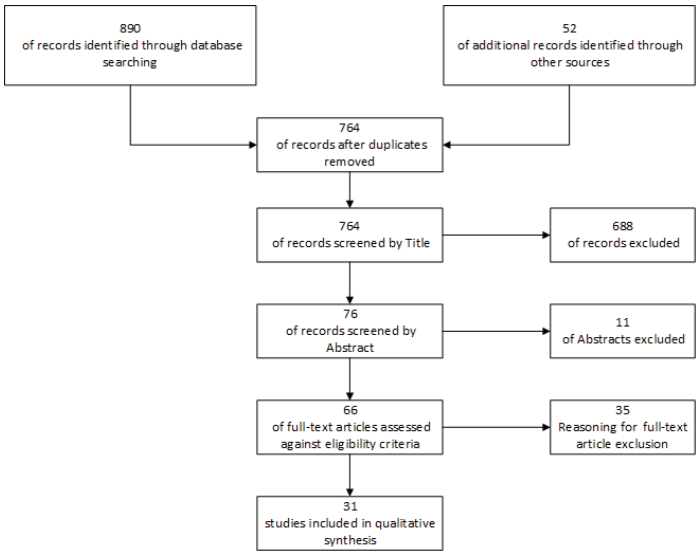

Figure 1: PRISMA Flow Diagram of Process for Systematic Review
(adapted from Moher et al. (2009))

3. Results and discussion

3.1 Bibliometric Analysis

Qualitative research is increasing the use of bibliometric analysis as an evaluation tool for research (Ellegaard et al., 2015). Bibliometric analysis evaluates the robustness of the research articles under review and the results can be used as a basis for a decision-making tool for organisations, funding bodies, future research applications as the analysis considers the relevance of the research to targets and goals (Ellegaard et al., 2015). Bibliometric analysis also supports the identification of incremental knowledge in areas where the production of academic articles where the production of academic articles is fast. The authors contributing to BIM: FM implementation research are based in twenty countries, as detailed in **Error! Reference source not found.**, with the leading number of authors based in Higher Education facilities in world regions of Europe, Asia, Australasia (Australia & New Zealand), North America (USA & Canada) and Africa.

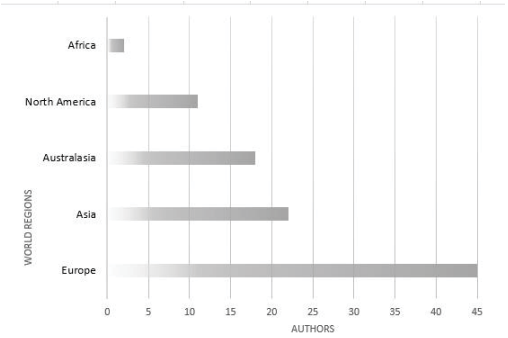

Figure 2: World regional distribution of research authors

The years with increased authors (above 15) for BIM implementation in FM, worldwide were 2015 and 2018, shown in **Error! Reference source not found.**. Authors based in Europe were 94% in 2015 which reduced to 41% based on the substantial increase overall, in articles published in journals in 2018. There was a significant increase in authors by 51% in 2018 with the European region authors contributing 44% between 2014 and 2018 inclusive as detailed in **Error! Reference source not found.**.

There are a range of external factors which are relevant to the increase in articles for BIM: FM implementation which include requirement to publish for a PhD, the research BIM for design and construction stages are saturated and BIM: FM is increasing in academic interest. The increase in articles is positive for raising the profile of BIM: FM implementation, however, low rates of BIM: FM implementation for existing buildings suggests practitioners are not sufficiently confident (NBS, 2018). An additional factor is that the research lacks sufficient detail regarding BIM: FM implementation methodologies for implementation for particular building typologies (Pishdad-Bozorgi et al., 2018).

Table 2: Authors location by papers submitted over time

		2014	2015	2016	2017	2018	Count per Region
Africa	South Africa					2	2
North America	Canada			1			1
	USA		1	4		4	9
Australasia	Australia	5			7	6	18
	New Zealand			1			1
Asia	Iran			1			1
	Malaysia			1		1	2
	Hong Kong				1	6	7
	Singapore				1		1
	South Korea					6	6
	Taiwan					5	5
	Turkey		2				2
Europe	Belgium			1			1
	UAE			1			1
	Italy				3		3
	Finland		3			5	8
	Portugal			2			2
	Netherlands		3				3
	Switzerland		1				1
	UK		7		2	16	25
	Count Total by year	5	17	12	14	51	99

Journal publication over time as detailed in **Error! Reference source not found.** demonstrates that Automation in Construction has published 7 articles between 2014 and 2018; Facilities published three articles and Built Environment Project and Asset Management, Engineering Construction and Architectural Management, International Journal of Building Pathology and Adaptation all published two articles each, over the time period. This demonstrates a wide selection of publications available for journal publication.

Considering the methods chosen to investigate the area of interest, the use of literature review is the initial approach in 2014, method choices then include case study and the use of mixed methods as a combination of interview, observation, secondary data and survey as detailed in **Error! Reference source not found.**. The method for the research profile changed in 2017 when mixed methods and case study increase by 50% when compared to the use of literature review in 2018.

Table 3: Distribution of articles published in Journals over Time

JOURNALS	2014	2015	2016	2017	2018	Total
Advanced Engineering Informatics					1	1
Automation in Construction	1			1	5	7
Buildings		1				1
Built Environment Project & Asset Management		2				2
Civil Engineering Journal			1			1
Construction Management & Economics		1				1
Engineering Construction and Architectural Management				1	1	2
Facilities			1	1	1	3
Innovative Infrastructure Solutions				1		1
International Journal of Built Environment			1			1
International Journal of Building Pathology and Adaptation					2	2
International Journal of Sustainable Built Environment				1		1
Journal for Facility Management		1				1
Journal of Building Engineering					1	1
Journal of Corporate Real Estate					1	1
Journal of Facilities Management					1	1
Journal of Management in Engineering					1	1
Renewable and Sustainable Energy Review		1				1
Structural Survey		1	1			2
Total	1	7	4	5	14	31

Mixed methods and Case Study reduce by 66% in 2016 and stays at that level for 2017, after a peak in 2015. However, from 2018 the increase in use is significant. It should also be noted that a significant number of articles reviewed do not state sufficient detail for the research to be repeatable.

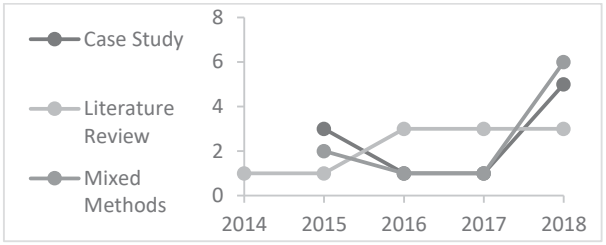

Figure 3: Methods chosen for articles

This review identifies eight case studies that are building typologies studied, limited to 5 universities, 2 Civic buildings and an office building. There are insufficient case studies to be able to draw conclusions that may be generalised across any of the typologies presented. Similarly, due to the low numbers i.e. under 100, the cumulative results of the research are not generalisable, however, all contribute to knowledge.

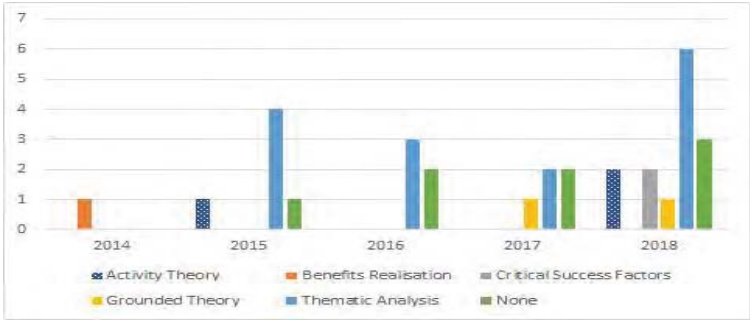

Figure 4: Methodological Models

The analysis used in this review is thematic and the articles under review were classified into three themes, as in **Error! Reference source not found.**, BIM: FM Challenges and Opportunities; BIM: FM Integration and BIM: FM Status. The research themes in 2014 and 2015 concerned BIM: FM integration and BIM: FM status. BIM: FM challenges and opportunities was introduced as a theme from 2016 onwards, in 2018 BIM: FM integration is the dominant theme.

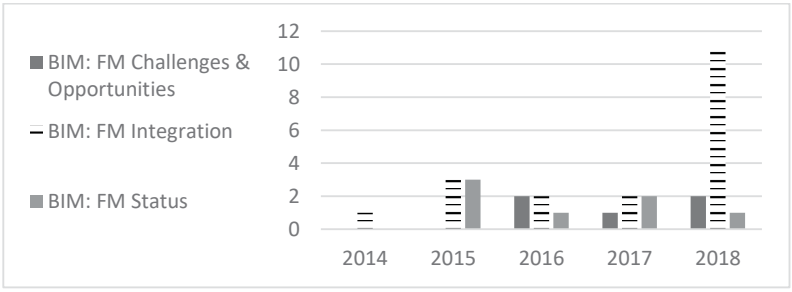

Figure 5: Classification of research Themes

2.2 Thematic Analysis of selected Journal Papers

The over-arching themes from the critical analysis of the articles when compared to Volk et al. (2014) are 1) BIM FM Challenges and Benefits, 2) Data Model Integration, 3) Expertise in BIM & Facilities Management and 4) Major Levers for BIM FM implementation. Two categories from Volk et al. (2014), which have not been addressed are 'data analytics' and 'capability & maturity assessment system'. Additional themes from the reviewed articles include 'FM collaboration with design & construction' and 'Api's and Plug-ins' identified by researchers after Volk et al. (2014) as shown in **Error! Reference source not found.**. These outcomes demonstrate that the review by Volk et al. (2014) was comprehensive at the time of publication and continues to align with research in this subject area today.

Table 4 Themes Unidentified by Volk et al. (2014)

New research themes *Unidentified* in Volk et al. (2018)	2014	2015	2016	2017	2018	Total Themes 2014-2018
FM collaboration with design & construction		1	1	1	3	6
Api's & Plug-ins		2		1		3
Sub-total of themes categories per year	0	3	1	2	3	9

Pishdad-Bozorgi et al. (2018) identified that data transfer from an FM enabled BIM model can directly import into computerised aided facilities management system (CAFM) software with no data loss or atrophy using the capabilities of interoperable software export i.e. COBie. However, there are four current version types of IfC and COBieLite which suggests that planning, testing and specifying data to a granular level is required to achieve successful delivery of data for an FM organisation with legacy software systems. The absolute clarity that is required regarding data when transferring between different software is a critical aspect of successful BIM: FM implementation methodology, as demonstrated by the interest in research undertaken about data integration for 2018 as in Figure 6. The most likely methodology will include web based middleware software solutions to achieve reliability, deliver bi-directional data synchronisation and automated validation and verification using the cloud (Ilter et al., 2015; Kensek, 2015; Pärn et al., 2017).

Considering the question of research interest in BIM: FM implementation for existing building indicates that the challenges for BIM: FM implementation are still as relevant and significant in 2018 as in 2013. Referring to **Error! Reference source not found.** the emphasis has changed within the research themes identified, 2016 & 2018 demonstrate reduction in research from BIM: FM Challenges and Opportunities and peaked at 20% in 2017. Data model integration reduced from 2015 to 2017 but sees a significant swing of from -28% from 2017 and in 2018 reaching a level of over 20%. Expertise in BIM and FM research is -10% in 2015 which showed a small increase in 2016 with levels dropping in 2017. Major levers for BIM: FM implementation peaked in 2016 with reducing levels in 2017 & 2018. IT is significant that in 2016 there was 20% research activity and 2018 achieved 45% in 2018.

It is unclear what the exact stimulus for the increase in 2018, external influencing factors that are relevant include the potential saturation regarding research into BIM for design and construction, with

Figure 6 Year-on year Thematic Distribution Percentage

BIM: FM implementation is the next logical research topic in the field. Additionally the increase in research in the UK could be due to the UK Government Soft Landing requirement for asset management in government funded procurement (Cabinet Office, 2013). Subsequent NBS national BIM reports demonstrate that BIM: FM implementation is slow to progress in the UK based on requests for COBie data at completion and has remained static in 2018/2019 (NBS, 2019).

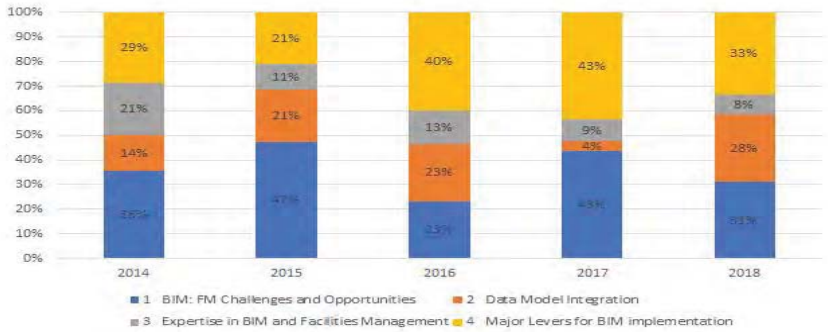

Figure 7 Distribution of Themes Comparative Analysis with Volk et al. (2014)

The themes in the articles as identified in **Error! Reference source not found.** can be further sub-divided to identify the priority themes. These are BIM: FM benefits, the Value of BIM for organisations and the adaptations required to achieve BIM: FM. FM data needs and FM engagement with BIM are a priority together with interoperability and lifecycle. Each of the themes receives similar research emphasis in 2018, however, expertise in BIM and FM management is less than 10% of activity.

Due to the lack of reported longitudinal case studies with regard to BIM: FM implementation, there are few cases of adoption that reach the attention of the FM community as identified by (Pishdad-Bozorgi et al., 2018). The Sydney Opera House, Sutter Health and Manchester Town Hall studies have some valuable insights. However, these are examples based on different continents with different national approaches to BIM standards and guidance for implementation; there are also typology differences of a concert hall, private healthcare and an historic building which make findings difficult to generalise.

4. Conclusion

This study set out to determine the 'state of the art' in research about BIM: FM implementation for healthcare between 2014 and 2018 inclusive. The systematic research process identified there were no articles in journals regarding this topic area. This is a significant finding considering the importance of healthcare buildings to society and the complexity of maintaining such building complexes. As a result, the research focus widened to the implementation of BIM: FM for existing buildings.

Comparative analysis of the selected articles against themes from Volk et al. (2014), was undertaken. The findings show that BIM: FM has seen a 45% increase in the number of articles using

the themes identified for Volk et al. (2014) between 2014-2018, with over 50% published in 2018. These findings suggest that research into BIM: FM implementation is now a primary research topic, although research into BIM: FM for existing buildings is limited.

Facility management teams understand, in the abstract, that BIM: FM for their organisation would deliver significant long-term benefits but have little or no knowledge how to take it forward, as most of the BIM knowledge sits within design and construction. Currently there is no strategy for education of the workforce in BIM: FM to aid transition to BIM solutions for FM. ISO 19650-2; 2019 delivers no advancement on a methodology for BIM: FM implementation for existing building, therefore, future research into BIM: FM standards and demonstration of the 'Value' of BIM for FM to facilitate funding from management, are an essential step together with decoding what types of data are required to deliver Facility Management, noting the distinction between data required for different building typologies (Love et al., 2014; Carbonari et al., 2015; Barbosa et al., 2016; Hosseini et al., 2018; Lu et al., 2018; Pishdad-Bozorgi et al., 2018).

This paper also identifies a gap in the body of literature where a methodology for implementation of BIM: FM for new and existing buildings across building typologies, is required. Additionally, those researching this area should make their contributions more robust by including sufficient detail regarding the method and methodology used to undertake the research to improve the rigour and repeatability of the research. The systematic literature review protocols used in this paper contribute to this gap as a way forward to deliver repeatability for research in construction. The systematic review contributes to the understanding of the status of BIM: FM implementation at this time; which can be likened to being in a waiting room, anticipating a move to a digitalised platform and the whistle has not blown to set everyone off. BIM for FM is most definitely lost in transition.

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