THE EVOLUTION OF FACILITY MANAGEMENT (FM)

IN THE BUILDING INFORMATION MODELLING (BIM) PROCESS:

AN OPPORTUNITY TO USE CRITICAL SUCCESS FACTORS (CSF)

FOR OPTIMISING BUILT ASSETS

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List of Abbreviations

AEC	Architecture, Engineering and Construction (industries)
AECO	Architecture, Engineering, Construction and Owners
AI	Artificial Intelligence
AIM	Asset Information Model
AIM CDE	Asset Information Management Common Data Environment
AIR	Asset Information Requirements
AM	Asset Management
AMs	Asset Managers
AMS	Asset Management System
AR	Augmented Reality
BA	Built Asset(s)
BCF	Building Collaboration Format
BCG	Boston Consulting Group
BEP	BIM Execution Plan
BIFM	British Institute of Facilities Management (Note: Now IWFM)
BIM	Building Information Modelling
BMS	Building Management System
BREEAM	Building Research Establishment Environmental Assessment Methodology
bSDD	buildingSMART Data Dictionary
BS	British Standard
BSI	British Standards Institution
CAD	Computer Aided Design
CAFM	Computer Aided Facility Management
CAGR	Compound Annual Growth Rate
CAPEX	Capital expenditures

CBRE	Coldwell Banker Richard Ellis (Company name)
cdbb	Centre for Digital Built Britain
CDE	Common Data Environment
CDO	Chief Data Officer
CIBSE	Chartered Institute of Building Service Engineers
CIC	Construction Industry Council
CIFM	Computer Integrated Facilities Management
CIOB	Chartered Institute of Building
COBie	Construction Operations Building Information Exchange
CMMS	Computerized Maintenance and Management System
CSF	Critical Success Factor(s)
CSR	Corporate Social Responsibility
CST	Critical Success Themes
D&C	Design and Construction
DO	Demand Organisation
EDMS	Electronic Data Management System or Electronic Document Management System
EIR	Employer’s Information Requirements (as per PAS 1192-2), or
EIR	Exchange Information Requirements (as per ISO 19650)
ETH	Eidgenoessische Technische Hochschule (University in Zurich)
FM	Facility Management
FMs	Facility Managers
FMS	Facility Management Standard
GDP	Gross Domestic Product
GSL	Government Soft Landings
GUID	Global Unique Identifier
H&S	Health and Safety

IAM	Institute of Asset Management
ICS	International Classification Standard
ICT	Information, Communications and Technology
IDM	Information Delivery Manual
IEA	International Energy Agency
IFC	Industry Foundation Classes
IFM	Institute for Facility Management (ZHAW, Switzerland)
IFMA	International Facilities Management Association
IFD	International Framework for Dictionaries
IM	Information Manager
IoE	Internet of Everything
IoT	Internet of Things
IPD	Integrated Project Delivery
IPI	Integrated Project Insurance
IPR	Intellectual Property Rights
IR4.0	Fourth Industrial Revolution
IWFM	Institute of Workplace and Facilities Management
IWMS	Integrated Workplace Management System
ISO	International Standards Agency
JCT	Joint Contracts Tribunal (as in contracts)
KPI	Key Performance Indicator
LCC	Life-Cycle Cost(s) (from BS ISO 15686-5)
LEED	Leadership in Energy & Environmental Design
LJMU	Liverpool John Moores University
LOD	Level of Detail or Level of Development
LOI	Level of Information

LOIN	Level of Information Need
MEP	Mechanical, Electrical and Plumbing (Applying to systems)
MCS	Model Collaboration Systems
MIDP	Master Information Delivery Plan
MoJ	Ministry of Justice
MPDT	Model Production and Delivery Table
MR	Mixed Reality
MSS	Management System Standard (from ISO)
MT	Main-Theme(s)
MVD	Model View Definition(s)
NBS	National Building Specification
NIST	The National Institute for Standards and Technology
OIR	Organisational Information Requirements
OPEX	Operating expenses
O&M	Operations and Maintenance
PAS	Publicly Available Standard
PDT	Product Data Template(s)
PIM	Project Information Model
PLQ	Plain Language Questions
PM	Project Management
PPM	Planned Preventative Maintenance
POE	Post Occupancy Evaluation
PoW	Plan of Work (Refers to RIBA Plan of Work) – Current version 2020
PropTech	Property Technology
PwC	PricewaterhouseCoopers
RICS	Royal Institution of Chartered Surveyors

RDS	Room Data Sheets
RIBA	Royal Institute of British Architects
RE	Real Estate
ROI	Return on Investment
SDGs	Sustainable Development Goal(s)
SFT	Scottish Futures Trust
SIA	Schweizerische Ingenieur- und Architektenverein
	(Swiss Association of Engineers and Architects)
SGNI	Schweizer Gesellschaft für Nachhaltige Immobilienwirtschaft
	(Swiss Sustainable Building Council)
SLA	Service Level Agreement
SME	Subject Matter Expert
SPSS	Statistical Package for the Social Sciences
SST	Sub-Sub-Theme
ST	Sub-Theme
STEP	Standard for the Exchange of Product model data
SWOT	Strengths, Weaknesses, Opportunities and Threats (Analysis technique)
TIDP	Task Information Delivery Plan
UN	United Nations
US	United States
VDC	Virtual Design and Construction
VR	Virtual Reality
W^3	World-Wide Web
WEF	World Economic Forum
WLC	Whole-Life Cost (from ISO 15686-5)
ZHAW	Zurich University of Applied Sciences

Abstract

Purpose: To explore the evolution of Facility Management (FM) in the Building Information Modelling (BIM) process. The research aimed to establish Critical Success Factors (CSF) which help deliver successful BIM projects, and to present these in a '*FM-BIM Mobilisation Framework'.*

Background: Inefficiencies, poor collaboration and a focus on short-term costs in the construction industry, combined with a lack of innovation and digital competency when ordering projects, have resulted in a failure to deliver assets which have sustainable outcomes over their whole-life.

Methodology: A mixed methods concurrent convergent design, incorporating side-by-side narrative text analysis was adopted to merge qualitative/quantitative findings. Critical Success Themes (CST) from literature were then used to establish CSF through; 19 interviews with FM/BIM experts, and a questionnaire to gauge FM industry awareness of BIM (using UK and international inputs). The final merged CSF were incorporated into a framework. This was validated using a two-stage process with a focus group using some of the same FM/BIM experts.

Key findings: 10 CSF Main-Themes (MT), with a 100 Sub-Themes (ST) were identified covering important digital skills, knowledge and competences people require to contribute to the BIM process. Clients and Facility Mangers (FMs) must engage early if the full benefits of BIM are to be realised in the operational phase. They must clearly define their information requirements to align with business processes, and collaborate with the delivery team to ensure information is captured/transferred into the relevant management systems.

Originality/value: The comprehensive end-to-end framework combines FM and BIM CSF into one online interactive tool which provides a wealth of useful knowledge, sources, benefits and practical examples. Although based on the UK BIM Framework, the alignment with *'ISO 19650'* ensures it will also benefit an international audience.

Keywords: Facility Management (FM), Building Information Modelling (BIM), '*FM-BIM Mobilisation Framework',* digitalisation, information requirements.

Declaration

I declare that the work presented in this thesis is entirely my own. No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning. Where other sources of information have been used; every effort has been made to indicate this clearly.

Signature:

Name: Simon Ashworth

Date: December 2020

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Chapter 1: Overview of thesis

1.1 Introduction

This thesis presents a significant contribution to knowledge in the area of Facilities Management (FM) and Building Information Modelling (BIM). The research explores the evolution of the role of Facility Managers (FMs) in BIM projects and how all involved stakeholders can benefit from BIM both strategically and operationally. It also explores how BIM can improve the design, sustainability and efficiency of Built Assets (BA) for people, organisations and wider society.

This chapter presents an introduction to the subject area and background to the research topic. The research problem, questions and objectives are outlined and the significance of the contribution of new knowledge explained. To help guide readers a one-page overview and a summary of each chapter are included.

1.2 Background

“The world is undergoing a technological revolution” stated Zaki (2019, p. 434). Daniotti, Gianinetto and Della Tora (2019, p. v) added “digitalization is perhaps the outstanding trend in all the sectors of life, all around the world”. The resulting pace of change has been exponential, with estimates predicting the global Internet of Things (IoT) market to reach $1,567B by 2025 (Statista, 2020), with 75.44 billion connected to online devices (Statista, 2016). New digital trends and technologies are driving innovation and changing the way industries around the world operate their business. However, “digitalization in the construction world is in its infancy” (Wyman, 2018, p. 14). This is reflected in the ‘McKinsey digitization index’ (Figure 1.1) which shows construction ranked last from a range of industries in Europe (Remes et al., 2018).

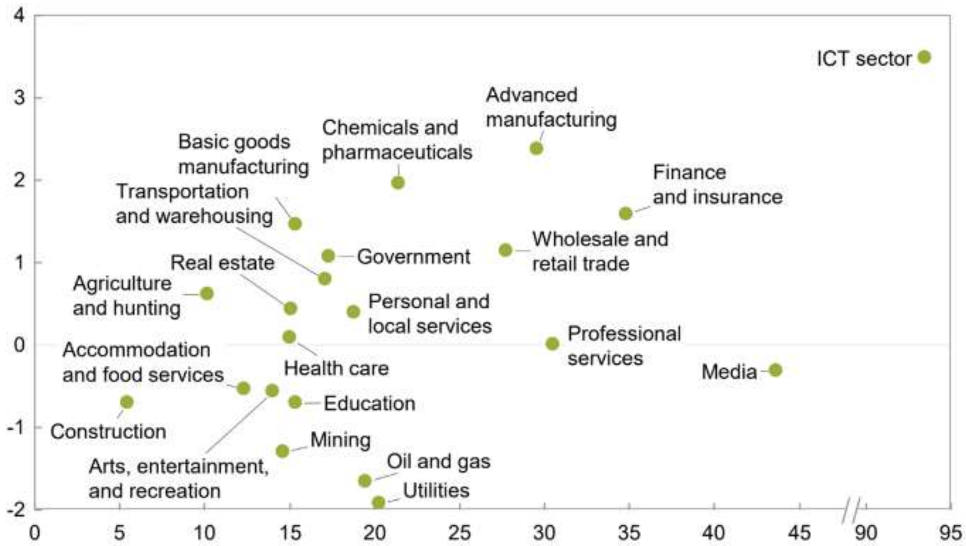


Figure 1.1: McKinsey digitisation index – Europe: 2018 (Remes et al., 2018)

If construction is to improve on this position, digitalisation must be taken seriously; the report notes a positive correlation between the productivity growth of an industry and its degree of digitalisation (ibid). The positive side is that potential savings could be enormous as the worldwide global construction market accounts for 13% of the world's Gross Domestic Product (GDP) according to Barbosa et al. (2017). It is estimated to reach $17.5 trillion by 2030 (Betts et al., 2015). The Boston Consulting Group (BCG) predict that within 10 years, full-scale digitalisation in non-residential construction could lead to annual cost savings of $0.7-1.2 trillion (13-21%) in the engineering and construction phase, and $0.3-0.5 trillion (10-17%) in the operations phase of BA (Gerbet et al., 2016).

BIM is one digitalisation trend that "has completely revolutionized the AEC industry" (United BIM, 2019). Berger (2017) predicts BIM will have the strongest impact on stakeholder's business models as is shown in Figure 1.2.

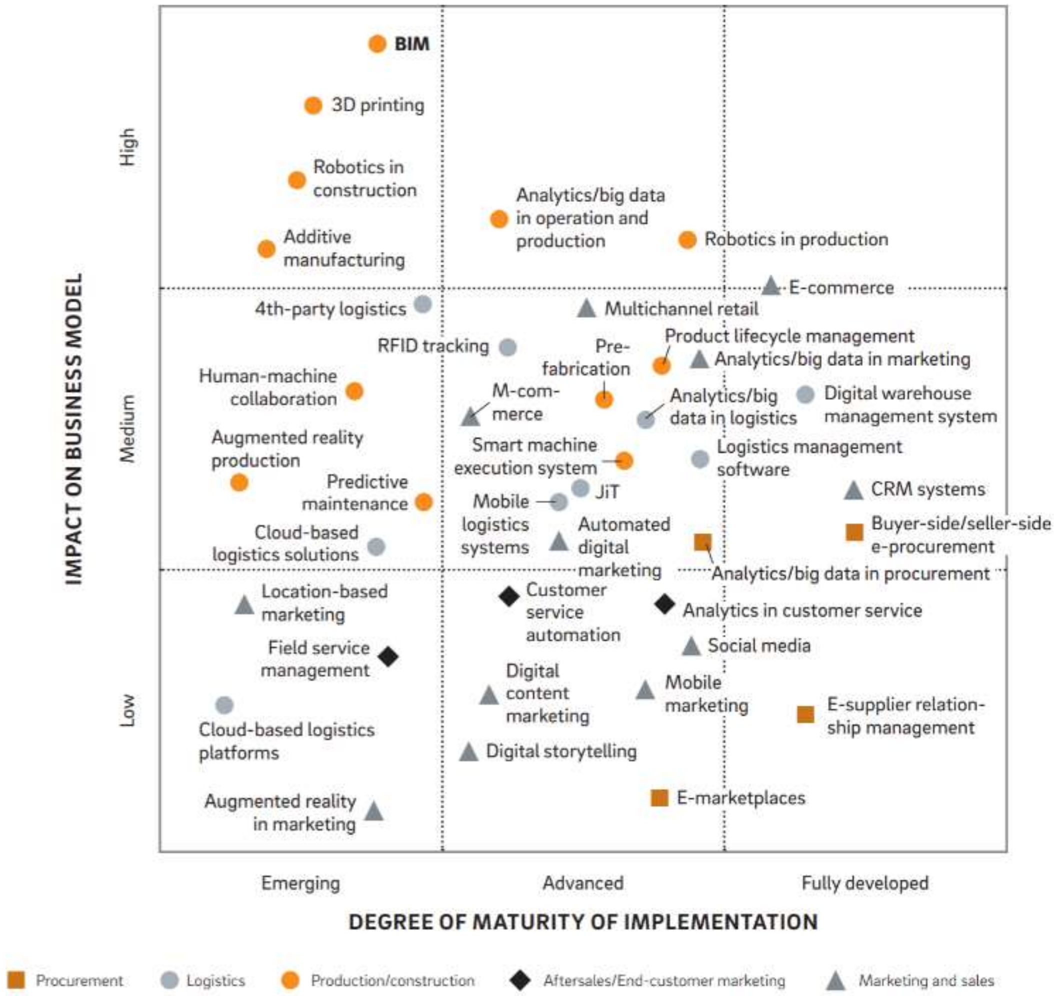


Figure 1.2: Trend radar for the construction industry (Berger, 2017)

BIM has become the norm for the procurement of new assets and "should be regarded as the backbone of the new way of working" (Wyman, 2018, p. 7). The UK is well placed to take advantage of BIM as it has achieved one of the highest BIM maturity levels according to Kassem and Succar (2017). The benefits of BIM are not just in the Capital Expenditures (CAPEX) phase, instead they are "expected to trigger significant improvement potential (direct costs, quality, delays, security, image) along the full construction value chain (design, construction, operations and destruction)" (Wyman, 2018, p. 7). In terms of financial benefits, estimates from PricewaterhouseCoopers (PwC) '*Benefits Measurement Methodology (BMM)*' report suggest:

> across the design, build and commission, and handover phases, our quantified estimates were 0.7% and 1.4% of capital expenditure respectively. If this level of saving could be achieved across the National Infrastructure Commission's projected public sector funded infrastructure spend of £31.7bn in 2018/19, this would imply savings to UK taxpayers of £226m-£429m (in 2017 prices) (PwC, 2018, p. 7).

There is wide acceptance that the largest potential benefits of BIM are to be realised not during the planning and construction phase but in the Operating Expenses (OPEX) phase. The International Standards Organisation (ISO) standard '*15686-5 Buildings and constructed assets - Service life planning. Life-cycle costing*' noted that up to 80% of the operational cost of an asset are influenced in the first 20% of the design process (ISO, 2017). FMs need to be involved at these early stages to influence the design and ensure the long-term costs are kept at the forefront when thinking about design decisions. This drives "heightened expectations for increased engagement of FMs, users and clients in the BIM process" (Ashworth et al., 2016, p. 1). The paradigm shift in thinking over a whole-of-life approach is crucial if cost-performance and added value are to be delivered over the long term according to Sanchez, Hampson and Vaux (2016). Eadie et al. (2013) added, there is an extra incentive for clients and FMs as they are considered respectively as those standing to benefit most financially from BIM. This is reflected in survey findings by Ashworth and Tucker (2017), indicating that 74% of respondents believe "BIM will have a significant impact on the FM industry".

However, Ayaz, Ruikar and Emmitt (2012) suggested, in order to achieve the desired benefits, significant changes must be made to current business processes with clients and FMs taking on new competencies and roles. Until recently 'silo mentality working' in the Architecture, Engineering and Construction (AEC) industries has meant "FM has been given a low priority in the property development industry, resulting in facilities managers being inadequately integrated into the development process" stated Tucker and Masuri (2018, p. 377). Overcoming these barriers will allow early FM engagement in BIM projects, ensuring their valuable knowledge is used to "help designers with key decisions, which will have lasting usability, cost efficiency and sustainability impacts over the whole of a building's life" (Ashworth, 2013, p. 1).

FMs are key stakeholders with ultimate responsibility for managing, optimising and replacing assets, as well as ensuring their safe operation after handover for the rest of their operational life. This requires them "to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology" (IFMA, 2020). In order to perform their role, they need all the available information about the asset. This highlights another key problem; 'information handover' is often poorly handled, or worse even lost. Time wasted searching for, and finding information can be significant. The National Institute of Standards and Technology (NIST) report (Gallaher et al., 2004) estimated potential annual losses in the US facilities industry of $67m. This is comprised of wasted time recapturing and transferring information provided by architects, engineers and contractors; and $613m regarding the automated transfer of information into available Computer

Aided Facility Management (CAFM) tools. To avoid waste and allow optimisation of BA in operation, clients and FMs must clearly define and specify essential information for day-to-day operations. The supply chain requires clarity; without it you could use the analogy of ordering a car with the expectation of a Rolls Royce, then being disappointed when the result is a Mini. At least with the car you can return it, that is not possible with a building. This requires competence from clients and FMs when 'ordering' BIM projects. Without such skills Talamo and Bonanomi (2019, p. 175) observed the "lack of knowledge about the process-oriented and organizational changes makes it difficult to establish a work environment within and between firms that is conducive to digital innovation".

The initial literature review focused on the evolving role of FMs in BIM projects and establishing Critical Success Themes (CST) which are key to successful outcomes. The CST key areas broadly aligned with the International Facilities Management Association (IFMA) definition of FM shown in Figure 1.3. An additional focus was the UK Government's 'policy' with respect to BIM which has played a major role in shaping the UK BIM landscape.

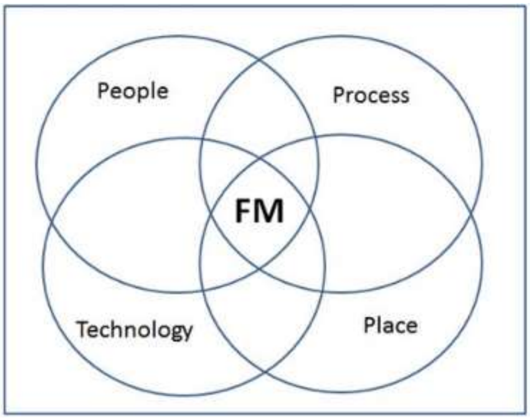


Figure 1.3: FM concept from IFMA (Bakri et al., 2018)

The CST were used in interviews and a questionnaire to establish the Critical Success Factors (CSF) which, if adopted, will help the FM industry better engage with BIM. The research culminated in the development of the '*FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects'* (hereinafter referred to as the '*FM-BIM Mobilisation Framework*'). It can be used by practicing FMs and other stakeholders involved in BIM projects to ensure successful project outcomes.

1.3 Research problems

Several issues have traditionally inhibited the engagement of FM in the design and construction of BA:

i) **Cost-focus:** typically the CAPEX of a BA is only 15% of the total life-cost (Teicholz, 2004). Grzyl, Miszewska-Urbańska and Apollo (2017) suggested the OPEX cost can be up to 75%. However, procurement is normally based on the short-term CAPEX. This drives solutions that initially seem cheaper by cutting as many costs as possible in design. Unfortunately, this does not usually provide value for money over the long term (Saxon, 2005). The report '*Procuring for Value*' (CIC, 2018, p. 4) supports this, recommending "an industry-wide definition of value that takes into account more than capital cost".

ii) **Lack of innovation**: the AEC industry has been plagued by problems including; waste, inefficiency, lack of collaborative working and innovation etc. noted Xue et al. (2014). Designing Buildings Wiki (2019a) stated that despite many 'construction industry reports', resulting attempts to address the issues have failed. The '*Future-Ready Index*' (KPMG, 2019, p. 3) reinforces this, reporting that "most people acknowledge the importance and impact of technology and innovation, but few were adopting it significantly, with even fewer reaping the benefits". Significant change and innovation are needed to ensure organisations are prepared for the inevitable digital transformation. There are signs of this already happening with significant numbers of construction companies in the early stages of digital transformation (Jones, 2019).

iii) **Resistance to change and collaboration:** until recently FMs were often excluded from projects until the point of handover (Durant, 2018). This approach denies D&C teams the benefit of operational know-how to help them ensure designs meet the needs of users, and avoid BA which are expensive to operate, suggested Liu and Issa (2015). Good collaboration, communication and sharing of information are essential if the project team want to reduce rework and improve efficiency and productivity whilst adding value (Johnson, 2019). However, collaboration is often limited due to 'silo-working mentality' (Gleeson, 2013).

iv) **Defining information needs:** the exclusion of early client and FMs in the BIM process often results in a lack of clear operational information requirements (Kelly et al., 2013). This results in what Ashworth, Tucker and Druhmann (2018) call a 'garbage in = garbage out' scenario. Clients must clearly define their information requirements at the start of each project in key BIM documents (i.e. the Organisational Information Requirements (OIR), Asset Information Requirements (AIR) and Exchange Information Requirements (EIR)), otherwise the supply chain will deliver what they assume is required. Where these are absent the result is often unnecessary, unstructured, and poor quality information at handover. This hampers the efficient transfer into FM management systems like CAFM and can be more costly to fix. Unsurprisingly clients are often disappointed with the end (Ashworth, 2018b).

v) **Digital experience/knowledge:** The AEC industry has been forced to getting to grips with BIM following the Government's mandate in 2016 to adopt BIM. However, across many disciplines "there is still a large knowledge gap around BIM data and its importance to the future of the construction industry" (Alexander, 2017). Kouch, Illikainen, and Perälä (2018, p. 888), stated "most of the active SME contractors are not aware of BIM, nor are they familiar with the BIM implementation framework and its key factors". The lack of early involvement of FMs has created a natural ‘digital knowledge divide’ between AEC and FM professionals. Few FMs have practical BIM experience often leading to uncertainty about when they need to engage in the process. This will have serious results if FMs do not know how to define, access, use and extract information from the BIM process. Many of the potential advantages could be lost and ‘data cemeteries’ created where valuable information is not accessed/used. FMs need “new technology and processes to face the challenge of collecting, categorizing, visualizing and updating the information for operation” (Ibrahim et al., 2016, p. 1).

vi) **Competency in BIM procurement:** many organisations have no BIM strategy in place, or adequate in-house staff skills, to order a BIM project competently. Kumar and Hayne (2016, p.1) suggested this is in spite of widespread acknowledgement that “information management and exchange processes, standards and protocols underpinned and enabled by modern BIM technologies could indeed achieve considerable benefits to all stakeholders”. However, “to enable individuals within these organisations to develop their BIM abilities, it is important to identify the BIM competencies that need to be learned, applied on the job, and measured for the purposes of performance improvement” stated Succar, Sher and Williams (2013, p. 174). Adequate training and experience are therefore critical to the success of BIM projects.

1.4 Research questions

A review of literature, industry standards, guidance and best practice was used to identify gaps in existing knowledge linked to the identified problems. This led to the primary research question:

i) What are the CSF in terms of relevant knowledge, skills and competences, which will empower FMs to fully engage with the BIM process and ensure that BA can be optimised in operation?

Secondary questions were established to help answer the primary research question:

ii) What CST can be identified from literature which help improve the successful engagement of FMs in the BIM process?
iii) Which quantitative and qualitative CSF are important for the successful delivery of BIM projects and can be identified respectively from best practice (the ‘general FM industry’) and experts (‘FM/BIM experts’)?
iv) What are the current levels of awareness of BIM in the ‘general FM industry’?
v) What are main benefits of BIM to FM and how can these be made more transparent?
vi) What possible barriers might prevent early FM involvement in the BIM process and how can they be overcome?
vii) How could the qualitative and quantitative CSF be brought together in a framework to help organisations and individuals deliver successful BIM projects which realise the benefit of BIM and improve the transfer and use of information for the operational phase of BA?

1.5 Research aim

The overall aim of the research was to create a *'FM-BIM Mobilisation Framework'* to help people better engage with the BIM process and optimise built assets in operation.

1.6 Research objectives

Research aims and objectives were devised to help answer the research questions. Namely to:

a) Review the **state of the art,** and identify the CST with respect to the role of FMs in the BIM process in broad grouped themes related to: 'policy', 'processes', 'technology and digitalisation' and 'people'. The review will focus on the UK market but include other international sources where relevant.
b) Establish **quantitative CSF** based on a 'general FM industry' awareness of BIM considering benefits and barriers to FM involvement in the BIM process. This will include inputs from the UK and other countries.
c) Establish **qualitative CSF** from **'**FM/BIM experts' to understand their view of how BIM is impacting on FM and what would help FMs best engage in the BIM process. Input will be mainly based on the UK but may include international experts.
d) **Merge the CSF** (from b and c) to establish a **final summary list of CSF**.
e) **I**dentify a suitable framework format for the '***FM-BIM Mobilisation Framework'*** and incorporate the final list of CSF (from d) into a draft framework. The guidance and links will provide both UK specific and more generic advice for international users. .
f) Validate the **'*FM-BIM Mobilisation Framework'*** with 'FM/BIM experts'.

1.7 Significant contribution to the body of knowledge

This thesis represents a significant contribution to the current body of FM and BIM knowledge. Firstly, by developing a detailed understanding of the critical issues and barriers which have prevented early FM involvement in the BIM process. Secondly, the development of a theoretical '*FM-BIM Mobilisation Framework',* which provides a practical tool with advice and guidance to help people deliver successful BIM projects. Ten CSF were established during the research which if followed, will produce better project outcomes for all stakeholders involved and add value to BA over their whole-life.

Evidence of originality is provided as the research goes beyond current established benefits and barriers of using BIM. Empirical evidence is presented illustrating how FMs knowledge can be used to benefit the whole BIM process; from early planning through the Design and Construction (D&C) and then in operation. This was achieved, firstly, by identifying CST from the literature, industry BIM standards and best practice guidance, essential to successful engagement and positive outcomes in BIM projects. Secondly, by establishing qualitative and quantitative CSF critical to the successful engagement of FM in the BIM process. The CSF were investigated from three perspectives: (a) the wider 'general FM industry' awareness of BIM using a questionnaire; (b) from interviews with 'FM/BIM experts; and (c) by developing the '*FM-BIM Mobilisation Framework'* which is unique to the field of study.

During the PhD several papers and contributions towards industry best practice guides were written. A few examples are shown below and a full list is provided in Appendix A.

- Ashworth et al. (2020) *'BIM Data for FM Systems: The facilities management (FM) guide to transferring data from BIM into CAFM and other FM management systems'*, Institute of Workplace and Facility Management, UK
- Ashworth, S., Druhmann, C. and Streeter, T. (2019) *'The benefits of building information modelling (BIM) to facility management (FM) over built assets whole lifecycle'*, 18th EuroFM Research Symposium, Dublin, Ireland.
- Ashworth, S., Tucker, M., and Druhmann, C. (2018) *'Critical success factors for facility management employer's information requirements (EIR) for BIM'*, Facilities, Vol. 37 No 1/2 pp 103-118.

1.8 Research overview

Figure 1.4 illustrates the convergent design based on Creswell and Clark (2018).

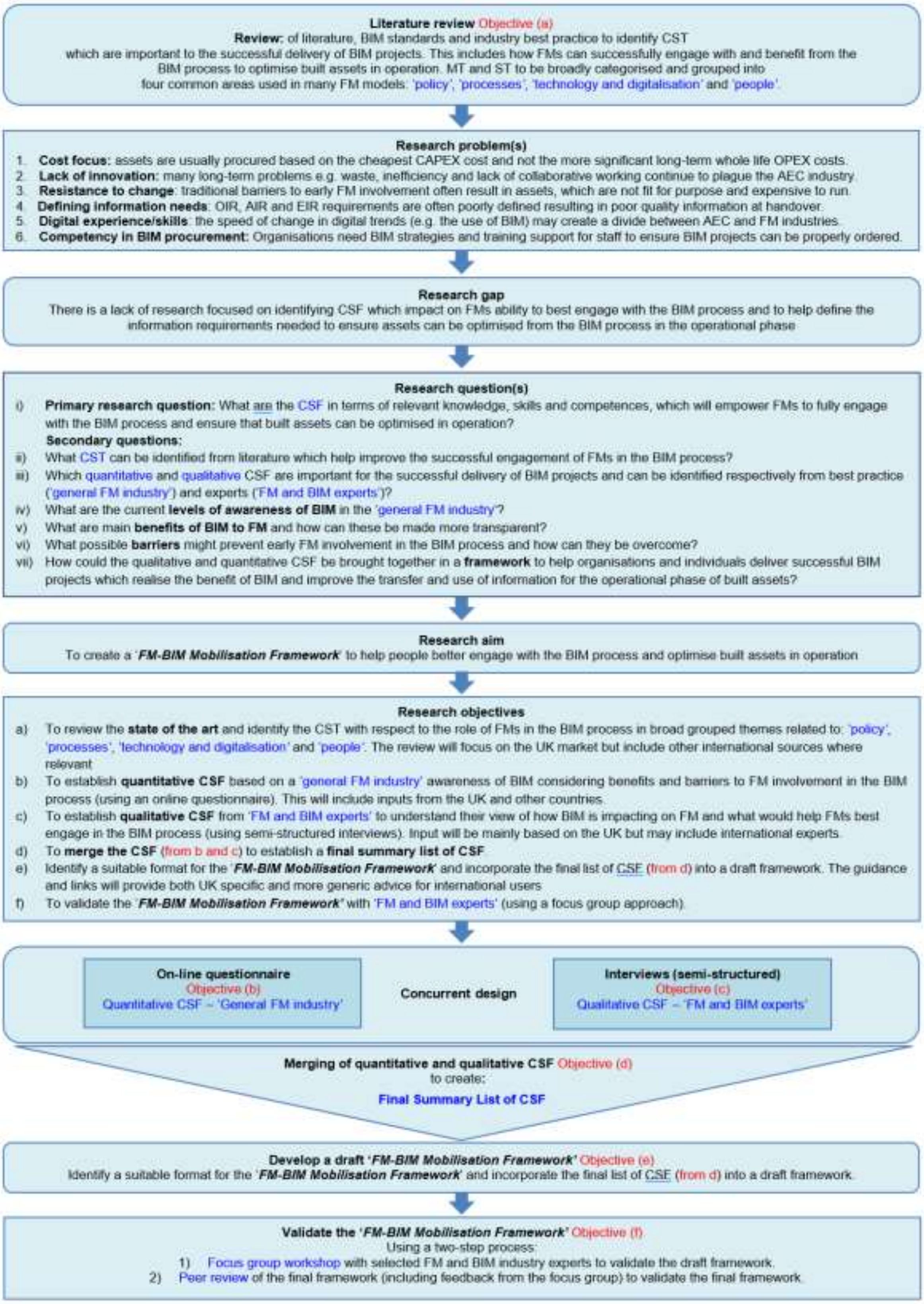


Figure 1.4: Convergent research design based on Creswell and Clark (2018)

1.9 Overview of chapters

The content is structured as follows:

<u>Introduction</u>:

Chapter-1: Overview of the thesis: highlights the background to the research, the research problems and questions, subsequent aims and objectives, and the contribution to the existing body of knowledge.

<u>Literature review</u>:

Chapters 2 to 8 address six key topics:

Chapter-2: Achieving best value of BA over built assets whole-life: reflects on the importance of BA to people, organisations, the economy, wider society and sustainability. The Government's policy of using BIM to drive change and address decades of problems with waste and inefficiency in the AEC industries was investigated. The literature highlights that long-term best value for money is only achieved when BA are considered over their whole-life, and the importance of transferring quality information to the operations teams to enable optimisation of the BA over the long-term.

Chapter-3: The evolving discipline of facility management: discusses the birth and subsequent development of the discipline as well as the critical role FMs play in helping to deliver and maintain BA. It explains the strategic role of FM in enabling businesses and organisations to focus on their core activity. It also explains the wider importance and added value of FM to society, the economy and other key issues including productivity and sustainability.

Chapter-4: The impact of digitalisation: highlights the impact of digitalisation trends on humanity and how knowledge is now available through the internet and IoT. It discusses how these trends including the rise of smart buildings/cities are changing the AEC and FM industries. It reflects on how the Government has adapted its construction strategy to make the most of digitalisation, and explores how organisations need to have a strategy in place if they are to keep pace with changes brought about by digitalisation.

Chapter-5: The evolution and advantages of building information modelling: demystifies important aspects of 'what BIM is, and what it is not'. It describes how BIM has completely changed the way BA are procured, designed, built and delivered. The importance of information requirements and BIM strategy are discussed and concept models introduced to help explain the BIM process. The incredible pace of change is highlighted with respect to changing BIM standards/guidance (now manged through the UK BIM Framework) over the last few years. Other important aspects of BIM are discussed including openBIM, IFC, COBie and use of BIM for existing buildings, and future government thinking regarding BIM and digitalisation.

Chapter-6: The role of facility management in the process: discusses the critical need for early client/FM engagement and how FMs can improve the BIM process. It highlights the benefits of BIM to FM and the importance of well-structured data for FM management systems. It considers the various barriers and challenges to the adoption and use of BIM, and how these can be overcome to deliver better project outcomes for all stakeholders. It also emphasises the need for upskilling of people as a CSF across the industry.

Chapter-7: Critical success factors and frameworks: discusses the use of CSF and frameworks and how these form the basis for the *'FM-BIM Mobilisation Framework'*. The focus here is to help readers understand how the conceptual framework was developed.

Chapter-8: Summary of the literature review: summarises the CST in terms of MT/ST identified in the literature chapters. It also reflects on the pace of change with respect to BIM literature, standards/guidance, and the updating of the literature chapters in the final write up.

Research design, methodological approach and findings

These are detailed in Chapters 9 to 13, specifically:

Chapter-9: Research design and methodology: provides an overview of the research design and methodology used.

Chapter-10: Qualitative methodology and approach: describes the qualitative approach using semi-structured interviews with 'FM/BIM experts' from practice.

Chapter-11: Qualitative analysis and findings: describes the qualitative analysis and presents the qualitative CSF findings.

Chapter-12: Quantitative methodology and approach: discusses the use of the online questionnaire '*FM Awareness of BIM'* to benchmark the 'general industry' awareness of BIM**.**

Chapter-13: Quantitative analysis and findings: describes the quantitative analysis and presents the quantitative CSF findings as narrative text. It also includes several hypotheses regarding relationships between variables.

CSF merging process to create the framework

Chapters 14 and 15 address:

Chapter-14: Merging the qualitative and quantitative themes: describes how the CSF (qualitative and quantitative) were merged using the 'side-by-side' narrative text analysis process.

Chapter-15: Validation process: describes how the '*FM-BIM Mobilisation Framework'* was validated using a group of 'FM/BIM experts'.

Discussion and conclusions:

Chapter-16: Presentation of the final '*FM-BIM Mobilisation Framework*': presents the final version of the validated '*FM-BIM Mobilisation Framework'*.

Chapter-17: Conclusion: presents a reflection regarding the success of achieving the research objectives, questions and the final production of the '*FM-BIM Mobilisation Framework'.* Limitations and recommendations for further research are presented as well as an overview of the final framework.

References and appendices:

These are listed at the back of the work.

Chapter 2: Achieving best value over built assets whole-life

The purpose of this chapter was to address research objective (a) to assess the state of the art and identify CST important to delivering successful outcomes when using the BIM process. Specifically it highlighted the need to think about how BIM will contribute towards sustainability and best add value when considered over the whole-life perspective.

2.1 How built assets support society, sustainability and our economies

The architect Stewart Brand observed "buildings are of particular importance to people as they contain our lives and all civilization" (Brand, 1995, p. 2). He saw them as fundamental to the structure of society, adding "office buildings are now the largest capital asset of developed nations" (ibid). Whether it is cities or smaller urban developments, BA surround us shaping the world we live in. They represent a significant proportion of all global wealth and employ over half our workforce (RICS and IFMA, 2018). When considering the complexity of what actually constitutes BA, the BSI suggested "building, multiple buildings (e.g. a site or campus) or built infrastructure (e.g. roads, railways, pipelines, dams, docks, etc.) that is the subject of a construction project or where the asset information is held in a digital format" (BSI, 2015, p. 3).

BA are critical to modern society, providing the places in which we live and work. Tucker and Masuri (2016) suggested that they need to be high-quality to sustain people's health and wellbeing, and support organisations worldwide in achieving their daily business objectives. To make us feel comfortable it is essential they feel 'human', providing ambience, organisation and flexibility (Chodasova, 2004). This requires creating a fine balance; a 'triple-bottom-line' in terms of 'best performance'. Savitz and Weber (2006) advised the needs of users, society and the environment all need to be taken into account whilst producing cost-efficient designs from an operational perspective. However, Lindholm and Leväinen (2006) observed that many organisations in practice often do not realise the true value of their real estate.

The importance of BA to 'sustainable development' is underlined in the United Nations (UN) report '*2030 Agenda for Sustainable Development*' (UN, 2015) which outlines 17 Sustainable Development Goals (SDGs) as shown in Figure 2.1.

Figure 2.1: UN 2030 SDGs (UN, 2015).

From the 17 global SDGs with 169 sub-targets Adshead et al. (2019) noted almost three-quarters are related to infrastructure. SDG 11 specifically addresses BA in terms of 'sustainable cities and communities'. Its accompanying infographic '*Sustainable Cities: Why They Matter*' highlights that "since 2007, more than half the world's population has been living in cities, and is projected to rise to 60 per cent by 2030" (UN, 2015a, p. 1). It also reports "cities occupy just 3 per cent of the earth's land, but account for 60-80% of energy consumption and 75% of carbon emissions" (ibid).

Science indicates world population growth is putting an increasing strain on our limited natural resources. These pressures will increase as numbers are predicted to rise to 9.7 billion by 2050 (UN, 2019). In 2020 estimates for the UK population were 65.7 million with urban population at 83.9% (CIA, 2020). Such high levels are driving mankind's increased need for energy, which according to the UN is now the dominant contributor to climate change (UN, 2015). It is now perceived as the most urgent issue and without change: "the compounded effects will be catastrophic and irreversible: increasing ocean acidification, coastal erosion, extreme weather conditions, the frequency and severity of natural disasters, continuing land degradation, loss of vital species and the collapse of ecosystems" (UN, 2019a, p. 3).

Many of the challenges can be directly attributed to the built environment. The International Energy Agency (IEA) suggested it accounts for; 55% of global electricity demand, 60-80% of total energy consumption and 75% of world CO2 emissions (IEA, 2018). It is also responsible for about 60% of urban waste, mainly from building operations (ibid). In the UK alone 221 million tonnes of waste were produced in 2016, of which construction, demolition and excavation waste was responsible for 62% (DEFRA, 2020). One can argue the industry has a moral obligation to change the way it works to help mankind address these challenges.

The UN SDGs call for all stakeholders including Architecture, Engineering, Construction and Owners (AECO) to consider their role and what contribution they can make to address the challenges of reducing waste, pollution and energy use, improving living conditions and quality of life, etc. This is especially important to societies across the world as the UN notes, currently "1 out of 4 of urban residents live in slum-like conditions" and "9 out of 10 breathe polluted air" (UN, 2019b). Our BA provide a critical role in supporting society: "at a national level, the prime purpose of infrastructure, property and services is to support and sustain business and public endeavours of all kinds and across all sectors" (Nutt, 2004).

From a financial perspective the AECO industries underpin world economies. Brand (1995) observed that, after agriculture, the building industry is the second largest in the world; 60% of global GDP being provided by the economic growth of cities and metropolitan areas. The industry's global economic impact is highlighted in the report: '*Reinventing construction: a route to higher productivity*' (Barbosa et al., 2017). It reports that $10 trillion is spent on construction-related goods and services every year, in turn employing 7% of the world's working population which represents 13% of the world's GDP. The construction industry is predicted to expand to meet the growing demands of increased population. Predictions indicate a Compound Annual Growth Rate (CAGR) of 5.7% reaching $12.031 trillion worldwide by 2024 (ConsTrack360, 2020). In the EU a GDP value is estimated at 9% for construction and is a key driver for economic growth employing 18 million people (EU BIM Task Group, 2017).

In comparison the global FM market is extremely hard to predict as so many services could be included. However, (CBRE, 2017) ascertained that the global outsourced market of FM services will be reach $1 trillion in 2025. Other predictions by Bhutani and Wadhwani (2019) put the figure higher, reporting the FM market already exceeds $1 trillion in 2018 with an expectation of $1.74 trillion by 2025. The EU 2018 market was estimated at €262.7 billion euros made up of; €19.2 integrated FM, €112.7 outsourced and €136.8 in-house, with FM making up 1.7% of total workforce (Global FM, 2018). The UK AEC and FM industries make a significant contribution to our GDP: 2018 saw construction contribute £117 billion to the UK economy (Rhodes, 2019) and this is predicted to rise steadily to £176.5 billion by 2024 (ConsTrack360, 2020).

In comparison, the UK FM market was estimated by the British Institute of Facilities Management (BIFM) in 2017 to be worth 8% of GDP, and estimated to reach £120 billion by 2021, whilst employing up to 10% of the country's workforce (CIBSE, 2017). As such even a small performance percentage improvement in either the construction or FM industry could result in savings that will have a significant impact on the UK economy.

2.2 Lack of productivity in the worldwide construction sector

The global construction market is significant, but also has one of the world's lowest annual productivity growth rates; a key metric in measuring industry performance. Whilst other sectors like manufacturing have managed 3.6%, construction has performed at only a 1% increase over the past 20 years (Barbosa et al., 2017).

The US market emphasises the problem; whilst agriculture and manufacturing productivity has increased 10-15 times since the 1950s, construction is essentially the same as 80 years ago (Sveikauskas et al., 2016). Egan (1998) observed that low profitability and too little investment in capital, research and development, and training had led to the industry's clients being dissatisfied with overall performance. This divergence with other industries has been increasing year-on-year as is illustrated in Figure 2.2.

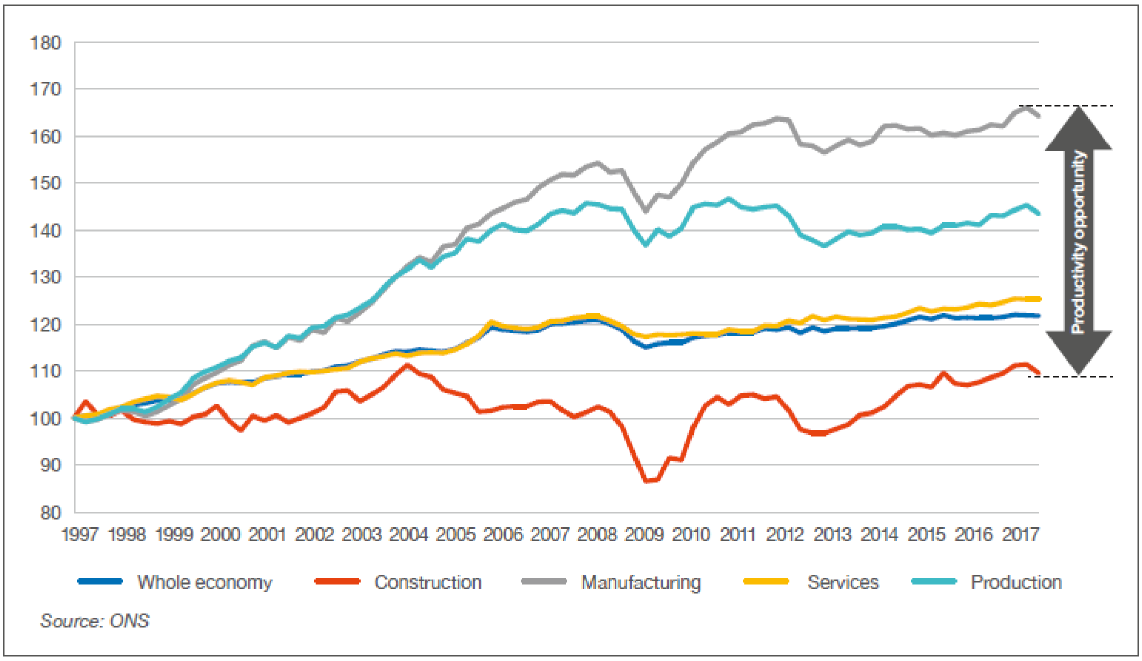


Figure 2.2: Construction productivity growth over time (IPA, 2017)

Taking all these issues into account, it is clear changes are needed in the way our BA are designed, built and operated. However, Langston (2011) noted that over time buildings, like other assets, can become obsolete. Barbosa et al. (2017) suggested incorporating 're-use' as a strategy to support a 'circular economy'. They went on to note the construction industry as being extremely poor when it comes to digitalisation and that it needs to use technology to drive change By integrating technology with these approaches ARUP (2016, p. 45) predicted:

> buildings will be designed for a whole-life-cycle and not simply an end use. Stakeholders will collaborate on cloud-based BIM models with analytical software that clearly visualises a proposal's externalities. Policy and incentives will encourage clients to issue full life-cycle contracts from design to operation and disassembly as well as pushing their ambitions in achieving holistic life-cycle certification and awards.

2.3 Construction: an industry ripe for change

Over many years, the AEC industries have been faced challenges on how to; improve cost efficiency, increase quality and productivity, and speed up project delivery (Azhar et al., 2008). Many reports over decades have highlight what needs to change. An extensive list of 88 examples (1934-2018) are available online (Designing Buildings Wiki, 2019a). From these, the first '*Building to the Skies*' suggested the construction process took too long, was too expensive and was not satisfactory for its clients (Bossom, 1934). The last, '*National Infrastructure Assessment*' reported: "over the last 50 years, the UK has seen an endless cycle of delays, prevarication and uncertainty" (Armitt et al., 2018, p. 3). Report examples include:

- *'Constructing the Team'* (Latham, 1994); the industry has 25-30% waste and needs to improve collaboration alongside a partnership approach.
- *'Rethinking Construction'* (Egan, 1998); need for improvements e.g. leadership focusing on customer needs, integrated processes/teams, improved quality and commitment to people.
- *'Modernising Construction'* (Bourn, 2001); over 73% of construction projects were delivered over budget and 70% late.
- *'Accelerating Change'* (Egan, 2002); need to end lowest cost tendering as the main industry procurement tool and consider how clients get value for money.
- *'Never Waste a Good Crisis'* (Wolstenholme, 2009); maximum value is created when the whole-life-cycle is considered rather than simply reducing construction costs.
- *'Exploring Procurement in the Construction Industry'* (CIOB, 2010); budget overruns 94% and late delivery 93%.
- '*PAS 1192-2*' (BSI, 2013, p. v): "basic problems exist with procuring public assets, which have been known for over 100 years, but little as yet has been achieved in resolving them."
- '*Infrastructure Assessment*' (Armitt et al., 2018) noted the need to move towards more energy efficient BA, concluding that infrastructure in the UK is not in line with population growth, nor technological demands and advances. The importance of digitalisation is made clear in seven key recommendations, the first of which suggests "building a digital society" (ibid, p154).

These reports paint a picture of a construction industry 'ripe for change', lacking innovation, and in need of an overhaul to address key sustainability issues. However, on a positive note the industry is working hard to improve. If it does there is potential to deliver significant savings to world economies and address many of the challenges identified by the UN.

Digitalisation offers exciting opportunities to achieve the required changes. Berger (2016) observed the industry is already aware of the importance of the megatrend toward digitisation but noted it is often not implemented in practice. Blume (2017) argued the built environment needs to adopt digitalisation quickly or the increased pace of change will likely increase obsolescence in the industry; especially of energy-inefficient buildings that are incapable of becoming smart buildings. Langston (2011) suggested digitalisation will enable design teams to significantly improve sustainability performance with more informed BA decisions, thereby providing property owners and investors with better economic, social and environmental benefits.

2.4 The UK Government's drive to adopt building information modelling

The 2008 world recession had a significant impact on driving change. The Government report, '*Key Issues for the New Parliament 2010,'* noted: "the downturn in economic activity was felt across the world, with many countries, including all G7 economies, falling into recession during 2008. The recession was the 'deepest' (in terms of lost output) in the UK since quarterly data were first published in 1955" (House of Commons, 2010, p. 28). The CIC (2009) noted that, since the Second World War, 2009 was the worst year economically leading to a period of austerity with limited resources to spend on new infrastructure.

The recession, together compounded by issues raised in Chapter 2.3, led to the 2011 '*Government's Construction Strategy*'. This underlined a need for change: "there is widespread acknowledgement across government and within industry that the UK does not get full value from public sector construction; and that it has failed to exploit the potential for public procurement of construction and infrastructure projects to drive growth" (Cabinet Office, 2011, p. 3). The strategy established a bold target to cut costs by up to 20%. In order for the Government and the country to achieve long-term social and economic infrastructure there needed to be a relationship change between public authorities and the construction industry. The aim was to ensure information was better co-ordinated, with specifically designed and procured requirements which was provided to the public sector clients.. It noted the design and construction of a facility needs to be aligned with those who subsequently occupy and manage it. Importantly it also introduced the Government mandate for "fully collaborative 3D BIM (with all project and asset information, documentation and data being electronic) as a minimum by 2016 (ibid, p14).

The 'UK BIM Task Group' was consequently set up on 31st May 2011 to help drive adoption of BIM across government in support of the strategy target to achieve 20% savings on the costs of capital projects by 2016 (BIM WiKi, 2017). The pressure was ramped up in the '*Construction 2025: Industrial Strategy: government and industry in partnership'* (HM Government, 2013, p. 5) which set four challenging targets, namely a:

- 33% reduction in both the initial cost of construction and the WLC of assets
- 50% reduction in the overall time from inception to completion for new-build and refurbished assets
- 50% reduction in greenhouse gas emissions in the built environment
- 50% reduction in the trade gap between total exports and total imports for construction products and materials

In 2014 the '*Government Construction Cost Reductions, Cost Benchmarks, and Cost Reduction Trajectories'* report (Cabinet Office, 2014) focused industry on producing benchmark data to emphasise the potential for savings to drive efficiencies and the use of BIM on all contracts. In 2015 we saw more emphasis on digitalisation in the Government's '*Digital Built Britain'* strategy. It recognised the need to use BIM as a key factor to reduce costs, whilst improving the collection and management of valuable information needed by operation teams, to optimise buildings performance over their whole-life. The strategy noted: "The information economy is transforming the way we live and work. It is crucial to our success on the global stage and to facing the challenges of urbanisation and globalisation that we grasp the opportunity" (HM Government, 2015, p. 3). The 2016 '*Government Construction Strategy: 2016-20'* digital technology advances have enabled increased productivity opportunities and efficiency within construction and asset operation (IPA, 2016).The strategy also noted collaborative approaches with the use of digital technology has been shown to drive innovation thereby reducing waste.

2.5 A paradigm change towards realising best value over the whole-life of assets

The Institute of Asset Management (IAM) report '*Asset Management - an anatomy'* observes that "modern society is heavily reliant on physical assets in order to function effectively" (IAM, 2015, p. 7). This is undoubtedly true, however from a customer perspective, Saxon observed that:

> Customers in the great majority do not seek to buy construction per se; they seek the use of facilities or the creation of assets. They find value in the availability of serviced space, developed and run to support their business or social service. Construction is only a periodic input to meet that need. To paraphrase the Zen master Lao Tsu; 'value lies not in the built artefact but in the use of the space within' (Saxon, 2005, p. 12).

We have seen a gradual paradigm shift in thinking how to achieve best value from BA for users and society by considering performance over their whole-life. "Global economic, social and environmental drivers are diving the AECO sectors to increasingly consider long-term value, rather than simply focusing on short-term returns and the initial capital cost of construction" (Ashworth, 2013, p. 250). Experience from historical reports concerning the construction industry has shown that acceptance of the lowest price bid does not provide best value for money. Mitchell, Swann and Poli (2009) argued organisations often use 'value engineering' to reduce short-term CAPEX. However, using cheaper components and systems often results in much higher whole-life OPEX costs (Bourn, 2001). If we are to deliver sustainable BA that meet the needs of people and society, we have to consider the relationship between long-term costs and the ability of assets to deliver benefits to the end users. This fine balance represents the best value for money (OGC, 2007).

Research has shown the degree of ability to influence the cost of BA is much higher during the early design stages. This idea first appeared in '*Designing to reduce construction costs*' (Paulson, 1976, p. 592). He wrote "the level of influence in determining and controlling costs drops rapidly as a project evolves from preliminary and detail design, through procurement and construction, to beneficial operation or utilization" His ideas, which have been widely replicated, are illustrated in Figure 2.3.

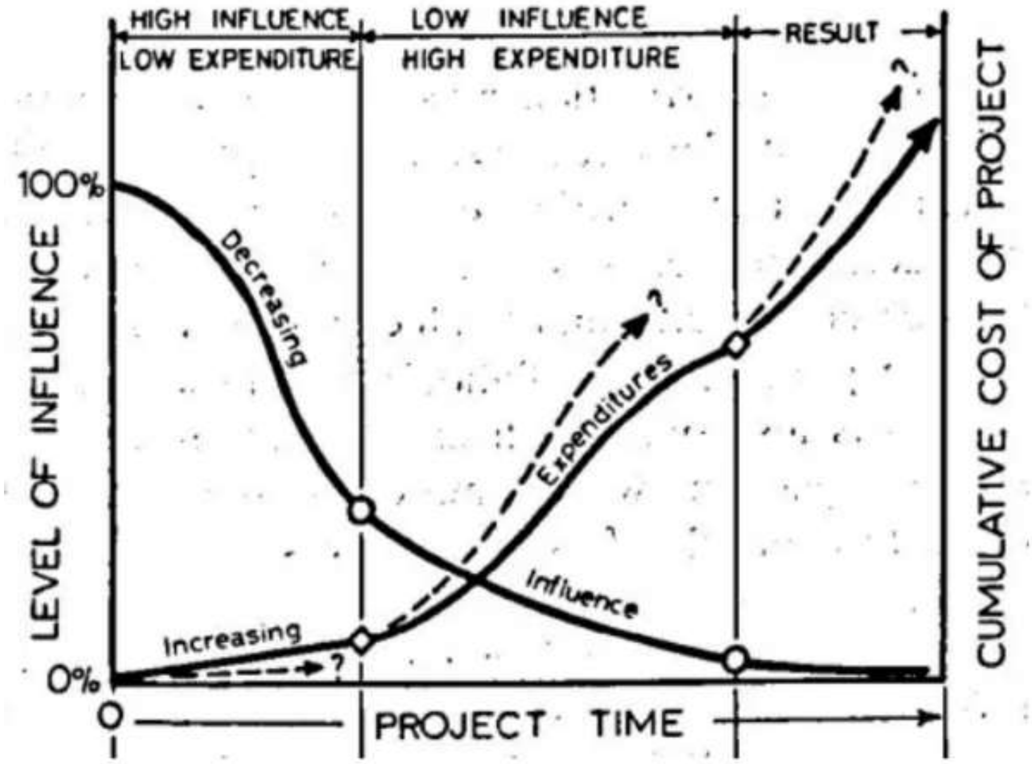


Figure 2.3: Level of influence on project costs (Paulson, 1976)

Davis (2013) suggested Patrick MacLeamy used this model in 2001 to develop what has become known as 'The MacLeamy Curve' (MacLeamy, 2010). He incorporated the ideas of Integrated Project Delivery (IPD), which contractually amalgamates project parties to guide the design team towards best value solutions early in the project; and BIM, to improve communication between team-members and provide a central database for project documentation. An important principle is the idea of 'full-collaboration' through information sharing. The report '*Collaboration, Integrated Information, and the Project Lifecycle in Building Design, Construction and Operation*' suggested many benefits to this approach including more efficient, and effective buildings which are delivered quicker (CURT, 2004).

The report shows a modified version of the MacLeamy curve showing the focus of design effort front loaded (black curve) in the earlier design stages (Figure 2.4). By bringing forward key analysis and design with open collaboration earlier in the process, project teams have maximum opportunity to impact on decisions that have long-term consequences to cost efficiency.

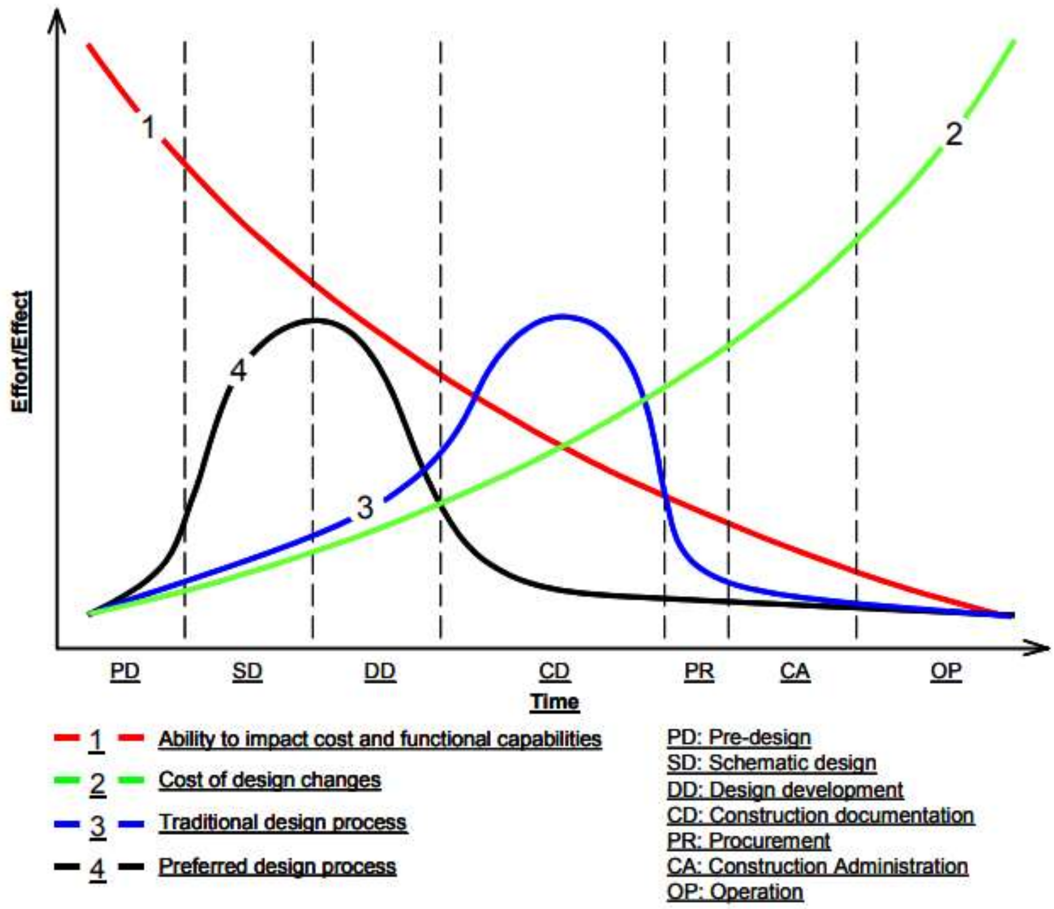


Figure 2.4: The MacLeamy Effort/Effect curve (CURT, 2004)

Two key questions, central to achieving best value are:

- What is the 'useful design life' of BA elements (i.e. remaining fit for purpose)?
- What are the ratios of cost for the life phases e.g. design-construction-maintenance?

With respect to 'useful design life'; research by Langston (2011) suggested the ratio of 'useful life' to 'physical life' as approximately two-thirds. It depends heavily on usage and quality of individual components. Estimates for predicted 'life expectancy' can be found online using sites like 'etool.com' (eTool, 2015) and 'costmodeling.com' which provides examples based on the UK '*Building Blackbook'* by Franklin and Andrews (2010).

Management teams often use guidelines like '*ISO 15686,*' (ISO, 2011) focused on 'service life planning' and such databases as a framework to make informed decisions as when to inspect, repair or replace components or whole systems. However, (Designing Buildings WiKi, 2019) noted "there is no legally agreed definition of design life". It suggests some examples of typical 'building design life' as shown in Table 2.1. In practice however, decisions as to when to act are usually based on individual condition reports from inspections.

Table 2.1: Examples of useful design life (Designing Buildings WiKi, 2019)

Design Life: (based on BS EN 1990)	Years
Category 1: Temporary structures, not including structures or parts of structures that can be dismantled with a view to being re-used	10
Category 2: Replaceable structural parts, e.g. gantry girders, bearings	10-25
Category 3: Agricultural and similar buildings	15-30
Category 4: Building structures and other common structures	50
Category 5: Monumental building structures, bridges and other civil engineering structures	100

Bogenstätter (2000) argued the 'early design phase' is critical and estimates that 80% of operational costs and environmental impacts are determined in this phase. '*ISO 15686'* (ISO, 2017, p. 12) supports this indicating the 80% is usually compressed "in the first 20% of the design process". This illustrates why the early involvement of FM know-how is critical during these early stages when key decisions are being made which will define the long-term usability and the Life-Cycle Costs (LCC) (Ashworth, 2013).

This is further compounded when considering the duration of BA life phases. Typically, concept, planning and construction takes 2-5 years, whereas operation can last 25-50+ years. However, 80-85% of the LCC occur in operation. The solid line vs. the dotted line in Figure 2.5 by Kovacic and Zoller (2015) shows the potential to save costs by a small increase in CAPEX to deliver increased OPEX savings.

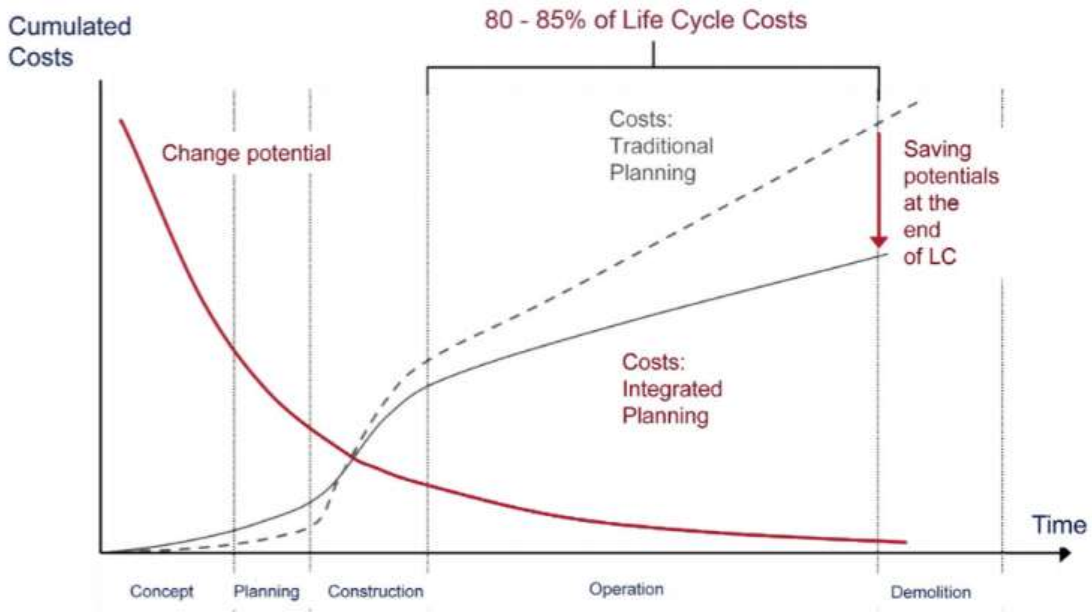


Figure 2.5: Cost vs. change potential over building life-cycle by Kovacic and Zoller (2015)

There are a wide range of estimates regarding the 'ratio of cost' for the life phases. The *'OGC Whole-life costing and cost management*' guide quoted "the Royal Academy of Engineering reports that the typical costs of owning an office building for 30 years (based on work from 1998) are in the ratio of 1, for construction costs; 5 for maintenance costs; 200 for costs of the operation being carried out in the building, including staff costs" (OGC, 2007). However, Hughes et al. (2004) argue the figures do not reflect reality and suggest a realistic figure would be 1:0.4:12. Flanagan and Jewell (2005) suggested a percentage figure for 'planning-design-construction-operation' of 1:2:22:75. MacLeamy's concept of 'BIM-BAM-BOOM' (MacLeamy, 2012) suggested using BIM in 'building design' is a fraction of the cost of 'building assembly' (BAM), and significantly less than in 'building operation' (BOOM). The concept shown in Figure 2.6 suggests a ratio 1:20:60.

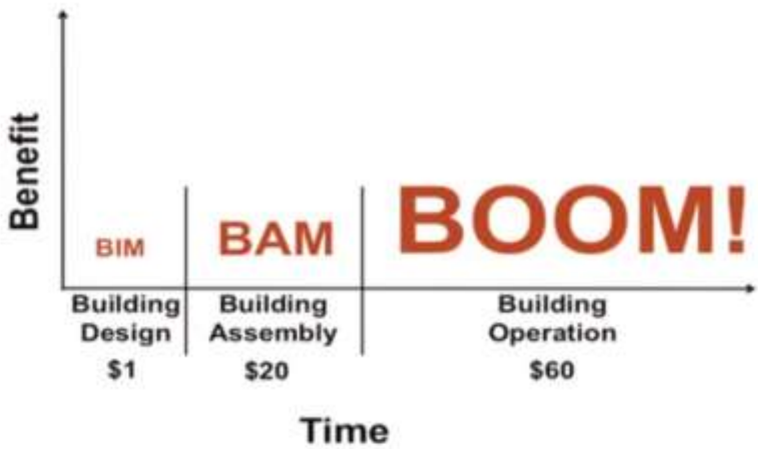


Figure 2.6: MacLeamy's BIM, BAM, BOOM concept (MacLeamy, 2012)

These examples illustrate a now generally accepted principle; the amount spent on buildings, in initial CAPEX is small in comparison to OPEX, and both are small in comparison to the value added by their occupants (Saxon, 2005). Ultimately the best value is achieved if all stakeholders involved can balance the relationship between minimising long-term costs and producing the best project outcomes for clients (Ashworth, 2013). However, practice suggests organisations often treat CAPEX and OPEX separately (BSI, 2014a). If organisations continue with separate approaches the challenges to the strategic and holistic management of assets will remain. However, if they are considered together and more emphasis is placed on a WLC approach then the aims of the UN SDG, and the potential to realise real value in economic, environmental and sustainable terms is entirely possible. On a positive note the '*Government Construction Strategy: 2016-20'* saw further commitment by the UK Government to push a sustainable approach with leadership being demonstrated in the areas of whole-life cost and whole-life carbon (IPA, 2016).

2.6 Bridging the gap between construction and operation

In order to deliver BA that society, organisations and users really need, clients and FMs must play their role. FM is seen by RICS and IFMA (2018) as the link between disciplines in the built environment which in turn allow physical assets to create organisational outcomes. The importance of linking people, places and process is highlighted by the definition of FM in '*ISO 41011:2017*' as an "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" (ISO, 2017a, p. 1). FMs are the experts who look after BA over the much longer operational stage where most energy, resources and costs are incurred. As such their input about early design decisions is critical.

There are good financial arguments for considering best value from a whole-life perspective. Estimates vary as to the proportion equated to the operational cost element of an asset over its whole-life.. IFMA estimated 57% (Eastman et al., 2011), which is very close to (Sacks et al., 2018) estimate of 57.5%. Others like Akcamete, Akinici and Garrett (2010) suggested 60% and Miettinen et al. (2018) even higher figures (67-85%). Supporting the graphics of Poulsen and MacLeamy, Fabrycky and Blanchard (1990) noted the ability to influence cost decreases continually as a project progresses, from 100% at project inception to typically 20% or less by the time construction starts. They also noted 80-90% of the cost of running, maintaining and repairing a building is determined at the design stage. '*ISO 15686-5: Life-cycle costing for buildings and constructed assets*' notes decisions made in the early design phase have a direct and lasting impact on future FM functionality (ISO, 2017). This is illustrated in Figure 2.7.

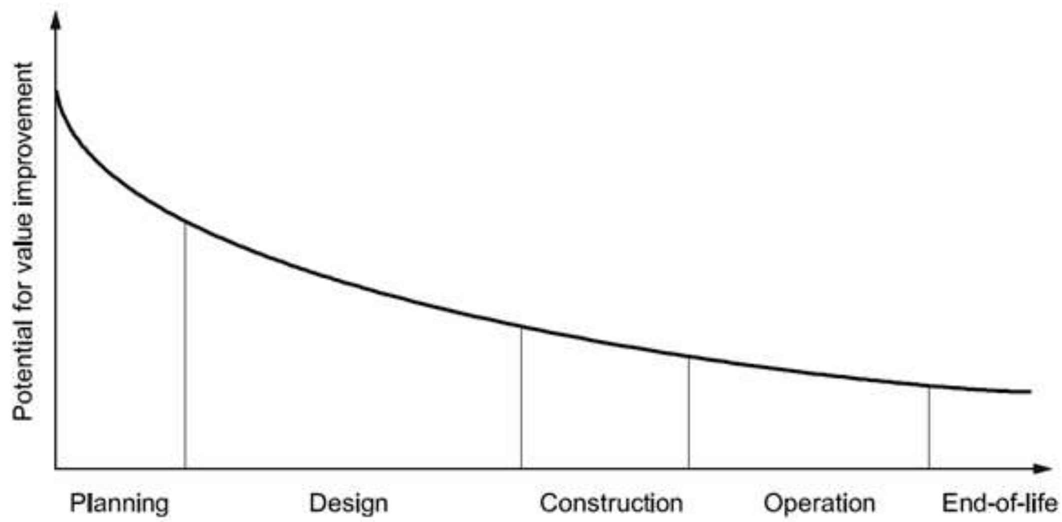


Figure 2.7: Scope to influence LCC over time (ISO, 2017)

These arguments illustrate why the early involvement of FM know-how is critical in the initial stages of design, when key decisions are being made, which will determine the long-term usability and LCC of the asset. Research by Hansen and Damgaard (2011) observed that FMs are the translators who need to be involved in construction projects at the design phase. Other research indicates digitalisation, and specifically BIM, offer an opportunity for project teams to improve decisions made in these early stages to help minimise the downstream operational costs. Examples from practice include (Zeiss, 2018) who reports on studies by colleague George Broadbent, which suggested an average positive 5% Return on Investment (ROI) on projects using BIM. He estimated that "introducing BIM for FM saved on average 5% of operating costs per annum" and "reduced the time looking for things by 83%" (ibid).

There is now an increasing acceptance of the added value FM know-how brings to ensuring users and building owners achieve the best value and performance from a building over its whole-life (Ashworth, 2013). The optimisation of value knowledge capture and transfer is achieved by involving FM in the early strategic and planning phases, ensuring users' needs are met and the benefits of cost management, sustainability can be maximised. To help understand how FMs can contribute to achieving best value the '*The 4P Life-Cycle Value Model'* (Ashworth, 2013a, p. 49) was developed as shown in Figure 2.8. It shows BA with a cyclic-life as discussed in '*ISO 15686-5'*. The model illustrates FM adding value across each whole-life stage. To ensure BA are sustainable they must deliver best performance through an optimal balance of economic, satiability and users' needs. The outer dark blue ring represents the idea of BA achieving an optimum balance between the '4Ps'. Project teams will achieve best value by working collaboratively to deliver BA that meets the user's needs (**P**eople), and which are sustainable (**P**lanet). These need to be balanced with the costs resulting in an optimal design with lower long-term operation costs (**P**rofit/savings). By taking this approach clients and their project teams can procure BA that achieve sustainable (**P**erformance).

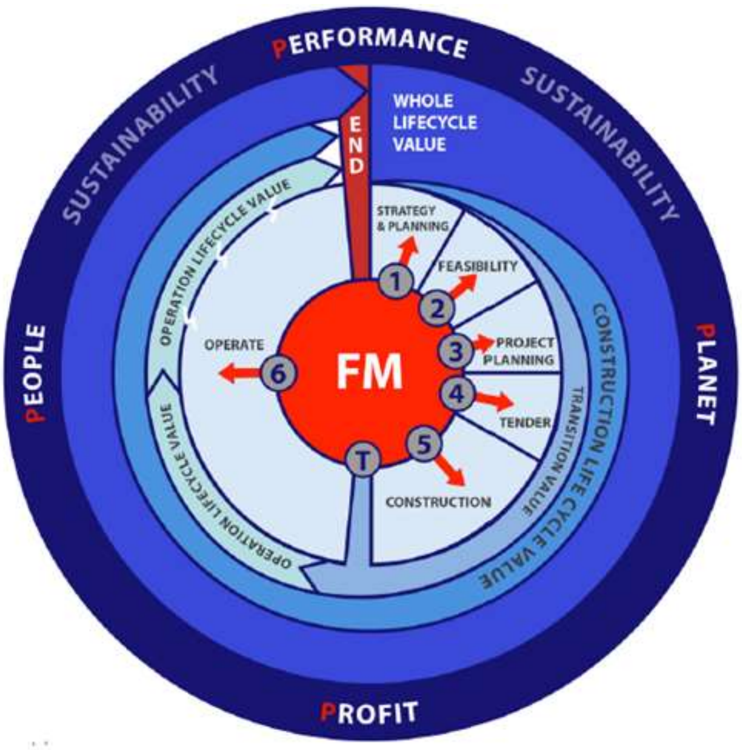


Figure 2.8: The 4P Life-Cycle Value: conceptual model (Ashworth, 2013a)

The model emphasises another issue; achieving a smooth 'transition value' between the design, construction and operation phases. This is illustrated by the gradually developing inner (light-blue) ring. The key issue here is to ensure the capture and handover of essential information which is critical to the optimisation of the BA in operation.

2.7 Information: the key to successful optimisation of assets in operation

Higson and Waltho (2010) argued that it is critical for organisations to acquire strategic asset information. Cavka, Staub-French and Pottinger (2013) stated that in order to support complex O&M activities it was imperative that FMs are conversant with current, reliable building information. They added "the quality, efficiency, and reliability of the information handover process is therefore critical for facility managers to reach the performance, sustainability and economic requirements of facility operations" (ibid, p1).However, research by Moody and Walsh (1999, p. 10), indicated that "of all the corporate resources (people, finances, assets, information), information is probably the least well managed".

As pressure grows for the AECO industries to become more digitalised it is essential that organisations consider "applying more connected and intelligent technologies like BIM in the built environment to further improve information-sharing and transparency" (ARUP, 2016). BuildingSMART research by Jackson (2018, p. 38) indicated "some 3% to 7% of total LCC could be saved by a more systematic handover of data". He went on to note that "BIM to date has been focussed on design and construction in its approach and there is a fundamental need to shift the focus towards making it more asset centric" (ibid).

One of the key impacts of digitalisation and BIM will be improving the handover and management of information state Saxon, Robinson and Winfield (2018). In the past the handover of information on large projects often meant clients and FMs receiving literally rooms full of 'as-built' drawings and documents. Fallon and Palmer's (2007) observations noted this process often resulted in poor quality, unstructured information which was often incomplete. Poor handovers can result in months or years to acquire complete information with FMs faced with the expensive task of manually populating the information into their CAFM systems. Akcamete, Akinici and Garrett (2010) argued that a key benefit of BIM will be to improve the automated transfer of such information from BIM to CAFM.

When considering what information to capture it is important to adopt a 'minimal useful' approach. "All parties, including the client, should only define the information they require, so that they can fulfil their own actions" (UK BIM Framework, 2020a, p. 49). The focus should be on collecting information that aligns with the business needs of the organisation. Frameworks like '*ISO 55000: Asset management*' (ISO, 2014) can help ensure the alignment. To keep information lean and usable "it is critical to understand its future use. This can be achieved by 'beginning with the end in mind' and identifying the downstream uses of information" (BSI, 2013, p. v). The role of FM in helping to define what information is required to support an organisation's business and Asset Management (AM) strategy is expanded upon in Chapter 6.

Putting a detailed CSF 'transition process' in place minimises information loss in transition and maximises best value This must bring together D&C and operations experts to plan how to identify, capture and then transfer information into FM managements systems. FMs are crucial in such projects as they understand the users' needs and the functional service requirements. They want materials and products that will last longer in operation and require less maintenance (Ashworth, 2013a).

To visualise how to incorporate operational knowledge in the process, a second '*4P Measurement of FM Added Value'* model (Figure 2.9) was developed. It incorporated the ideas of the 4P model in a linear format to illustrate an ideal transition process. The FM involvement at the beginning of the project should be appropriate to the task, and then continuous inputs given as required (by a FM or FM consultant). The model visualises 'adding value' by incorporating 'FM know-how' during each project stage as a project is developed (Ashworth, 2013a).

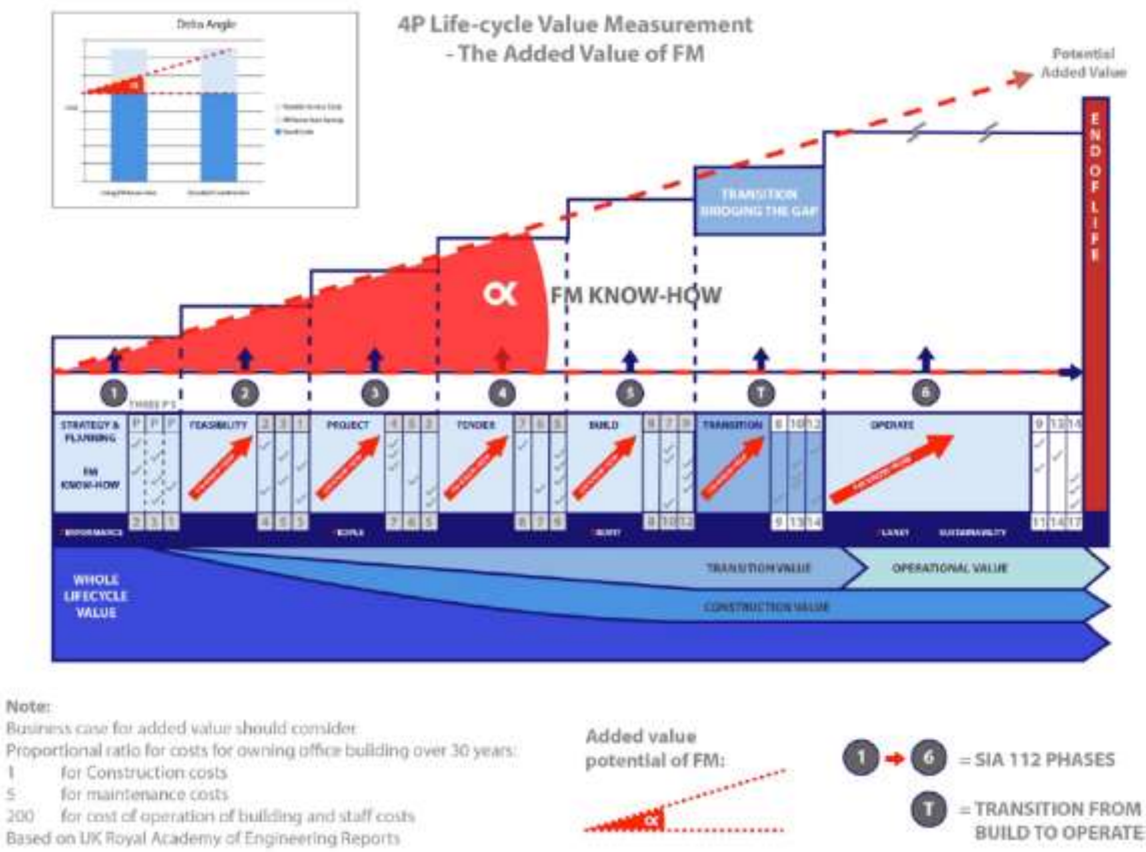


Figure 2.9: 4P measurement of FM added value: conceptual model (Ashworth, 2012)

The FMs provide their inputs to the D&C teams to help them plan better project outcomes for usability, functionality, sustainability, energy efficiency etc. This provides a checking mechanism for the BA design from a whole-life perspective. The operational knowledge is focused in the key areas of **P**eople, **P**lanet and **P**rofit (represented by the Three P's columns). The red arrows represent transition of 'FM know-how' at each phase. The '**α** angle' represents to what extent the 'added potential of FM' is incorporated in the project.

These early conceptual models helped establish the following conclusions to explore in the PhD work:

- Early FM involvement has the potential to deliver added value to project teams
- Best value is delivered through a balance of economic, social and environmental factors
- The best value is achievable if a long-term WLC view is adopted
- The handover of information is a CSF for clients and FMs

2.8 Chapter summary

The literature highlighted the importance of BA which underpin our lives, society and economy. It exposed problems with the built environment which for decades has had a poor performance track record. This has directly and indirectly contributed to the severe environmental, social and welfare challenges outlined in the UN '*2030 Agenda for Sustainable Development.*' The literature exposed gaps in research around how the AEC and FM industries need to build bridges to come together and proactively use BIM to help address these challenges. There is a moral obligation on all AECO stakeholders involved to collaborate and adopt a whole-life approach to ensure BA which balance the needs of users, society and the environment. It is clear that digitalisation and BIM offer the industry a way of bringing stakeholders together to deliver against the UN SDG and deliver a triple-bottom-line of improved performance.

Chapter 3: The evolving discipline of facility management

The purpose of this chapter was to address research objective (a) to assess the state of the art and identify CST important to delivering successful outcomes when using the BIM process. Specifically it discusses how FM has evolved as a professional discipline and its increasingly important strategic role with respect to managing organisation's real estate portfolios. It highlighted how FM adds value to the triple bottom line by providing services which directly and indirectly support organisations wider strategic goals as well as the needs of the users.

3.1 The birth of facility management

As Appleby (2018, p. 253) observed:

> Since humans first sought shelter in caves and dwellings, an element of facilities management entered into their lives. From managing waste, cleaning and repairing the fabric to ensuring catering arrangements are maintained, there has always been a maintenance element to ensuring the health, comfort and wellbeing of building occupants.

Chapter 2 highlighted mankind's dependence on BA. However, buildings need maintaining and this is where FMs come in. There is little historical record of the early evolvement of FM as Becker (1990, p. 8) noted: "although facility management has existed as long as building, its recorded history is a nanosecond in time". Wiggins (2014, p. 1) suggested the term FM emerged in the 1960s, stating: 'Facilities Management' was "coined by Ross Perot of EDS in the USA". She argues the origins of FM "can be traced to an era of scientific management and the subsequent explosion in office administration" (ibid). Others like Nor, Mohammed and Alias (2014, p. 1) maintained: "It is to railroads in general and US railroads in particular that many authors ascribe the origin of the coordinated multi-functional but dispersed firm, which is the basic methodology of the FM organization". The different terms for FM can be confusing. Appleby (2018) observed that in the UK the use of the term 'facilities management' is often used, whereas internationally the phrase 'facility management' is widespread. Both these terms are interchangeable alongside the expression 'property management'

According to IFMA there were no umbrella associations in the early stages of FM development. Their webpage notes: "the first step towards the formation of something people would recognise today as an FM organisation occurred in December 1978 when Herman Miller Research Corporation hosted a conference called 'Facility Influence on Productivity' in Ann Arbor, Michigan, USA" (IFMA, 2018). This resulted in the founding of the National Facility Management Association in 1980. It was then changed in 1981 to the 'International Facility Management Association' (IFMA). Tucker and Masuri (2016) noted literature generally describes FM as a relatively new discipline, but one which has evolved quickly into a profession that plays a critical role in supporting organisations.

Becker (1990, pp. 8-13) suggested the early evolution of FM was shaped by five factors; information technology (IT), global competition, high cost of space, employee expectations and cost of mistakes. He argued these factors came together to stimulate the early growth of FM into a discipline:

- **The proliferation of IT**: both office automation and Building Management Systems (BMS) saw increased demands which needed to be coordinated by FM.
- **Global competition:** as recognised by researchers like Naisbait (1982), rapid market expansion drove organisations to be leaner in order to survive. FM provided opportunities to reduce costs in space management, equipment, furniture, IT etc.
- **Increasing costs of space:** forced many companies to consider their office locations and had a major impact on decisions to own/lease property. FM provided a vital link between managing space and operation effectiveness.
- **Increasing employee expectations:** demanded more than just safe workplaces; it meant comfortable, pleasant and effective workplaces to work productively, and be recognised and valued. FM became increasing responsible for creating workplaces that retained people.
- **Money and the cost of mistakes:** increasing complexity with high costs/square metre of space, very expensive buildings and BMS systems meant mistakes were expensive. FMs spent more time on quality over the long-term, avoiding buying cheap only to pay more later.

Similarly, Smith, Seth and Wessel (2000) suggested 'impinging forces' came together to influence the development of FM in the workplace as shown in Figure 3.1 (green boxes). They included changes brought about by historical major events, advances in technology, science, construction etc., increasing complexity, and the steady recognition of FM as a profession.

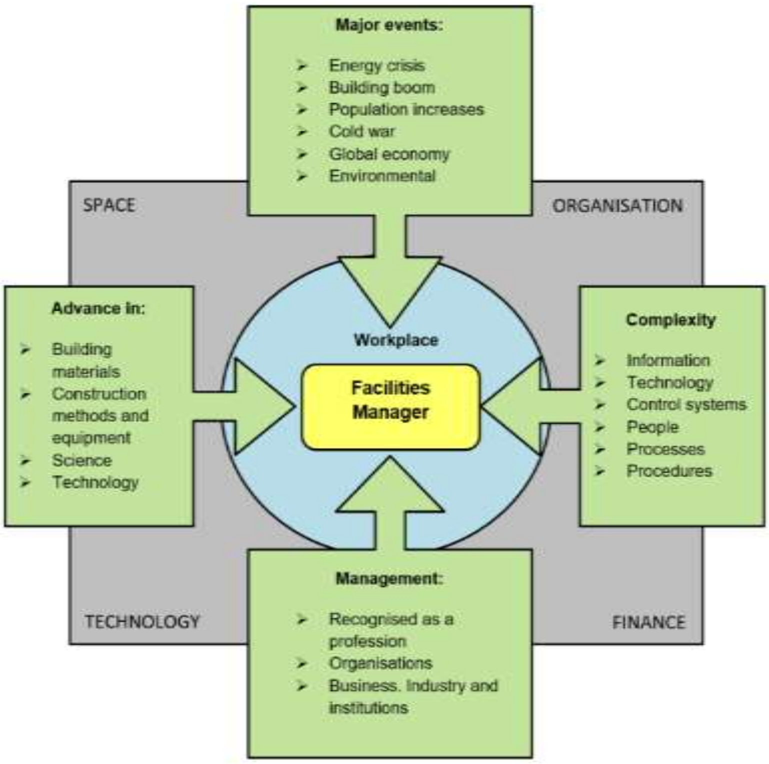


Figure 3.1: Smith, Seth and Wessel (2000) - forces impinging on FM

These forces shaped FM into a critical management function which integrated a wide range of facility services supporting organisations' daily business operations. Interestingly we see the early impact of; 'information', 'technology' and 'processes' which would underpin FM and the BIM process in the future. Clark and Hinxman (1999) observed the FM profession as emerging towards the end of the century and that this happened in parallel with the technological revolution.

This brings us to a question many academics have tried to answer; 'what is FM?' Its very nature has made it challenging to pin down, and everyone seems to have a different view. Research by Clark and Hinxman (1999) exposed the complexity of FM when they reported BIFM had 23 competencies covering the necessary skills needed by FMs. Later research by Tucker and Roper (2015) found 25 as shown in Table 3.1 when comparing professional competency frameworks from BIFM, IFMA and the Royal Institution of Charted Surveyors (RICS) **Note:** Darker shading indicates more occurrences, lighter shading several occurrences, and white few or no occurrences.

Table 3.1: Tucker and Roper's (2015) FM competency matrix

	BIFM	IFMA	RICS	Total
Compliance and standards	18	12	17	47
Contracts and procurement	11	14	16	41
Maintenance and operations	7	24	4	35
Sustainability	14	8	11	33
Projects	5	6	17	28
REM-PM	6	6	16	28
Information and knowledge	14	6	6	26
Finance	7	5	13	25
Strategy and planning	17	1	2	20
Performance	6	11	2	19
Management	7	9	1	17
Risk	6	10	1	17
Customer perception	6	5	4	15
Technology	2	7	6	15
Building design & construction	0	0	14	14
Relationships	6	1	6	13
Leadership	5	7	0	12
Communication	0	8	2	10
Change	7	2	0	9
Role of FM	6	3	0	9
Consultancy	0	0	7	7
Innovation	5	2	0	7
Space planning	5	1	1	7
Conflict	1	2	2	5
Ethics	0	2	3	5
	161	152	151	

Their research clearly demonstrated the complex and diverse nature of FM as a role that requires a wide range of management skills. Tay & Ooi (2001, p. 1) suggested this has caused conflicting opinions; some consider FMs as a "jack of all trades"; whereas Tucker, Masuri and Cotgrave (2016, p. 390) noted "therefore by implication as a master of none". The author's 20+ years of FM experience underlined this tension. Many roles he undertook came under a different job title e.g. 'service manager', 'phase-in manager, 'contract manager' etc. His impression was that management teams, and sometimes other FMs, thought using these job titles would clarify what FMs do for client's. Thomson (1991) reflected this view, observing, five different FMs could describe FM in different ways. Observations from practice indicate most FMs have a broad range of competencies with specific specialisms. Another issue adding to its complexity has been the geographical development of FM. Maliene, Alexander and Lepkova (2008) observed: that FM is interpreted in many different ways around the world. Unsurprisingly all of these factors together have caused much confusion about what FM is, and is not.

3.2 Academic definitions

Many academics have tried to define FM. It is a contentious issue, with definitions being defined by local culture, personal and organisational interests noted Nor, Mohammed and Alias (2014).It crosses several professional boundaries as Aderiye (2015, p. 15) observed; FM is like "an octopus with legs in a combination of classic professions which span real estate to engineering and several others in between". Table 3.2 from the paper '*Facilities management: a Jack of all trades*' by Tay and Ooi (2001) illustrates different examples of definitions from literature, ISO standards and practice, which illustrate the complexity of FM attempting to capture its essence. They are purposely wide ranging to demonstrate the breadth and complexity of the profession, but also the lack of clarity about what constitutes the discipline of FM.

Table 3.2: Sample of academic FM definitions by Tay and Ooi (2001, p.358)

Author	Definition of FM
Becker (1990)	FM is responsible for co-ordinating all efforts related to planning, designing and managing buildings and their systems, equipment and furniture to enhance the organisation's ability to compete successfully in a rapidly changing world
Nourse (1990)	FM unit is seldom aware of the overall corporate strategic planning, and does not have a bottom-line emphasis
NHS Estates (1996)	The practise of co-ordinating the physical workplace with the people and work of an organisation; integrates the principles of business administration, architecture, and the behavioural and engineering science
Alexander (1999)	The scope of the discipline covers all aspects of property, space, environmental control, health and safety, and support services
Then (1999)	The practice of FM is concerned with the delivery of the enabling workplace environment – the optimum functional space that supports the business processes and human resources
Hinks and McNay (1999)	. . . common interpretations of the FM remit: maintenance management; space management and accommodation standards; project management for new-build and alterations; the general premises management of the building stock; and the administration of associated support services
Varcoe (2000)	. . . a focus on the management and delivery of the business "outputs" of both these entities [the real estate and construction industry]; namely the productive use of building assets as workplaces
Nutt (2000)	The primary function of FM is resource management, at strategic and operational levels of support. Generic types of resource management central to the FM function are the management of financial resources, physical resources, human resources, and the management of resources of information and knowledge

These serve to illustrate the differing opinions of academics. Tucker and Masuri (2016) highlighted the importance of theoretical models including the '3P model' (Figure 3.2). Developed in 1984 by Duffy, Bleeker, Alexander and Prodgers, it illustrated how FM overlaps and integrates different worlds; physical, mental and virtual; represented by the '3Ps of Place, Process and People'. Industry actively adopted the model which was presented in the 'IFMA Report #1' (EuroFM, 2020a).

Figure 3.2: The 3P model of Place, Process and People (EuroFM, 2020a)

McGregor and Then (1999) built on this concept. Their model (Figure 3.3) placed the 'building' at the centre; a physical representation of the 'space' (or place) which supports all other FM activities. Key 'management elements' were added in blue and 'factors' in red to illustrate the key influences on FM. Interestingly we see 'technology' appearing as an important factor which would become to be so crucial across all aspects of FM.

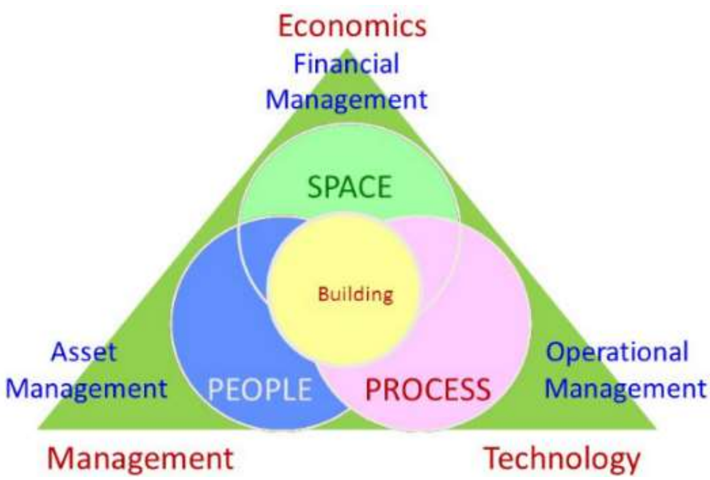


Figure 3.3: FM beyond buildings – interfaces by McGregor and Then (1999)

Then (1999, p. 462) suggested FM as a hybrid management discipline, which in essence combines people, property and process management expertise. Together these provide vital services in support of organisations.

Researchers have struggled for years to categorise the wide range of FM services. Jensen (2008, p. 493) observed “within FM it is common to distinguish between building related and service-related function” and “between hard FM and soft FM” (ibid). Appleby (2018, p. 253) provided further clarity stating that “hard FM includes maintenance and repair of fabric and building services and soft FM includes cleaning, catering, waste management, reception and such like”.

As FM developed some definitions tended more towards one of the ‘3Ps’. ‘Place’ was commonly highlighted in earlier definitions. Becker (1987, p. 82) described FM as “responsible for coordinating all efforts related to planning, designing, and managing buildings and their systems, equipment and furniture to enhance the organization’s ability to compete successfully in a rapidly changing world”.

Other researchers like Alexander (1996) put great emphasis on ‘Process’ arguing that FM can be considered as a process that organisations use to deliver services within a quality environment to deliver against strategic objectives. Similarly, Fleming, Lee and Alexander (2008) suggested FM processes are a key to delivering innovative services to the highest levels of excellence in the developing market in Europe. Other FM process models have been developed around the world e.g. the Swiss ProLeMo FM Process model. Sigg (2008, p. 41) who was involved in developing the model observed “performance is the result of processes”.

With respect to ‘People’, Alexander (1994, p. 6) argued FM “can be summarized as a belief in potential to improve processes by which workplaces can be managed to inspire people to give of their best, to support their effectiveness and ultimately to make a positive contribution to economic growth and organizational success”. People are a key factor in FM: they deliver the services and are the stakeholders who receive them.

The importance of FM with respect to Corporate Social Responsibility (CSR) and social aspects was noted by Jensen (2014, p. 863): “Facilities can have a huge influence on employee well-being, satisfaction and even recruiting. This can comprise community use of corporate facilities, providing jobs for people with physical disabilities and securing proper conditions for employees in the FM supply chain”.

FM is often associated with service delivery as (Aderiye, 2015, p. 5) observed “FM typically covers the non-core but crucial services of the organisation”. But here we see more complexity; Atkin and Brooks (2009) described FM as holistic in nature, covering everything from real estate and financial management to maintenance and cleaning. The research of (Chotipanich, 2004) demonstrated the wide diversity of FM services. Sixty-one services were identified under the banner of FM and categorised into nine groups (some overlapping) as shown in Figure 3.4.

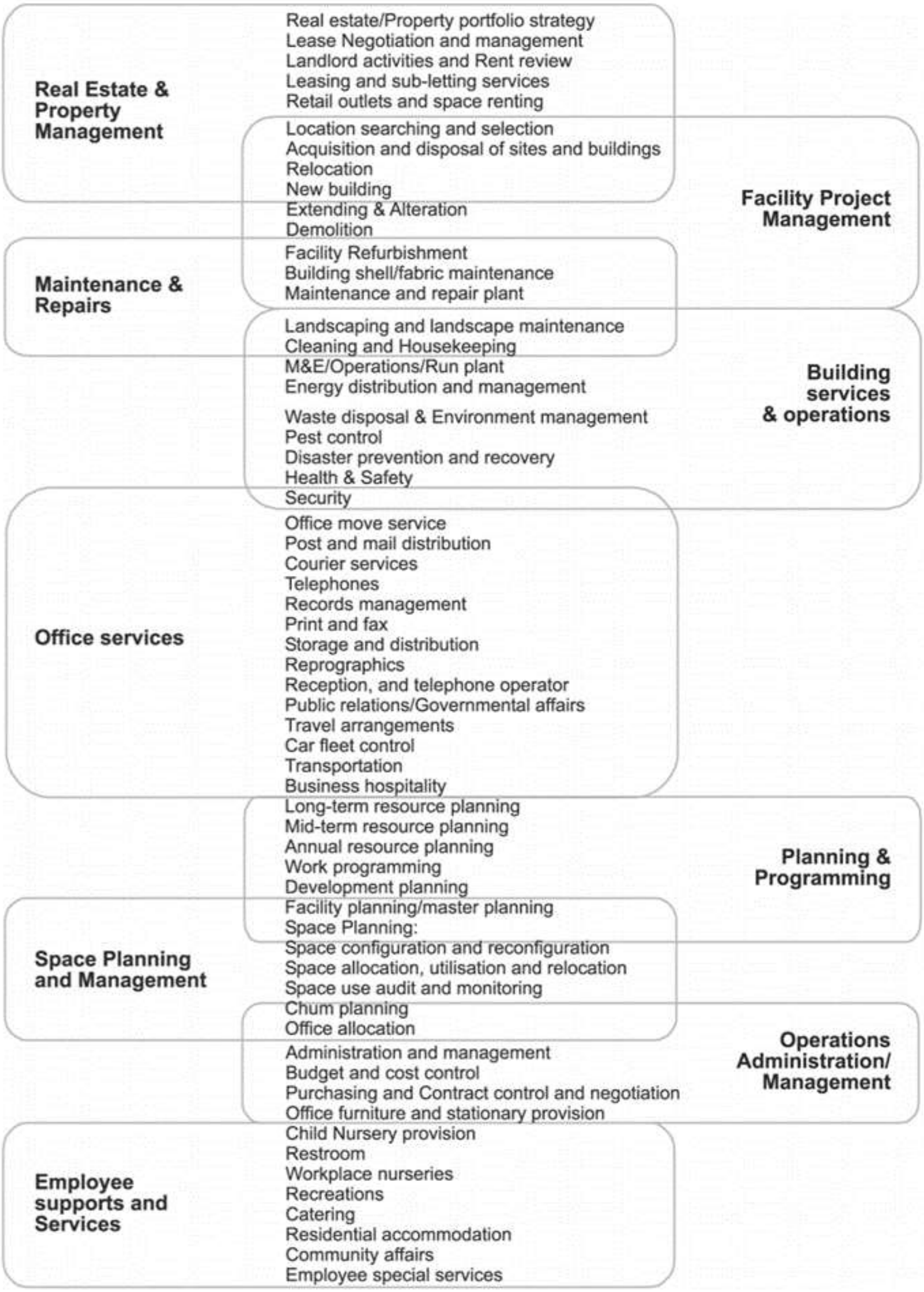


Figure 3.4: Range of FM support services (Chotipanich, 2004)

Yiu (2008) commented on Chotipanich's findings. He concluded that FM focus is lost and in crisis due to the impossibility of one being conversant in the complexity of multi-disciplinary and multi-professional areas. This was supported by calls for standardisation in defining FM terminology/processes. Figure 3.5 illustrates the complexity of FM by showing a generic model (Hubbuch, 2020a) for the typical functions in real estate management.

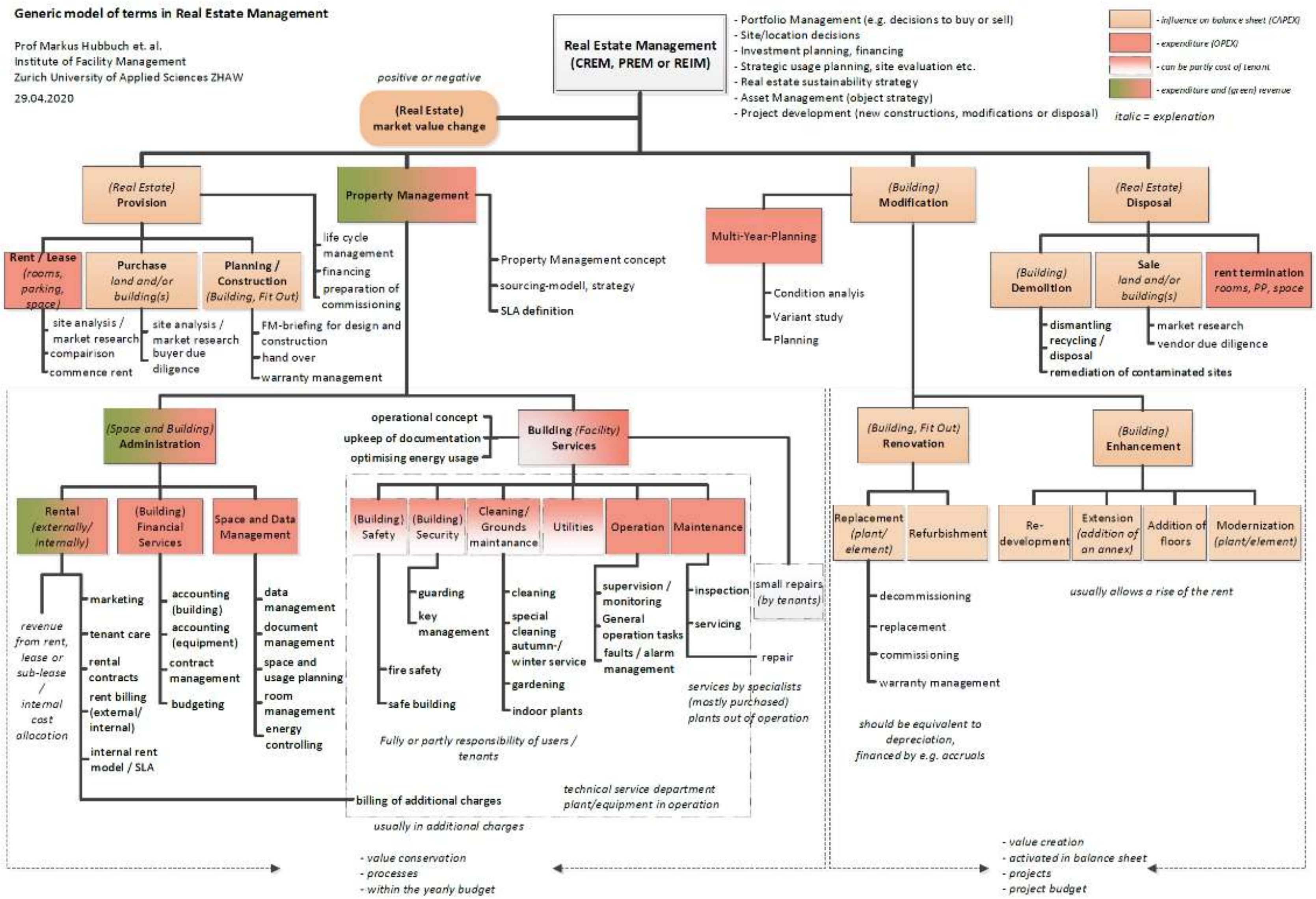


Figure 3.5: Generic model of RE and FM terminology (Hubbuch, 2020a)

3.3 Standardisation in the field of facility management

Mitchell (2012, p. para 4) summarised the situation in 2003 observing: "at this time, there was considerable debate within the UK and Europe regarding the legitimacy of FM as a professional discipline and its place within the context of the built environment sector". This drove the need for dedicated ISO standards considering the many differing views of FM across Europe. The technical committee CEN/TC 348 (CEN, 2018) started work on what would become a suite of seven '*ISO 15221 FM standards'* published between 2006 and 2012 which focused on key aspects of FM. However, Ashworth, Strup and Somorová (2015) suggested, complexity was a challenge; it took four years to find common agreement between countries as to definition of FM at a European level. The standards are shown in Table 3.3.

Table 3.3: '*ISO 15221'* FM standards (ISO, various)

Number	ISO 15221 FM Standards (1-7)
15221-1:2006	*'Terms and definitions'*
15221-2:2006	*'Guidance on how to prepare facility management agreements'*
15221-3:2011	*'Guidance on quality in facility management'*
15221-4:2011	*'Taxonomy, classification and structures in facility management'*
15221-5:2011	*'Guidance on facility management processes'*
15221-6:2011	*'Area and space measurement in facility management'*
15221-7:2012	*'Guidelines for performance benchmarking'*

'*ISO 15221-1'* (BSI, 2006, p. 5) produced the first internationally accepted definition of FM as: "the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities".

Interestingly the focus was on the 'Processes', making no reference to 'Place' or 'People'. It introduced a 'FM agreement' conceptual model which was widely used in teaching and business internationally. Although withdrawn in 2017, the model (shown in an adapted by Ashworth, 2016) is a helpful visualisation for students and people in understanding how FM contracts work between a DEMAND 'organisation' (DO) (left) and the SUPPLY 'provider' (right). The organisation's stakeholders have different levels of decision making, i.e. client, customer and end-user. He suggests possible examples using the coloured boxes e.g. strategic-(client)=board-level, tactical-(customer)=FM and operational-(end-users)=those needing the service. Typically, FMs agree a specification with the board of required services to meet the organisation's and end-user's needs. A contract (red box) is then initiated between the DO and the provider often involving Service Level Agreements (SLA) and Key Performance Indicators (KPI) to measure how well the provider services are delivered. The provider must ensure their support process/facility-services align closely to support the client's primary-process/activities (Ashworth, 2016, p. Slide 20).

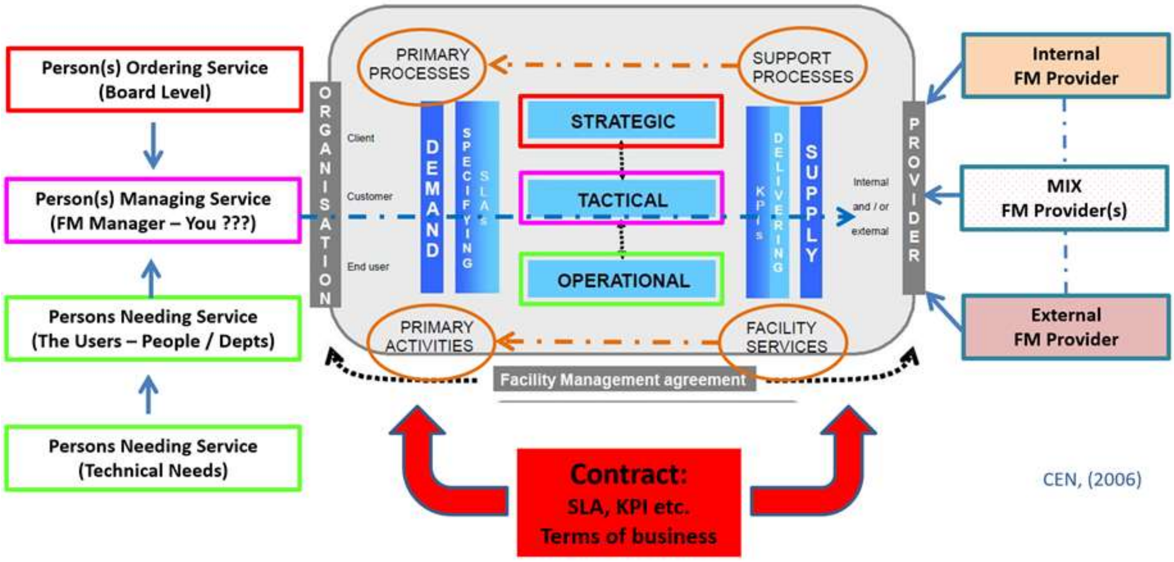


Figure 3.6: '*EN 15221-1' FM* agreement model adapted by Ashworth (2016)

Findings by Ashworth, Strup and Somorová (2015) showed wide variations regarding the adoption/use of '*ISO 15211 (parts 1-7)'* in practice across Europe. The Czech Republic had purchased the most copies of '*ISO 15221'* (735) and the standards had higher use in countries with developing FM markets. This highlighted a need in such countries for standards and a framework to empower a common understanding of FM. The '*ISO 5221-4'* presented a taxonomy classification and structure of FM services at strategic, tactical and operational levels (BSI, 2011). Figure 3.7 is one example showing the proposed series of hierarchy of facilities products. The codes can be used to ensure standardisation in cost allocation.

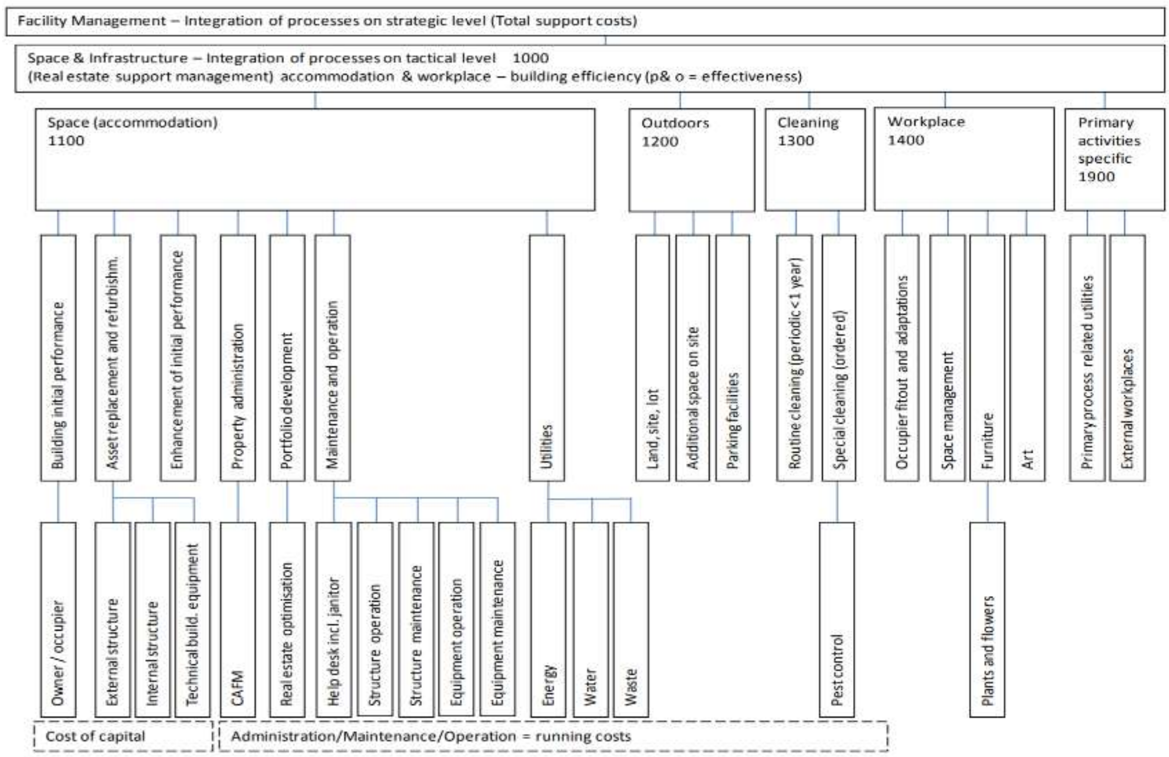


Figure 3.7: Example from *'ISO 15221-4'* - hierarchy of 'facilities products' (BSI, 2011)

After several years' practitioners identified a need to update the standards. This was led by the ISO/TC 267 technical committee represented by over 42 countries (ISO, 2018). The result was the development of the '*ISO 41000 Facility Management'* series. These replaced ISOs '*15221-1'* and *'I5221-2'* in 2017 and introduced a new Facilities Management System (FMS) in 2018 (Reynolds, 2019). This was an ISO Management System Standard (MSS). The new standards are shown in Table 3.4.

Table 3.4: The *'ISO 41000'* FM standards (various)

Number	ISO 41000 FM Standards
ISO 41011:2017	*'Facility management – Vocabulary'*
ISO 41012: 2017	*'Facility management - Guidance on strategic sourcing and the development of agreements'*
ISO/TR 41013:2017	*'Facility Management (FM) – Scope, key concepts and benefits'*
ISO 41001:2018	*'Facility management - Management systems - Requirements with guidance for use'*

Interestingly the '*ISO 14011'* definition of FM saw the return of all the '3Ps': an "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" (ISO, 2017a, p. 1). However, an opportunity was missed to include 'technology' in the definition; as inescapably fundamental to delivering any service in today's business world.

'*ISO 41012'* updated the previous '*ISO 15221-2*' FM agreement model now presented as the 'Sourcing Process Overview' model in a flow chart format with process steps as shown in Figure 3.8.

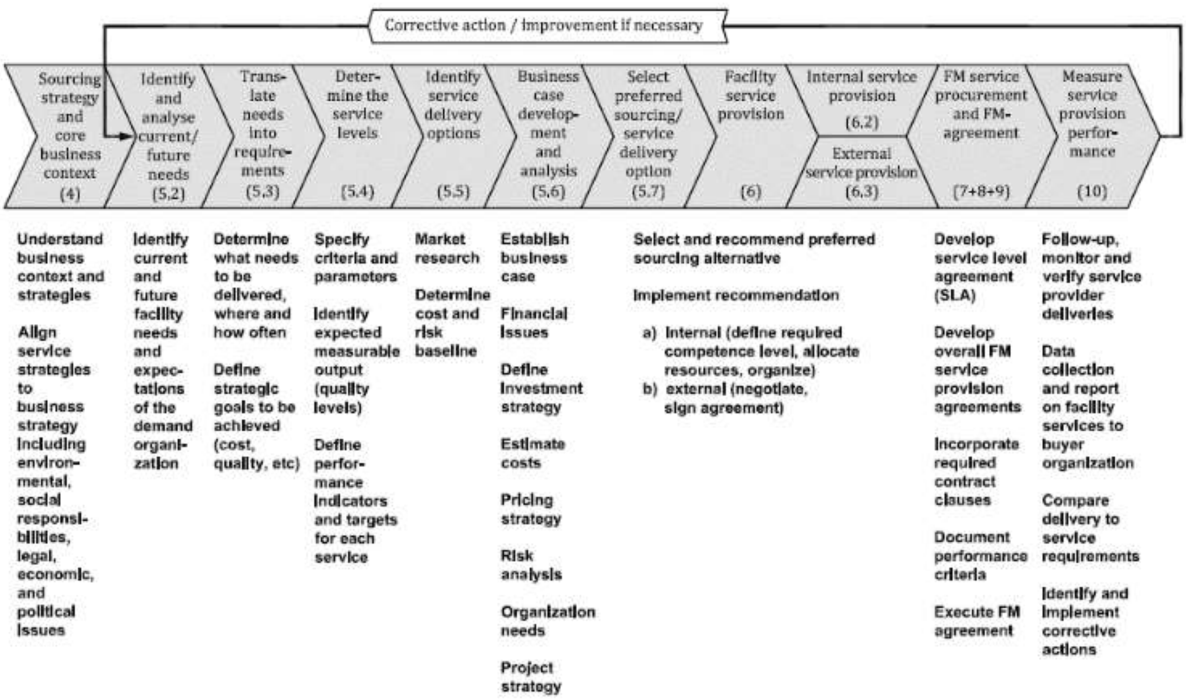


Figure 3.8: FM 'Sourcing Process Overview' (ISO, 2017b)

It clarified in line with Appleby's observations that, "the terms facility management, facilities management and FM can be used interchangeably" (ISO, 2017a, p. V). Stanley Mitchell, (Chair of ISO/TC 267) noted "every company, big or small, has some element of facility management. It is a complex discipline that directly affects everyone, as it is all about the spaces that we occupy and how those spaces meet the needs of the people who use them on a daily basis" (Naden, 2018, p. para 5). He observed it has "the potential to make a real difference to organizations by improving workforce health and safety, reducing their impact on the environment and making considerable cost savings and efficiencies" (ibid, para 6). Importantly, the FMS can be "integrated with ISO 9001 Quality Management, ISO 14001 Environmental Management, ISO 55001 Asset Management and ISO 50001 Energy Management" (Croner-i, 2018, p. para 2).

3.4 The evolution of facility management into a profession

Roper (2017) observed that after a period of 35 years that the FM profession is reaching maturity. However, it has not all been straightforward as Price (2003) highlighted. He discussed a topic that has irritated many FM professionals for a long time: the negative stereotype impression of their industry being perceived as some type of 'janitorial service'. Even recently Pinder and Ellison (2018, p. 2) suggested FM is a "profession that has a problem with its status and identity". Roper and Borello (2014, p. 2) noted that FM has had to struggle to throw off this association as it elevated itself "from the boiler room to the board room". The reality is similar to observations by Tay and Ooi (2001), who suggested FM has had to adapt to manage at both operational and strategic levels.

The IFMA website notes that "FMs can have many different titles and arrive in their profession through a variety of career paths" (IFMA, 2020, p. para 3). A "professional facilities manager is one who is formally trained and whose main responsibility is the strategic management of the workplace" noted Tay and Ooi (2001, p. 357). Aspiring FMs now have possibilities that simply were not open to people who started their FM careers early in the development of FM. There are a variety of options and routes to become qualified/certified and these are becoming wider and more developed all the time. As (Roper, 2017, p. 236) observed: "an estimated 50+ universities now teach FM education at the undergraduate, graduate and in some cases at PhD levels". She goes on, adding that, "as the FM industry has reached a point of adequate maturity there is a need to standardize FM education. There is also a need for FMs to have more 'soft skills'" (ibid). She suggested FM be introduced into secondary-level education "to attract more appropriately educated graduates to the FM practice" (ibid, p237).

In terms of future development, the Institute of Workplace and Facility Management (IWFM) report *'FM and the future world of work'* by Pinder and Ellison (2018) highlights the lack of customer focus from FMs. They suggest they will be on an even par with other professionals, the better educated and qualified they are Professional associations like IWFM, IFMA and RICS are offering certification schemes as we will now see.

3.5 Facility management associations and research networks

FM professional associations such as IFMA have evolved as umbrella organisations for FMs around the world. They now have some "24,000 members in more than 100 countries" (IFMA, 2020). The IFMA definition (ibid, para 2) of FM, which interestingly includes all 3Ps and 'technology', is: "a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology".

Many countries have established local FM associations. In the UK the BIFM was established in 1993, but changed to IWFM on 12 November 2018 (IWFM, 2018), following findings from the '*The Workplace Advantage'* report (Stoddart, 2016). The IWFM now has some 17,000 members (IWFM, 2019, p. para 1) and like many other local organisations has adopted the '*ISO 14011'* definition (IWFM, 2020a). RICS with some 134,000 members worldwide (2020) recognised the strategic importance of FM in a series of three '*Raising the Bar*' reports (RICS, 2017). They now have a programme for chartered FM status (RICS, 2019). FM strategies are essential throughout every stage of a building's life-cycle. This is highlighted in the *'Strategic FM Framework'* by RICS and IFMA (2018) which sets out guidance for planning FM Both organisations also contributed to the '*International Property Measurement Standard (IPMS)'*, which aimed to standardise measurement across industry; applying to offices, residential, industrial and retail buildings to ensure that property assets are measured in a consistent way (IPMSC, 2020).

The IWFM established their '*Professional Standards Handbook'* in 2014 to clearly define "the competences that are necessary to be a competent facilities management practitioner at all career levels" (2020, p. para 1). The '*Professional Standards Wheel'* (Figure 3.9) is an interactive infographic on their website to illustrate the competencies (ibid, para 4).

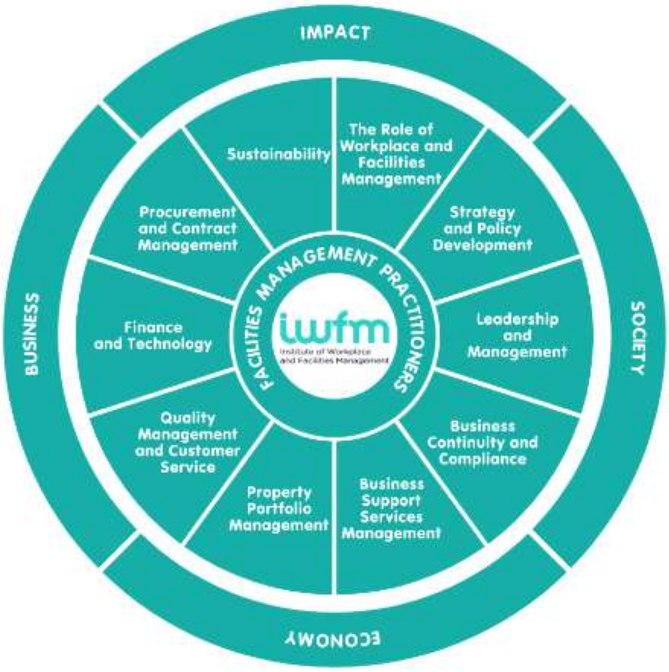


Figure 3.9: IWFM professional standards wheel (IWFM, 2020)

The industry focus is now on higher level management functions required to support every aspect of an organisation's key services and their CSR. IFMA have developed a similar model with 11 core competencies. These are aimed at three levels of certification: Facility Management Professional (FMP), Sustainable Facility Professional (SFP) and Certified Facility Manager (CFM). The competencies and model are shown in Figure 3.10.

Figure 3.10: IFMA certification model (IFMA, 2020a)

Strong links between practice and research are critical to ongoing development and education. Developments in FM over the last few decades should facilitate the integration into practice of research findings argued Roper and Borello (2014).. Two FM networks which have helped push this agenda are noted by (Wiggins, 2014):

- **EuroFM:** a networking platform for research institutes, universities, service providers, corporate organisations and national FM related associations with members in over 30 different countries. Its aim is to "bring forward the FM profession and to come to a better mutual understanding by learning and sharing FM knowledge" (EuroFM, 2020, p. para 1).
- **Global FM:** is a worldwide federation of member-centred organisations committed to providing leadership in the FM profession (Global FM, 2020).

3.6 The strategic impact of facility management on the triple-bottom-line

The arguments presented in Chapter 2 conclude that FM is fundamental to the global economy and corporate RE, as noted by Adhikari, Hoffman, Steve and Lietke (2019), whose research estimates FM "(both in-house and outsourced) is expected to grow at more than 6 percent a year from 2018 to 2024, hitting nearly $1.9 trillion" as shown in Figure 3.11.

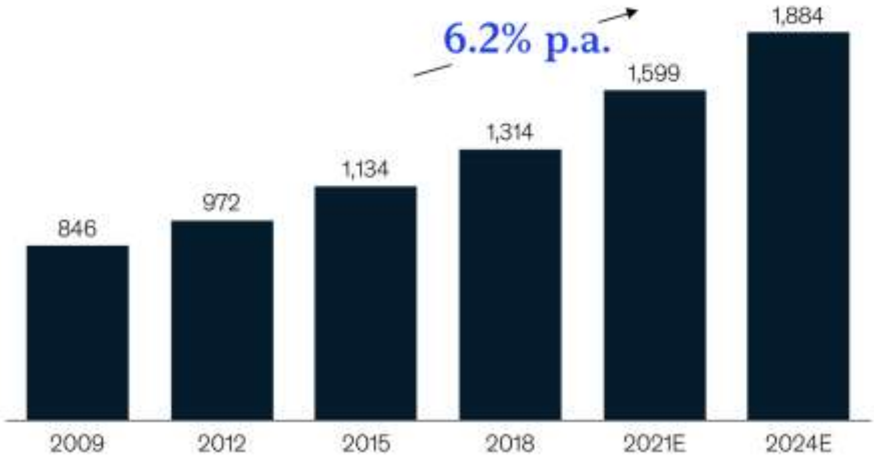


Figure 3.11: Global FM market - Adhikari, Hoffman, Steve and Lietke (2019)

With this increase the importance of FM has become increasingly recognised in helping organisations meet their strategic objectives. This was well described by Rondeau, Brown and Lapides (2017, p. 253) who discussed FM with the chairman of Chrysler Corporation, Lee A. Iacocca. He declared FM is “already a useful tool for strategic planning because planning today involves billions and billions of dollars”. He went on to say:

> You don’t spend that kind of money unless your confident that the facilities your building with it can be managed effectively, provide a return on your investment over time and do the competitive job you intend them to do. Our overall goal is to design, develop and build the world’s best automotive products. We will do that only if we have the best facilities (ibid).

However, Savitz and Weber (2006) observed that success is not measured by the financial bottom line, but by overall consideration of economic, social and environmental impacts. Roper and Borello (2014, p. 2) agreed, observing: “Primarily driven by the sustainability movement across the world, facility professionals not only deal with the design, construction, and operation of facilities but also now provide these functions with an eye toward improving triple-bottom-line accounting”.

Professional FM associations and FM researchers are coming together to help drive the future of the industry. RICS and IFAM summarised this position stating: “applied correctly, FM is about much more than the management of buildings and services, it is critical to the successful functioning of every organization which occupies property or manages infrastructure that supports our society” (RICS and IFMA, 2018). The complexity of FM is seen in the increased complexity of contracts and outsourcing solutions as is illustrated in Figure 3.12 from Adhikari, Hoffman and Lietke, (2019).

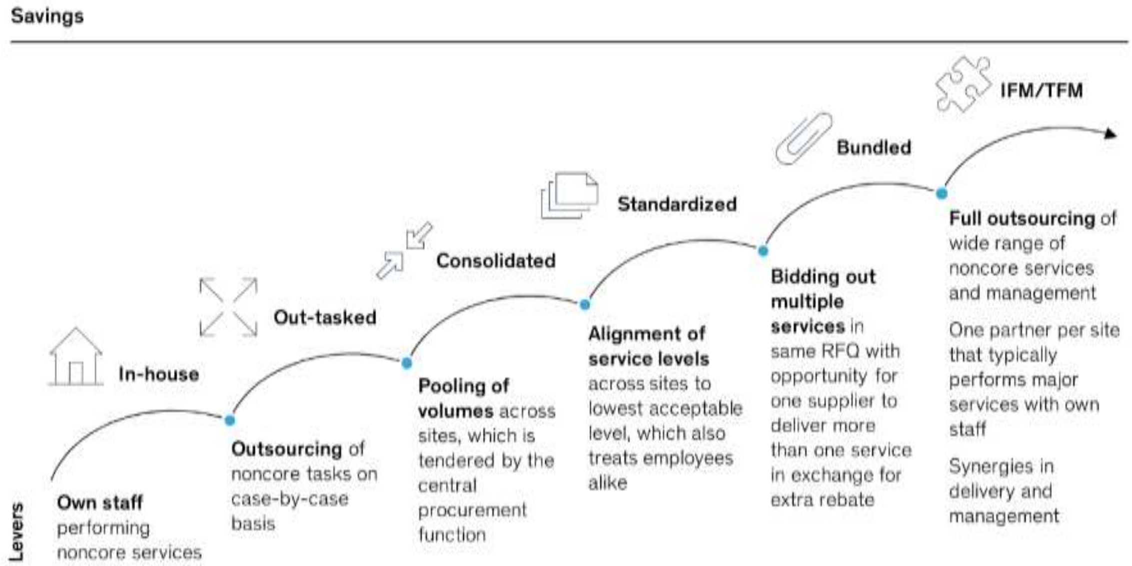


Figure 3.12: Typical evolution of FM over time - Adhikari, Hoffman and Lietke (2019)

FMs are uniquely positioned to support an organisation's triple-bottom-line objectives. Their intimate understanding of customers' strategic needs enables them to create better BA with workplaces that integrate the 3Ps; 'People, Place and Processes'. FMs expertise ensures our BA are managed in an optimal way over their whole lives resulting in a reduced impact on the environment in terms of CO2, waste etc., whilst also contributing towards the UN SDGs and the Government's construction strategy to achieve best value for users and society.

3.7 Facility management supporting organisations' strategic objectives

Barret and Baldry (2003) argued that FM and corporate strategic management need to be very closely interlinked. Chotipanich (2006) observed that FM support services within an organisation strengthens and supports its operations and strategies. RICS and IFMA have pushed the role of FM as a strategic one (often at, or closely linked to board level) which can help organisations meet their objectives. They have developed several specific guides for FMs involved in strategic planning of facilities including:

- '*Strategic Facility Planning'* (IFMA, 2009)
- '*Strategic Facilities Management: RICS guidance note'* (White, 2013)
- *'Strategic FM Framework RICS guidance note'* (RICS and IFMA, 2018)

A CSF as to why FMs are uniquely placed to help organisations develop their strategy is highlighted in the guidance; their unique position and intimate understanding of the demand organisation's values, culture and strategy. Figure 3.13 from the 2013 guidance illustrates the complex relationships FMs have to manage and negotiate when developing policies to support the corporate strategy (White, 2013). It is important to understand managing such complex relationships, and interpreting customers' needs against strategic objectives requires great skill.

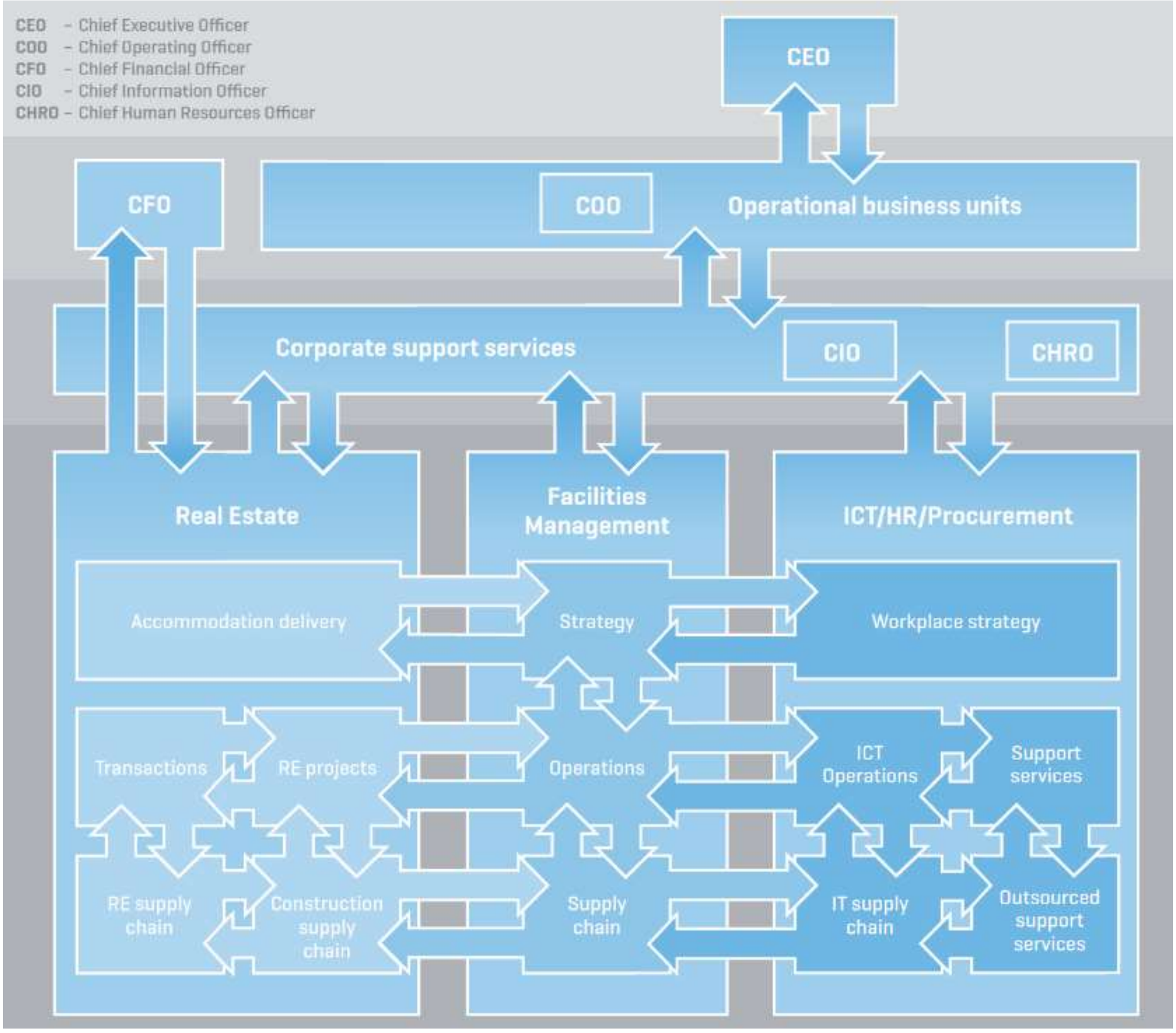


Figure 3.13: Example of complex relationships FM have to manage (White, 2013, p. 8)

'*ISO 41012'* reinforces the importance of these close relationships stating: "FM should be in close synchronization with the mission, vision, objectives and domains of the demand organisation core business. It is the role of FM to provide strategic guidance to the core business, interpreting needs and translating them into explicit service demand and requirements" (ISO, 2017b, p. 3). The 2018 guidance emphasises a wider role stating FM must:

> move beyond merely managing buildings and assets, to leading on issues related to property search and disposal, the design of space, and the development and promotion of new working methods and technology, to create and deliver workplaces which enhance staff recruitment, retention, and overall success for the organization (RICS and IFMA, 2018, p. 8).

The guidance goes on to note two other key issues; FM "should lead on issues including operational sustainability, energy usage, safety and wellbeing and other issues where facilities operations impact external stakeholders" (ibid). Also, "there is a very clear iterative relationship between corporate objectives and resource planning, asset management and facility management" (ibid, p7). It highlights seven steps FMs need to ensure their strategy aligns with the strategic planning of the DO. The steps are show in Table 3.5.

Table 3.5: Steps for aligning FM strategy with DO strategy (RICS and IFMA, 2018)

Step	RICS / IFM suggested steps for setting up a FM stagey which aligns with and supports a DO strategy
1	Understand the DO goals and corporate strategy to achieve those goals.
2	Understand the 'primary activities' of the DO.
3	Understand how other components of the DO and support functions are planning to meet that challenge.
4	Align the FM strategy with the corporate strategy.
5	Set out the key deliverable outcomes from the FM service.
6	Create a service delivery plan (including funding needs), which meets the required outcomes.
7	Measure the results of the service delivery and feed back into the next round of planning.

Direct alignment between the FM and DO corporate strategies will deliver maximum benefit to the organisation. Figure 3.14 shows the ideal alignment at all levels from strategic purpose to the feedback level (RICS and IFMA, 2018, p. 10).

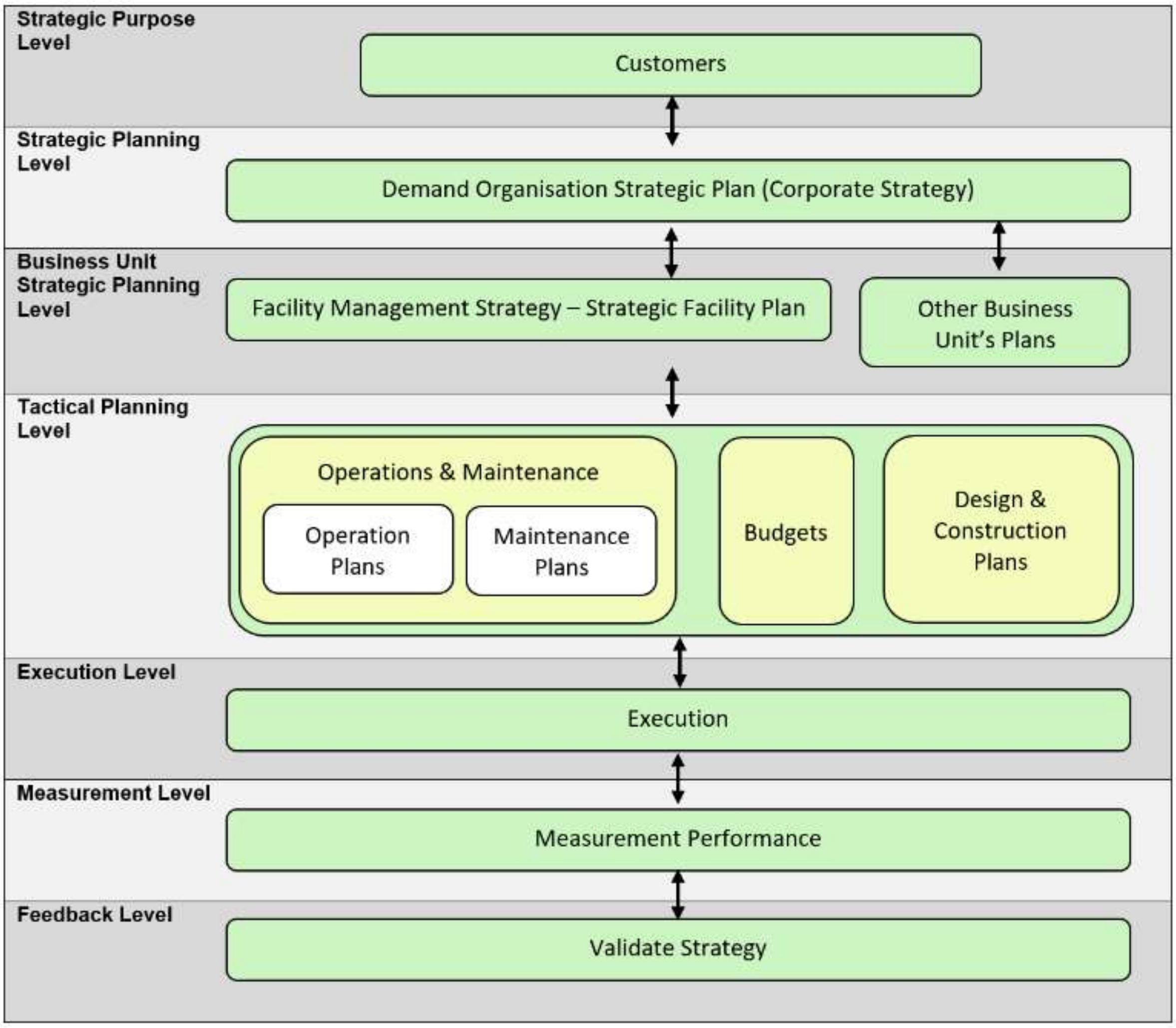


Figure 3.14: Framework - deriving FM strategy (RICS and IFMA, 2018)

3.8 The added value of facility management

Academics and practice have become more interested in how FM can add value to organisations. Examples include the '*FM Value Map'* (Jensen, 2010), the '*ISS 2020 Vision*' (ISS, 2013) etc. Coenen, Alexander and Kok (2013) observed that in the past the most common perception of FM adding value to a client's organisation was in a financial context, by achieving higher revenue and/or lowering costs. They stated that the importance of FM and its impact within an organisation has been compromised by the narrow focus on costs. Jensen (2014, p. 857) argued, "FM has gradually shifted from primarily steering on cost reduction towards managing of facilities as a strategic resource to add value to the organization and its stakeholders and to contribute to its overall performance".

Designing better workplaces in our BA to meet the needs of people to increase agility, and the use of smart technology to improve productivity, is now in vogue as discussed in '*The Workplace Advantage*' report (Stoddart, 2016). Duncan Weldon observed even a 1% productivity gain across the UK macro economy "would add almost £20 billion to our national output" (ibid, p3). Such an increase could reduce the annual government deficit by around £8 billion, add £250 a year to the average wage packet and increase annual profits across the country by almost £3.5 billion. However, many of these concepts are not new. The theme of FMs enabling workplace environments was extensively explored in Then's PhD (1996). He argued: "The dominant concept of REAM is to provide an informed interface between strategic business planning and operational asset management via SFB and SLB" (ibid, p236) as illustrated in his model shown in Figure 3.15.

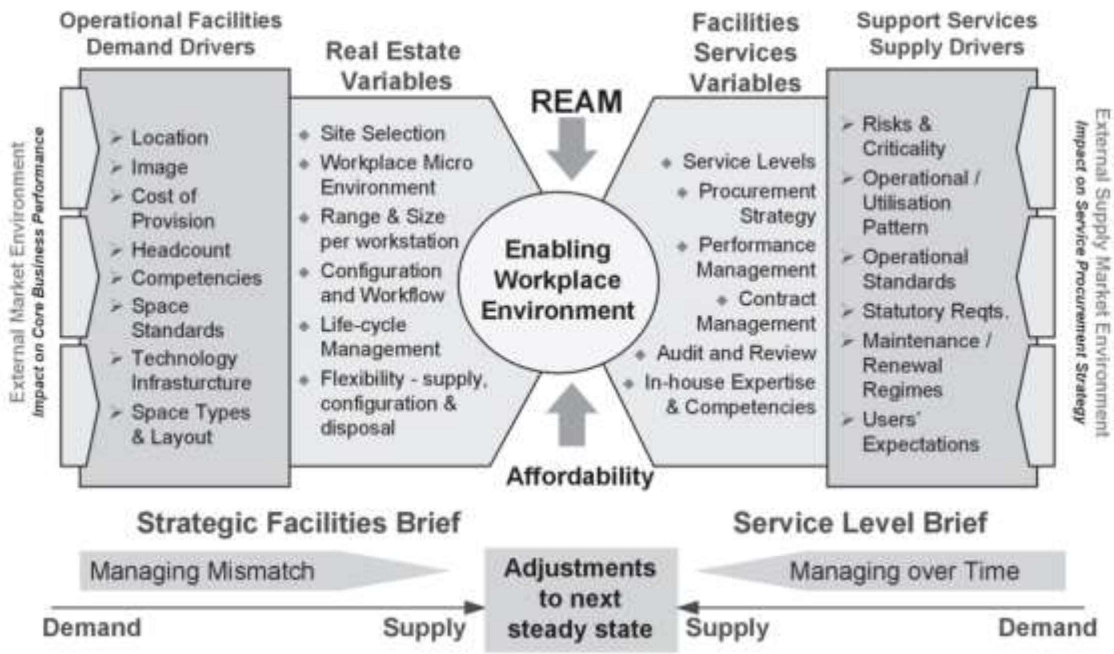


Figure 3.15: REAM as managing the enabling workplace environment (Then, 1996)

Then (2005, p. 33) later observed: “the value contribution of real estate assets can only be optimised when the property/facilities professional takes on the responsibility of continuously providing appropriate facility solutions to business challenges”.

Kaya et al. (2005) noted that an organisation’s business cycle and development is sustained by the added value that FM provides. Lindholm and Leväinen (2006) developed the framework in Figure 3.16 to illustrate how decisions made at a real estate level can impact organisations and contribute to revenue and profitability growth thus maximizing wealth of shareholders.

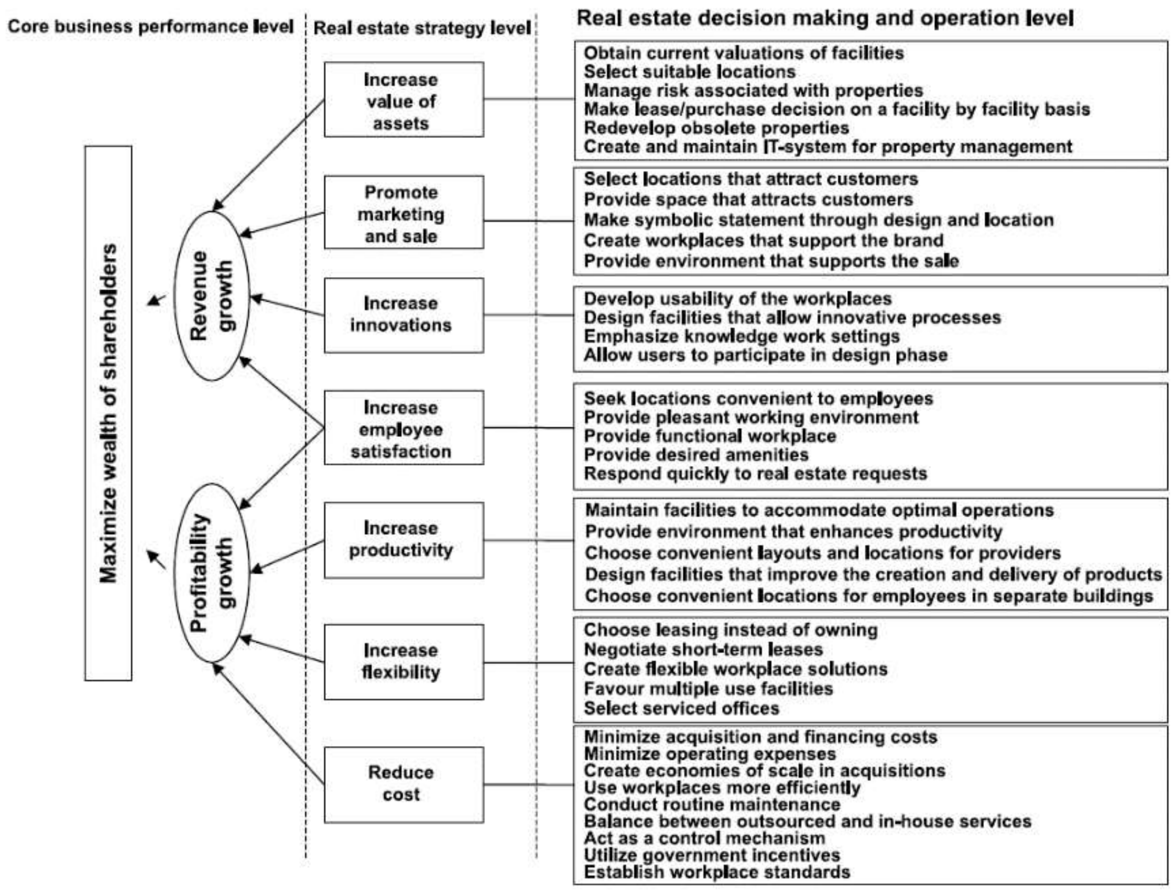


Figure 3.16: RE supporting organisations - Lindholm and Leväinen (2006)

Jensen et al. (2014, p. 856) argued “added value is expected to be central in the future development of FM”. Boge et al. (2018) noted the importance of early FM involvement in planning as this determines the lifetime, value and usability of a building.

3.9 Place: the important link between facility and asset management

A key role of FMs and one in which BIM will feature heavily is managing the ‘Place’ or BA. Shohet and Lavey (2004, p. 210) argued FM “has evolved from increasing pressures for the economic operation of the built environment”. Researchers Tay and Ooi (2001, p. 357) observed: “since the late 1980s, FM has gradually gained a foothold as discipline and profession within the property and construction industry". Whilst Chotipanich (2004) argued the strong links between FM and AM were critical to wider society and the strategic planning of organisations. FMs bring vital operational knowledge which can greatly improve AM for clients. Research by Felton, Coenen and Arnold-Moos (2009) highlighted strong economic reasons for involving FM, especially when procuring and constructing new BA. They suggested increased willingness of owner's investments in a building of 3-5 percent, and the early introduction of FM may save annual operating costs of 20 percent.

Successful AM is a critical part of the discussion. A robust Asset Management System (AMS) enables "an organization to realize value from assets in the achievement of its organizational objectives" (ISO, 2014, p. 1). A considered strategy for managing assets is especially critical to the bottom line, as BA are usually the second largest cost after salaries (Douglas, 2006), and enable FMs to actively reduce operational risk (IAM, 2015). Having an AM strategy focusing on producing good workplace environments is seen as increasingly important by industry, to meet the needs of the users who represent "90% of an organisation's cost" (Stoddart, 2016, p. 42). '*ISO 55000: Asset Management'* is one possible AMS which can deliver significant benefits to organisations. It defines an asset as: "an item, thing or entity that has potential or actual value to an organization" (ISO, 2014, p. 2), and AM as, "coordinated activity of an organization to realize value from assets" (ibid, P14). Possible key benefits are highlighted as per Table 3.6.

Table 3.6: Benefits of AM (ISO, 2014, p. 2)

Benefit	Description
Improved financial performance	Improving the return on investments and reducing costs can be achieved, while preserving asset value and without sacrificing the short or long-term realization of organizational objectives.
Informed asset investment decisions	Enabling the organization to improve its decision making and effectively balance costs, risks, opportunities and performance.
Managed risk	Reducing financial losses, improving health and safety, good will and reputation, minimizing environmental and social impact, can result in reduced liabilities such as insurance premiums, fines and penalties.
Improved services and outputs	Assuring the performance of assets can lead to improved services or products that consistently meet or exceed the expectations of customers and stakeholders.
Demonstrated social responsibility	Improving the organization's ability to, for example, reduce emissions, conserve resources and adapt to climate change, enables it to demonstrate socially responsible and ethical business practices and stewardship.
Demonstrated compliance	Transparently conforming with legal, statutory and regulatory requirements, as well as adhering to asset management standards, policies and processes, can enable demonstration of compliance.
Enhanced reputation	Through improved customer satisfaction, stakeholder awareness and confidence.
Improved organizational sustainability	Effectively managing short and long-term effects, expenditures and performance, can improve the sustainability of operations and the organization.
Improved efficiency and effectiveness	Reviewing and improving processes, procedures and asset performance can improve efficiency and effectiveness, and the achievement of organizational Objectives.

Figure 3.17 illustrates the '*ISO 55000'* perspective of the relationship between key asset management terms. FMs work across all of these spheres and as such are ideally placed to manage client's assets.

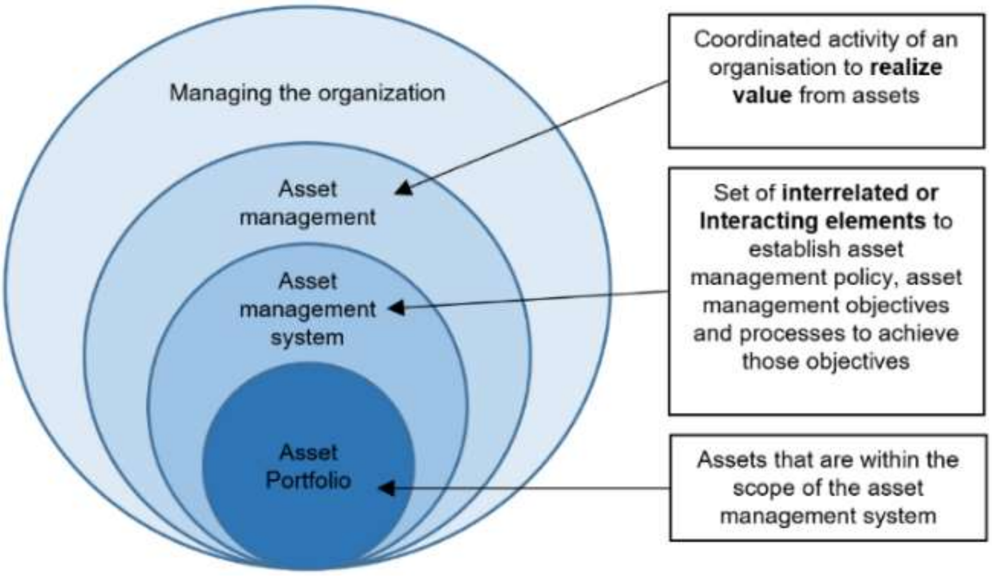


Figure 3.17*:* Relationship between key asset management terms (ISO, 2014)

In line with the circular economy concept, outlined in Chapter 2, FMs are responsible for assets at every stage of their life. This starts at the point of acquisition, then ensuring their optimum operation by maintaining them appropriately until they are replaced or disposed of in a responsible way. This "will typically involve an almost continuous cycle of assets being created, operated, maintained/overhauled and then decommissioned or demolished prior to more asset creation activities" (BSI, 2014a, p. V). The IAM have a 'Conceptual Asset Management Model' shown in Figure 3.18 which illustrates the cyclic nature of assets used to support an organisation.

Figure 3.18: IAM AM conceptual knowledge (IAM, 2015)

The model illustrates the importance of integrating ‘Organisation & People’ and ensuring ‘Life-cycle Delivery’ is managed to reduce ‘Risk’. All this is underpinned by good quality ‘Asset Information’ which informs ‘AM Decision Making’ to improve ‘Strategy & Planning’. The planning and subsequent management of BA in this cycle depends heavily on good quality information. This topic and how BIM can provide such information is explored in Chapter 5.

3.10 Chapter summary

The literature highlighted that FM is a relatively young discipline which has evolved into an essential management function helping organisations achieve their wider strategic objectives. The development of standards for FM are even newer and the breath of service covered means FMs need an extensive range of competencies to manage a complex range of in-house and outsourced services. It also highlighted gaps in the research regarding a lack of wider understanding regarding how FMs and Asset Managers can add value and help organisations deliver more sustainable buildings and services, especially if they are brought in early in the process of planning and designing buildings. FM has the potential to add value to the core business by helping integrate the 3Ps; Place, People and Processes. It is also a key aspect of creating more sustainable BA and workplaces focused on people. The significant impact of technology and digitalisation impacting the FM industry was touched on and will now be explored in Chapter 4.

Chapter 4: The impact of digitalisation

The purpose of this chapter was to address research objective (a) to assess the state of the art and identify CST important to delivering successful outcomes when using the BIM process. Specifically it discusses the increasing impact of digital transformation on the AEC and FM industries and how UK government policy has taken a lead in driving industry to adapt to new digital ways of working with the aim of; reducing waste, becoming more productive and addressing many issues which have plagued the construction industry over many years.

4.1 Empowering sharing of human knowledge

As highlighted by the UN SDGs in Chapter 2, trends like globalisation, population growth and increasing pressure to improve sustainability and welfare for people, present humanity with significant challenges; if left unchecked the damage will be irreversible (UN, 2019c). However, we have the power to act as UN Under-Secretary-General for Economic and Social Affairs, Liu Zhenmin observed: “New advances in science and technology hold immense promises for achieving the 2030 Agenda for Sustainable Development” (UN, 2018, p. para 2). Baller, Dutta and Lanvin (2016) argued industrial, scientific and technical advancements in recent decades brought about by digitalisation offer us the biggest hope to address these challenges. A positive effect of digitalisation has been the exponential acceleration of technological growth in a very condensed period of time as illustrated by (Strategic Futures, 2018) in Figure 4.1.

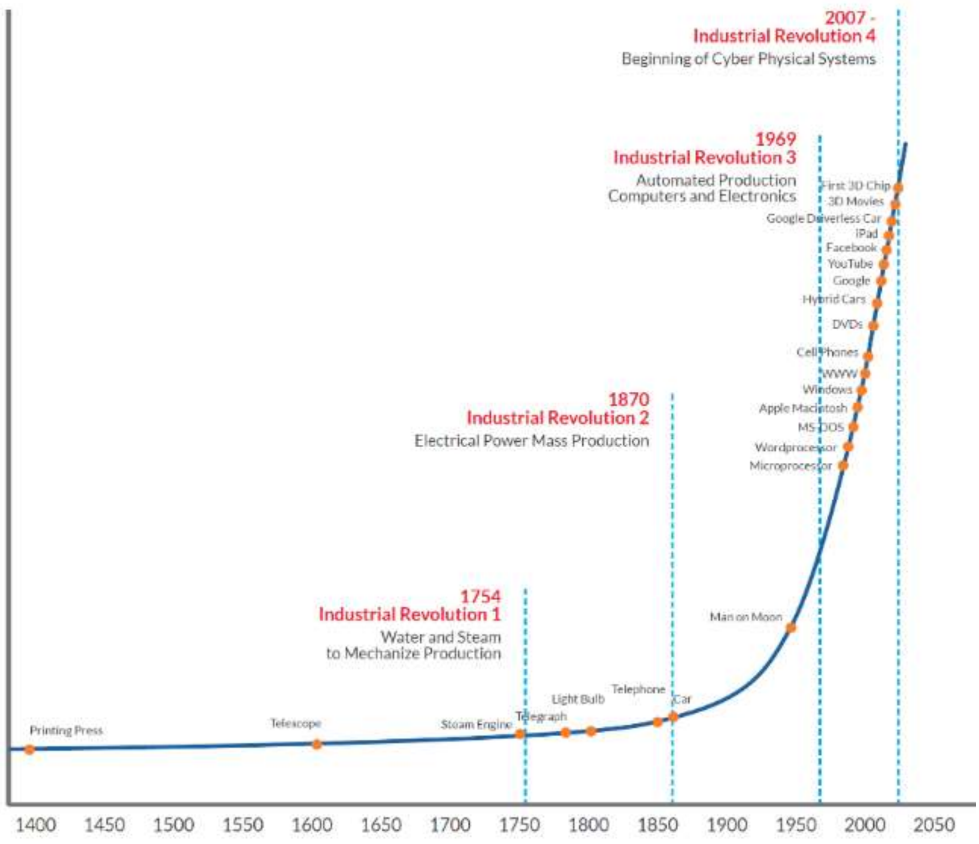


Figure 4.1: Major technological advances timeline (Strategic Futures, 2018)

The internet and technology have in parallel driven an explosion in the amount of information and knowledge now available to humanity. Our connected world empowers people to collaborate and share knowledge to address critical issues. This was recently illustrated in the unprecedented data sharing between scientists around the world to find ways to battle the Covid-19 virus (Horizon, 2020). The book '*Critical Path'* (Fuller, 1982) described that until 1900 human knowledge had doubled approximately every century. By 1945 it was every 25 years, and by 1982 every 12-13 months. Hart (2020) observed that, driven by computing power and the internet, IBM predicted that by 2020 the doubling will be every 12 hours. The concept showing this exponential change was illustrated by Michael Richey from Boeing (Herr et al., 2019) as shown in Figure 4.2.

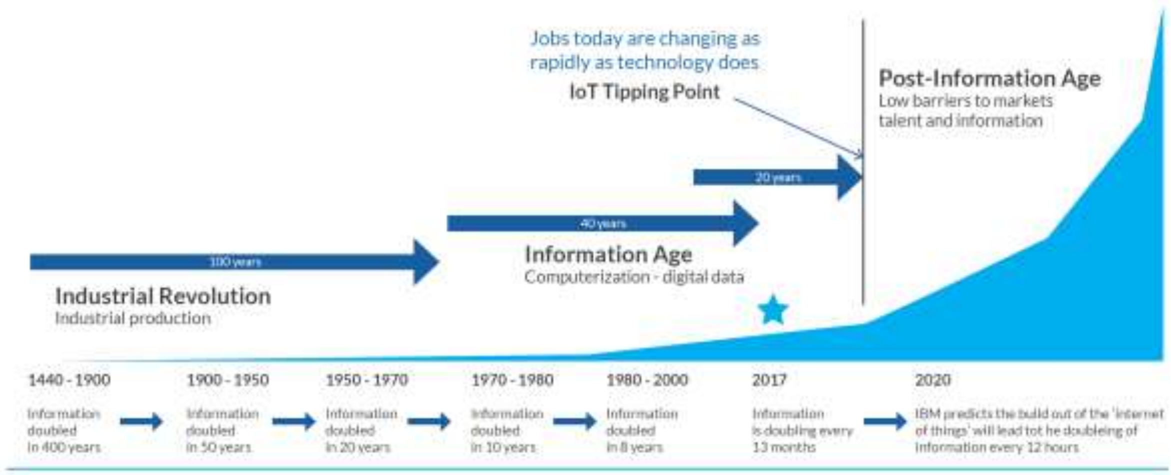


Figure 4.2: Illustration of the growth of human knowledge (Herr et al., 2019)

The explosion resulted in a new phenomenon; 'information overload' credited by Strother, Ulijn and Fazal (2012) to the scientist Vannevar Bush. In his essay '*As we may think'* (Bush, 1945) imagined the 'memex'; a 'collective memory' machine or library of knowledge that would empower mankind to address many of its problems through sharing knowledge. However, this change had some negative connotations as explored by Toffler (1970) in his book '*Future Shock'*. He observed that people have limited capacity to process information and that overloading the system leads to serious breakdown of performance. Interestingly, these observations are true in today's world where people, both in their private and business lives are bombarded by information often leaving them trying to find ways to make sense of it all. Bush's work would later inspire Tim Berners-Lee's article; '*Word-wide Web: The Information Universe*' (Berners-Lee et al., 1992) in which he acknowledged Bush's concept as a seed of inspiration for the World-Wide Web (W^3).

Goldman Sachs (2014) noted that cheaper sensors and an increase in discounted processing are two key facilitators driving change.. The result has been an increase in worldwide connected devices. Statista (2020) reports, from 15.41 billion in 2015 to an estimated 75 billion by 2025 as per Figure 4.3.

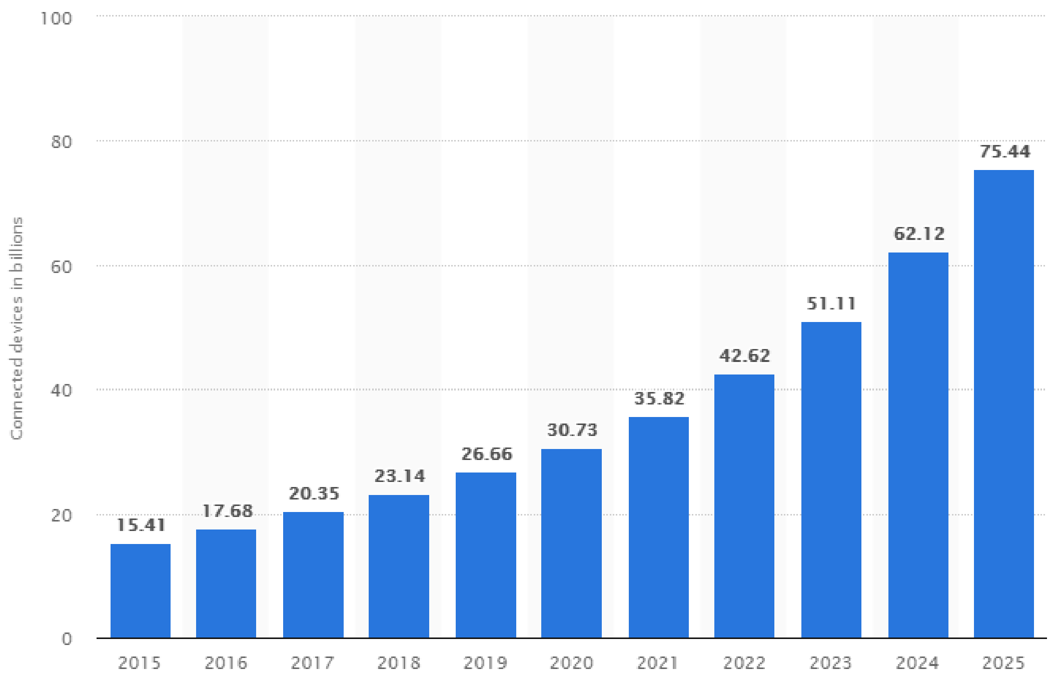


Figure 4.3: Worldwide IoT device increase, 2015-2025 (Statista, 2020)

The IoT market growth shown in Figure 4.4 follows a similar growth profile; valued at $190.0 billion in 2018 and projected to reach $1,102.6 billion by 2026 (Fortune Business Insights, 2019, p. para 1).

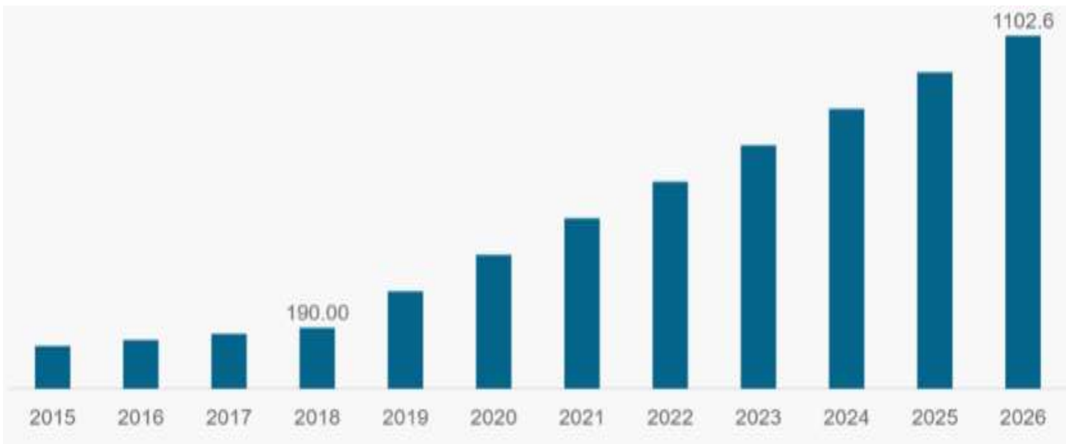


Figure 4.4: Worldwide IoT market, 2015-2026 (Fortune Business Insights, 2019)

An almost 'perfect storm' of conditions have now been created for knowledge sharing and technology development as "computing power increased by 10,000 times since the year 2000. The cost of storing the data has gone down by around 3000 times since the year 2000" (Menon, 2018, p. para 26). This is illustrated in Figure 4.5.

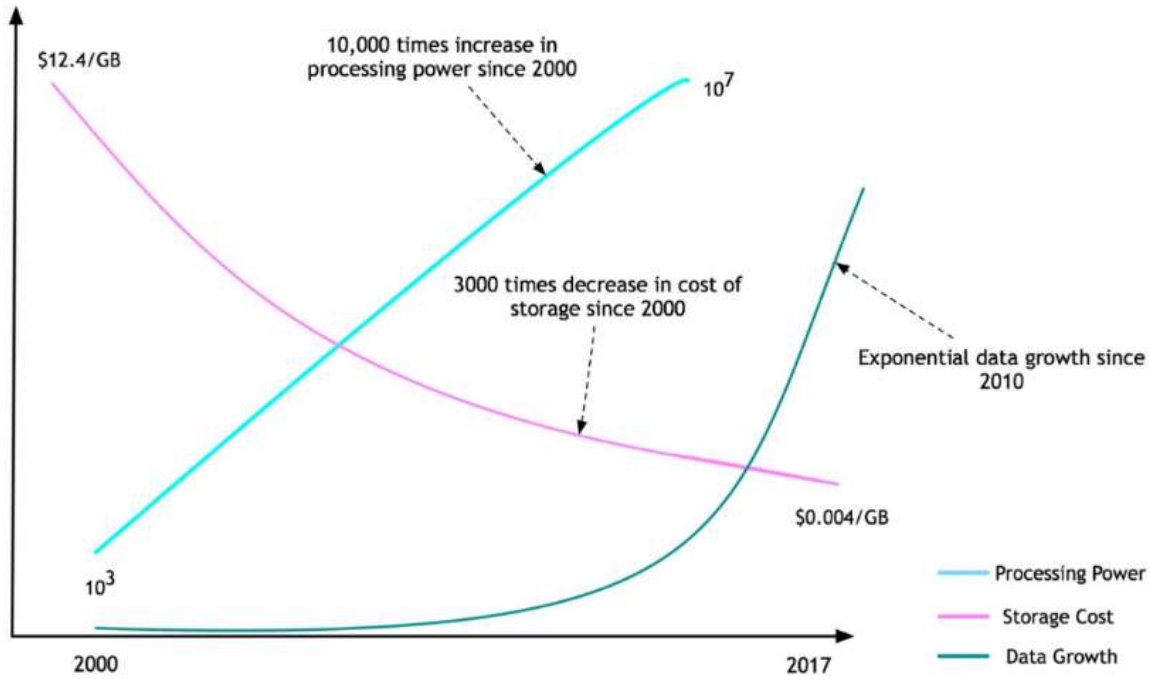


Figure 4.5: Knowledge sharing and technology development (Menon, 2018)

This phenomenal growth was eloquently summarised by Schwab (2015, p. para 4): “when billions of people and devices are all connected with ever increasing computer processing power, storage capacity, and access to knowledge, then the possibilities are endless”. In the next section we will consider the impact on industry.

4.2 IR4.0: the impact of the digital revolution on industry

We are now living in the Fourth Industrial Revolution (IR4.0) born from the ‘digital revolution’ and the rise of electronics in the 1970s. The impact on industry has been considerable with many analogue, electronic and mechanical devices being gradually transformed to digital technologies (Alaloul et al., 2020). Klaus Schwab who coined the phrase ‘IR4.0’ summed up its potential impact: “We stand on the brink of a technological revolution that will fundamentally alter the way we live, work, and relate to one another. In its scale, scope, and complexity, the transformation will be unlike anything humankind has experienced before”. (Schwab, 2015, p. para 1). He later observed “from the perspective of human history, there has never been a time of greater promise or potential peril” (Schwab, 2016, p. 8). Erik Brynjolfsson was quoted by the World Economic Forum (WEF) as saying: “now comes the second machine age. Computers and other digital advances are doing for mental power - the ability to use our brains to understand and shape our environments - what the steam engine and its descendants did for muscle power” (WEF, 2015, p. 3).

The IR4.0 is “characterised by a fusion of technologies that is blurring the lines between the physical, digital and biological worlds” (Lee et al., 2018, p. 1). Trends such as robotics, Artificial Intelligence

(AI), BIM etc. will have profound, lasting impacts, and will transform entire industries (WEF, 2018). However, research indicates most organisations are not well prepared for the impact of digitalisation as noted by Kane et al. (2016) in the report '*Aligning the Organization for its Digital Future'*. Industry disruption by digital trends was anticipated by 90% of executives, however only 44% stated that they had prepared for future disruption. Reports such as the '*Made Smarter Review'* illustrate how the digital transformation will drive new development of the UK economy (Dept for Business, 2017).

Academics such as Xu, David and Kom (2018, p. 91) observed "leading researchers argue that the fourth industrial revolution will shape the future through its impacts on government and business". In order to understand its impact, we need to consider the term 'digitalisation'. Several definition examples are shown in Table 4.1.

Table 4.1: Definitions of digitalisation (various)

Source	**Definition**
EU BIM Task group (2017, p. 8)	"Digitalisation is the adoption or increase in the use of digital or computer technology by an entity such as an organisation, industry sector or country".
Innolytics (2020, Para 1)	"Generic term for the digital transformation of society and the economy. It describes the transition from an industrial age characterized by analogue technologies to an age of knowledge and creativity characterized by digital technologies and digital business innovation".
Gartner Glossary (2020, Para 1)	"The use of digital technologies to change a business model and provide new revenue and value-producing opportunities; it is the process of moving to a digital business".
Oxford English Dictionary (2020, Para 1)	"The process of changing data into a digital form that can be easily read and processed by a computer".
IGI Global (2020, Para 6)	"The adoption of digital technologies to modify a business model. The aim is to create a value from the use of new, advanced technologies by exploiting digital network dynamics and the giant digital flow of information".

In practice people often confuse terminology. To avoid this we can refer to (Chapco-Wade, 2018, p. 3) who describes 'digitisation', as "the conversion of analogue to digital", and 'digitalisation' as "the use of digital technologies and digitized data to impact how work gets done, transform how customers and companies engage and interact, and create new (digital) revenue streams" (ibid).

The connective power of internet has led to the development of the IoT but there is sometimes confusion regarding the terms; 'internet' and 'IoT'. Some of the key differences focus on the connection of devices as illustrated by (Goldman Sachs, 2014) in their '*S-E-N-S-E Framework'* (Table 4.2).

Table 4.2: Goldman Sachs *'S-E-N-S-E Framework'* (Goldman Sachs, 2014)

S-E-N-S-E	What the IoT does	How it differs from the internet
Sensing	Leverages sensors attached to things (e.g. temperature, pressure, acceleration).	More data is generated by things with sensors than by people.
Efficient	Adds intelligence to manual processes (e.g. reduce power usage on hot days).	Extends the internet's productivity gains to things, not just people.
Networked	Connects objects to the network (e.g. thermostats, cars, watches).	Some of the intelligence shifts from the cloud to the networks edge ("fog" computing).
Specialised	Customises technology and process to specific verticals (e.g. healthcare, retail, oil).	Unlike the broad horizontal reach of PCs and smartphones, the IoT is very fragmented.
Everywhere	Deployed pervasively) e.g. on the human body, on cars, homes, cities, factories).	Ubiquitous presence, resulting in an order of magnitude, more devices and even greater security concerns.

The two together have made digitalisation tremendously important to organisations today as "a strategy or process that goes beyond the implementation of technology to imply a deeper, core change to the entire business model and the evolution of work" (ibid). In a wider context the IoT landscape now touches almost every part of our lives as illustrated by Goldman Sachs (2014) in Figure 4.6.

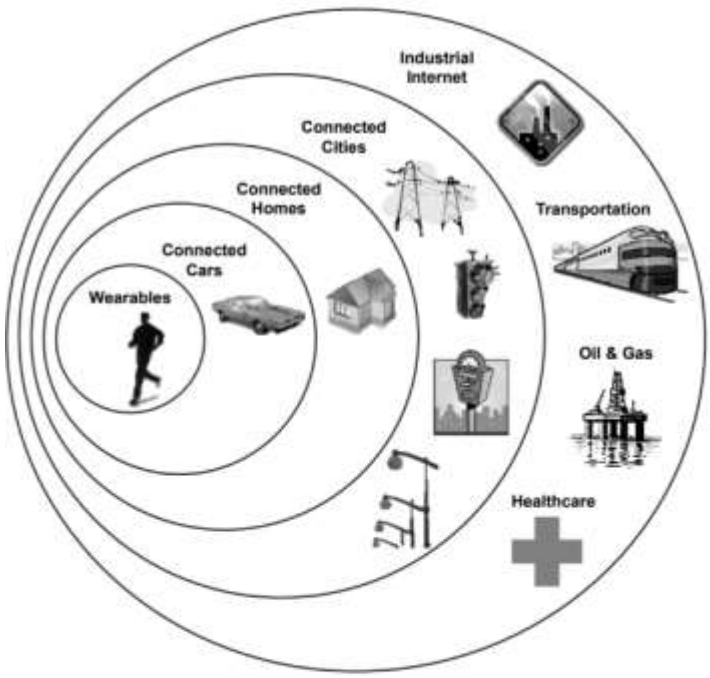


Figure 4.6: IoT landscape (Goldman Sachs, 2014)

Most organisations are now concerned with two key questions: which technology trends will have the most impact? and how can their organisations prepare for digitalisation?

4.3 Technology trends driving change

Research by well-respected organisations such as Gartner provide useful overviews for organisations to consider. Founded in 1979, they aim to "provide senior leaders across the enterprise with the indispensable business insights, advice and tools they need to achieve their mission-critical priorities and build the organizations of tomorrow" (Gartner, 2020a). Their annual industry prediction reports are helpful when considering 'emerging technologies'. Other reports considered were the '*Top 10 strategic technology trends'* and the '*Gartner Hype Cycle*' which make predictions for the coming year. Table 4.3 shows a summary of the last 4 years' reports for the top 10 trends.

Table 4.3: Gartner '*Top 10 strategic technology trends'* (including trends 2017-2020)

Year	Gartner predicted top strategic trends	Year	Gartner predicted top strategic trends
2017	1. Applied AI and Advanced Machine Learning. 2. Intelligent Apps. 3. Intelligent Things. 4. Virtual and Augmented Reality. **5. Digital Twins.** 6. Blockchain and Distributed Ledgers. 7. Conversational System. 8. Mesh App and Service Architecture. 9. Digital technology platforms. 10. Adaptive security architecture.	2018	1. AI Foundations. 2. Intelligent Apps and analytics. 3. Intelligent Things. **4. Digital Twins.** 5. Cloud to the Edge. 6. Conversational Platforms. 7. Immersive Experience. 8. Blockchain. 9. Event-Driven Model. 10. Continuous Adaptive Risk and Trust.
2019	1. Autonomous Things. 2. Augmented Analytics. 3. AI-Driven Development. **4. Digital Twins.** 5. Empowered Edge. 6. Immersive Experience. 7. Blockchain. 8. Smart Spaces. 9. Blockchain. 10. Smart Spaces.	2020	**1. Hyperautomation.** 2. Multi experience. 3. Democratisation. 4. Human Augmentation. 5. Transparency and Traceability. **6. Empowered edge.** 7. Distributed Cloud. 8. Autonomous Things. 9. Practical Blockchain. 10. AI Security.

The relatively new trend of 'digital twins' (highlighted in red in Table 4.3) are very important. Even though the concepts of BIM and digital twins are distinct, they are also closely linked in the context of construction. The BIM process has become the standard way of collaboratively delivering construction projects, and generates the critical digital information and data which FMs need for optimising and running BA in operation. However, the BIM models and data are static in nature, whereas the purpose of a digital twin is to provide a 'dynamic' model. This is usually achieved through the use of sensors linked by the IoT, that provide real time information about a building and its associated systems, allowing more interaction between people and physical assets.

The important link in the research, is that in the context of construction, the next logical step is to use the static BIM models and data created during construction as the basis for creating more dynamic digital twins. These can then be used (and evolved) over the whole-life of BA to provide real time information allowing for data modelling, simulations, and the development of new services to enhance users experiences in buildings. In practice, FMs will use both BIM models/data for reference purposes and digital twins for more real time task-like building maintenance systems.

However, today many of the sensors that could better enable the digital twins are an afterthought and are installed as a 'retrospective' fit-out. In the future it is likely the design process will include specific stages where the development of BIM to digital twin is actively considered in the planning stages. This could include proactive consideration early in the planning phases to review what IoT and sensors should be fitted to enable the digital twin to evolve from the BIM process. The result will generate data that can be actively analysed and used, for example, for predictive maintenance.

It should be noted that digital twins can also be created using other data capture techniques (e.g. laser scanning or photogrammetry), but where BIM is used it already provides a rich data source which is available for the natural development into a digital twin for use over the life-cycle.

Research by Lamb (2019) for the Centre for Digital Built Britain (cdbb) considered 850 academic papers discussing digital twins: 96% were published since 2016. She added "in the built environment, the use of digital twins is just beginning to take off" (ibid, p 6). They appeared in the reports: 2017 (Panetta, 2016); 2018 (Panetta, 2018); and 2019 by Clearly and Burke (2018). Although not listed in 2020 they were highlighted in the Gartner yearly report '*Top 10 Strategic Technology Trends for 2020'* which was themed on "people-centric smart spaces, i.e. considering how technologies will affect people" (Cearley, 2020, p. 2). He noted digital twins are strongly linked to other trends. 'Hyperautomation' examines the concept for the 'Digital Twin of an Organisation' which "visualizes the interdependence between functions, processes and Key Performance Indicators" (ibid, p. 52). For the trend 'Empowered Edge', "data from multiple digital twins can be aggregated for a composite view across a number of real-world entities such as a power plant or a city" (ibid, p. 32).

So, what is a digital twin? Shaw and Fruhlinger (2019, p. para 3) described it as "a digital representation of a physical object or system". Parrott and Warshaw (2017, p. 3) expanded this suggesting they mirror real-life objects, processes or systems and can be defined "as an evolving digital profile of the historical and current behaviour of a physical object or process that helps optimize business performance". However, Tao, Zhang and Nee (2020) noted the concept is not new having originated from NASA's Apollo program. Duplicate 'twins' of space vehicles were used to compare the one in space with a replica on earth to allow scientists to mirror conditions and test scenarios.

The model shown in Figure 4.7 from (Roper, 2019, p. para 13) illustrates how a digital twin "takes the building's data from all sources, including the physical (which BIM forms part of) and systems (which Integrated Services Platform forms part of), and it adds the missing data pieces. Namely the people and processes aspects, to give us a full digital picture of a building".

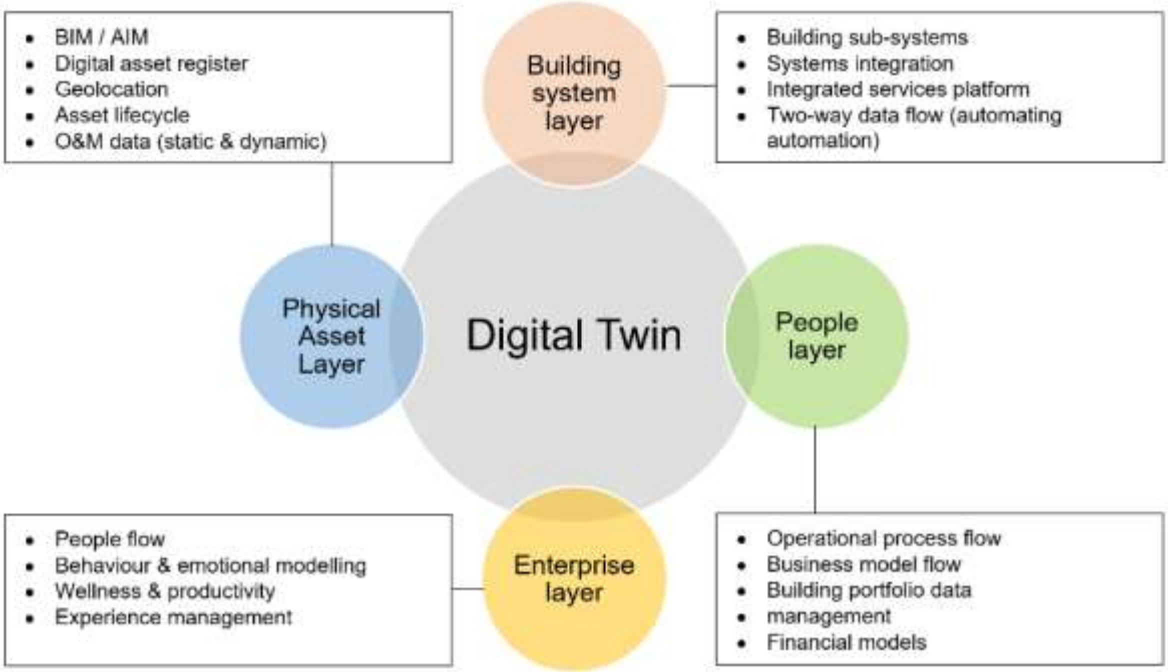


Figure 4.7: Visual representation of a digital twin (Roper, 2019)

Gartner (2019) reported that digital twins will be implemented by 75% of organisations using IoT within a year due to their popularity skyrocketing. The market is expected to grow very fast from $3.8 billion in 2019 to $35.8 billion by 2025 (MarketsandMarkets, 2020, p. para 1). Their key benefit comes as a way to analyse “data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations” (Marr, 2017, p. para 2).

Technologies and applications are graphically represented in the ‘Gartner Hype Cycle’(2020). demonstrating their relevance in capitalising on new opportunities and resolving real business issues. Figure 4.8 illustrates the hype cycle concept which has been adapted to illustrate the development of digital twins. The curve shows in 2017 they were considered an ‘Innovation Trigger’, whereas by 2018 they had already reached the ‘Peak of Inflated Expectations’. The ‘Trough of Disillusionment’ is where people doubt the real potential of a technology whereas the ‘Plateau of Productivity’ indicates the point when a technology enters mainstream industry use. Organisations are obviously keen to invest in technology which reaches this plateau and not ones which become redundant before reaching the stable plateau. The Gartner 2017/8 predictions were that digital twins will become mainstream somewhere between 2022 and 2026.

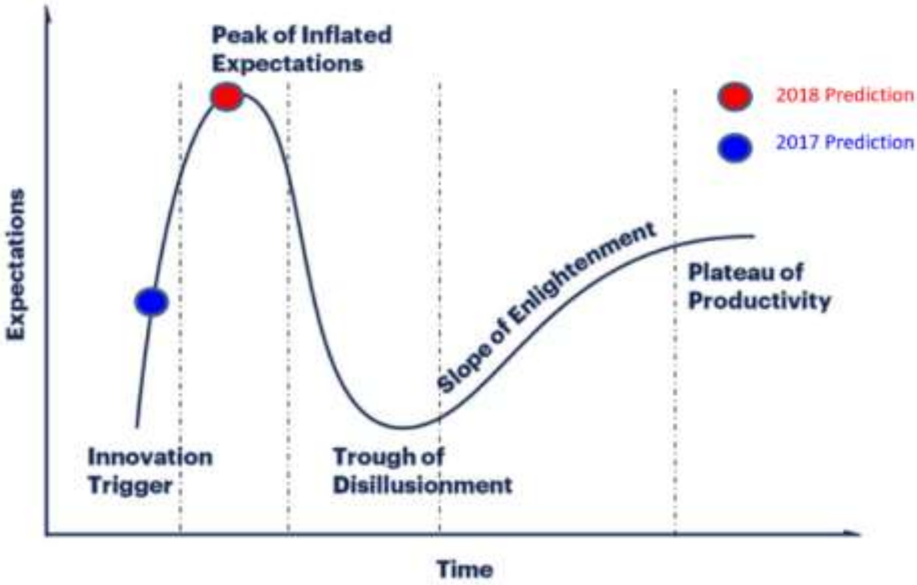


Figure 4.8: Hype cycle (Gartner, 2020) adapted to show digital twins in 2017/8

With respect to a National Digital Twin (NDT), Lamb (2019, p. 8) noted that "ecosystems of digital twins could be created within networks of service-based assets, such as healthcare facilities or transport, in order to coordinate services across the network".

Another popular buzzword is Property Technology (PropTech). The idea encapsulates "technology being developed for the property industry, and it uses information technology (IT) to help property owners, property managers, and landlords to make better manage their assets" (HqO, 2020, p. para 5).

The report '*PropTech 2020: the future of real estate'* (University of Oxford Research, 2020) used the Gartner Hype Cycle to assess the maturity and time period for several technologies they considered to be most likely to succeed in PropTech markets. The findings are shown in Table 4.4.

Table 4.4: Maturity of PropTech technologies (University of Oxford Research, 2020)

Hype Cycle	PropTech application	Position	Time until plateau of productivity
2018	Augmented reality	Trough of disillusionment	5-10 years
2018	Autonomous driving (level 5)	Innovation trigger	More than 10 years
2018	Smart workspace	Peak of inflated expectations	5-10 years
2018	IoT platform	Peak of inflated expectations	5-10 years
2018	Digital twin	Peak of inflated expectations	5-10 years
2018	Blockchain	Peak of inflated expectations /trough of disillusionment cusp	5-10 years
2018	Flying autonomous vehicles	Innovation trigger	More than 10 years
2018	Virtual assistants	Peak of inflated expectations	2-5 years
2019	Immersive workspace	Innovation trigger	5-10 years
2019	Flying autonomous vehicles	Innovation trigger	More than 10 years
2019	Light cargo delivery drones	Peak of inflated expectations	5-10 years
2019	Autonomous driving (level 5)	Peak of inflated expectations	More than 10 years
2019	5G	Peak of inflated expectations	2-5 years
2019	3D sensing cameras	Trough of disillusionment	2-5 years
2019	Decentralised Web	Innovation trigger	More than 10 years

Digital twins are seen as increasingly important to governments. Gartner (2019a, p. para 2) predicted their use in planning and strategy to develop "models of major systems, such as a road network or a water system, that allow agencies to manage, monitor and maintain them". They suggested "It's a trend that's expected to have a transformational benefit in the public sector within five to ten years" (ibid). Figure 4.9 shows the '*Gartner Hype Cycle for digital government technology – 2019' in* which we see the maturity of various key technologies including 'IoT Platform' and the new concept 'Digital Twins of Government' appearing as an 'Innovation Trigger'.

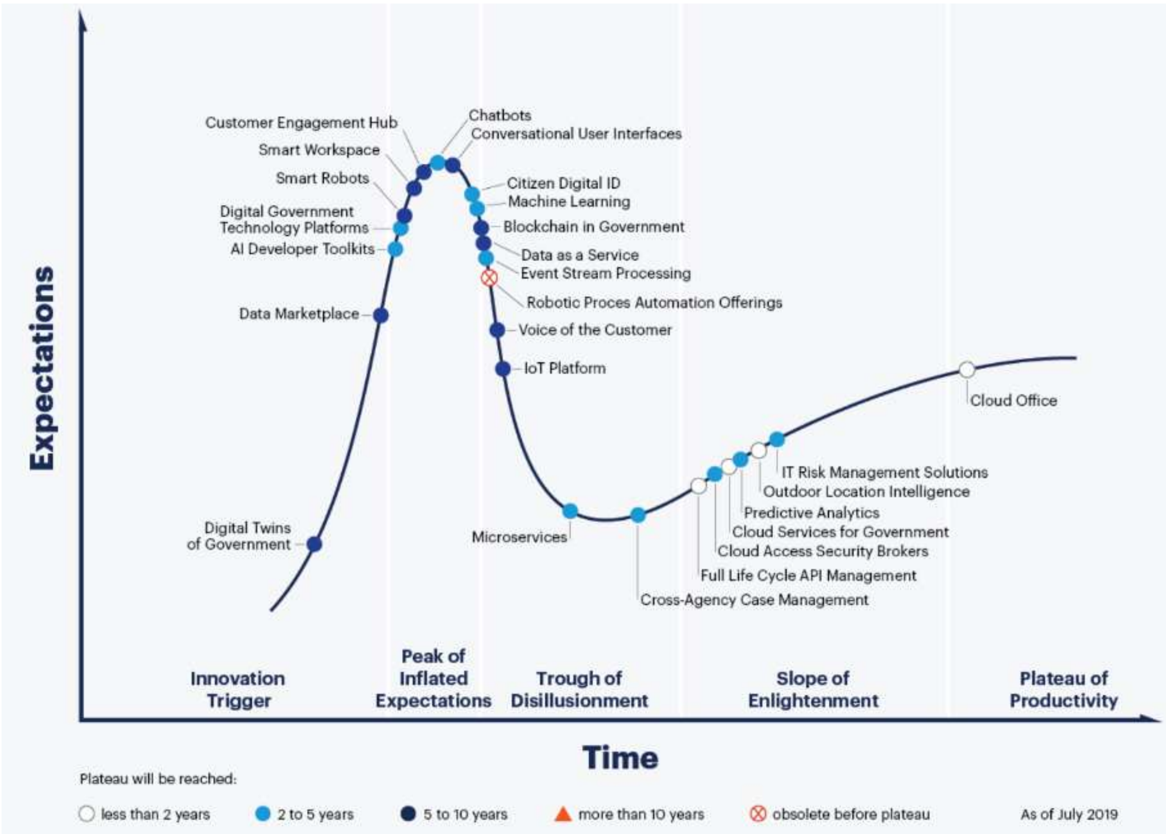


Figure 4.9: Hype cycle for digital government technology (Gartner, 2019a)

Panetta (2016, p. para 14) reported Cearley from Gartner saying "digital twins will exist for billions of things in the near future. Potentially billions of dollars of savings in maintenance repair and operation and optimized IoT asset performance are on the table". With respect to how these savings will be achieved, Cearley (2020) noted the digital twin will be the key trend which will make these savings possible. Indicative research shown in Figure 4.10 by Lamb (2019, p. 12) around the maturity of use by various industry sectors found their use in the built environment is growing.

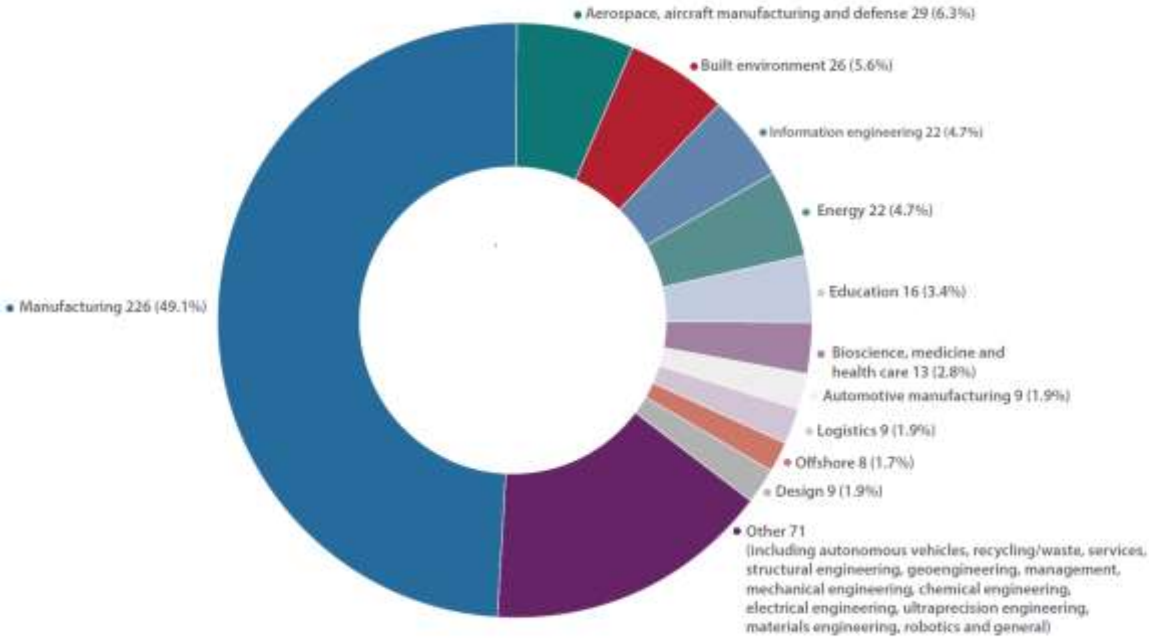


Figure 4.10: Use of digital twins by industry sector (Lamb, 2019)

Their impact will be significant to RE and FM as ARUP (2019, p. 85) noted, the “argument for having a digital twin of a built asset is compelling”. We see a critical link here with BIM as Siemens (2018, p. 3) note: “BIM is used to virtually simulate a physical building using what is called its digital twin”. However, the idea is not limited to one building and is being extended to whole cities (Smart.City_Lab, 2019). For organisations wanting to create digital twins of their BA it is important they understand that BIM will be used for ‘new build’ scenarios. For existing BA different approaches can be used for data collection and modelling e.g. ‘Scan-2-BIM’ modelling or photogrammetry and new approaches are being developed all the time.

4.4 The impact of technology on the construction industry

As discussed in Chapter 2, and observed by WEF (2016, p. 3), in the face of growing pressures of globalisation, climate warming, population growth etc. the construction industry is “under a moral obligation to transform” and digitalisation and new technologies are empowering the change. Their impact will be wide and far ranging as Berger (2016) observed; it changes the whole of the construction industry from builders to manufacturers. Companies will have to address the challenges or be left behind. He went on to add “93% of construction industry players agree that digitization will affect every process” (ibid, p3). In this section we review the impact on the AEC industry. Oesterreich and Teuteberg (2016, p. 126) observed, “BIM is considered as the central technology for the digitisation of the construction manufacturing environment”.

The potential savings to the ACE/FM industries will be substantial as reported by BCG by 2025: “full-scale digitalization...will lead to annual global cost savings of 13% to 21% in the design, engineering and construction phases and 10% to 17% in the operations phase”. The report ‘*The Transformative*

Power of Building Information Modeling' (Gerbet et al., 2016, p. 10) suggested "by 2025, the total global cost-saving potential in non-residential sectors will be $0.7-1.2 trillion in design, engineering, and construction and $0.3-0.5 trillion (10-17%) in the operations".

Research regarding the impact of various digital trends by Alaloul et al. (2020) investigated 160 construction companies to assess the maturity of specific trends. The evolvement of technologies such as virtual, augmented and mixed reality is behind other fields, e.g. modularisation, cloud computing and BIM, which are developing extensively. Their findings in Figure 4.11 highlighted Social Media and BIM had the highest use.

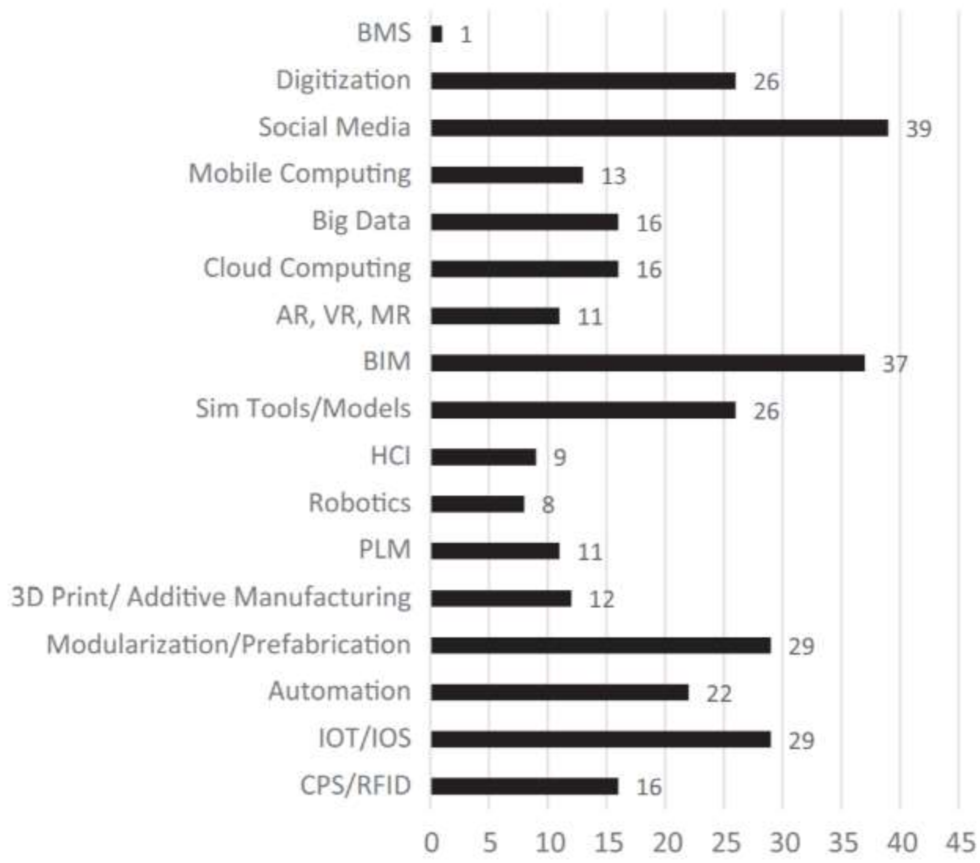


Figure 4.11: Use of technologies by the AEC industry (Alaloul et al., 2020)

Other research by the Altus Group (2019), of 417 individuals in RE development firms, reported the top three technologies likely to cause maximum disruption were: smart building technologies, pre-fabrication (modular construction) and BIM as shown in Table 4.5.

Table 4.5: Top disruptive technologies to the RE industry (Altus Group, 2019)

	NO OR ONLY MINIMAL IMPACT ON DEVELOPMENT INDUSTRY	POTENTIAL FOR SIGNIFICANT IMPACT ON EFFICIENCIES AND HOW DEVELOPMENT IS CONDUCTED	WILL CREATE MAJOR DISRUPTIVE CHANGES IN THE DEVELOPMENT INDUSTRY
Smart Building technologies	8%	42%	49%
Pre-fabrication	16%	34%	49%
Building Information Modeling (BIM)	10%	42%	47%
Construction site robotics	32%	32%	34%
Intelligent building design (using Artificial Intelligence + Machine Learning)	30%	37%	30%
Drones	36%	36%	28%
Process automation (Contracts, Workflow, Proformas/Feasibility, Procurement)	56%	22%	22%
Connected job sites	54%	26%	20%
Augmented reality/Virtual reality	45%	34%	20%
3D printing	65%	19%	16%

Research by Singh (2018) based on the WEF report '*Shaping the Future of Construction a Breakthrough in Mindset and Technology*' (WEF, 2016) rated the likely impact and importance of new technologies and global drivers on the future of construction. Table 4.6 summarises the findings.

Table 4.6: Likely impact/importance of new technologies in construction (Singh, 2018)

	New technologies		Global trends	
	Impact	Likelihood	Impact	Importance
High	• **Integrated BIM** • Prefabricated building components • Real-time mobile collaboration • Advanced project planning tool • Wireless monitoring/IoT	• **Integrated BIM** • Wireless monitoring/IoT • 3D laser scanning • Real-time mobile collaboration • Prefabricated building	• Energy and climate change • Aging and need infrastructure • Complex projects • Funding and investment gaps • Talent shortage • Corruption	• Energy and climate change • Aging and need infra • Complex projects • Resource scarcity
Moderate	• 3D printing of components • Self-healing materials • New active materials • Augmented reality • 3D laser scanning	• Drones • Augmented reality • Advanced planning tool • Advanced building material	• Resource scarcity • Regulatory requirements • HSE and labour laws • Urbanization and housing crisis • Aging workforce • Geopolitical uncertainty	• Funding and investment gaps • Talent shortage • Corruption • HSE and labour laws • Urbanization and housing crisis • Aging workforce • Geopolitical uncertainty
Low	• Contour crafting of buildings • Drones • Big data analytics	• Contour crafting of buildings • Self-healing materials	• Cyberthreats • Inhabitant health and comfort needs • Stakeholder pressure	• Regulatory requirements • Cyberthreats • Inhabitant health and comfort needs • Stakeholder pressure

Interestingly, Singh observed, "BIM appears to be at the centre of most of the foreseen advancements in digital construction, whether it is incremental advancements toward design and construction management or more radical advancements toward robotics or direct digital construction" (ibid, p2). Key technologies were considered by Gerbet et al. (2016) over the whole-life-cycle of a BA as shown in Figure 4.12. They note "the key feature of the technology transformation is the software platform and control layer, which consist in large parts of BIM" (ibid, p4).

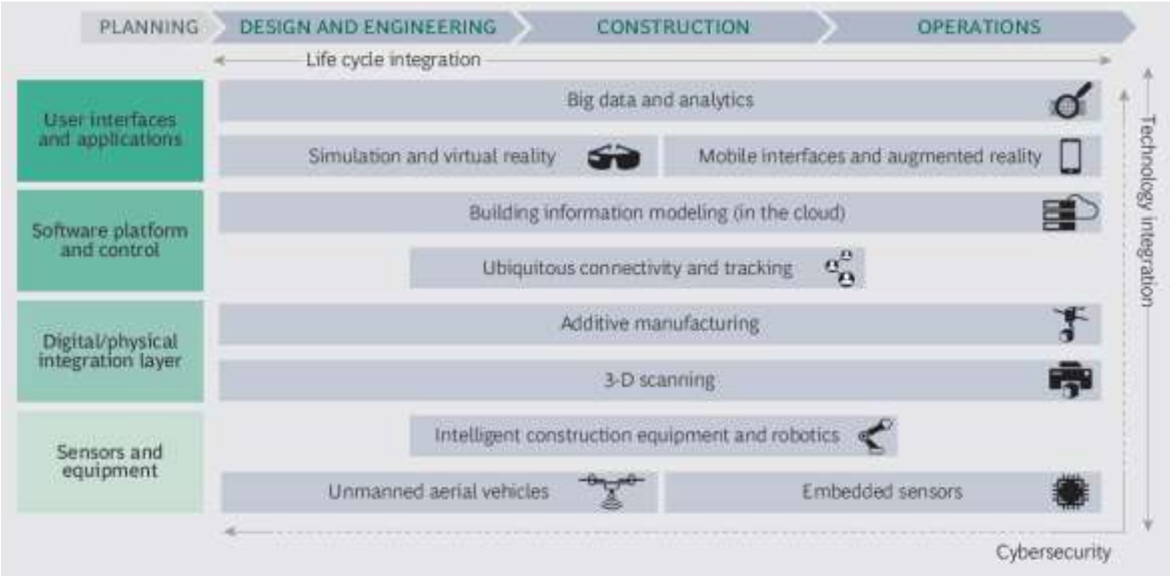


Figure 4.12: Impact of technology over a BA whole-life-cycle (Gerbet et al., 2016)

Industry groups like the EU BIM Task Group (2017, p. 8) suggested the introduction of BIM "represents the construction sector's moment of digitalisation". The WEF (2016) agree noting BIM is the technology-led change most likely to deliver the highest impact to the built environment sector. They describe possible applications of BIM over the whole-life-cycle of BA as shown in Figure 4.13.

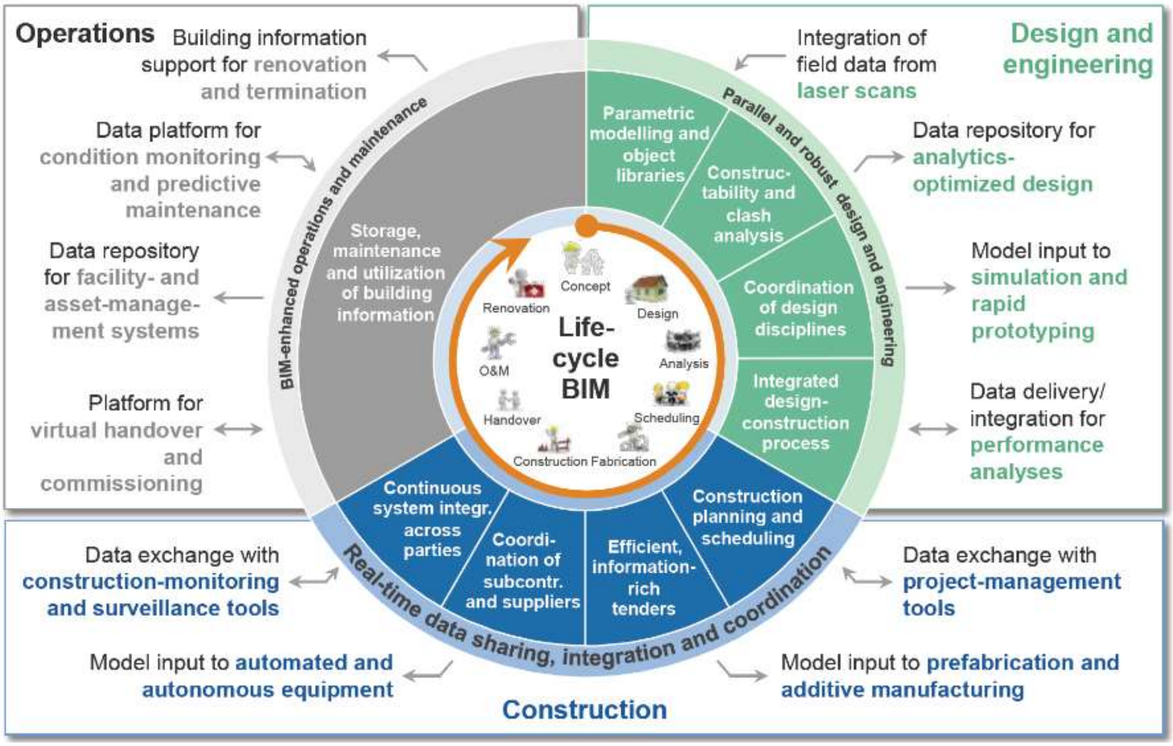


Figure 4.13: Applications of BIM over the whole-life-cycle of BA (WEF, 2016)

4.5 The rise of smart buildings and cities

The cdbb (2020, p. 3) noted "the purpose of infrastructure is human flourishing". We now see "technological advances are empowering wide ranging digitalisation of RE and leading to the creation of smart buildings and cities. Interestingly Roper (2019, p. para 5) argues both are a "sub-set of a digital twin". She perceived a 'smart building' as "a connected, integrated and insights-driven building, personalized and fine-tuned for specific outcomes". Whereas, Gemalto (2020, p. para 3), described a 'smart city' as "a framework, predominantly composed of Information and Communication Technologies (ICT), to develop, deploy, and promote sustainable development practices to address growing urbanization challenges". Optimisation is possible stated Desjardin (2019). through mobile-based applications, and the use of low powered sensors and wireless networks. These sensors connected to billions of devices and with digitalised processes will allow vast amounts of data to be collected and acted upon (Fraunhofer-Gesellschaft, 2019). A key aim, argued Ghaffarianhoseini et al. (2016), is production of intelligent building designs and smart infrastructure to help maximise occupants' comfort and well-being, and produce sustainable designs. The smart city concept and 3D models are already developed by companies working with for example the open data model 'CityGML' standard (OGC, 2020). These include firms like Virtualcity-SYSTEMS (2020), Sanborn (2020), WRLD (2020) etc.

The cdbb '*Smart Infrastructure'* report (Bowers et al., 2016, p. 1) predicts: "smart infrastructure is a global opportunity worth £2trn-4.8trn". The report outlines the concept in Figure 4.14, which is achieved by "combining physical infrastructure with digital infrastructure, providing improved information to enable better decision making, faster and cheaper" (ibid, p2).

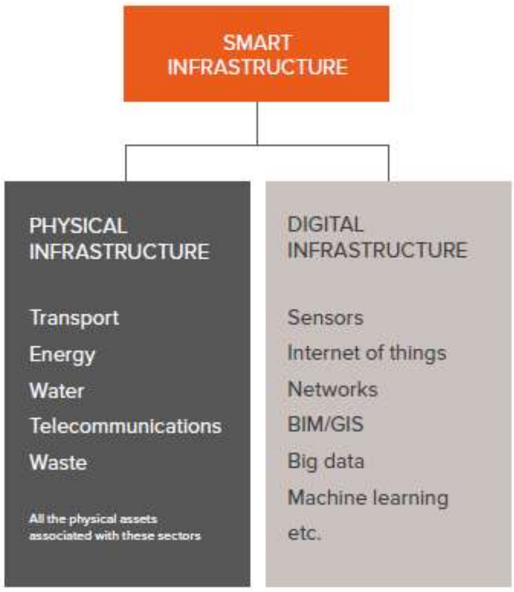


Figure 4.14: Smart infrastructure concept (Bowers et al., 2016)

Berlin (2018) noted activities carried out on a daily basis will be transformed by smart buildings. Research by Buckman, Mayfield and Beck (2014) suggested the concept of smart buildings will develop with technology to the point where we have predictive thinking buildings. Their ideas illustrating development concepts are shown in Figure 4.15.

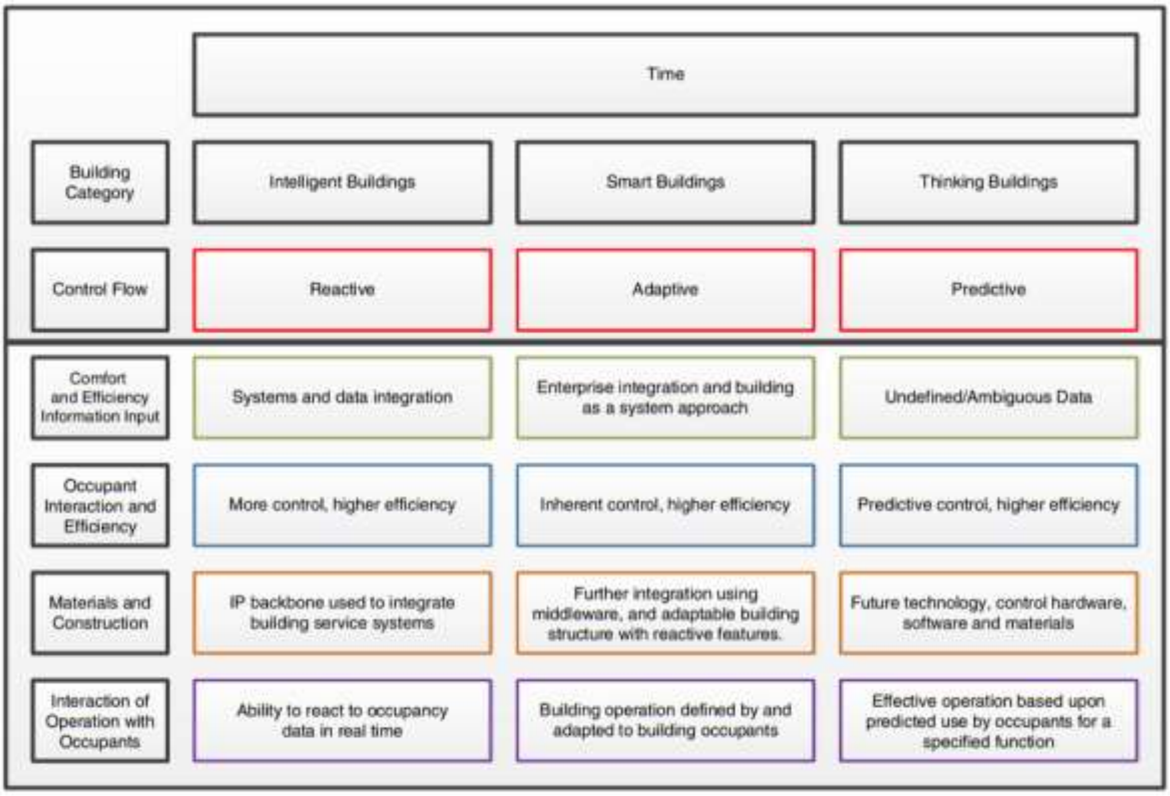


Figure 4.15: Smart buildings evolution - Buckman, Mayfield and Beck (2014)

In summary we can see technology and digitalisation offer many opportunities to improve and address the issues facing the industry's lack of productivity, innovation etc. as discussed in Chapter 2. We need to give credit to the Government which has played a key role in driving change by incorporating digitalisation into wider government strategy.

4.6 The UK Government strategy for digitalisation in the construction industry

The Government has recognised the importance of digitalisation as highlighted in the '*Transforming Infrastructure Performance*' report (IPA, 2017, p. 4) which stated: "Lifting productivity growth by even one quarter of one per cent a year, on a sustained basis over 10 years would add £56 billion to GDP. Infrastructure investment can help increase our national productivity, which is why we have made it a cornerstone of our national economic plan".

Examples of incorporating digitalisation in their strategic planning to drive change across industry can be seen in the '*Digital Built Britain Strategy'* which noted: "our social and economic infrastructure is mature and in need of extensive maintenance, renewal and modification to meet emerging needs" (HM Government, 2015, p. 8). It goes on: "our facilities and networks are becoming ever more integrated, to the point where their reliability often determines their capacity, stifling economic growth and social wellbeing" (ibid).

The latest '*Government Construction Strategy: 2016-2020*' (IPA, 2016) noted that the use of digital technology facilitates innovation and waste reduction through collaborative approaches. By capitalising on these approaches and a better understanding of construction related data the Government envisages more efficient delivery of construction projects through the use of BIM.

This commitment was further reinforced in the Government's '*Industrial Strategy'*: "we must make sure our infrastructure choices not only provide the basics for the economy, they must actively support our long-term productivity, providing greater certainty and clear strategic direction" (HM Government, 2017, p. 127). The supporting '*Industrial Strategy: Construction Sector Deal'* report reinforced the importance: "the life of every person in Britain is affected by the construction sector" (HM Government, 2018, p. 6). It added they will invest heavily in "digital technologies, including BIM, sensors, data analytics and smart systems technologies and the information management landscape; which will increase the efficiency of construction techniques" (ibid, p13).

Importantly the sustainability issues raised in Chapter 2 are addressed: "a commitment to shift focus from the costs of construction to the costs of a building across its life-cycle, particularly its use of energy" (ibid, p7).

This support regarding digital infrastructure is critical to industry if the UK is to be in a leading position in the new digital world. As can be seen from the '*The Global Information Technology Report'* (Knoema, 2019), the UK is doing well but is behind other nations. The report ranked the UK eighth on the 'Network Readiness Index' (NRI) of 143 countries, behind, 1-Singapore, 2-Finland, 3-Sweden, 4-Norway, 5-United States, 6-Netherlands, and 7-Switzerland.

The Government has committed to support essential research centred around the cdbb to "promote the adoption of UK BIM standards overseas, and develop collaborations with international partners" (ibid, p20). Examples of cdbb work include '*The Gemini Principles*' report by Bolton, Enzer and Schooling (2018) lays out key principles for national development of digital twins; and the '*Smart Infrastructure'* report (Bowers et al., 2016) illustrates the need to bring technologies together and focus on data quality not quality as illustrated in Figure 4.16.

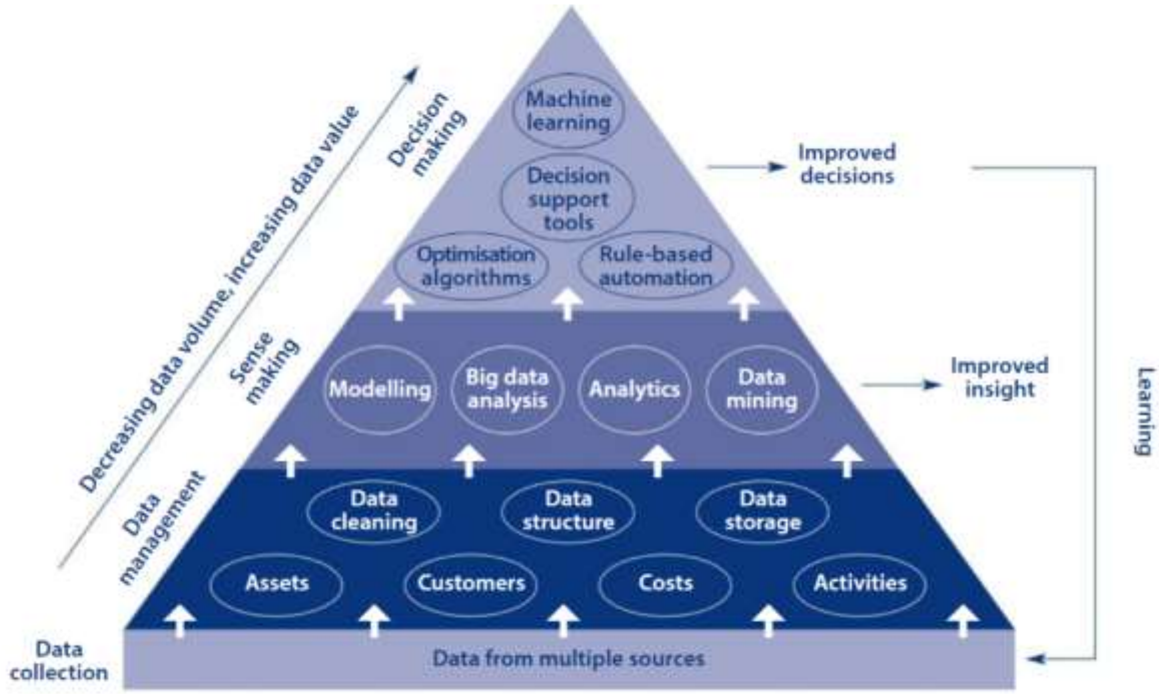


Figure 4.16: From big data to better decisions (Bolton et al., 2018)

According to Dr Li Wan from the University of Cambridge the cdbb vision is that digital twins will:

> become the next-generation tool for smartening city planning and management. It is crucial to use digital technology to deepen our understanding of cities and urban societies. This knowledge will enable us to take advantage of opportunities, while recognising limitations and taking pre-emptive measures to contain the possible risks (CSIC, 2019, p. 27).

The Government's report '*Transforming infrastructure performance'* (IPA, 2017) noted that government decisions on what to build, and where will be driven by a built environment management landscape and digital twin of real world estate. Whole-life performance benefits will be maximised through refurbishing, maintaining, replacing and disposing of existing assets. Importantly, the Government has recognised manufacturers are a CSF and must be included in the wider discussions, as digitised product data forms an essential starting point for digital solutions and wider digital strategies. UK BIM Alliance (2018) suggested this is central to the manufacturers marketing and survival, and the PwC report '*Digital Factories 2020: shaping the future of manufacturing'* notes many factories are "already investing in rolling out digital solutions" (Geissbauer et al., 2020, p. 3).

4.7 The impact of digitalisation on facility management

Like the AEC industry, Atta and Talamo (2020) argued, the transformation of FM with regard to practices, processes and tools has meant FMs have had to adapt to the impact of IR4.0. The where, how and when aspect of peoples' work environments have changed dramatically and been redefined by digital technology, suggested JLL (2016). This is driving profound change in the FM industry as Stoddart (2016, p. 42) observed: "technology is an enabler of the workplace" and "smarter buildings are just around the corner" (ibid). Kazado, Kavgic and Eskicioglu (2019) observed today's buildings are high-performance and more commonly are equipped with sophisticated monitoring systems, which combined with sensors to collect large amounts of data, will provide detailed overviews of buildings' indoor environmental quality and energy consumption. Meyrath (2018, p. 2) stated that the IoT has "catalysed FM into a new era, in which critical equipment is internet-enabled, allowing communication from all sorts of devices so they may report on their own condition and needs".

We already take the internet for granted and soon we will not be able to imagine the world without the IoT. A concept first conceived of by (Weiser, 1991) in his paper '*The Computer of the 21st Century'* and then coined by Kevin Ashton (Claveria, 2019) IoT is central to delivering new services in FM as Atta and Talamo (2020, p. 269) noted:

> The IoT is rapidly becoming one of the core technologies of the digital transformation of the FM sector because of its capability of connecting building users, building components and services merging the physical and virtual worlds and letting them communicate through intelligent digital interfaces.

Sensors and IoT provide FMs with new opportunities to provide better operations management, cost savings and proactive maintenance (Meyrath, 2018). Bauer, Patel and Veira (2014) noted that IoT platforms are easily connected to data analytics platforms, informing decision making; as a result our workplaces have become increasingly dependent on technology. Rossall, Armstrong and Dunn (2018) argued concepts of flexible workplace are changing the way buildings are being used. Often what is important is no longer just the office building, but where and how people want to work.

Research by JLL (2016) suggested that new technology within the digital workplace facilitates FM by allowing them to engage in more strategic roles to improve services. By improving spaces and facilities within the business model through FM advice, companies have better chances of attracting and retaining top talent. Other research by (CBRE, 2017) highlighted that 75% percent of FMs thought that key to achieving strategic real estate goals was having better quality and accurate data.

In Chapter 3 we discussed the wide range of competencies needed by FMs. In a similar way they are increasingly faced with a complex mesh of digital technologies, (most of which are not integrated), which they need to be familiar with as they support modern FM operations. Research by (Ebbesen, 2016) illustrated this complexity as shown in Figure 4.17. He grouped the plethora of technologies into seven different use areas for FM.

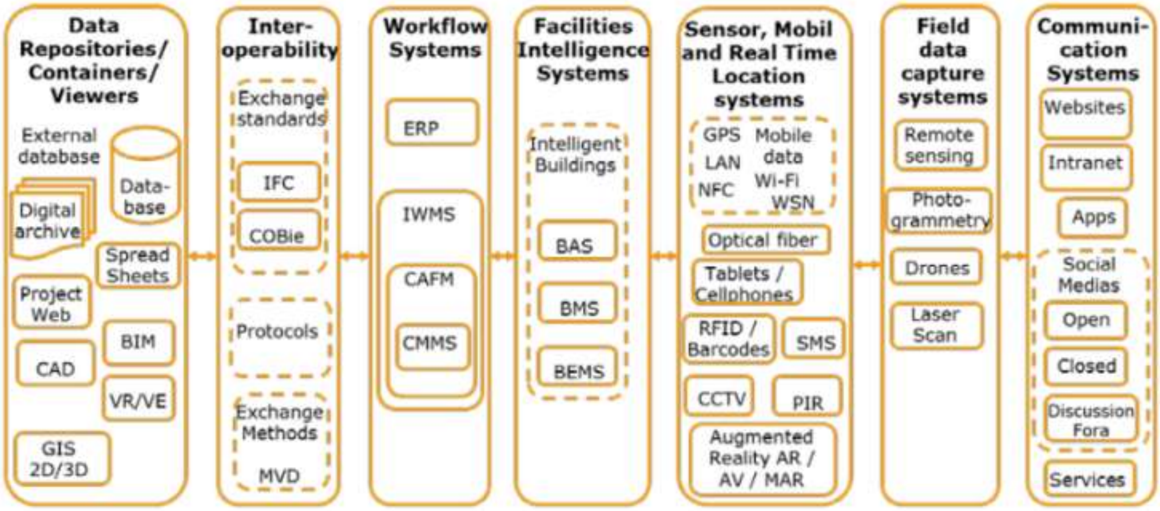


Figure 4.17: Technologies being used and implemented in FM (Ebbesen, 2016)

An emerging theme highlighted by the McKinsey Global Institute (2015) is interoperability. Enabling integration of data from IoT sensors and building systems will empower managers to gain valuable insights. The value of data and data analytics is becoming increasingly important and technology allows a way of bringing real time data into the decision-making process. This is supported by research from the McKinsey Global Institute (2015, p. 107) which suggests organisations making databased decisions are "5-6% more productive".

The IBM report '*Descriptive, predictive, prescriptive: Transforming asset and facilities management with analytics*' (IBM, 2017, p. 5) suggests that "an organization that uses basic automation to expand its reporting capabilities can improve its ROI by 188 percent". This aligns with findings from academia e.g. Araszkiewicz (2017, p. 1035), who carried out a literature review (2010-2016) focusing on the impact of digitalisation on FM, in which she noted: "the evolution of digital tools and technology applied in FM is oriented towards integration with other management systems".

Other research by Wong, Ge and He (2018) reviewed literature (2004-2017) and categorised the most important technologies impacting FM into four areas:

1. BIM
2. GIS
3. IoT (i.e. RFID and sensor network technologies)
4. Reality capture technology (i.e. point cloud, photogrammetry, 3D laser scanning)

Their findings are summarised in Figure 4.18.

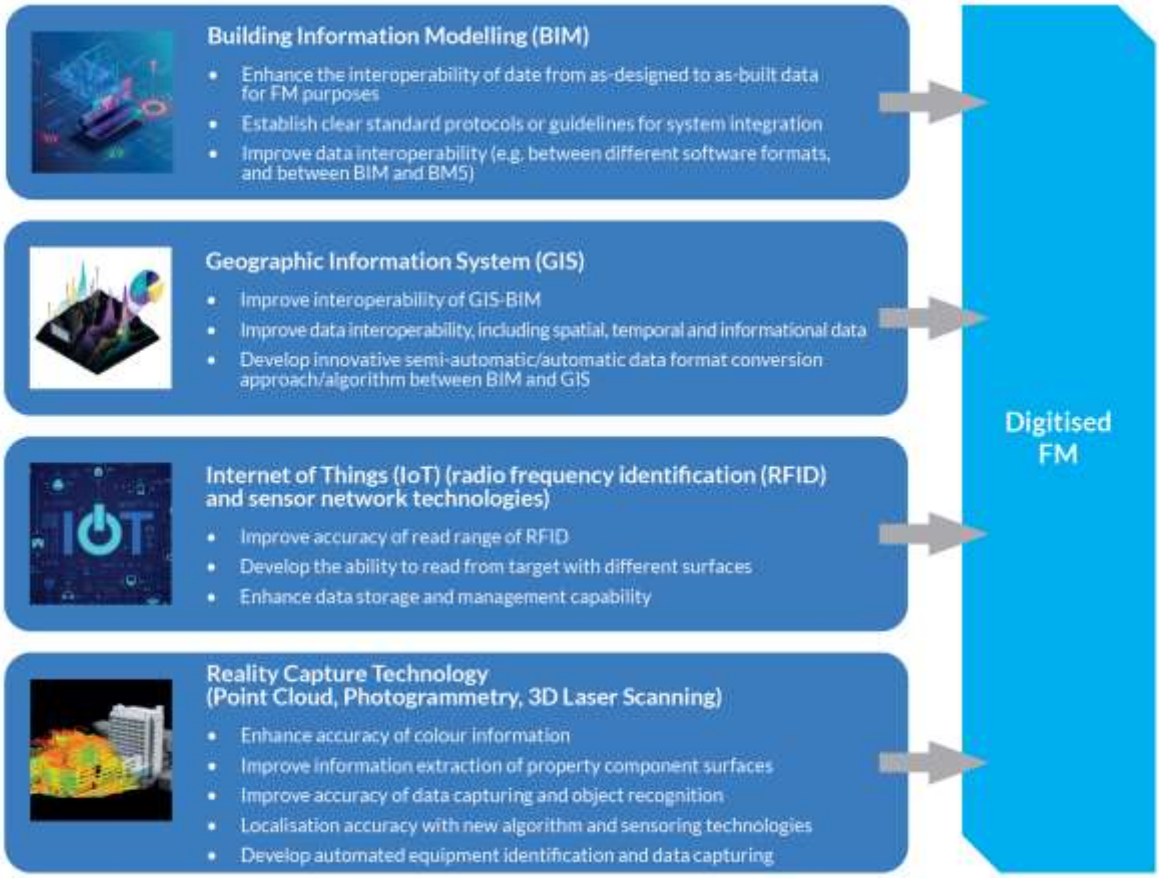


Figure 4.18: Wong, Ge and He's (2018) future digital technology research roadmap

FMs need analytical solutions to efficiently manage and analyse the data from IoT sensors and other data sources, argued Assunção et al. (2014).

They maintained data mining and analytics, will help FMs achieve objectives. Added benefits are cost savings; informed and improved decision making; increased revenue; better service quality and delivery; and improving the workplace experience for employees.

The importance of BIM models is noted by Ahmed et al. (2017), which "can present a data visualisation platform for data mining and Big Data analytics".

It is important to consider how people fit into this picture and how data can be collected to create better user experiences of a building or workplace (JLL, 2019). They argue digitalisation has a strong part to play in making employees feel happier and more engaged, reducing the number of days people are sick, and providing service solutions that help reduce employee turnover and improve retention rates. Locatee and Memoori (2019) noted that "building owners and operators are becoming far more interested in increasing occupant well-being and productivity. This is resulting in an increasingly complicated landscape of Smart Building solutions". They suggest seven "fundamental attributes or capabilities enabled by digitization, which can define a Smart Building" (ibid, p5) as shown in Figure 4.19.

Figure 4.19: FM attributes enabled by digitalisation (Locatee and Memoori, 2019)

FMs are now seeing a ‘digital journeys’ Boag (2019). This is seeing organisations look to enhance user experience within a building (or campus) often supported by digital ‘touch points’. An example of a digital journey by one of ZHAW BSc students is shown in Figure 4.20.

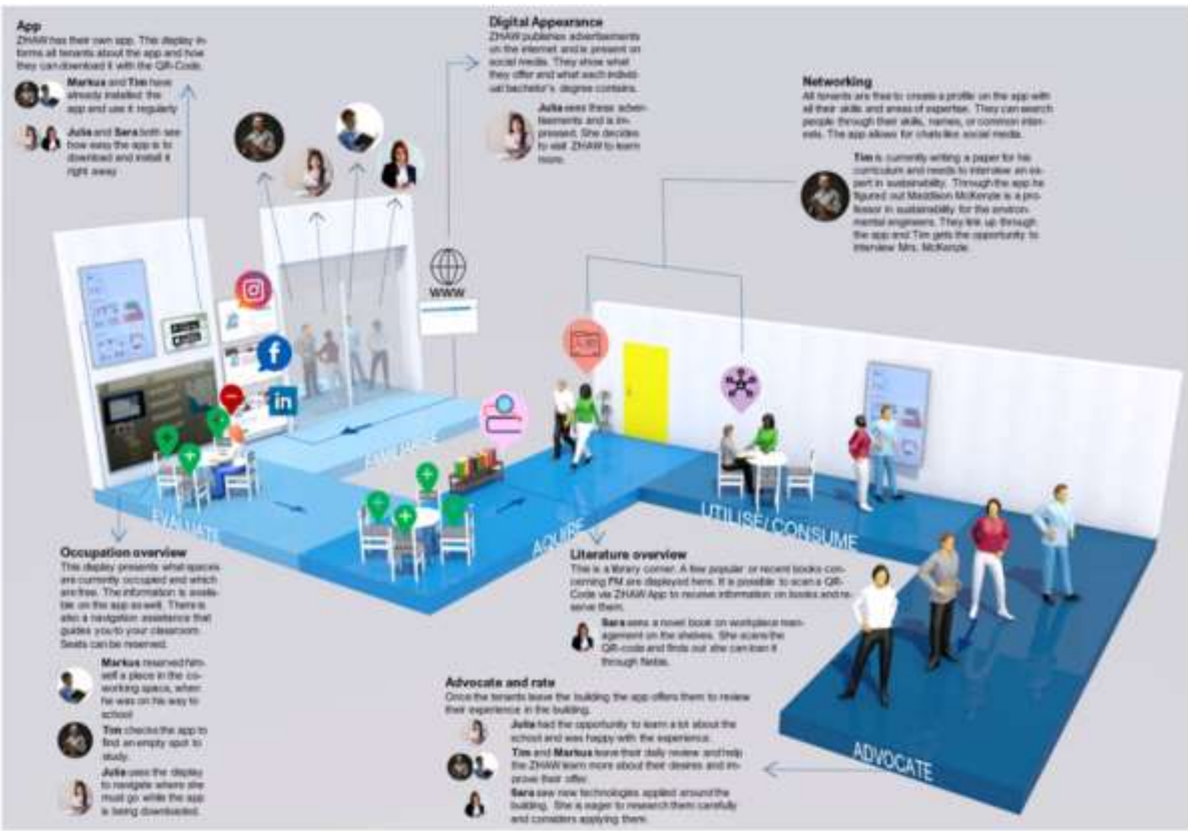


Figure 4.20: Typical digital experience journey map (Sema-Der, 2020)

4.8 The need for organisations to develop digital strategies

The trends discussed have led to organisations thinking about digitalising their RE portfolios. As smart buildings and cheap sensors become the norm, the ability to report on the state of all systems within buildings will offer a significant step-change in how buildings and RE can be optimised. This will revolutionise the way we operate our RE empowering more efficient working, allocation of space, and pre-emptive maintenance which will avoid breakdowns and prolonging equipment life. Saxon, Robinson and Winfield (2018, p. 32) noted the next step will be the addition of AI which, when "added to the analytics in the smart system, the building becomes 'cognitive', able to learn, co-operate with occupants and largely automate building operation".

Having a well-developed digital strategy for BA with access to data (live and static) will enable FMs to better optimise their operation. This was reflected by Deloitte who noted "greater data sharing could release an additional £7bn per year of benefits across the UK infrastructure sectors" (Deloitte, 2017). However, Bauer, Patel and Veira (2014) and Yeates (2015) noted that what will determine the ROI, and added value for RE, is the ability to integrate the data from IoT devices and extract information needed. The WEF suggest organisations "need to prepare strategically to thrive in the face of anticipated disruptions to their businesses" (WEF, 2018, p. 19). They recommend "actions should also include embracing digitalization to foster rigorous use of data and digital models, as well as adopting other advanced technologies at scale" (ibid). Figure 4.21 from the WEF illustrates their recommended generic model with process steps to help organisations.

Figure 4.21: Key steps on a digitalisation journey (WEF, 2018)

However, Simpson and Carlton (2019) suggested the digital transformation of the built environment will be a significant undertaking, and organisations need time to develop an approach that is right for them within the limits of technology and their budget planning. Mott MacDonald (2018) reported most owners have multiple, piecemeal RE strategies across different parts of the business that include digital elements (such as BIM, information systems and data strategies.

Meyrath (2018, p. 2) noted significant benefits of the IoT to FM: "greater visibility into the equipment and maintenance ecosystem eliminates inefficient processes, driving more informed repair and replace decisions with a desired impact on the bottom line". Other benefits include; "self-monitoring assets facilitate pre-emptive maintenance, with everything from heating, ventilation and air conditioning (HVAC) equipment to lighting, as well as food and beverage dispensers reporting on their respective needs" (ibid). Figure 4.22 illustrates some of the benefits to different stakeholders (Siemens, 2018).

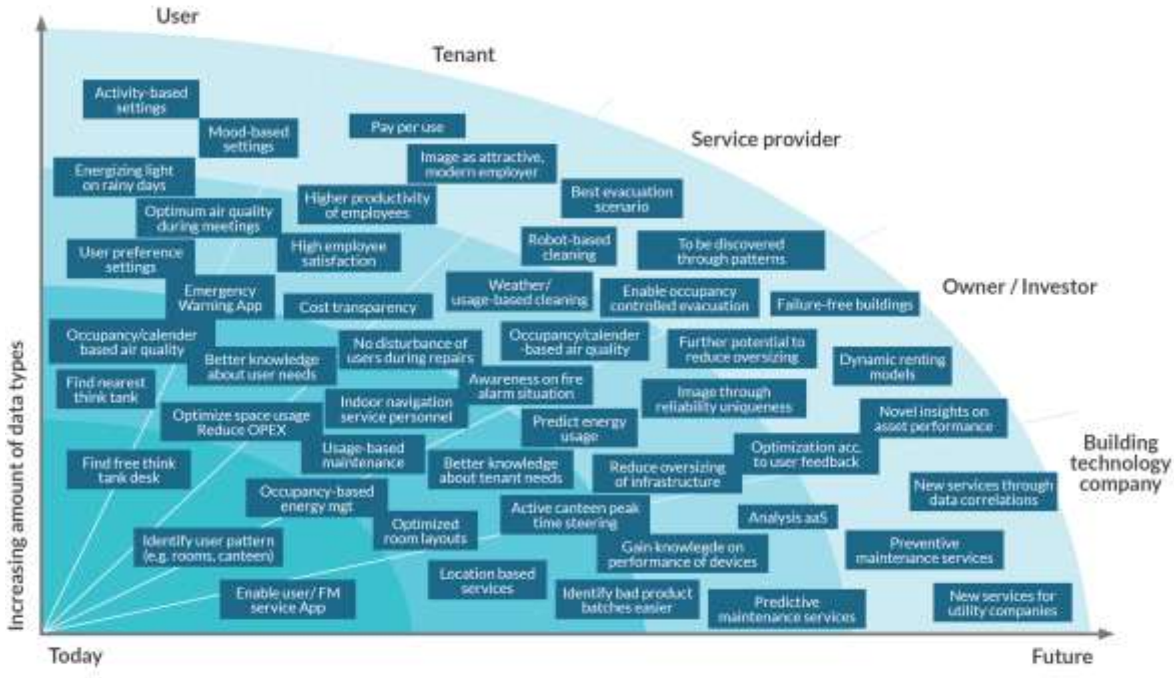


Figure 4.22: Digital twins driving opportunities for stakeholders (Siemens, 2018)

However, with this increased digitalisation FMs and owners are facing new challenges. Their BA are becoming more "IT-like in the sense of being instrumented, intelligent and interconnected and this convergence of physical and digital infrastructures makes their management increasingly complex" (IBM, 2017, p. 3).

As Støre-Valen (2019, p. 1) recognised, a major challenge "is to approach the existing building stock that does not have 'digital twin' representation". The importance of the existing BA is made apparent in Figure 4.23 which illustrates 'in development' BA (new builds) represent a very small percentage against those already 'in use' (IPA, 2017).

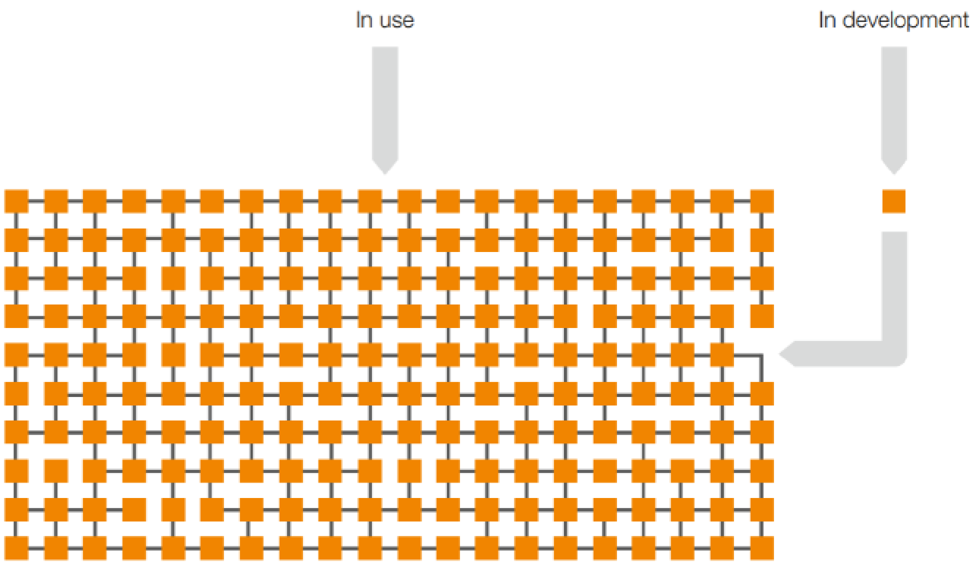


Figure 4.23: Infrastructure in use and development (IPA, 2017)

It is not possible in this chapter to cover all the methods of digitalising existing BA, but Stojanovic et al. (2018, p. 270) noted "current approaches for capturing the built environment using remote sensing and photogrammetry-based methods allow for the creation of 3D point clouds that can be used as basis data for a digital twin". GRESB (2020) suggested the following steps for organisations considering the digitalisation of the RE (Table 4.7).

Table 4.7: Suggested steps to digitalise a RE portfolio (GRESB, 2020)

Steps	Actions to follow in digitalisation process for RE
1	**Take stock of existing data and missing data:** according to the organisation's RE strategy . This will allow people to identify the available data sources and determine how to find the missing ones (e.g.: retrieve missing consumption data directly from supplier's user account).
2	**Aggregate and harmonize all data:** in a single solution to facilitate access to information and save time in their exploitation.
3	**Make data reliable:** by assessing its quality based on its source and making sure the organisation has complete data before using it.
4	**Cross-reference and analyse your existing data:** using appropriate tools to meet your objectives: setting up an energy management approach, regulatory compliance, ESG reporting, responding to a request from your Property Manager, taking voluntary initiatives to enhance the extra-financial performance of your assets, etc.

Parrott and Warshaw (2017, p. 7) argued that the focus needs to be "on the kinds of information that will be required across the life-cycle of the asset under consideration". This is where BIM will come to the fore.

4.9 Core capabilities required for the next decade

Work for the cdbb, carried out by Turner Harris, provides a 10-year horizon on core outcomes that will "support the UK's overarching vision for high-performing, value-adding infrastructure" (Harris, 2019, p. 19). A visualisation of these ideas is presented in Figure 4.24.

ASSET INTRODUCTION & FINANCE

- Projects are conceived and delivered with the full lifecycle in mind, using digital (BIM) methods;
- Digitalised collaboration on a single platform from conception / funding / design through to delivery is commonplace;
- Investment cases are predicated on lifetime value, driven by digital simulations of Return on Investment as standard
- Industries share data and knowledge readily and through known, transparent channels;
- There is mainstream use of big data analytics, AI and machine vision in making investment decisions and protecting assets.

ENGINEER, PROCURE AND CONSTRUCT

- The owner procures the physical and digital item at the same time, under the same contract;
- 'subscription'-style supply and maintenance of physical and digital assets is commonplace, and a recognised procurement/supply model;
- The procuring entity has full confidence that their functional and information specification will be met by the contractor, and legal protections to support them;
- The progress of construction is updated in real-time (smart sensors, drones, wearables);
- Rework is dramatically reduced due to clearer communication and availability of design intent.

OPERATIONS & MAINTENANCE

- Maintenance costs and workforces are reduced through workforce efficiency and automation (e.g. predictive maintenance, automated procurement through ERP, critical spares management)
- Asset management is a core business function and funding/resourcing is driven by the Return on Investment model for the asset.
- The Owner/Operator entity has clarity on lifecycle costs (5D/6D forecasting, subscription-based procurement etc.)
- Maintenance is data-led. Maintenance is also done 'on' data assets as well as physical assets.
- Digital tech is reducing hazard and human risk on sites (e.g. wearables, Immersive Augmented Reality, BMS) – human communication is flawed. Improved by this.
- The digital asset supports decision making for decommissioning and/or life extension.

DEMOLITION AND DECOMMISSIONING

- The cost of this stage is known and has been known since the construction of the asset.
- Identification of hazardous and valuable materials and waste streams are known.
- There is a clear technology solution for long-term record management for data/digital models and associated information sources after the demolition of the asset.
- The cost/value of demolition equation is materially different from 10 years ago. Old facilities could be valuable assets, with salvage values known in advance due to the persistence of material information trough-life.
- The owner/operator or demolition contractor meets its regulatory obligations for site remediation at significantly lower cost through use of the digital twin.

CROSS CUTTING THEMES

- Organisations have cyber-shielded data repositories for built assets and use them to reduce the cost, risk and uncertainty of asset ownership.
- There is an informed regulatory landscape that understands the role and benefit of the digital asset and discharges their duties with this in mind. (mandates where appropriate for aspects of digital asset adoption – research theme!)
- Agreed digital asset metrics are defined and data accessibility is fluid. And the organisation understands the value.

Figure 4.24: Vision for 2030 – how the industry will look (Harris, 2019)

4.10 Chapter summary

The literature highlighted how the AEC and FM industries are facing unprecedented disruption brought about by the digital revolution. However, it also underlined the fact that construction is one of the industries that will benefit the most, Mitchell (2018). It also exposed current gaps in many organisations (and professionals) understanding of how they can bring together new technology trends, and adapt their processes, to better support people in new innovative and collaborative ways. The importance and tremendous potential of digitalisation to deliver advantages in many areas of our lives was underscored during the developing COVID-19 crisis. It has given us all a glimpse into a future world, one in which digital has become central to every interaction, forcing organisations and individuals further up the adoption curve almost overnight (Blackburn et al., 2020). Of all the technological trends BIM has been highlighted as the one which will change “the way buildings are designed, constructed, operated, and maintained” (Spence, 2019, p. para 4). It offers us new hope to overcome many of the issues which have plagued the industry to deliver BA which can be optimised over their whole-life. BIM is considered in depth in the next chapter.

Chapter 5: The evolution and advantages of building information modelling

The purpose of this chapter was to address research objective (a) to assess the state of the art and identify CST important to delivering successful outcomes when using the BIM process. Specifically it discusses how BIM has evolved for both new-build and existing buildings and its significant potential to deliver a wide range of benefits to many stakeholders and especially clients and FMs. It explores the importance of both general and openBIM standards and the need for well-defined information requirements at the start of the BIM process.

5.1 Building information modelling: what it is and is not

BIM is "one of the greatest technological innovations in the construction industry" (Liu et al., 2015, p. 157). The RICS describe it as "central to the digital transformation of the industry" (RICS, 2015, p. 1) and argued it changes "processes and culture, enabling better collaboration and ultimately an integrated construction and asset management modus operandi" (ibid). The BIM revolution has enabled the construction industry to stay current, providing added value to stakeholders and increasing productivity suggested Noor et al. (2018).

According to Saxon, Robinson and Winfield (2018, p. 7) the most mentioned question from clients in surveys of the industry is: "What is BIM?" Khemlani (2014) argued BIM is not new and Cherkaoui (2017) suggested the term 'Building Modelling' was first used in papers in 1986 by Aish (1986) and Ruffle (1986).

The origin of BIM (Sacks et al., 2018, p. 32) can be traced back to "object based parametric modelling developed in the 1970s and 1980s for manufacturing". BIM entered into common use at "end of the last century" (Jackson, 2018, p. 7). Table 5.1 based on work by Nisbet and Dinesen (2010) outlined a timeline of BIM development between 1970-2009.

Table 5.1: Development of BIM (1970-2009) - Nisbet and Dinesen (2010)

Year	Key events
1970	Concept of BIM starts to emerge.
1976	Scottish Special Housing Association saves 4% of construction costs using fully automated design, detailing and tendering.
1977	Oxford Regional Health Authority deploys comprehensive BIM to accelerate hospital design using OXSYS.
1981	GMW uses RUCAPS to design the largest university building in the world.
1983	1983 Royal Bank of Scotland, Islington is the first project to be modelled in 2D and in 3D and as thermal model and shown to client as animated walkthrough – all from one model.
1987	ArchiCAD from Graphisoft (now owned by Nemetschek) able to create both 2D and 3D drawings on a PC.
1992	Autodesk releases AutoCAD 12 for DOS.
1995	US chapter of BuildingSMART founded (as Industry Alliance for Interoperability).
1996	UK chapter formed.
1997	First version of IFC standard released and Bentley releases its first BIM application to run on MicroStation.
2002	Autodesk acquires Revit Technology Corporation and changes its basic platform, Singapore launches CORENET e-submission – a collaborative digital tool for planning application.
2003	IFC2x2 released General Services Administration (GSA) sets up its National 3D-4D-BIM program.
2005	IFC becomes ISO PAS 16739 (publicly available specification).
2006	Bentley's MicroStation V8i BIM application released.
2007	In Finland and Denmark BIM use required for public-sector projects; in the US, the GSA also mandates BIM use.
2008	Revit 2009 released and Bridge Academy, Hackney: new £50 million 7-storey school building opens – the project made targeted use of BIM. Heathrow Terminal 5 opens, having achieved unprecedented savings through structured information sharing. Akershus Hospital opens in Norway BIM was a vital tool throughout the project.
2009	48% of the US industry using BIM (McGraw-Hill survey).

The pace of change has been impressive during the five years of this PhD. In the first year of research many people described BIM as a passing trend. Now it is seen as a "necessity for modern construction projects" (Ashworth, Druhmann and Streeter, 2019, p. 2).

However, defining BIM is not so easy. Aziz, Nawawi and Ariff (2016, p. 355) observed many scholars have a "different view and perspective of life-cycle". This aligns with many BIM practitioners who express confusion about 'what BIM is, and what it is not'. Table 5.2 illustrates some examples showing the challenge of clearly defining BIM.

Table 5.2: Possible definitions of BIM (various 2006-2020)

Source	**Suggested definition of BIM**
Lee et al, (2006, p758)	"the 'process' of generating and managing building information in an interoperable and reusable way".
Sabol, (2008, p13)	"representation of a building as an integrated database of coordinated, internally consistent, and computable information in design and construction".
Arayici & Aouad, (2010, p. 3)	"the use of ICT technologies to streamline the building lifecycle processes to provide a safer and more productive environment for its occupants, to assert the least possible environmental impact from its existence, and to be more operationally efficient for its owners throughout the building lifecycle".
Azhar, (2011, 242)	"a virtual process that encompasses all aspects, disciplines, and systems of a facility within a single, virtual model, allowing all design team members (owners, architects, engineers, contractors, subcontractors, and suppliers) to collaborate more accurately and efficiently than using traditional processes".
Teicholz et al, (2013, 17)	"describe the three-dimensional geometry, objects, and attributes of a physical facility. The core of BIM is building geometry, but BIM is also a structured information base of nongraphic data that provides detailed information about the building components"
Golabchi et al, (2013, p187)	"BIM is a value creating processes that involves the generation, management and exchange of knowledge of a facility forming a reliable basis for decision making throughout its life cycle from the conceptual, design and construction phases through its operational life and subsequent closure".
NBS, (2016)	"a process for creating and managing information on a construction project across the project lifecycle. One of the key outputs of this process is the Building Information Model, the digital description of every aspect of the built asset".
EU BIM Task Group, (2017, p. 4).	"a digital form of construction and asset operations. It brings together technology, process improvements and digital information to radically improve client and project outcomes and asset operations".
Eastman et al, (2011, xxi)	"a socio-technical system that ultimately involves broad process changes in design, construction and facility management"
Jackson, (2018, p. 7)	observes BIM models are often perceived as a 3D representation of a built asset. The model can be defined as "a digital representation of physical characteristics and functional characteristics of a facility or asset".
BIM Dictionary, (2019)	"a set of technologies, processes and policies enabling multiple stakeholders to collaboratively design, construct and operate a Facility in virtual space. As a term, BIM has grown tremendously over the years and is now the 'current expression of digital innovation' across the construction industry".
ISO, (2019, p5)	"use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions" **Note**: Built assets include, but are not limited to, buildings, bridges, roads, process plants.
Autodesk, (2020)	"a process that begins with the creation of an intelligent 3D model and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance)".

Butt, Francis and Greenwood (2015, p. 560) suggested "in the life-cycle context BIM can be defined as a digital representation of physical and functional characteristics of a facility and a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle – spanning from earliest conception to demolition". This view of BIM applying across the whole-life-cycle has led to many versions of the graphic shown in Figure 5.1 (Petri et al., 2020). This illustrates the impact of BIM across every stage of a BA's life-cycle.

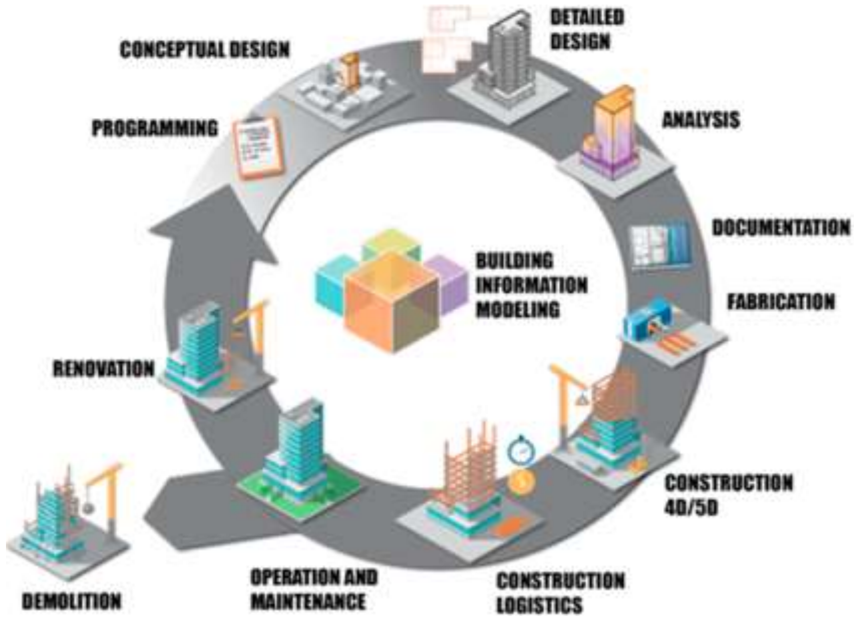


Figure 5.1: BIM across the whole-life-cycle (Petri et al., 2020)

From the various definitions common themes emerge; e.g. process, information, 3D representation etc. However, many people find it difficult to relate the wide range of definitions as to what BIM actually is. Further confusion has arisen regarding the acronym BIM itself. Some see it as a verb: '*building information modelling*'; some, as a noun, '*building information model*'; and others as a process, '*building information management*'. This aligns with views from Azhar (2011): noted that BIM is a combination of software and process; and Jackson (2018) who observed that information is critical to BIM. Baldwin (2019, p. 6) noted, "BIM will make project data computer-readable and openly exchangeable". This brings us to the important topic of standardisation which provides a common framework of reference for the BIM process and its terminology.

5.2 Building information modelling standards and guidance

As discussed in Chapter 2 the UK Government's 2011 '*Construction Strategy'* (Cabinet Office, 2011, p. 14) mandated "fully collaborative 3-D BIM (with all project and asset information, documentation, and data being electronic) as a minimum by 2016". Berstein (2019) argued that, rapid transformation throughout the industry, has been facilitated by the Government's drive and support for BIM standardisation. Whilst the NBS (2019a) reported "BIM adoption shot up from 10% in 2011 to around 70% by 2019" and BIM+ (2019) reported the BIM approach has helped "users save up to 22% in construction costs". The UK is seen as world leading with its BIM standards but there has been recognition that there was a need to move towards international standards (Shillcock, 2019).

Jøns Sjøgren, chair of the ISO technical subcommittee that developed the new '*ISO 19650'* BIM standards, stated the "tried-and-tested British standard '*BS 1192'* and publicly available specification *'PAS 1192-2'* have been used as the basis to develop the latest international standards" (BIM+, 2019). The new '*ISO 19650'* standards are now "part of a landscape, or ecosystem, of national and international standards supporting information management processes and technical solutions" (UK BIM Framework, 2020, p. 6). Figure 5.2 (BSI, 2020), illustrates the transition which took place during the PhD, sometimes making it a challenge to stay abreast of all the changes. It shows the developments from the early '*BS 1192:2007'* up until the first two '*ISO19650'* standards and '*Transition guidance to BS EN ISO 19650'*.

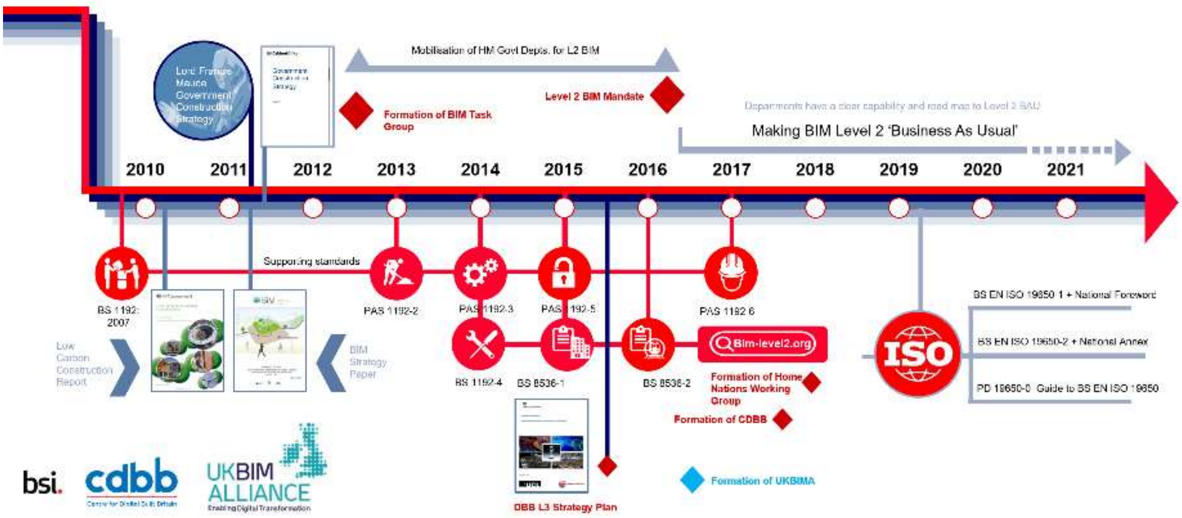


Figure 5.2: Timeline of BIM standards and guidance (BSI, 2020)

The new standards have been important to reduce confusion and empower common understanding and communication in BIM projects, particularly where different countries are involved. The new series general name is: '*ISO 19650, organization and digitisation of information about buildings and civil engineering works, including building information modelling – Information management using building information modelling'.* The first two parts were published in 2018:

- *'**ISO 19650–1:** Concepts and principles'* (ISO, 2018b)
- *'**ISO 19650-2:** Delivery phase of assets'* (ISO, 2018d)

Further change was on the way as the cdbb (2018) reported the next two standards in the series which were subsequently published in 2020. They replaced '*PAS 1192-3'* (BSI, 2014a) focused on the 'operational phase' and *'PAS 1192-5'* (BSI, 2015) on 'security' respectively:

- ***'ISO 19650-3**: Operational phase of assets'*
- ***'ISO 19650-5**: Specification for security-minded building information modelling, digital built environments and smart asset management'.*

A further part is planned for delivery in 2021:

- ***'ISO 19650-4**: Information exchange'*

The way practitioners access standards has changed significantly. The two main government BIM websites that were used over the last few years; the 'UK BIM Task Group' and 'BIM-Level2' have now been replaced with the UK BIM Framework website. This is now the main UK reference with links to the BIM standards and guidance (UK BIM Framework, 2020).

The process of transitioning from PAS to ISO is explained in several videos available on the UK BIM Framework website. In one Dr Kemp, Chair of the UK BIM Alliance, noted the new standards are effective at ISO and CEN levels, meaning all national standard bodies across Europe must now withdraw equivalent local standards and use the new '*ISO-19650'* suite (Kemp, 2019). The resulting transition means that '*BS 1192:2007* and '*PAS 1192-2'* were withdrawn in 2018 and '*PAS 1192-3'* and '*PAS 119252'* in 2020.

The full list of BIM standards forming the UK BIM Framework are shown in Table 5.3

Table 5.3: List of key BIM standards (UK BIM Framework, 2020)

Title	Key aim of standard or guidance document
'ISO 19650-1:2018'	Outlines the concepts and principles for information management at a stage of maturity described as BIM according to the ISO 19650 series. It provides recommendations for a framework to manage information including exchanging, recording, versioning and organizing for all actors. **Note:** this document replaced the UK 'BS 1192'.
'ISO 19650-2:2018'	To enable an appointing party to establish their requirements for information during the delivery phase of assets and to provide the right commercial and collaborative environment within which (multiple) appointed parties can produce information in an effective and efficient manner. **Note:** this document replaced the UK 'PAS 1192-2'.
'PD 19650-0: 2019'	Transition guidance to BS EN ISO 19650.
'ISO 19650-3:2020'	To enable an appointing party (such as an asset owner, asset operator or outsourced asset management provider) to establish their requirements for information during the operational phase of an asset. **Note:** this document replaced the UK 'PAS 1192-3'.
'ISO 19650-5:2020'	Provides a framework to assist organizations in understanding the key vulnerability issues and the nature of the controls required to manage the resultant security risks to a level that is tolerable to the relevant parties
'BS 1192-4:2014'	Addresses COBie which is an internationally agreed information exchange schema for exchanging facility information. It is the UK government's chosen schema for information exchange. Its spreadsheet format can be used to exchange the alphanumeric information between BIM and other FM systems. COBie ensures that information can be prepared and used without the need for knowledge of sending and receiving applications or databases. The information exchange can be reviewed and validated for compliance, continuity and completeness. **Note:** COBie does not address geometrical information.
'BS 8536-1:2015'	Aims to include the operations team and their supply chain in the design process. It also aims to extend the involvement of the supply chain for the project's delivery through to operations and defined periods of aftercare. It gives recommendations for briefing design and construction teams to ensure that designers consider the expected performance of a building in use. The standard applies to all new building projects and major refurbishments. It also includes briefing requirements for 'Soft Landings', BIM and Post Occupancy Evaluation (POE).
'BS 8536-2:2016'	Gives recommendations for briefing design and construction teams in relation to energy, telecommunication, transport, water and other utilities' infrastructure. It aims to ensure that design considers the expected performance of the asset in use over its planned operational life. It is applicable to the provision of documentation supporting this purpose during design, construction, testing and commissioning, handover, start-up of operations and defined periods of aftercare. It incorporates the principles of briefing associated with BIM Level 2 and government 'Soft Landings'.

The UK BIM Framework's website hosts guidance to help people working on BIM projects. The current guidance at December 2020 is shown in Table 5.4 (ibid).

Table 5.4: BIM guidance documents (UK BIM Framework, 2020)

Title	Key aim of standard or guidance document
Guidance Part 1: Concepts'	This guidance has been written to help individuals and organisations in the UK to understand the fundamental principles of building information modelling (BIM) according to BS EN ISO 19650 Parts 1 and 2.
'Guidance Part 2: Parties, teams and processes for the delivery phase of the assets	Supports the implementation of ISO 19650-2 and is relevant to any organization involved in the delivery phase of an asset.
Guidance Part 3: Operational phase of the asset life cycle'	Supports the implementation of BS EN ISO 19650-3, which sets out the information management process for the operational phase of the asset life-cycle. It is important that guidance part 2 is read in conjunction with guidance parts A-F.
'Information protocol to support BS EN ISO 19650-2 the delivery phase of assets'	This Information Protocol Template provides an example of what could be included in an Information Protocol to be used when conforming to BS EN ISO 19650-2:2018 for projects and their appointments to which English law applies
'PD 19650-0:2019 Transition Guidance to BS EN ISO 19650'	This transition guidance has been prepared specifically to help the existing users of BS 1192 and PAS 1192-2 understand any changes made between the UK's existing standards, and the ISO documents which are to replace them.
'Part A The information management function and resources'	Considers the information management function and resources needed for successful information management. It is relevant to parties, teams and individuals involved in implementing the ISO 19650 series across a project, within an appointment or within an organization.
'Guidance Part B: Open data, buildingSMART and COBie'	For people undertaking the information management function on behalf of an appointing party (a client) or a lead appointed party (for example, a project manager, designer or a main contractor).
'Guidance Part C: Facilitating the common data environment (workflow and technical solutions)'	For the appointing party, the lead appointed party and each of the appointed parties involved in the common data environment (CDE) in terms of workflow and technical solutions.
'Guidance Part D: Developing information requirements'	To help parties throughout the asset delivery lifecycle who seek to produce reliable information requirements that meet defined purposes and enable effective delivery of information across project lifecycle.
'Guidance Part E: Tendering and appointments'	For the appointing party, the lead appointed party and each of the appointed parties to establish the delivery teams' BIM execution plan (BEP) in accordance with the information management approach.
'Guidance Part F: About information delivery planning'	For the parties overseeing information delivery planning activities in terms of responsibility matrices and master and task information delivery plans (federation strategy and information container breakdown structure will follow in future guidance)
'Government Soft Landings' Revised guidance for the public sector on applying BS8536 parts 1 and 2: Updated for ISO 19650	This guidance explains how the adoption of GSL can be aided if design and construction projects work in accordance with BS EN ISO 19650-1: 2018 and BS EN ISO 19650-2: 2018.
'UK BIM Framework Learning Outcomes'	Identifies desired learning outcomes of introductory training in information management using building information modelling (BIM).

From a practitioner perspective Ford (2019) noted people "don't need to panic about the introduction of the new international BIM standards". He adds: they are "practically identical to those defined in BS 1192:2007 and PAS 1192-2:2013" (ibid) and "the process is the same, and if you already have good compliance with the 1192 suite, then believe it or not, you are good to go already" (ibid).

5.3 Using building information modelling to improve project collaboration

The increased use of BIM and digital software platforms, has in some ways, made construction projects more complex. However, the aim is to improve communication in an industry that has had a reputation of working in stovepipes. Such traditional approaches in the past led to poor collaborative working environments and in turn “unsatisfactory project performance in the important dimensions of; time, cost, safety and health and quality” (Rowlinson et al., 2017, p. 290).

The UK BIM Alliance (2019, p. 14) noted “success often boils down to the parties involved and how well they work together”. A critical factor influencing successful implementation is the collaboration social factor, which requires teamwork, communication and transparency stated Alaloul et al. (2020), Butt, Francis and Greenwood (2015) suggested BIM offers project teams a new opportunity to achieve a more collaborative way of working.

BIM projects involve a wide range of ‘actors’. However, most are the same stakeholders who have been involved for many years in designing and delivering BA as shown in Figure 5.3 by Butt, Francis and Greenwood (2015).

Figure 5.3: BIM project stakeholders - Butt, Francis and Greenwood (2015)

However, there are some new exceptions. One is the ‘information manager’ role which is central in BIM projects. Clause 5.1.1 of ‘*ISO 19650-2’* (ISO, 2018d, p. 3) suggests that “an information manager role is set up on the side of the client” (the appointing party) and clause 5.3.1 recommends the same for the ‘appointed party’ (ibid, p9).

Importantly, “collaboration and effective team working are at the heart of the ISO 19650 series” (UK BIM Alliance, 2019, p. 14). The standards require all parties involved to “collaborate to agree key roles and responsibilities and to agree an information delivery plan” (ibid, p21). The standards define the key roles in a BIM project using the terms ‘appointing party’ and ‘appointed party’ to reflect contractual relationships as well as types of team delivering work/information. These are summarised in Table 5.5.

Table 5.5: Types of actors/teams in a BIM project (UK BIM Alliance, 2019)

Types of actor			Types of team		
1	Appointing party	The organisation leading the project or asset management. For a project this is typically the client, who may also be the asset owner.	1	Project team	Everyone involved in the project, regardless of appointment/contract arrangement
2	Lead appointed party	The party who is accountable for coordinating information exchange between task teams or between a delivery team and the appointing party.	2	Delivery team	A lead appointed party and their associated task teams. E.g. a contractor and its subcontractors and suppliers.
3	Appointed party	Anyone generating information about the project, e.g. a contractor, subcontractor, supplier, consultant.	3	Task team	A person or group of people performing specific task. E.g. the architecture team or the subcontractor who is designing/constructing curtain walling.

To help improve collaboration '*ISO 19650-2'* clarifies the interfaces between parties and teams for the purpose of information management. Figure 5.4 illustrates these relationships (ISO, 2018d, p. ix).

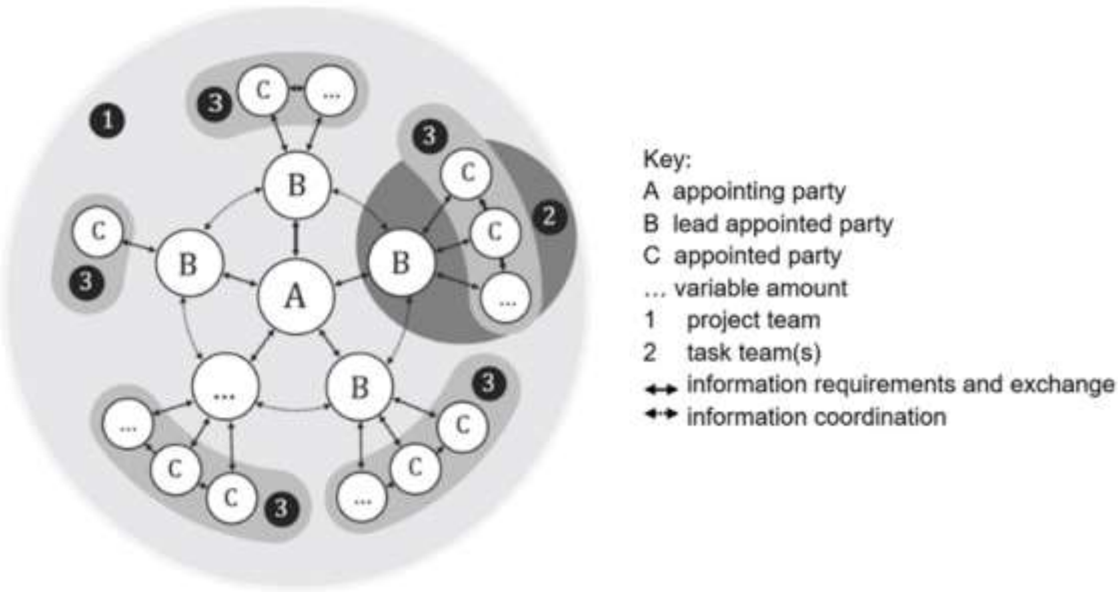


Figure 5.4: Interfaces between parties in a BIM project (ISO, 2018d, p. ix)

A real-life example of how these relationships might look on a typical project is illustrated in Figure 5.5 (Hooper, 2019).

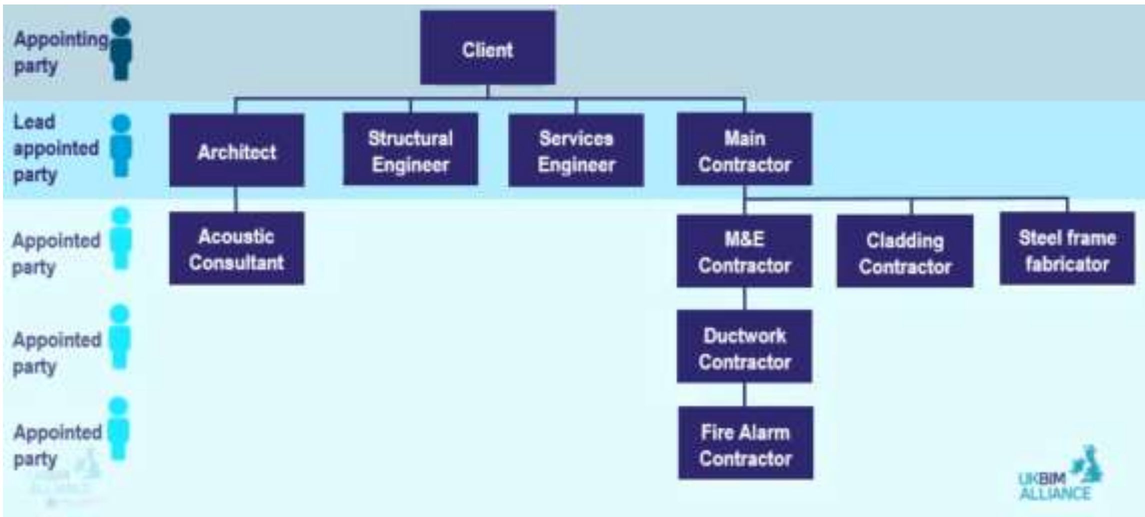


Figure 5.5: Functional relationships for information deliverables (Hooper, 2019)

Another very important aspect of standardisation is the use of a 'classification system'. ISO's '*International Classification Standard'* (ICS) (ISO, 2015) can be used for producing classification systems. '*ISO 12006-2:2015'* (ISO, 2015b) specifically "defines a framework for the development of built environment classification systems". There are many classification systems across different countries and the Government's nominated classification system is '*Uniclass 2015'.* The National Building Specification (NBS) described it as "a way of identifying and managing the vast amount of information that's involved in a project, and it's a requirement for BIM projects, as set by the ISO 19650 series of standards" (NBS, 2020a, p. para 2). Additional guidance about Uniclass is available at the Construction Project Information Committee (CPIC) website.

5.4 The information management cycle

Conceptual models offer a good way to explain the BIM process to people who are not so familiar with it. Figure 5.6 taken from '*ISO 19650-1'* is useful to help illustrate the different levels of management and specific information requirements within organisations.

Figure 5.6: *'ISO 19650'* information management cycle (ISO, 2018b)

Good information management is key to the success of these higher-level management processes and individual projects. The outer orange band represents the highest level of 'organisational management', normally controlled using a quality management system e.g. *'ISO 9001*' (ISO, 2015a). The yellow band represents the organisation's AM strategy & project management approach, possibly using standards e.g. '*ISO 55000*' (ISO, 2018a) and '*ISO 21500*' (ISO, 2012) respectively. The blue band represents organisations using information management processes e.g. '*ISO 19650'* at the project level. The organisation needs to establish what information is needed to meet the requirements of the first two levels, enabling managers to control and report on assets/projects, as well as ensuring statutory compliance and meeting other management requirements e.g. CSR reporting.

The jigsaw pieces inside the blue band represent a project in the 'delivery' and 'operational' phases. The letter A indicates the start of a project where the organisation must consider any relevant existing information before the project starts. B represents the project in progress when the bulk of information needed for the operational phase is collected. C represents handover, where all relevant information should be transferred to the client and operations team for use in the 'operational phase'.

The model shown in Figure 5.7 was adapted from '*PAS 1192-2*' (BSI, 2014a, p. viii). It focuses on the project level and illustrates the 'BIM information life-cycle' (process) starting with the initiation of a CAPEX project. The project team should 'start with the end in mind'. The 'START' position (red box) requires the client to assess their current higher-level need for information as per the previous model i.e. "do we have an existing AM strategy' and 'what information is needed for the operational OPEX phase?'. This needs to be done both at the organisational and AM strategy levels (examples might include information needed for management reports, processes etc.). The organisation instructing the work (usually the client) acts as an 'appointing party' (ISO, 2018b) and must consider what 'performance' and 'project outcomes' are expected, as well as any existing information which should inform the start of the project. **Note:** The green and red circles underneath represent various 'exchanges of information' and 'decision points' during the project.

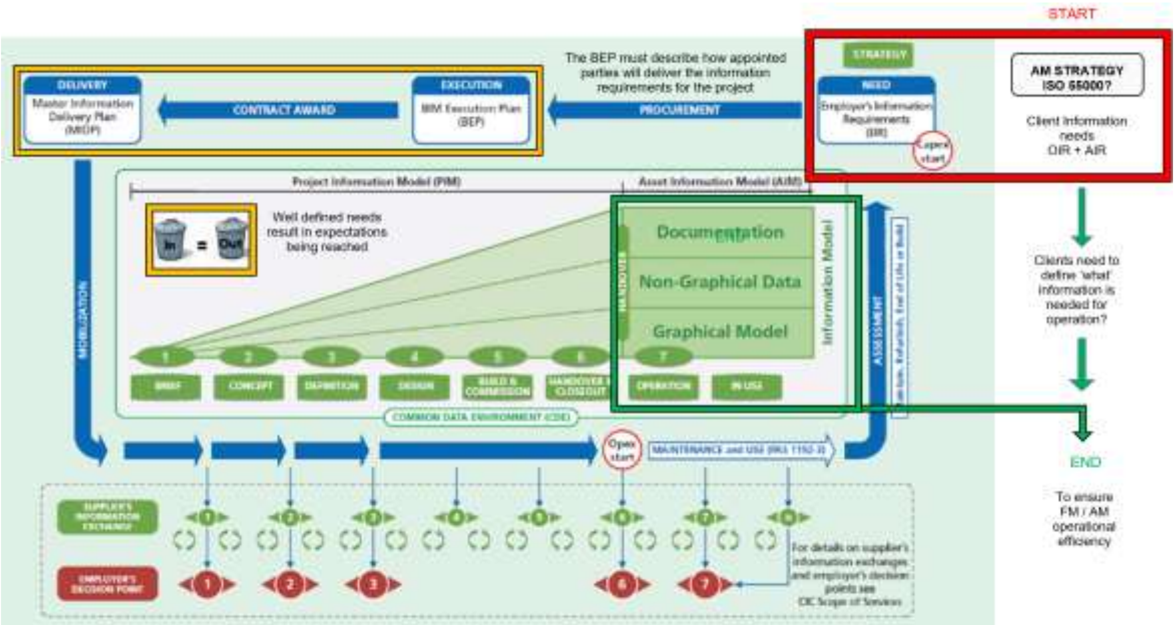


Figure 5.7: BIM information life-cycle (adapted from '*PAS 1192-2'* for teaching)

The start of defining the information requirements is represented by two key BIM client responsibilities: the OIR and AIR. Both of these should be in place at the start to inform the creation of the EIR which should be a very clear 'specification' of the client's overall information needs. All three should be updated, as required by the client or 'appointing party', for individual projects in order to procure their BIM project in a competent and informed way. The OIR/AIR/EIR must provide clear guidance, avoiding a 'garbage in = garbage out' scenario (Ashworth, 2018a). Clients may be disappointed at handover, if the required information, based on their organisation's management strategy, is not clearly specified.

Clarity helps each 'appointed party' (ISO, 2018b) know exactly what is expected of them (UK BIM Alliance, 2019). They must then respond with a pre-contract BIM Execution Plan (BEP) which describes how the project will be managed and how the information requirements will be delivered. All parties can then review the OIR/AIR/EIR and ensure they are realistic before the final contract BEP.

Once the contract is in place the 'appointed party' starts the project, following the standard RIBA 2020 PoW stages (RIBA, 2020), and develops the Project Information Model (PIM). At handover to the operation team this becomes the Asset Information Model (AIM) and includes three types of information as suggested by Ashworth, Druhmann and Streeter, Tenny (2019):

1. Documentation, e.g. PDF, Jpeg, Excel etc.
2. Non-graphical or alphanumeric data
3. 3D graphical models

The green area over the project stages 1-6 represent the growing quantity of information up to 'handover' (stage 6). In order for the project to be a success this information must be structured in such a way it is easily transferable without loss (and lots of manual effort) into client management systems e.g. CAFM, SAP etc. (ibid). The 'END' goal is to ensure FMs have all the information they need to manage and optimise the BA over their life.

The newer version (ISO, 2018b, p. 28) of the same concept from '*ISO 19650'* is shown in Figure 5.8.

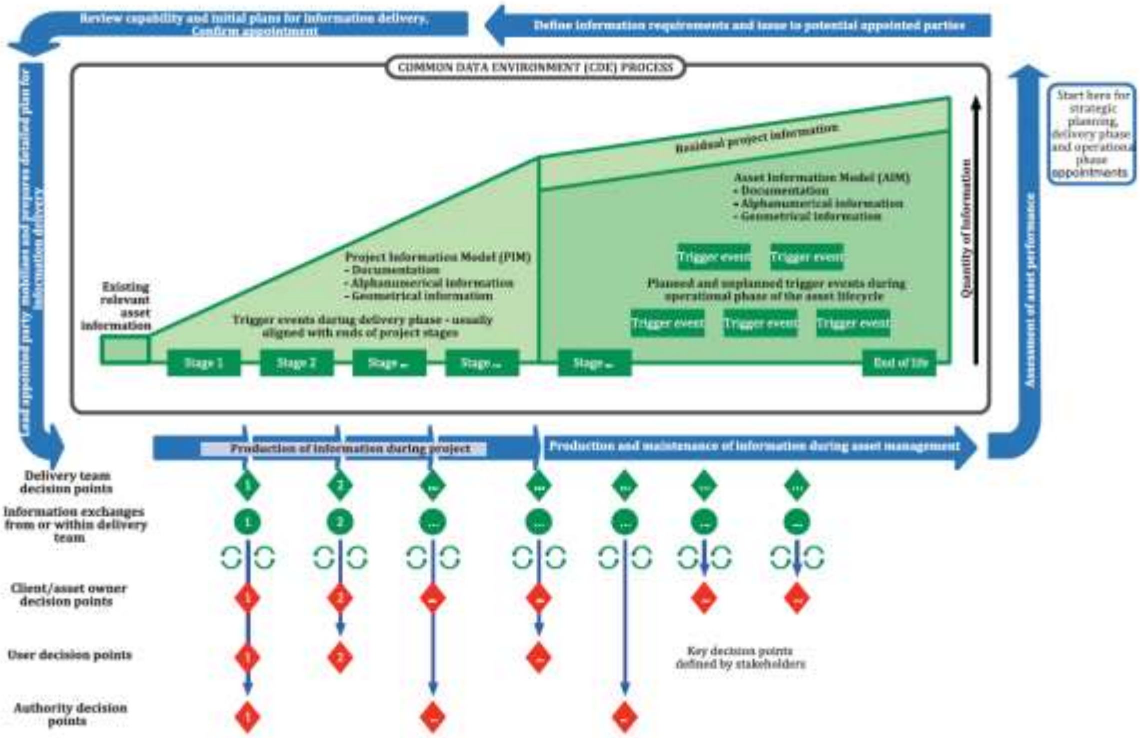


Figure 5.8: *'ISO 19650'* conceptual model of BIM (ISO, 2018b, p. 28)

This version can appear a bit generic (as it has to apply to many countries), and the 'start' lacks clarity around the need to define the client's needs (OIR, AIR and EIR). However, it does illustrate the need for a project 'Common Data Environment' (CDE) for the centralised collection, sharing, managing, dissemination, exchange and retrieval of information during the life-cycle (for this reason the CDE is sometimes referred to as 'the single source of truth').

The model also highlights that at handover there will be some 'residual information' not required by the day-to-day operations teams, but which may be very important in the future, e.g. where a potential renovation project is carried out. One of the key challenges is deciding how to identify which information will be needed on a day-to-day basis. Figure 5.9 taken from '*ISO 19650-2'* (ISO, 2018d, p. 3) illustrates the BIM process using a series of key linked activity steps 1 to 8, helping provide an overview of the activities involved in tendering and realising a BIM project.

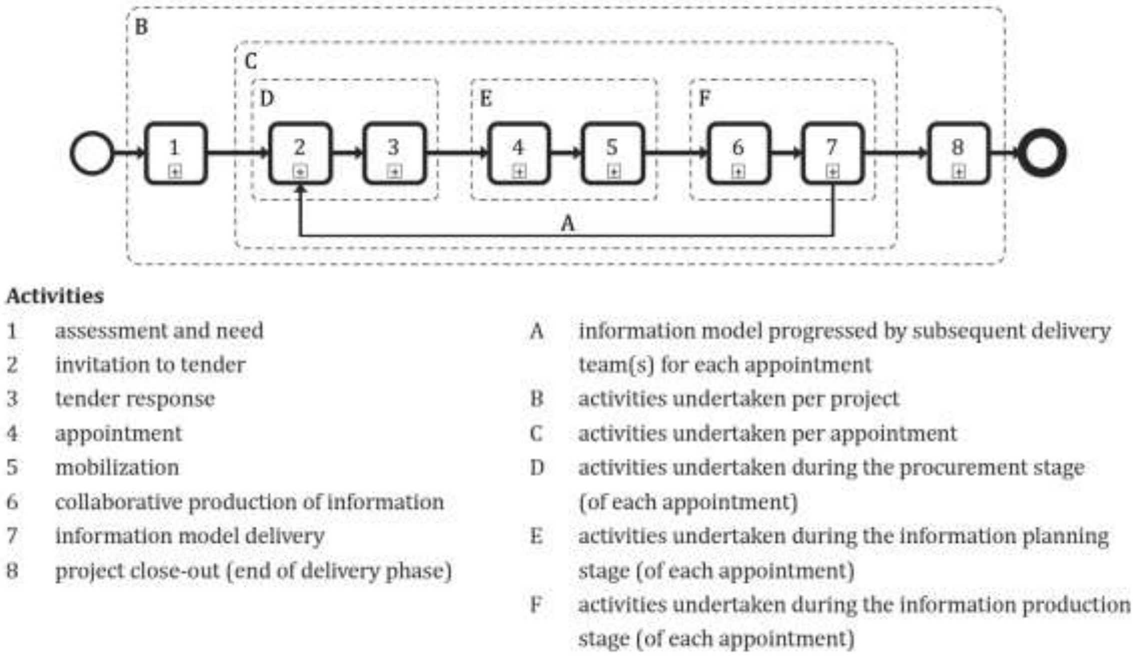


Figure 5.9: Information management process - delivery phase (ISO, 2018d)

A good place to start when trying to understand BIM are the '*ISO 19650'* standards and the suite of UK BIM Framework guidance documents.

These provide a good overview of the whole BIM process and how to implement BIM projects. It is important to understand that the '*ISO 19650'* series now use the terms 'resources' and 'content' needed for BIM projects, recognising that sometimes these may not be physical documents and could be integrated into other systems. Now "the emphasis is on the existence of content, not how the content is transported" (UK BIM Framework, 2020a, p. 24).

The concept model from the '*Guidance Part 2'* shown in Figure 5.10 (ibid, p27) gives an excellent and detailed overview of the BIM process. It also provides a detailed list of the resources needed for a BIM project (ibid, p25).

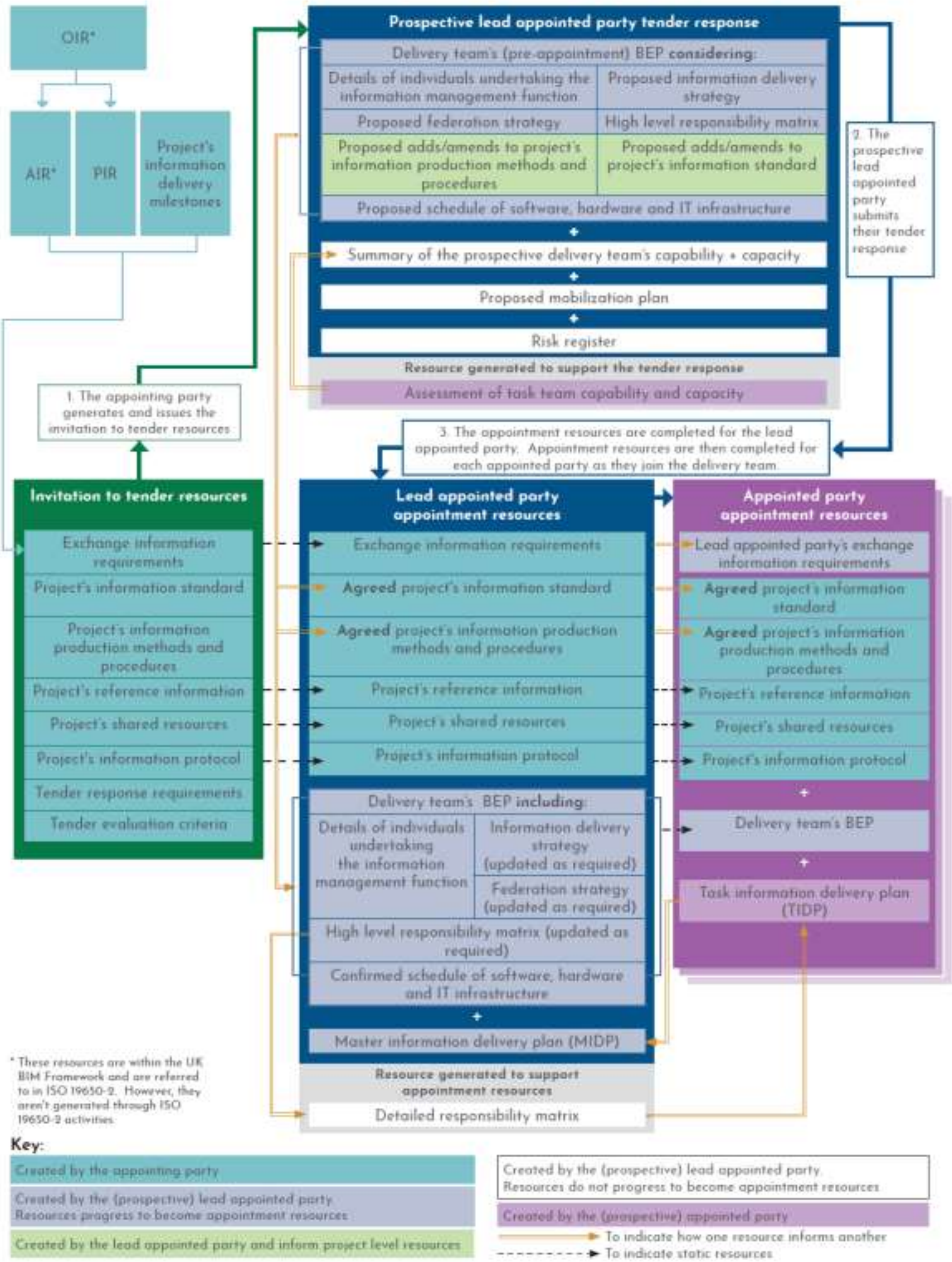


Figure 5.10: Overview of resources in a BIM project (UK BIM Framework, 2020a)

5.5 Building information modelling: maturity, levels and dimensions

The UK's approach to BIM has been seen as a model of excellence and influenced other governments around the world (EU BIM Task Group, 2017). Many have now mandated the use of BIM recognising its value as a strategic enabler for cost, quality and policy goals. BIM has become the modern design process approach used by professionals with respect to the planning, design and construction of new assets albeit with different progress rates of adoption across countries (Ashworth et al., 2016). Research on levels of BIM maturity in 21 countries was carried out by Kassem and Succar (2017) using eight 'macro components' to measure maturity. Their findings shown in Figure 5.11 clearly indicated the UK was in a leading position with respect to BIM.

	Objectives, Stages & Milestones	Champions & Drivers	Regulatory Framework	Noteworthy Publications	Learning & Education	Measurements & Benchmark	Standardised parts & Deliverables	Technology Infrastructure
Australia	13	20	20	20	20	13	33	45
China	58	43	43	43	50	43	58	43
Canada	25	25	0	0	0	0	25	38
Finland	40	50	30	30	40	5	40	50
Hong Kong	25	43	25	25	43	0	25	33
Malaysia	20	20	8	8	13	13	20	13
New Zealand	13	25	13	13	0	25	13	25
Brazil	8	25	18	18	8	0	25	43
Ireland	25	43	18	18	68	0	33	25
Italy	13	25	38	38	25	13	13	38
Mexico	25	43	25	25	25	18	18	50
Netherlands	25	50	50	50	38	13	25	50
Portugal	15	50	23	23	33	20	38	48
Qatar	20	20	20	20	10	10	25	40
Russia	25	25	0	0	0	13	13	38
Spain	33	45	25	25	33	25	33	43
Switzerland	0	25	0	0	25	0	0	75
UAE	18	25	18	18	25	0	8	33
UK	65	63	58	58	45	38	48	65
USA	20	40	35	35	30	15	25	60
South Korea	25	58	43	43	43	18	25	68

Figure 5.11: BIM maturity levels across 21 countries - Kassem and Succar (2017)

The report '*Building Information Modelling: Evaluating Tools for Maturity and Benefits Measurement'* (Kassem et al., 2020) includes a detailed analysis of tools currently in use in industry to measure maturity. This included measuring them against '*ISO 19650-2'*.

There is often confusion in practice with people using the terms 'levels of BIM' and 'dimensions of BIM'. This aligns with research by Dakhil and Underwood (2015, p. 229) who noted "the term BIM represents different things to different people". Most practitioners were familiar with the *'Bew/Richards BIM Maturity model'* (BSI, 2013) used in parts 2/3 of *'PAS 1192'* and shown in Figure 5.12; often referred to as the 'BIM Wedge'. Many people have found it useful for illustrating the progressive development in maturity of the use of BIM and the relationship to BIM standards.

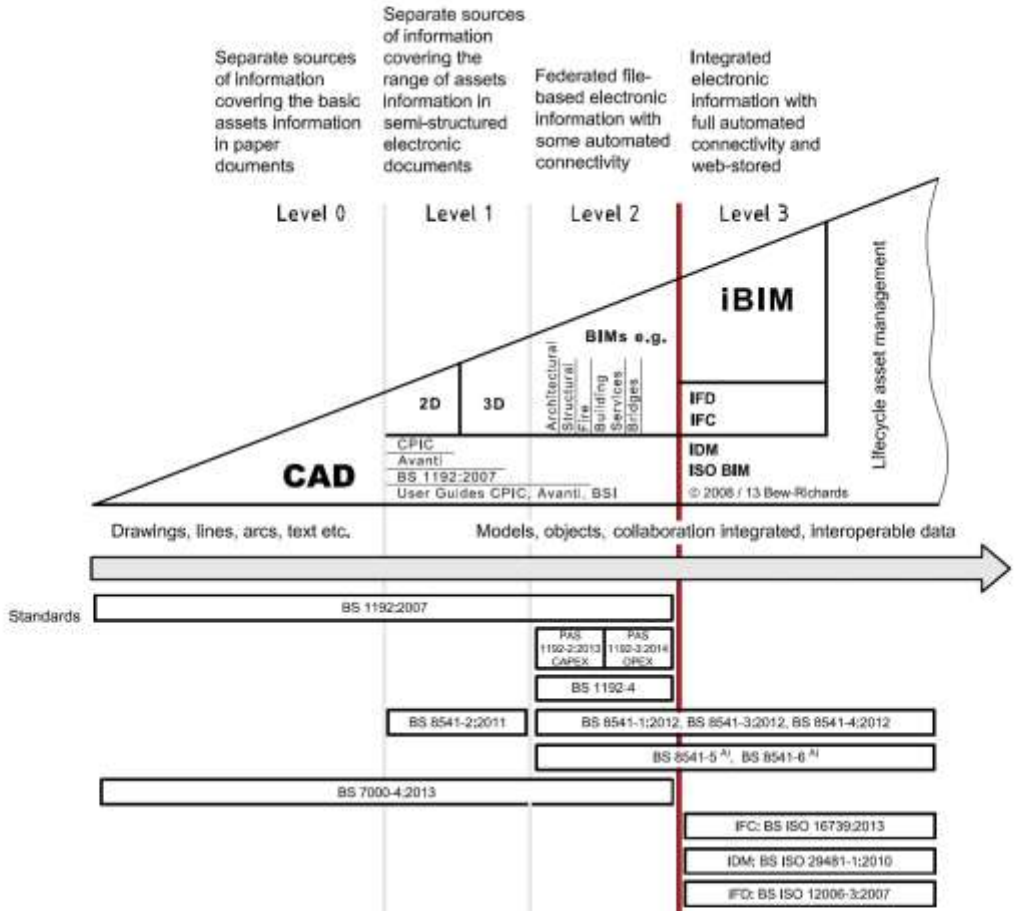


Figure 5.12: BIM maturity levels from '*PAS 1192-3'* (Bew and Richards, 2008/13)

However, people were often not clear what each specific level involved. Table 5.6 based on the work of (McPartland, 2018) helped provide clarification regarding the 'maturity levels of BIM'.

Table 5.6: BIM levels of maturity, adapted from (McPartland, 2018)

BIM Level	Explanation of what constitutes the Level of BIM
0	Effectively no collaboration. 2D CAD drafting only is utilised, mainly for production information (RIBA 2020 stage 4). Output/distribution is via paper or electronic prints, or a mixture of both. The majority of the industry is already well ahead of this now.
1	Typically, a mix of 3D-CAD (concepts) and 2D (approval documentation and production information). Electronic sharing of data using a common data environment (CDE), often managed by the contractor.
2	Distinguished by collaborative working. Requires "an information exchange process" specific to each project, coordinated between various systems and project participants. All software used must be capable of exporting to one of the common file formats such as IFC or COBie.
3	Full collaboration between all disciplines using a single, shared project model which is held in a centralized repository. All parties can access and modify that same model, and the benefit is that it removes the final layer of risk for conflicting information. This is known as 'Open BIM'.

The new '*ISO 19650-1:2018'* updated the 'BIM Wedge' with the graphic shown in Figure 5.13. Commenting in a video on the changes Hooper (2019) observed "Maturity is now measured in stages rather than levels". She went on to note that we need to remember "the most important thing in the BIM process is the information and it's management" (ibid). The standard notes "Information management can be represented as a sequence of maturity stages" (ISO, 2018b, p. 6). Churcher (2019) observed they are made up of four discrete 'layers' defining maturity and 'increased benefit from collaboration'. We also see the importance of the CDE (technology layer) which supports the federated models at Stage 2 (information layer).

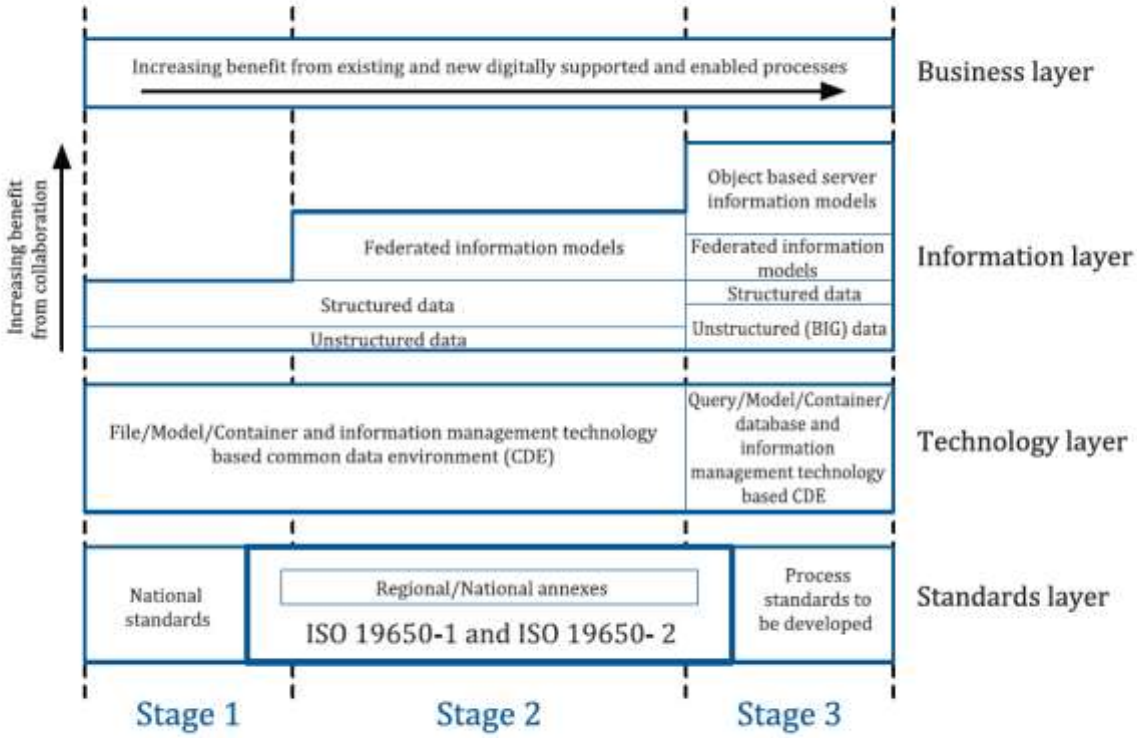


Figure 5.13: *'ISO 19650'* stages of maturity (ISO, 2018b)

Until *'ISO 19650'* government projects were required to be delivered to BIM Level 2. Churcher (2019) noted in order to achieve this (Stage 2) now requires the following:

- A CDE
- Structured and unstructured information which form the federated information models (i.e. the PIM and AIM). Note: the information requirements should be defined by the client.
- The project also needs to abide by the UK BIM Framework standards listed in Chapter 5.2.

Another expression that causes confusion is 'dimensions of BIM'; Cunha (2018, p. para 4) noted they are "different to BIM maturity levels. They refer to the particular way in which particular kinds of data are linked to an information model". Each dimension can be thought of as adding an additional layer of information: 3D = Geometry, 4D = Time, 5D = Money, 6D = Sustainability, 7D = FM (United BIM, 2020). Each dimension has specific uses to different stakeholders as illustrated in Figure 5.14.

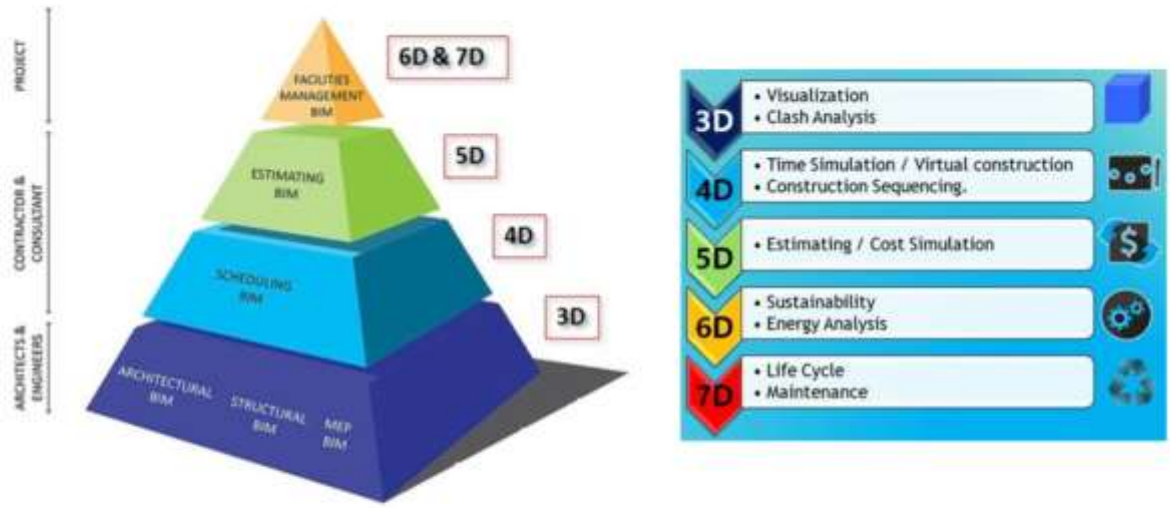


Figure 5.14: Dimensions of BIM: terminology and stakeholder use (Cunha, 2018)

5.6 The importance of a digital transformation strategy

Critically, Ashworth and Heijkoop (2020) stated that to ensure competent procurement of a BIM project, clients need to have a clear strategy in place before commencement. This aligns with Wildenauer (2020, p. 134) who argued they must "clearly state which data and information they need at which point in the project and order it accordingly". This is reinforced by '*ISO 19650-1'* which states "the appointing party should understand what information is required concerning their asset(s) or project(s) to support organisational or project objectives" (ISO, 2018b, p. 8). Clients must confirm how their BIM projects will be managed and supported, in terms of resources, in order to deliver required information, and how this will align with existing AM strategy. Shepard (2015) argued this is critical if BIM projects are to deliver maximum value to clients.

So how do clients start to put together such a strategy? A good starting place would be the UK BIM Alliance's '*Going Digital'* guide by Saxon, Robinson and Winfield (2018). This suggested required investments, potential benefits, and early involvement of FM. It notes importantly that:

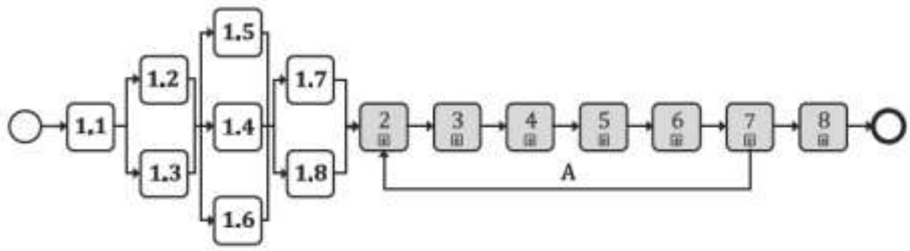
> When digital working methods are employed, the standard forms of appointment and contract need to be augmented to take into account changes in traditional processes and obligations. Properly managed BIM requires that all parties involved have clarity as to their rights and duties, particularly regarding the digital models. Unless these rights and duties are contractually binding there may be poor coordination, unexpected risks and avoidable disputes (ibid, p19).

The guide suggested organisations starting out take incremental steps as set out in Table 5.7.

Table 5.7: Client digital strategy development - Saxon, Robinson and Winfield (2018)

Step	Incremental steps to going digital and using BIM
1	**To become aware:** just knowing what BIM really is and what it can do for similar clients opens up discussion.
2	**To make a strategy:** top client management needs to decide what is worth doing, and how to progress, as part of a project or to make a context for future projects.
3	**To equip the client office to work digitally:** depending on the strategy chosen, clients will need to invest in their capability to instruct their team and to work with digital data.
4	**To formalise the use of digitalisation:** client instructions need to be given to appointed consultants and constructors, to avoid new risks and to define requirements contractually.
5	**To re-consider team formation:** BIM works best when compatible teams are formed and stay together, often through framework agreements.
6	**To define decision-support needs:** brief-making in a digital environment adds information requirements to the matrix of design, cost and time factors, in order to support the decisions of all interested parties at each stage.
7	**To define operation and maintenance needs:** where the asses will be retained and managed by the client, BIM can transform facility performance if the required O&M data is requested up front.
8	**To create useful standards:** digital models can be made of elements required by repeatedly by clients, such as standard rooms or preferred products, for time-saving and re-use.

Clients should understand the requirements placed on them and other parties as stated in the '*ISO 19650'* standards. They should use the UK BIM Framework guidance documents prior to starting any BIM project to understand how the standards should be used in. Figure 5.15 from '*ISO 19650-2'* (ISO, 2018d, p. 7) demonstrates key steps required by an organisation at the start of a BIM project to ensure their needs are assessed thoroughly.



Key

1.1 appoint individuals to undertake the information management function
1.2 establish the project's information requirements
1.3 establish the project's information delivery milestones
1.4 establish the project's information standard
1.5 establish the project's information production methods and procedures
1.6 establish the project's reference information and shared resources
1.7 establish the project's common data environment
1.8 establish the project's information protocol
A information model progressed by subsequent delivery team(s) for each appointment

NOTE Activities shown in parallel are to highlight that these activities can be undertaken concurrently and apply to all instances.

Figure 5.15: '*ISO 19650'* information management process (ISO, 2018d)

BIM does however generate certain risks and legal issues stated Winfield (2018). These need to be addressed through clear communication and clarified within the contract documents. Saxon, Robinson and Winfield (2018) noted that a legal contract tool such as '*The BIM Protocol'* (CIC, 2018a) can be utilised to avoid possible misunderstandings between parties. This "provides clarity to all parties on their rights to use, and obligations over the shared digital models and the intellectual property they contain" (ibid, p. 21). The protocol incorporates agreements between team members which define contractual roles and responsibilities in the BIM process. It also highlights the need to appoint an Information Manager (IM) who can act as a source of advice on what the client should ask for and recommendation for a CDE. '*The BIM Protocol'* appendices include:

1. Responsibility Matrix: specified information to be produced, shared and published by team members and the applicable Level of Definition (LOD)
2. EIR covering the client information needs and BEP covering the contractors' response
3. The Security Minded Provisions addressing the client's security requirements and any that apply to information in the project or if these do not apply

Note: A new '*BIM Protocol',* from the UK BIM Framework is now available which more closely aligns with the *'ISO 19650'* standards.

5.7 Information requirements

The "information requirements are the most important concept of information management as they define the inputs for the whole information management ecosystem" (UK BIM Framework, 2020a, p. 45). '*ISO 19650-1'* defines 'information' as "reinterpretable representation of data in a formalised manner suitable for communication, interpretation or processing" (ISO, 2018b, p. 3). When defining the requirements an often-quoted expression in the BIM process: to 'start with the end in mind'. Ashworth, Tucker and Druhmann (2018) interpreted this as: "the analogy of completing a jigsaw puzzle. One needs to have all the pieces and a strategy to bring them successfully together to be able to see the big picture". The strategy and jigsaw pieces are like the various information requirements in the BIM process (OIR, AIR, EIR, etc.). The 'appointing party' must first understand what information they need and why. A way to visualise this is shown in Figure 5.16 where the information 'receiver' (usually the client/FMs) have to clarify the need for the 'provider' so they can clearly understand why they need to provide the specific information for the project (UK BIM Framework, 2020a, p. 46).

Figure 5.16: Reverse engineering approach (UK BIM Framework, 2020a)

Figure 5.17 from '*ISO 19650-1:2018*' (ISO, 2018b, p. 9) illustrates the 'pieces of the jigsaw' (the various information requirements) and the relationships between them at a project level.

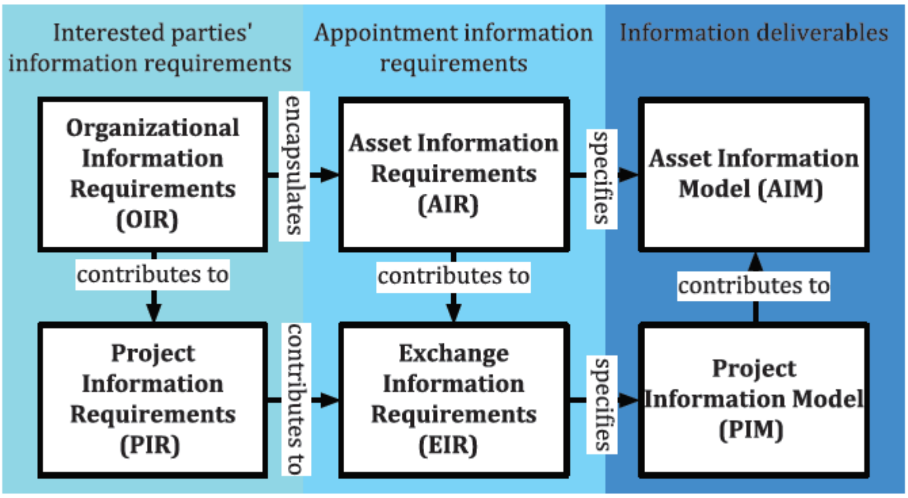


Figure 5.17: Hierarchy of information requirements (ISO, 2018b)

Experience has shown that often people are not clear what each of these require. Table 5.8 highlights the very short '*ISO 1965-1'* definition of each term. In addition further clarification is included to make them clearer.

Table 5.8: Information requirements - OIR, AIR, EIR and PIR (ISO, 2018b)

Information requirements	**ISO 19650-1:2018 definition of 'information requirements – with authors perspective**
OIR	"in relation to organizational objectives" (p.4): e.g. The OIR must be clearly articulated by the client team before the start of the BIM project (the author suggests writing them down to help think about the words used to describe the need). The OIR should cover the high-level information needs of the organisation and why these are important. For example, this could cover reporting needs for quality management, CSR, security, H&S, environmental finance, risk, space use, regulators, policy, business operations etc. The 'UK BIM Framework' website guidance offers further guidance.
PIR	"in relation to the delivery of an asset" (p.4): These are specific to projects enabling better understanding of the high-level purposes for information requirements and decision points. Sometimes referred to in the past as the 'plain language questions' that used to be used and are a series of questions that help to inform the needs in relation to assets e.g. What management reports are required regular about the organisation's assets. Guidance is given in ISO-19650-2 clause 5.1.2.
AIR	"in relation to the operation of an asset" (p.4): e.g. The AIR must be a clearly articulated by the client team before the start of the project (the author suggests writing them down to help think about the words used to describe the need). The AIR should provide specific details of asset information needed (not lists of 'nice to have') to manage and operate assets on a daily basis and over their whole life. This may require discussion with operational teams to establish what they need to do their work, meet regulatory requirements and report on assets for specific purposes e.g. which equipment by type is still under warranty. The AIR should address the LOIN and include a list of 'specific FM criteria' and 'documents etc.' needed. Careful thought and clear guidance should be given as to what must be included in BIM model(s) and what can be delivered in others way e.g. external data bases and also if the information will go into a CAFM or other FM management system. **Note:** This may require additional data mapping and use of COBie.
EIR	"in relation to an appointment" (p.4): The EIR must take into account the OIR, AIR and PIR and be created by the client/lead appointed teams. EIR needs to be specific as they are contractual documents. They must be clearly and communicate to the 'appointed party' what is required from them in terms of information. It can also prescribe certain project issues from the client's perspective about how the project is to be delivered. It is recommended readers refer to the authors EIR document available from the IWFM website .

Note: *'BS 8536-1:2015'* suggests the use of Plain Language Questions (PLQ) as a 'request (or a check) for information' that is expressed in simple, easy-to-understand terms (BSI, 2015a). They can be used as "a check against the complete, comprehensive contents of EIRs" (UK BIM Alliance, 2018, p. 11).

The delivery team develop their 3D models and collect the supporting alphanumeric data and documents during the 'delivery phase'. During this time this is collectively referred to as the PIM. At the end of the project the delivery team transfer the information to the operations team. It is then referred to as the AIM for use in the 'operational phase' (ISO, 2018b).

Experience has shown people and organisations need time to develop their OIR/AIR/EIR properly. Organisations should ask for what they really require and not a long list of 'nice-to-haves'. This was highlighted by UK BIM (2019) who ascertained that worthless information has a specific bearing where relevant information is required. Ford (2020) noted that habitually EIR templates are manipulated with changes in name and content and then referred to as a true EIR. As noted by (UK BIM Framework, 2020a, p. 48): "defining information requirements is not a tick box exercise; poor inputs tend to produce poor outputs leading to risks and unpredictability".

Ford (2020, p. para 16) observed that in practice "a tiny fraction of our projects are truly following the process defined in the PAS/ISO". He believed many clients are still "struggling to understand the impact of the EIR" (ibid, para 17). Ashworth, Tucker and Druhmann (2017, p. 1) argue "there is need for FM and client specific guidance including how to prepare an EIR". This led to several pieces of work during the PhD, including two papers by Ashworth, Tucker and Druhmann (2018): '*Employer's Information Requirements (EIR): A BIM case study to meet client and facility manager needs*' (ibid) and '*Critical success factors for facility management employer's information requirements (EIR) for BIM*'. In addition a project with the then BIFM resulted in the '*EIR Template and Guidance*' by Ashworth and Tucker (2017a) which can be used as a reference guide for producing an EIR document.

5.8 Assessing the delivery teams response and competencies

The BEP is defined in '*ISO 19650-2'* as a: "plan that explains how the information management aspects of the appointment will be carried out by the delivery team" (ISO, 2018d, p. 2). It has two main purposes: "first, it allows the design team to demonstrate that they have the relevant experience, skills, software and hardware to produce the Information Requirements; and second, it sets out how they will use these tools to undertake the project, including details on collaborative workflow and file naming" (RIBA, 2020, p. 115). A 'pre-appointment' BEP is used to allow the client (appointing party) to assess the delivery team's BIM delivery and federation strategy, team competencies, capacity, approach to risk and whether they have understood the client's information needs. The BEP must include a "responsibility matrix" (ISO, 2018d, p. 10) and a "proposed schedule of software (including versions), hardware and IT infrastructure the delivery team intend to adopt" (ibid). Once the 'pre-appointment' BEP is signed it becomes the 'contractual' BEP.

The '*ISO 19650'* standards state the delivery supply chain (the main appointed party and their suppliers) are required to plan their project deliverables and tasks using "a task information delivery plan (TIDP)" (ISO, 2018d, p. 15). The "lead appointed party shall aggregate the TIDP from each task team to establish the delivery team's master information delivery plan (MIDP)" (ibid). This is the plan used to control the BIM project and deliver the PIM.

5.9 Using a common data environment to manage the project information

A CDE is essential to the success of every BIM project; McPartland (2016) suggested it should serve as the ultimate source of 'truth'. A project CDE can be thought of as a 'digital data room' or a shared workspace and Rock (2017) observed it allows progression and functioning of a project, enabling information to be accessed and shared. '*ISO 19650-1*' defines a CDE as the "agreed source of information for any given project or asset, for collecting, managing and disseminating each information container through a managed process" (ISO, 2018b, p. 5). Section 12 of the same standard states a "CDE solution and workflow should be used for managing information during asset management and project delivery" (ISO, 2018b, p. 24).

Clients should be aware that clause 5.1.7 of '*ISO 19650-2*' note this is the responsibility of the 'appointing party' (client) but it can be managed by a third party (ISO, 2018d). If set up correctly McPartland (2016) suggested the benefits in Table 5.9 can be achieved:

Table 5.9: Benefits of a CDE to a BIM project team (McPartland, 2016)

Area	**Benefit of the CDE to project team**
Saving time and costs	Shared information and coordinated data reducing both time and costs.
Using information/models for collaboration	All team members can generate documents/ views needed using different combinations of the central assets, confident that they are using the latest assets.
Improved coordination	Spatial co-ordination is inherent in the idea of using a centralized model.
Access to latest information	Production information should be right first time assuming that contributors adhere to processes for sharing information.

It is important to note that the CDE has two main elements: 'the workflow' and the 'technical solution'. The '*ISO 19650'* standards clarify the difference "the CDE workflow describes the processes to be used and a CDE solution can provide the technology to support those processes" (ISO, 2018b, p. 24). To ensure control of the information sharing process the CDE for each project requires "well-defined access areas for the project stakeholders combined with clear status definitions and a robust workflow description for sharing and approval processes" (Preidel et al., 2016, p. 2).

In today's digital world the CDE will often be a digital 'cloud-based' solution. It could be a single system e.g. an Electronic Document Management System (EDMS) or multiple systems depending on the needs of the project (UK BIM Framework, 2020a). This requires a debate on whether to use an 'open' or 'closed' BIM approach. It was observed by Oldfield et al. (2017) that "the world of BIM encompasses proprietary BIM such as the products produced by Bentley or Autodesk and then openBIM, represented by buildingSMART BIM standards". Juan and Zheng (2014) stated, a closed BIM solution uses one of these 'native' platforms, whereas an open BIM solution allows the stakeholders to use whatever system suits them best (with an 'open exchange') to best meets their needs. Figure 5.18 illustrates the two approaches (Siemens, 2017).

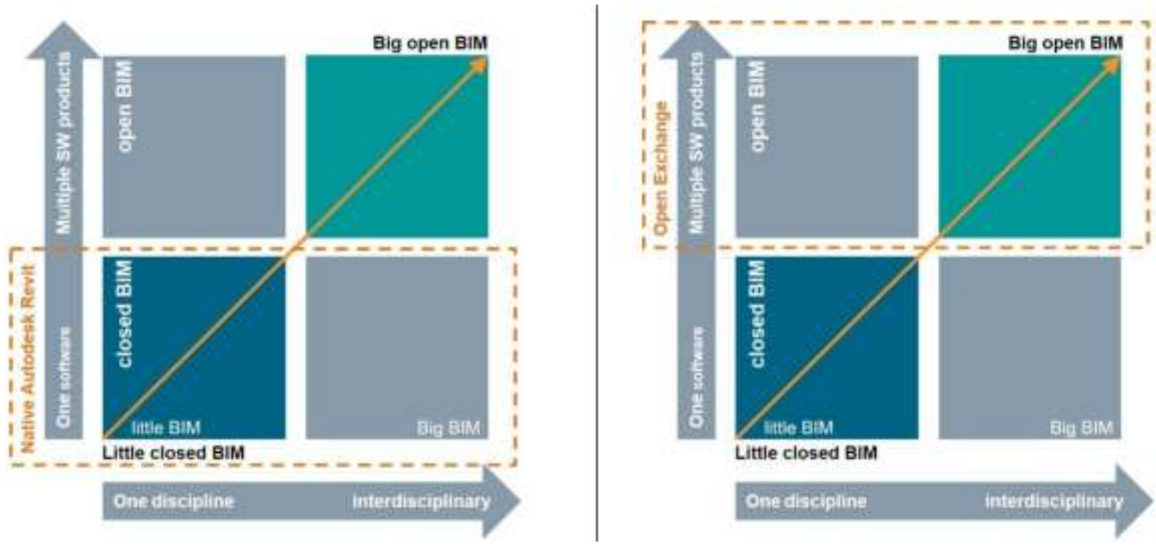


Figure 5.18: Illustration of open and closed BIM and closed BIM (Siemens, 2017)

The future trend seems to be leaning towards open BIM solutions However, whichever solution is adopted, early definition of the CDE functionality; the proposed workflow; and establishing whether system interfaces are required (UK BIM Alliance, 2019) is very important. '*ISO 19650-2*' suggests "using open standards whenever possible and clearly defined operating procedures to enable a consistent approach by all organizations involved and bring a number of advantages for all involved" (ISO, 2018d, p. 11).

Figure 5.19 from '*ISO 19650-1'* illustrates the concept of a CDE as a control process for version control of current work. Submissions of documents/models/information are in one of three states: progress; shared; or published. Each author maintains control of their own information and uses status codes to identify the status of information. The codes are contained in '*The National Annex – 'ISO 19650-2'* Table NA.1. The last state 'archive' contains information not required for day-to-day operations, but which might be needed in the future e.g. for renovations projects.

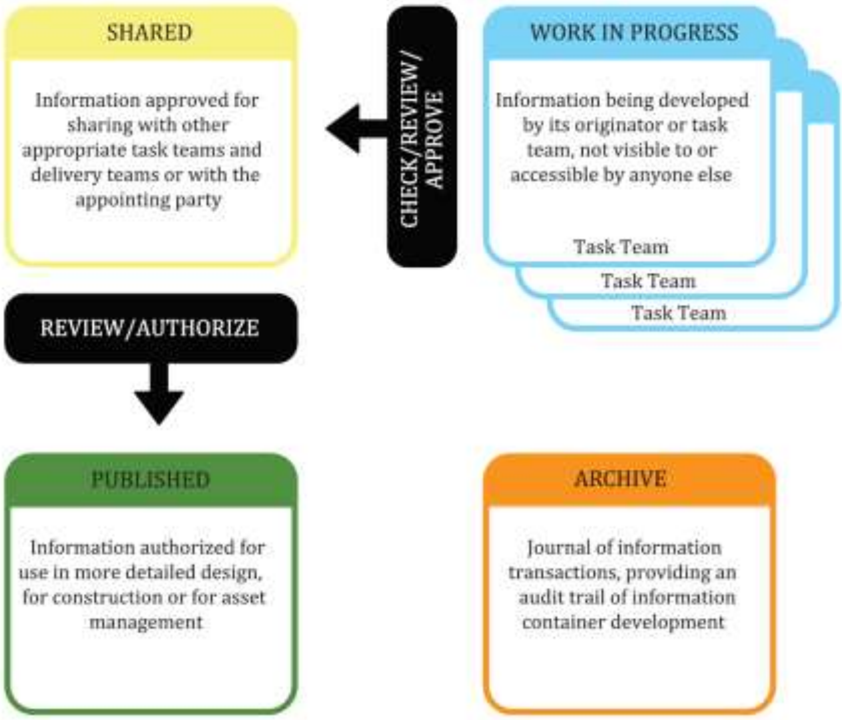


Figure 5.19: CDE concept as explained in *'ISO 19650-1'* (ISO, 2018b)

When set up properly a CDE will allow information including 3D models, information and other documents such as concepts and calculations to be easily shared. A detailed review of the processes for information sharing in the CDE prior to issue are listed in clauses 5.6.3-5 and 5.71-4 of '*ISO 19650-2'.* It is important to understand that in practice teams work with more than one BIM model. Each discipline is usually responsible for all aspects of their own model(s) stored in the CDE. These can then be brought together for clash detection and to check the overall design. They are then referred to as a 'federated model' (RICS, 2015, p. 19). This principle is illustrated in Figure 5.20.

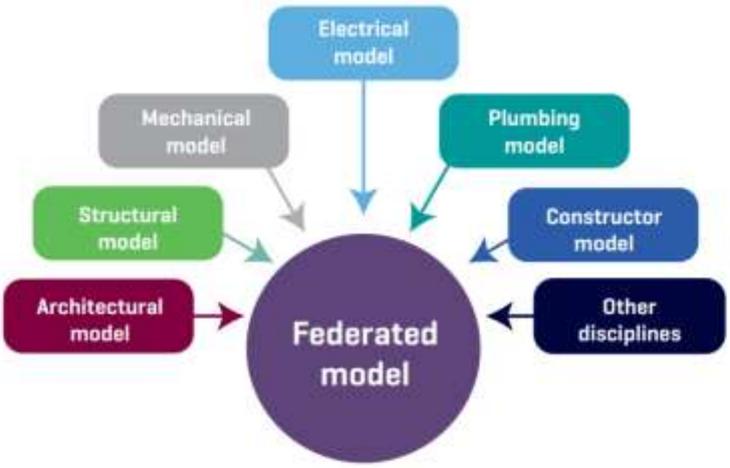


Figure 5.20: BIM models making up a federated model (RICS, 2015)

'*ISO 19650-1*' notes the CDE solution and workflow must "enable the development of a federated information model" (ISO, 2018b, p. 23) and "at the end of a project, information containers required for asset management should be moved from the PIM to the AIM" (ibid, p24). As such BIM offers clients a way to electronically store a centrally managed dataset, which will minimise data duplication, and facilitate up-to-date data sharing between various decision-makers; and that such systems can support decision-making at the organisational and national level (Wanigarathna et al., 2108). Another key benefit was highlighted by Miettinen et al. (2018, p. 14): "the idea of BIM as a model and a database that can be used during the whole-life-cycle of the building is one of the most enduring elements in defining the potentiality of BIM".

5.10 OpenBIM standards

The report '*Data for the Public Good*' (National Infrastructure Commission, 2017, p. 5) highlighted the importance of open data reporting an "annual economic benefit of approximately £8.9bn for the UK". Rossiter and Hooper (2020) define open data as, data available/visible to others and that can be freely used, re-used, re-published and redistributed by anyone. They added "open formats include: HTML, PDF, DOCX, XLSX, PPTX, ODT, ODS, ODP, IFC, PNG, GIF, MP3, CSV and ZIP".

With specific respect to BIM Patacas et al. (2015, p. 313) observed:

> Open data standards such as the Industry Foundation Classes (IFC) and specifications such as the Construction Operations Building information exchange (COBie) provide the capability to capture Facilities Management (FM) data requirements in a structured manner from the early stages of project development.

However, it is important to understand "throughout a design and construction project, information will pass through multiple software solutions. During these exchanges it is the information, not the software used, that provides value. The software is merely a tool" (UK BIM Framework, 2020a). It logically follows that structuring the data to ensure interoperability is critical to the success of BIM. Rossiter and Hooper (2020) suggested the international organisation buildingSMART play a central part as "the worldwide industry body driving the digital transformation of the built environment". They manage the 'openBIM' standards which provide "a collaborative process that is inclusive of all participants, promoting interoperability to benefit projects and assets throughout their life-cycle. They also have a 'certified software' list used by industry which can be accessed on their website (buildingSMART, 2020a).

The open standards enable workflows so different stakeholders can "share their data with any BIM compatible software" (buildingSMART, 2020b, p. para 3). Importantly they are 'vendor neutral' meaning software suppliers do not control them. Figure 5.21 from Lai and Deng (2018, p. 539) highlights the critical issue on 'interoperability' between different software tools and the concept where "IFC schema acts as a medium for bidirectional data sharing and exchange between heterogeneous software".

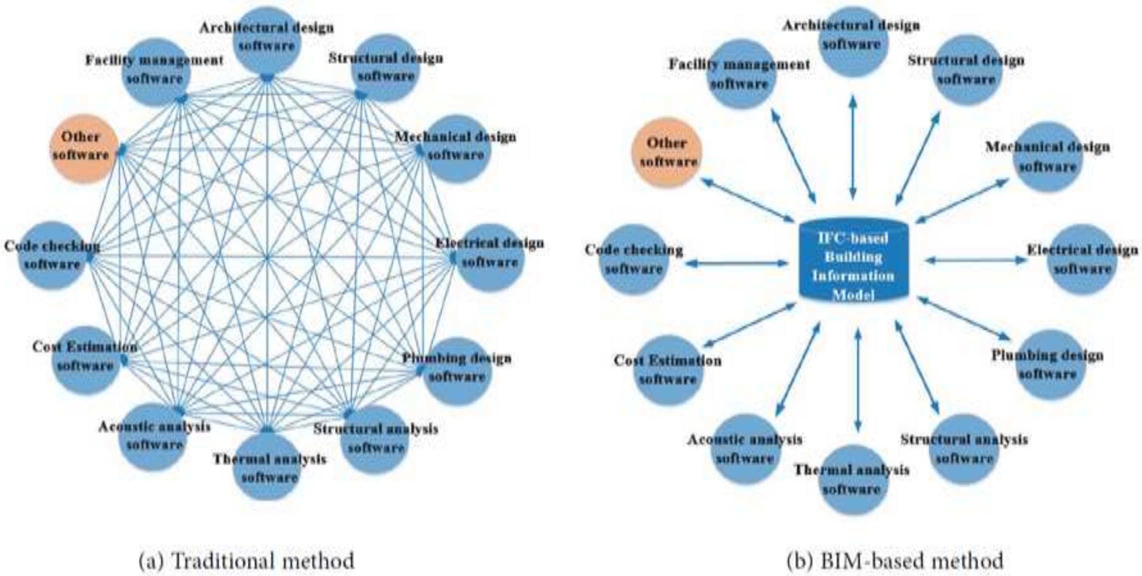


Figure 5.21: Data interoperability between software tools - Lai and Deng (2018)

It is exactly the 'lack of interoperability' that is at the heart of open standards and IFC. Table 5.10 highlights the key buildingSMART openBIM standards which are in place to overcome such problems.

Table 5.10: Key buildingSMART standards (buildingSMART, 2020b)

Name (process)	Standard	Standard purpose (buildingSMART, 2020)
Industry Foundation Classes (IFC)	*'ISO 16739-1:2018'*	An industry specific data model schema.
Information Delivery Manual (IDM)	*'ISO 29481-1:2016'* *'ISO 29481-2:2012'* *'ISO 29481-3'*	A methodology for defining and documenting business processes and data requirements.
Model View Definitions (MVD)	*'buildingSMART MVD'*	Data model exchange specifications
BIM Collaboration Format (BCF)	*'buildingSMART BCF'*	Model-based, software-independent communications protocol.
buildingSMART Data Dictionary (bsDD)	*'ISO 12006-3:2007'* *'buildingSMART bsDD'*	A standard library of general definitions of BIM objects and their attributes.

A key benefit is improved interoperability and open sharing of data which in turn empowers "collaborative design, construction and operation of assets" (RICS, 2015, p. 21). BIM tools which use the standards can "more easily exchange project and spatial data in common file formats" (National Infrastructure Commission, 2017). Some of the benefits of the openBIM approach are shown in Table 5.11.

Table 5.11: Benefits of openBIM standards (buildingSMART, 2020b)

No	Functional benefit	Specific benefit (buildingSMART, 2020)
1	Interoperability	Provides the key to the digital transformation in the BA industry.
2	Open	Open and neutral standards should be developed to facilitate interoperability.
3	Reliable	Data exchanges depend on independent quality benchmarks.
4	Collaboration	Workflows should not be limited by proprietary processes or data formats.
5	Flexibility	We need open choice of technology to create more value to all stakeholders.
6	Sustainability	Sustainability is safeguarded by long-term interoperable data standards.

IFC is central to openBIM, Baldwin (2018a) highlighting its importance: "some would say the primary standard, for openBIM data exchange". Its use crosses borders and Areo (2016) note IFC as the best known global standard which is actively used for data exchange by many stakeholders in the building industry. It is the key to stakeholders sharing "data regardless of what software application they use to get their job done". Baldwin (2018a) suggested thinking of IFC like the 'pdf' of BIM. Native software like Revit, ArchiCAD etc. can produce 'IFC exports' which are like "a frozen copy of the original content". These can then "be viewed, measured, used for clash detection, cost estimation, simulations etc." (ibid). However, IFC is not intended for making changes. If required, these must be made back in the Native software. The use of Native and IFC formats for working between software systems and the CDE is represented in Figure 5.22.

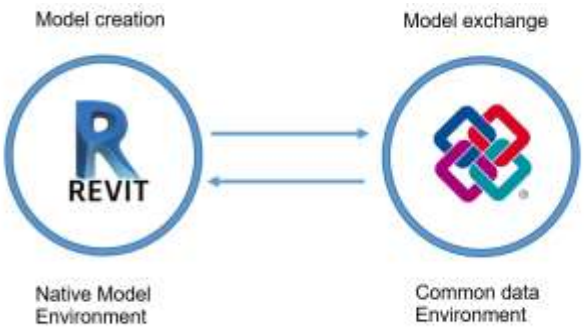


Figure 5.22: Native BIM software in relation to IFC (Baldwin, 2018a)

The other standards empower more flexibility for stakeholders using BIM. The buildingSMART (2020) Data Dictionary (bSDD) provides "an online tool to map synonyms and multiple language translations. It's sort of like the Google Translate for BIM" (Baldwin, 2018b). It ensures a standardised use of terminology across BIM software in multiple languages e.g. the dictionary aligns a 'window' in English as a 'Fenster' in German. Model View Definitions (MVD) are very important providing "filtered IFC views basically allowing you to simplify the data exchange process and to avoid sharing useless or redundant information while following standardized procedures" (Biblus, 2020). For example, if someone wants an IFC export for energy simulations then they can request that specific 'data package' to avoid getting everything. The principle is shown in Figure 5.23.

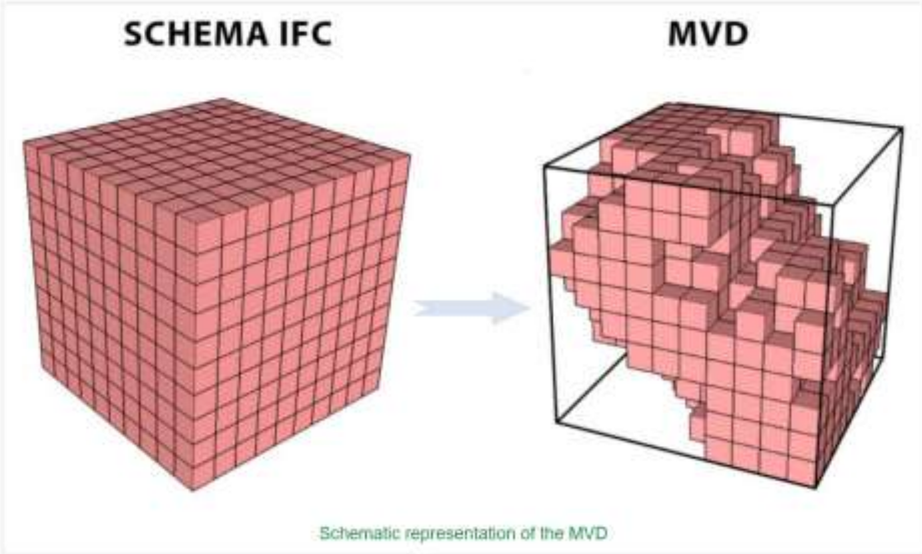


Figure 5.23: Sharing information packages with IFC using MVD (Biblus, 2020)

Building Collaboration Format (BCF) is especially useful during projects to track and resolve issues in design. It allows people to send mark-ups of models and automatically track issues which need resolving (Baldwin, 2018c). IDM is "used to identify discrete processes that are undertaken during the life-cycle of a built asset, and to detail the information required to carry them out" (Designing Buildings WiKi, 2017).

One of the most significant tools for FM is COBie. Wilkinson (2019) described it as an important "subset of IFC", and '*BS 1192-4*' (the BS for COBie) "as a buildingSMART model view definition (MVD) which includes operational information" (BSI, 2014, p. 4). Hamil (2018) noted COBie is "a non-proprietary data format as distinct from geometric information". As such it importantly addresses the transfer of 'alphanumeric information' in BIM projects. It was originally developed by East (2007) with an interdisciplinary team of architects, planners, builders, operators and software companies for the US Army Corps of Engineers in the USA. Their aim was to meet requirements for information exchange during the planning and execution phase up to the transfer of data into the management phase.

Yalcinkaya and Singh (2014) noted IFC can be viewed as a Standard for the Exchange of Product model data (STEP) file, but these were designed for machines and not humans to read. Consequently, COBie is usually viewed in spreadsheet format. Hamil (2018) argued COBie was very important as one of UK Government's key '*BIM Level 2'* deliverables and as of "January 2019, the UK National Annex within '*BS EN ISO 19650-2'* states that non-geometric information exchanges in open data formats should be structured to COBie format". The various COBie spreadsheet views are described in great detail in '*BS 1192-4*'. Figure 5.24 illustrates an overview of all the spreadsheets used to capture essential information required for the operations phase (BIM Working Party, 2011, p. 61).

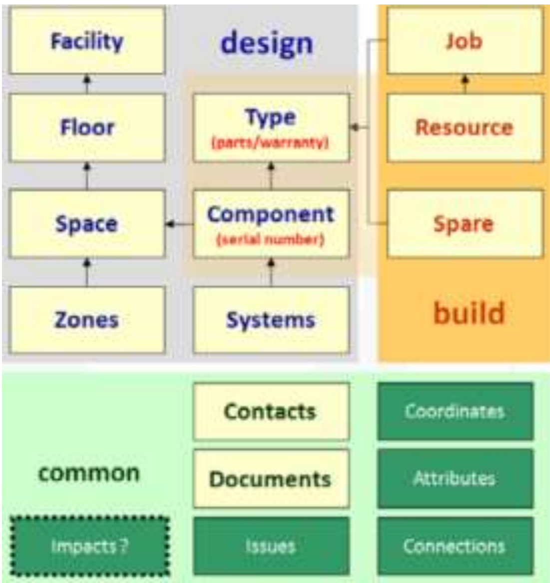


Figure 5.24: COBie spreadsheets (BIM Working Party, 2011)

In terms of the future possibilities, Figure 5.25 below based on work by Meslec, Hubbuch, and Ashworth (2019) illustrates a future scenario where BIM teams work using an 'IFC based object orientated database with a BIM server' which prevents the need to constantly exchange large files.

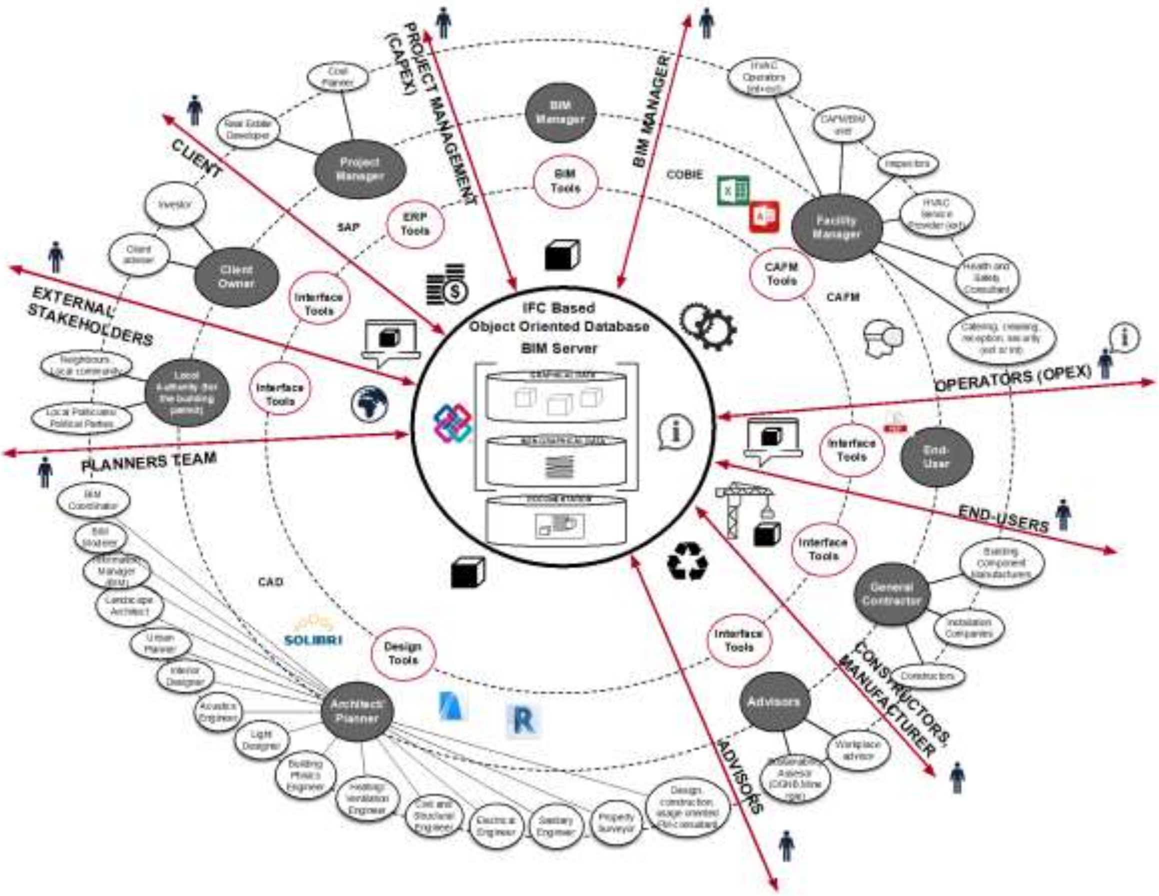


Figure 5.25: Stakeholders/tools in BIM projects - Meslec, Hubbuch, and Ashworth (2019)

Figure 5.26 shows another perspective where we can see the use of IFC to ensure information flow across the whole-life of a BA.

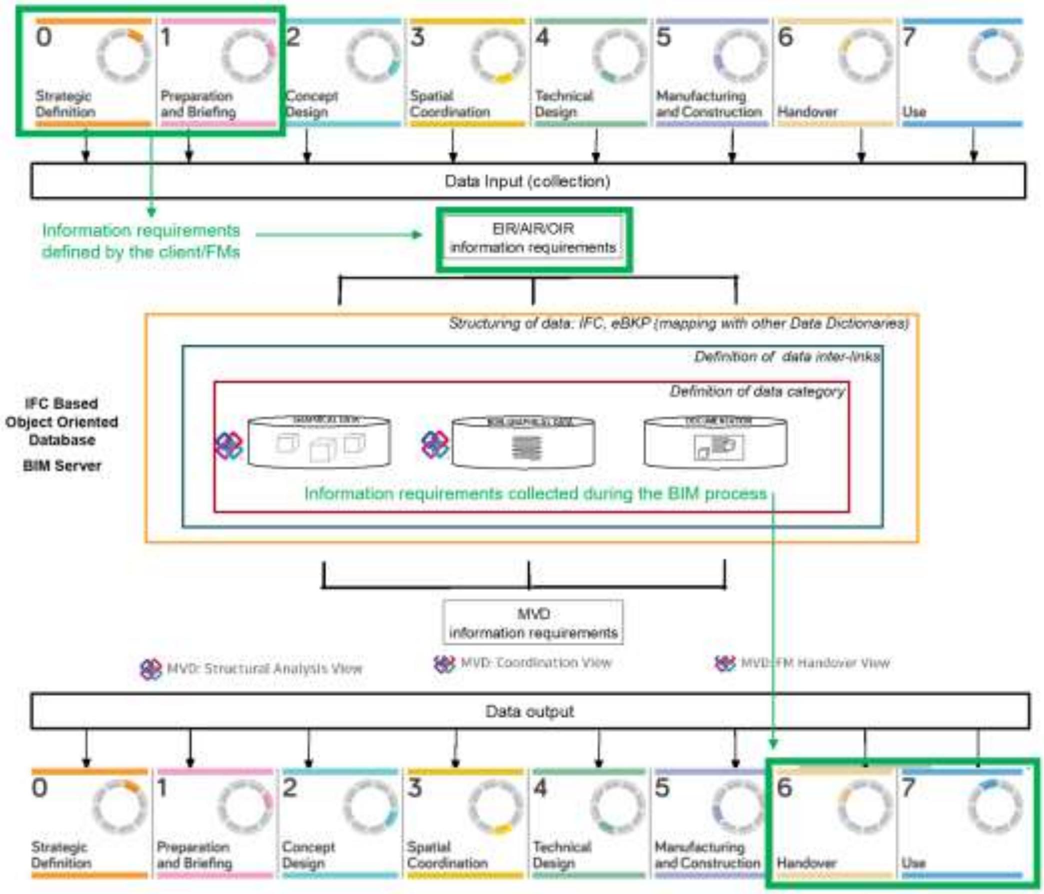


Figure 5.26: IFC information across project life - Meslec, Hubbuch, and Ashworth (2019)

5.11 Using building information modelling for existing built assets

Most of the focus of BIM is on new builds. However, as we saw in Chapter 4.8 the majority of the BA we currently use already exist. Carbonari, Stravoravdis and Gausden (2015) argued that existing constructions could benefit from BIM management. Some research case studies report savings using retro-modelling of existing buildings: "3D modelling applications helped Copenhagen Airport A/S achieve a 4.46 percent cost savings" (Civil + Strucural Engineer, 2018, p. para 1).

Other academics like Hossain and Yeoh (2018, p. 6) observed: "most existing buildings do not have a BIM and creating a BIM for existing buildings is challenging". Khaddaja and Srourb (2016, p. 1532) suggested there are considerable technical challenges to be overcome "mainly revealed in the automation of data capture for BIM creation, maintenance and updates for a pre-existing BIM model, as well as in handling uncertain data". They also note: "proper data management and interoperability are the most serious informational challenges" (ibid).

A literature review of over 180 publications by Volk, Stengel and Schultmann (2014, p. 109) assessing data capture techniques for existing BA indicated: "scarce BIM implementation in existing buildings". Their findings highlighted three major challenges:

1. High modelling/conversion effort from captured building data into semantic BIM objects
2. Updating of information in BIM
3. Handling of uncertain data, objects and relations in BIM occurring in existing buildings

They also researched a range of possible techniques for capturing/analysing existing BA. Figure 5.27 shows their summary of the techniques.

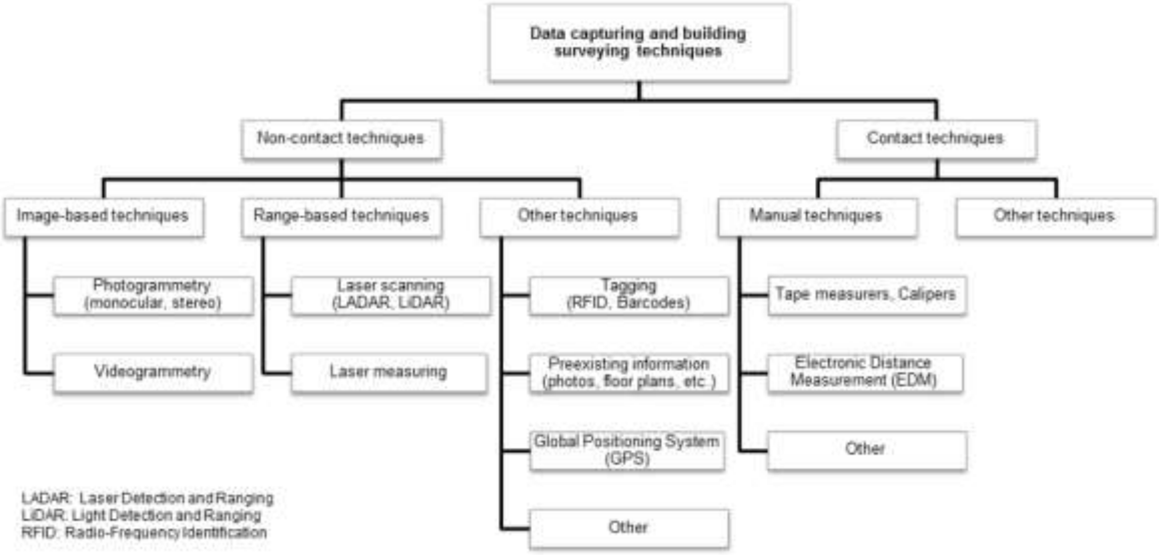


Figure 5.27: Data capture techniques for existing BA - Volk, Stengel and Schultmann (2014)

They went on to suggest the simple flow chart shown in Figure 5.28 to indicate possible paths to create a BIM model for new and existing BA (ibid).

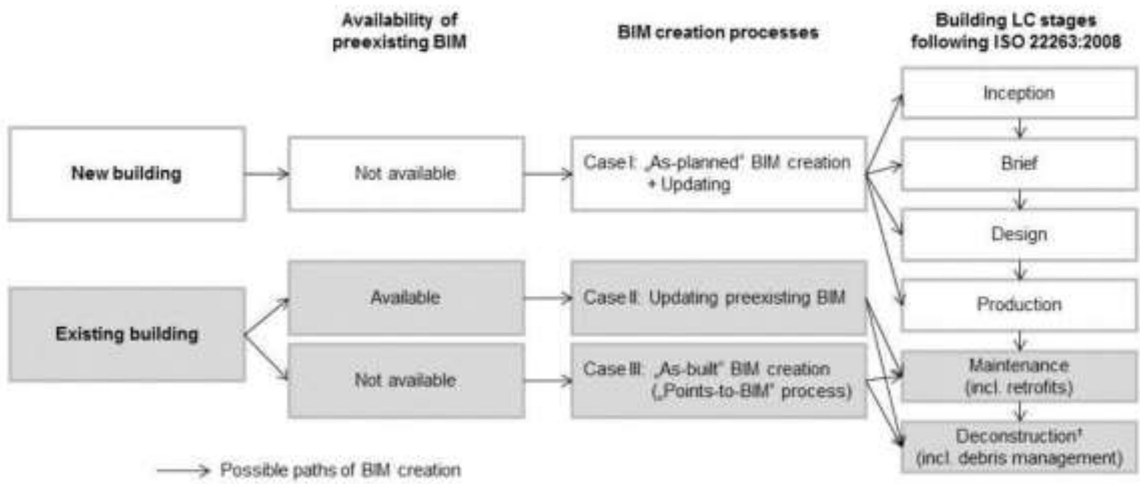


Figure 5.28: BIM models for new and existing BA - Volk, Stengel and Schultmann (2014)

The use of the various technologies described by Volk, Stengel and Schultmann (2014) encompass many significant fields of research. Major advances are being made all the time which will make the creation of simpler 3D models (BIM and others) more possible in the future. Khaddaja and Srourb (2016, p. 1526) noted BIM is becoming popular for projects like “energy-driven retrofits”. Other ideas for how BIM can be used with existing BA are explored in the ‘*BIM & Existing Building Magazine*’ (Charlton, 2018). In construction there is increased use of automated data capture technology for quality and progress checking to reduce faults at handover. Alizadehsalehia and Yitmena’s (2016, p. 102) research reported “significant progress towards automating field data capturing real-time information from real-life physical project processes and visualization of as-built status of a project using BIM has been achieved”.

5.12 The Government’s future plans with respect to digital transformation

Both this and Chapter 4 highlight that digitalisation and BIM has developed at a fast pace. Back in 2011 the Government had already set out a ‘final vision’ for information delivery. This reflected technological advances with the aim of using “fully web enabled transparent (to the user) scenario, based on the buildingSMART IFC/IDM and IFD standards” (BIM Working Party, 2011, p. 61). Figure 5.29 illustrates the Government’s vision in 2011 in relation to the old BIM levels and the BIM wedge.

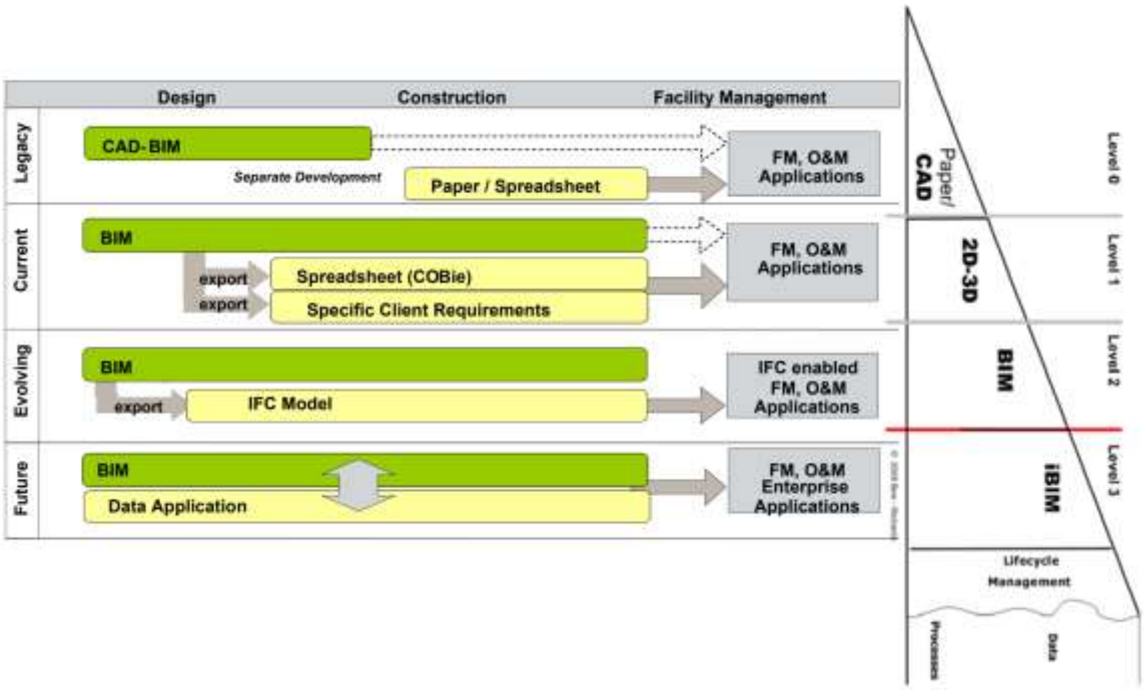


Figure 5.29: UK Government BIM ‘final vision’ (BIM Working Party, 2011)

The BIM2050 group report ‘*Built Environment 2050’* (Thompson et al., 2014) provided further useful insights as to government thinking about the digital future as we approach a ‘second wave’ of BIM and key technologies moving the industry to Levels 3/4 (Figure 5.30).

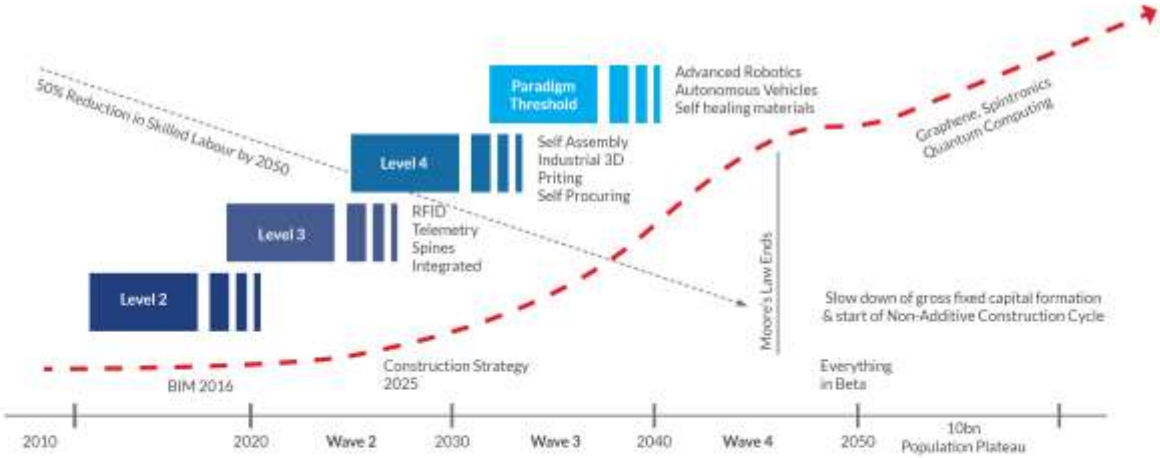


Figure 5.30: Socio-technological frontier (Thompson et al., 2014)

Philp (2014, p. para 4) noted: "the report envisages that digitisation will change the construction industry landscape, giving life to new innovative ways of working which are transformative, dynamic, rapid and disruptive by design". Thompson et al. (2014) also reported that the rate of change in technology is going to lead to a need to adapt today's skills to suit the demand of tomorrow's requirements. Considering what might come in the future, we can see that CDE will become increasingly important forming digitally managed platforms "made up of a number of information management systems (Preidel et al., 2016)".

The report '*Asset Information Management - Common Data Environment Functional Requirements*' described the future government vision for "a BIM Level 2 Asset Information Management Common Data Environment (AIM CDE)" (BIM Working Group, 2018, p. 2). The purpose "is to provide a standards compliant environment to specify, collect, assure, store, present and exploit BIM Level 2 information (structured data, 3D models and documents) about the development and operational phases of maintained and operated assets" (ibid). The cdbb (2020) noted "we must recognise infrastructure as a system of systems and manage it accordingly". They went on to add "national infrastructure strategies must address the whole system, existing infrastructure as well as new" (ibid).

Figure 5.31 illustrates how different systems might be combined to create such a 'AIM CDE' across an asset's life-cycle in practice (Burgess, 2016, p. para 3). It also shows the possibility for combining systems from different providers.

Figure 5.31: Example concept from PCSG of an extended CDE (Burgess, 2016).

Other technologies such as AI and machine learning are starting to impact on industry. Architectural practices are already experimenting with these technologies to improve and optimise the layout of space in buildings (Chaillou, 2019). The Government recognises the importance of bringing BIM and these other technologies together. Figure 5.32 illustrates how the functional requirements of an AIM CDE might look enabled by a wide range of technologies to help governments and society have many useful future outputs.

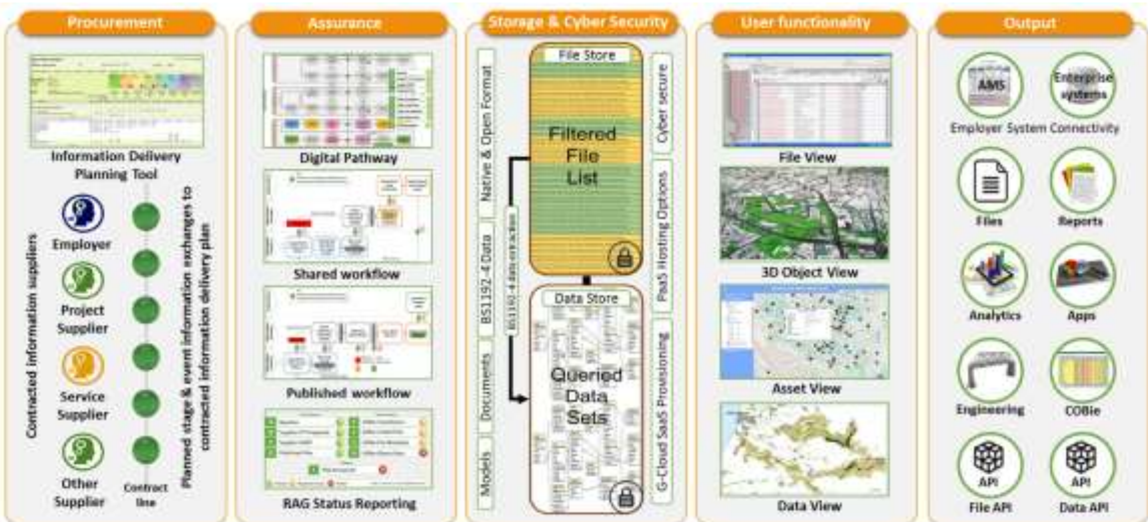


Figure 5.32: AIM CDE functional requirements (BIM Working Group, 2018)

5.13 Chapter summary

The literature emphasised that the new digital economy is changing the way in which we work and live. This impact is currently in full flow in the construction industry which is running to catch up with other industry sectors (Philp, 2014). BIM is the key trend which is driving the ACE industry transformation at incredible pace, even within the timeframe of this PhD. It offers new collaboration opportunities for new and existing BA to improve productivity and address issues which have plagued the industry for many years. However, the research also exposed gaps in understanding that in order to deliver the potential benefits of BIM people need to develop competencies with respect to ordering BIM projects and adapting to more digital ways of working. This includes developing a deeper understanding of issues such as standardisation, openBIM, IFC, COBie etc. People need to become more familiar with BIM standards which have undergone a complete overhaul moving from local PAS, to international '*ISO 19650'* standards. he UK BIM Framework website which replaced older Government websites is now seen as the focal point for all UK BIM guidance. Clients need to set up BIM strategies which align with their strategic needs and there must be a focus on clearly defined information requirements (OIR, AIR, PIR and EIR). Projects need to consider the CDE setup and all stakeholders including FMs to work towards what is really needed avoiding the 'garbage in = garbage out' scenario. Chapter 6 discusses the role of FMs in detail.

Chapter 6: The role of facility management in the process

The purpose of this chapter was to address research objective (a) to assess the state of the art and identify CST important to delivering successful outcomes when using the BIM process. Specifically it discusses how BIM can deliver not only significant cost savings over the whole-life of assets but also to deliver sustainable and social outcomes for society. How FMs have a critical role in the BIM process is discussed. The importance of ensuring people have the right competencies and training was also discussed to ensure vital operational knowledge can be brought early into the process and FMs can help define operational information requirements.

6.1 Early facility management involvement

In an interview with Ashworth and Tucker (2017, p. 5), Mark Bew noted, “the asset and facilities management sector play a critical part in the safe, reliable and productive delivery of services across the nation”. However, exactly how FMs should best engage in the BIM process “has generated fervent debate within the extant literature” (Hosseini et al., 2018, p. 2). An important concept is that the ‘i’ in BIM represents the “information which is at the heart of BIM” (Hamil, 2012, p. para 21).

Planning, designing and constructing a BA produces enormous amounts of information, much of which is critical to FM operations and software. However, Lavy and Jawadekar (2014) observed much of this information is lost due to a poor ‘handover process’, leading to additional time and cost in retrieving mislaid data. Research by Newton (2004) noted inadequate information access and interoperability issues during operation cost the US $20 billion annually.

Figure 6.1 from Ashworth (2019) illustrated challenges FMs traditionally faced at handover. They need information from the ‘BIM process’ (shown in green) i.e. 3D models, alphanumeric data and documents, in order to support ‘day-to-day FM operations’ (shown in pink) i.e. ‘FM processes, services, cost control, and products’. The diminishing green lines reflect the loss of ‘onsite knowledge’ as the D&C team leave the project as the day of handover (acceptance & opening) approaches. In the past FMs were often only invited to join the process at this point (Ashworth et al., 2020). They then somehow, had to familiarise themselves with, and find all, the information needed for operations. Not surprisingly this has often led to a significant loss of information in the transition process. This is illustrated in Figure 6.1 as I ‘Death Valley of knowhow’.

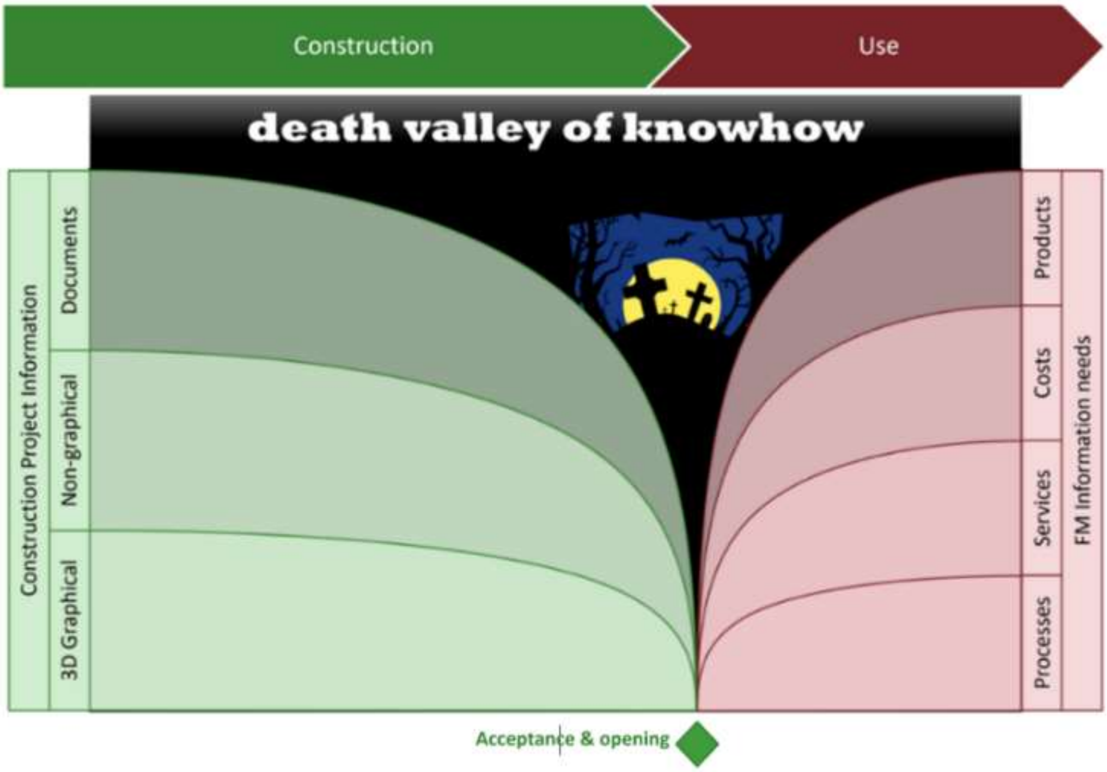


Figure 6.1: The Death Valley of knowhow at handover (Ashworth, 2019)

Azhar, Khalfan and Maqsood (2012, p. 21) suggested "BIM will significantly help to prevent these losses".

Figure 6.2 (Ashworth, 2019) represents a view of what should happen in the process of transition. First is that it is a process and one which requires adequate time to be done properly. Early FM engagement within the design and construction process is vital in order that owners and designers receive value for money Beadle et al. (2017) noted. This is represented by the pink lines brought forward to the project start. FMs can then ensure the right information requirements are in place as shown by the blue boxes from the start of the project.

Plans should be put in place at handover to ensure the right as-built information (AIM) is transferred to FM management systems, enabling FMs to optimise assets, costs, processes and user satisfaction in operation.

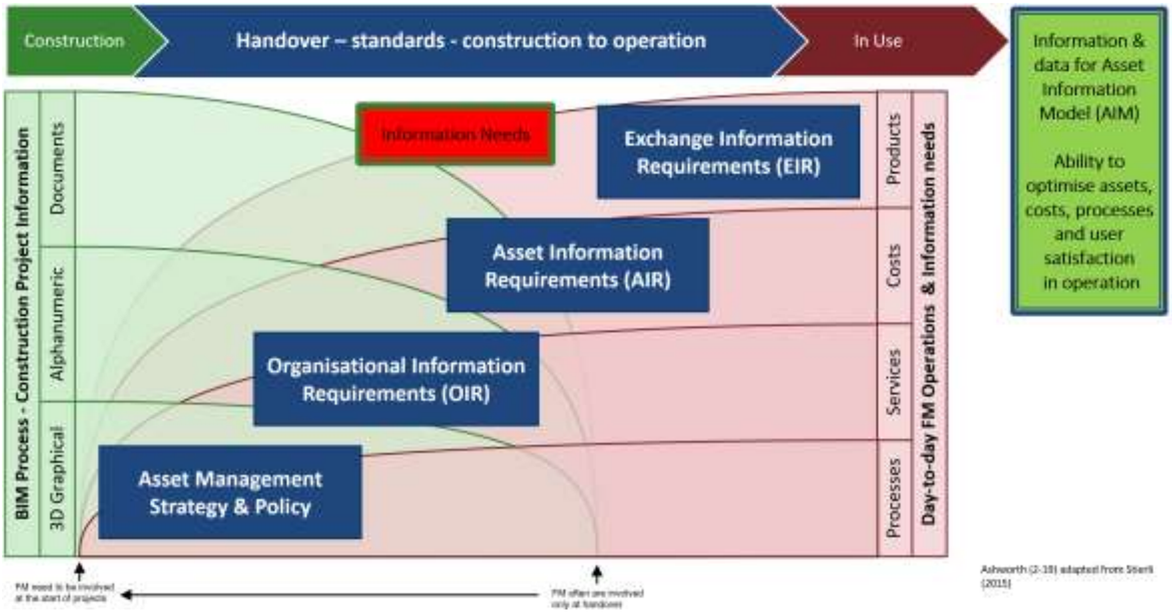


Figure 6.2: The need for early FM engagement in BIM (Ashworth, 2019)

In industry there has been a gradual paradigm shift in thinking that in order to get the maximum benefit FMs need to be included at the start of a BIM project (Ashworth et al., 2020, p. 4). This is reinforced in '*BS 8536-1:2015,* which promotes "early involvement of the operator, operations team or facility manager, as appropriate" (BSI, 2015a, p. 1). It also notes the importance of 'operability', and that to ensure 'usability': "design decisions have to be based upon accurate and relevant information and data, and their impact on operational needs has to be understood before they are committed to construction work and/or installation" (ibid).

6.2 Ensuring the benefits of building information modelling in the operational phase

With respect to the key beneficiaries in the BIM process; research by Eadie et al. (2013, p. 145) indicated: "clients followed by facilities managers benefit most from BIM implementation". Still, "despite this, over 70% do not provide a 3D model and Cobie dataset at the conclusion of a project" (ibid). Chapter 2.6 illustrated that most of the cost of BA over their lifetime e.g. up to 85% (Miettinen et al., 2018) occur in the operational phase. Eadie et al. (2013) noted that, in the norm, less than 10% of projects utilise BIM in operation and management phases, unlike construction where BIM is well established. Haines (2016, p. para 1) agreed, adding the "use of BIM technology in the operational phase of a building's life-cycle is just beginning to take hold as building owners look for new ways to improve the effectiveness of their facility operations". The perceived value by owners of BIM for FM was reported as very high by McGraw Hill Construction (2014) who noted 98% of UK building owners would perceive high value from BIM. They also reported that D&C contractors believed ROI will be highest at handover, yet the adoption and usage figures tell another story, reducing as projects move to operations as shown in Figure 6.3.

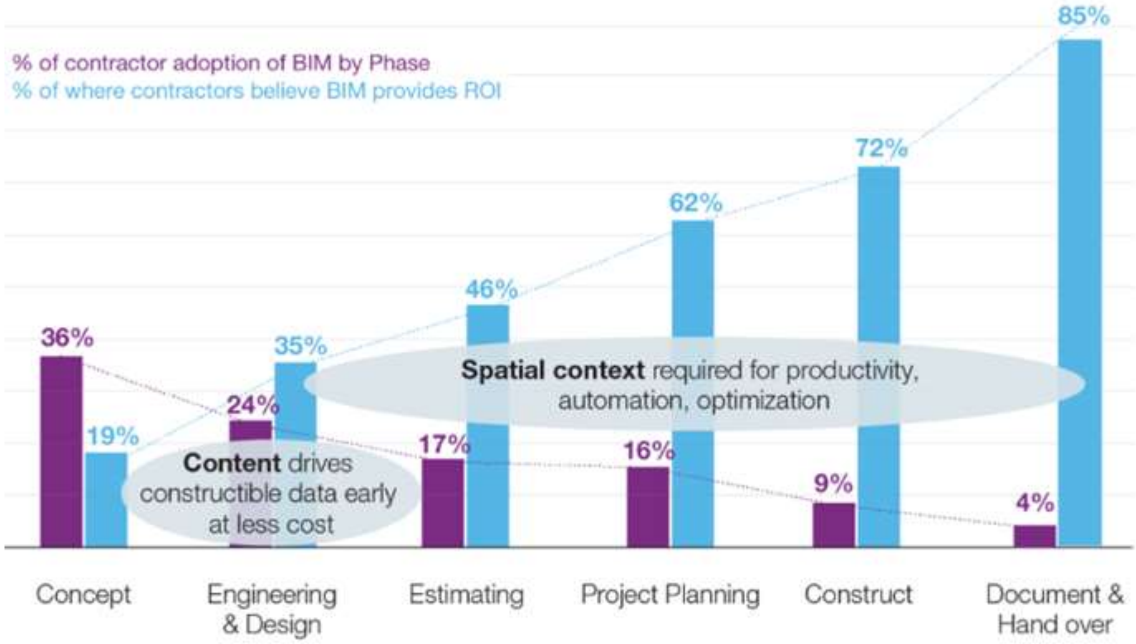


Figure 6.3: Potential vs actual – BIM in operation (McGraw Hill Construction, 2014)

Only by increased engagement in the process will clients/FMs reap the rich benefits in operation. This was highlighted by Sarah Davidson in the '*10th Annual BIM Report'* (NBS, 2020c, p. 8): "The client has a significant (and arguably the most important) role to play within the information management ecosystem". However, it noted the most common barrier (at 64%) to BIM adoption was "lack of client demand" (ibid, p3); reinforced the argument more needs to be done if BIM is to be successful in the operational phase of BA.

Thomas (2017, p. 2) noted the main role of FMs is to "represent the interests of the owner, client (employer) and end-user to ensure that a facility can be operated, maintained and managed effectively".

Figure 6.4 illustrates an 'FM-BIM strategy' concept model developed by Ashworth (2016) and subsequently updated in 2020. It highlights the role of FMs in BIM projects showing a client 'FM representative' (preferably in-house FM, but it could be a FM consultant) appointed as recommended by '*BS 8536-1*'. They should be familiar with important BIM standards and the IWFM and UK BIM Framework BIM guidance documents. Their primary role as part of the project team is to review the client organisation's information needs (OIR and AIR) and then draft an EIR which takes into account the organisation's wider corporate and AM strategic approaches.

Note: The original 2016 model was updated in 2020 to align with the new '*ISO 19650'* standards, UK BIM Framework guidance with new '*BIM Information Protocol'*, IWFM guidance and the '*RIBA 2020 PoW'*.

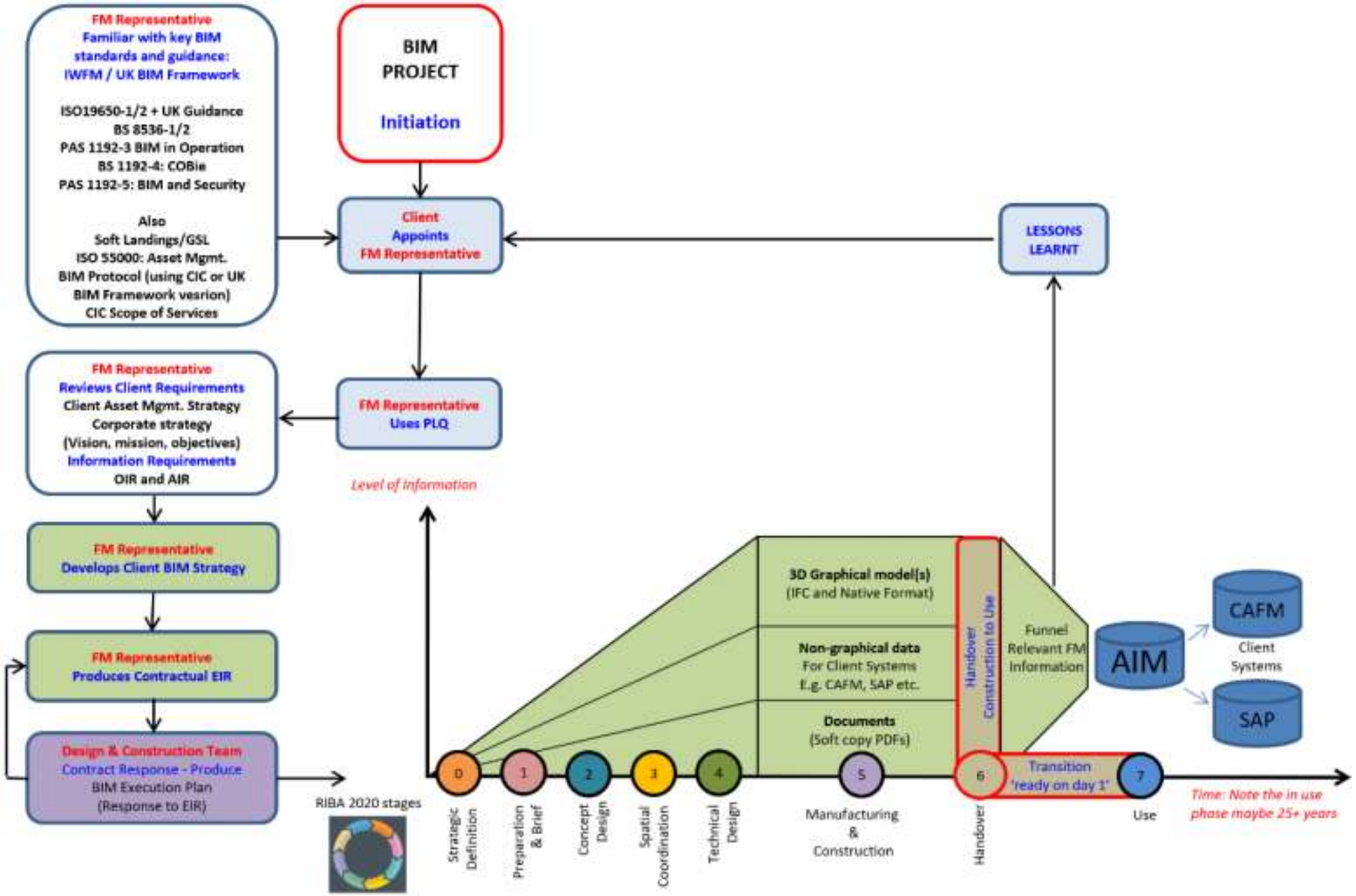


Figure 6.4: FM-BIM strategy concept model 2016 updated (Ashworth, 2020)

Where there is no client BIM strategy the representative should help put one in place. The initial steps should be guided by using the IWFM/UK BIM Framework guidance. Ashworth (2016) suggested PLQ are used to establish the information requirements prior to creating the client EIR, which should be focused on the needs of the client and specific to the project. This is then shared with the delivery team so they can cascade the client's EIR and information requirements through their supply chain. The lead appointed party from the supply chain can then respond with their BEP. This will ensure the project starts with a clear set of information requirements.

When preparing the requirements Ashworth et al. (2020, p. 4) noted: "It should be clear why information is needed for everyday operational processes and reporting needs Ultimately, the AIM, should be transferred at handover so it can be utilised without delay by the relevant stakeholders stated (not in 6 months or 2 years, as is sometimes the case) Thomas (2017) . Another argument is that FMs are ideally placed as they understand both the client's vision, mission and business objectives. They also have unique operational knowledge to best plan the information really needed to deliver, operate and maintain BA over its whole-life-cycle; and work with the client to ensure commercial, sustainability and other aspects are taken into account.

Schley (2011, p. 4) argued FMs need access to "information that is current, accurate, and relevant". Florez and Afsari (2018, p. 2) stated the plan for acquiring such information should be SMART and include: "material types, floor characteristics, building functions, floor plans and systems, equipment lists, connections between equipment, product data sheets, warranties, preventive maintenance schedules etc." This information builds during the project following the RIBA 2020 PoW stages until handover at stage 6. The delivery team is tasked until this time to "collect O&M information about the systems and assets" (Ashworth et al., 2020, p. 6).

It is important to note that the handover is a 'transition process' as highlighted in the 4P model in Chapter 2.6. This requires careful planning over time so that the information needed to operate the BA is ready from day one. Teams must consider at the start of the project how the process for checking data quality will be conducted during handover, and how relevant information can then be linked, or transferred into relevant FM management systems (CAFM, SAP etc.). A 'lessons learnt' exercise should be conducted to provide an improvement feedback loop for the next BIM project.

The process may require a final 'reduction process' to ensure relevant information can be migrated (Using COBie or other means) into FM management systems. The process of information build-up over time is illustrated in Figure 6.5.

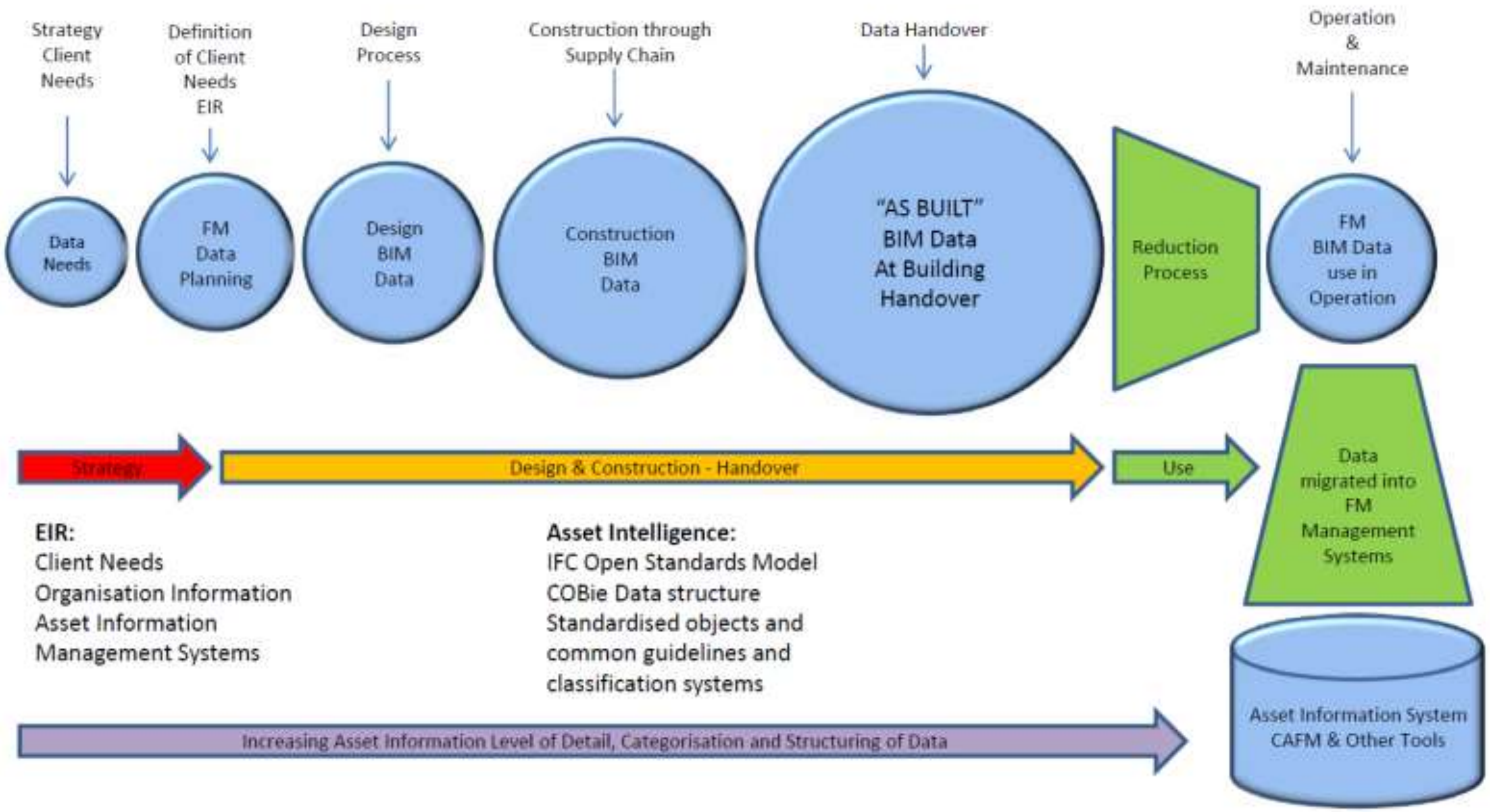


Figure 6.5: Information build up: construction to handover (Ashworth, 2018c)

The UK BIM Framework notes that in order to support the delivery of BM projects clients/FMs need to fulfil certain key tasks. Their guidance (UK BIM Framework, 2020a, p. 10) provides a summary of the tasks to be undertaken by the client ('appointing party') in line with '*ISO 19650'* as per Table 6.1.

Table 6.1: Client activities in the BIM process (UK BIM Framework, 2020a)

Activity	Client (appointed party) and FM activities in a BIM project (UK BIM FRAMEWORK, 2020)
1	"Establish the project's information requirements, information delivery milestones and information standards" (p.10). **Note:** includes the OIR, AIR and EIR.
2	"Identify specific procedures for the production of information including its generation, delivery and secure management" (p.10).
3	"Identify existing information and/or resources that are relevant to the delivery teams you will be appointing to this project" (p.10). **Note:** this should be communicated to the delivery team, so they are fully aware of any existing relevant information.
4	"Establish the project's information protocol for incorporation into all project appointments" (p.10).
5	"Establish a common data environment (CDE) to support the project and the collaborative production of information" (p.10). **Note**: this can be done by a third party.
6	Review tender returns (including BEP and MIDP) to ensure they meets the client's requirements and also assess the delivery team's BIM capability and competencies, mobilisation plan and approach to risk . **Note:** author's own interpretation.

'*BS 8536-1'* notes: "the owner should take steps to ensure that there is sufficient information technology in place to support 'Level 2 BIM', where this is to be adopted" (BSI, 2015a, p. 22). Clients should accept an element of investment for IT; possibly the CDE, and training for staff will be required when engaging with their first BIM project (UK BIM Alliance, 2019). Table 6.2 helps give a sense of the time required by FMs across the RIBA stages. This was taken from the IWFM '*The role of FM in BIM projects*' (Thomas, 2017, p. 15) and updated to reflect the new RIBA 2020 stages.

Table 6.2: Estimate of FM involvement in RIBA 2020 stages (Thomas, 2017)

Estimate of FM time spent during each stage of the RIBA PoW (Thomas, 2017)		
RIBA Stage	**Description of the RIBA 2020 PoW stage**	**Percentage of FM total project time**
0	Strategic definition	5%
1	Preparation and briefing	15%
2	Concept design	10%
3	Spatial coordination	10%
4	Technical design	15%
5	Manufacturing and construction	5%
6	Handover	30%
7	Use (BIM related tasks): time for POE of process and design	10%

Figure 6.6 from the UK BIM Framework reminds us of the need to define a clear hierarchy of 'information requirements' (as detailed in Chapter 5.7) and are central to the success of BIM. The OIR is the starting point and its focus should be 'high-level business related'. The AIR is more 'detailed appointment specific', the PIR are 'high-level project related' and finally the EIR should take all these into account and be 'detailed appointment specific'.

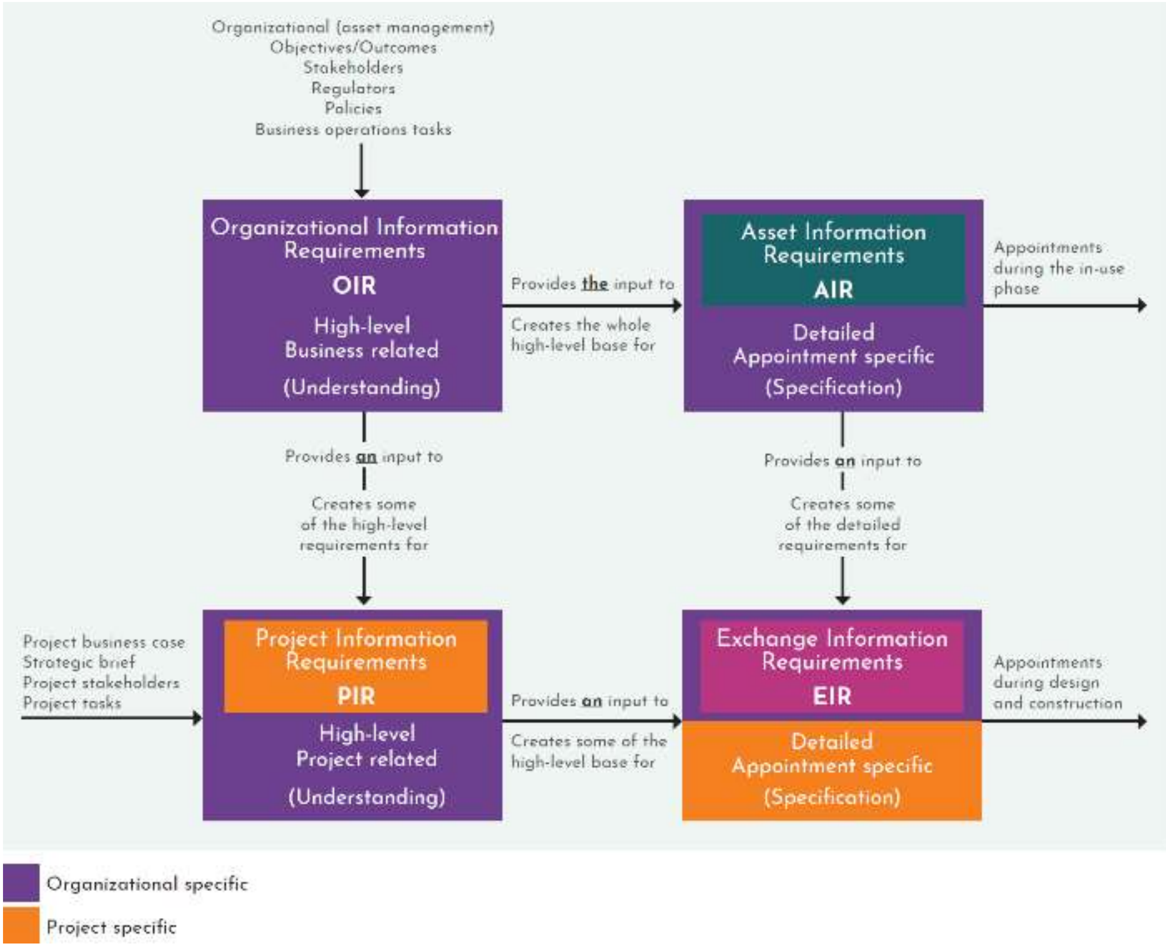


Figure 6.6: Hierarchy of information requirements (UK BIM Framework, 2020a)

However, as Heaton, Parlikad and Schooling (2019, p. 14) observed, when trying to translate the OIR, AIR, PIR and EIR into defined outputs, there is often a “fundamental lack of understanding of what information should be collected to support the efficient management of assets throughout their life”.

Experience has shown a good way of establishing the information needs of the OIR and AIR, is to develop them directly through workshops, with relevant experts from within the organisation who have a detailed understanding of the organisation’s needs. An example from this approach in practice was conducted in 2019 with the Viva Real AG (2019) organisation in Switzerland. The project team shown in Figure 6.7 included the client, Drees & Sommer (taking the BIM manager role), and Leuthard (construction partners) working together with our ZHAW university (as FM advisors) to develop their BIM strategy, OIR, AIR and EIR. The construction team prepared their BEP in parallel and the whole team collaborated to eliminate any surprises and ensure the project started with clearly defined requirements.

Figure 6.7: Collaborative OIR, AIR and EIR development (Viva Real AG, 2019)

Figure 6.8 illustrates an example agenda used during the initial workshop to explore key OIR issues. Note: the Swiss equivalent is OIA. These included: core business strategy, management and statutory reporting needs, pains and gains (used to explore where they would hope to get maximum benefit from BIM), processes, software, information needs etc.

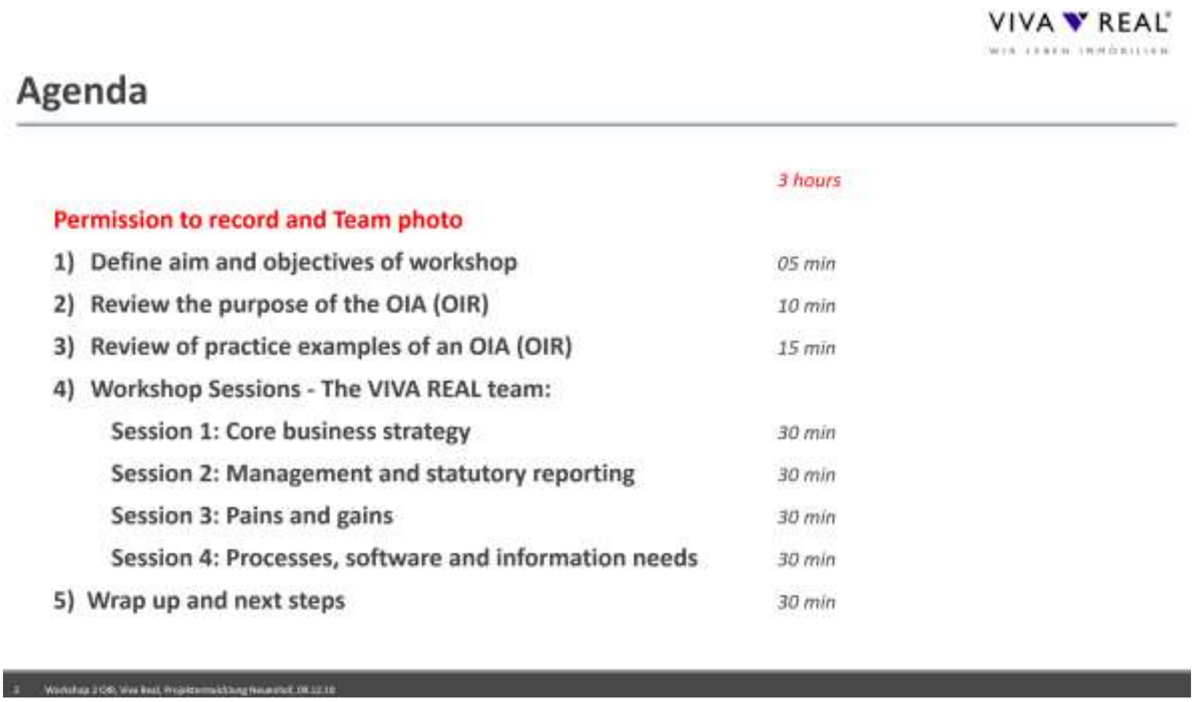


Figure 6.8: Example OIR development agenda (Viva Real AG, 2019)

The next step after the workshop was to turn the outputs into an OIR document. Similar workshops were then used to help the project team develop their AIR. This allowed the information requirements to be clear and developed in partnership based on detailed inputs from the client organisation. This workshop approach aligns with suggestions made later by Heaton, Parlikad and Schooling (2019, p. 14) who described a similar process for establishing an AIR as shown in Figure 6.9.

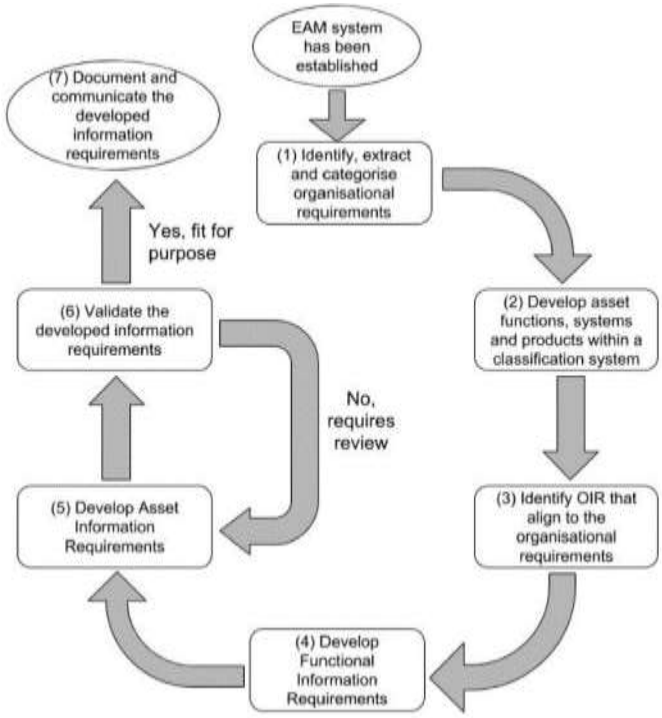


Figure 6.9: Process for establishing AIR - Heaton, Parlikad and Schooling (2019)

Experience of developing OIR, AIR and EIR documents has shown they have both ‘unique’ and ‘generic’ elements. For example, most OIR will describe ‘management reporting’ needs which usually include similar reports across many organisations e.g. H&S, compliance, energy reporting etc. With the AIR generic similarities occur as they are developed around standard building elements (most buildings have a roof, doors, windows etc.) that require maintenance etc. In this context some of the sections of typical OIR/AIR may be similar to others. However, each organisation and project is unique. As such the worst thing people can do is use a ‘copy-paste’ approach using other OIR/AIR documents without going through the process of ensuring they are specific to the organisation/project. This extends to the EIR, as was highlighted by Ford (2020) in Chapter 5.7. It is essential that project teams put in the effort at the front of the project to properly work through and define the information requirements.

Part of the role of the project team is the important task of defining who has responsibility for what, and who, is the most appropriate party to deliver specific sets of information. These responsibilities should be clearly defined in the EIR and incorporated into formal contracts using an ‘Information management responsibility matrix’ similar to the example shown in ‘*ISO 10650-2:2018: Appendix A’.*

This avoids later misunderstandings and possible legal action. Clients can download the IWFM ‘*EIR Template and guidance’* by Ashworth and Tucker (2017a), from the IWFM website which was developed specifically to meet the needs of clients/FMs. Figure 6.10 from the paper ‘*Critical success* *factors for facility management employer's information requirements (EIR) for BIM*' (Ashworth et al., 2018) illustrates the overall structure of the EIR.

0. General guidance and notes (note: this section is provided as guidance and is removed on formal issue)

1. Purpose and scope
1.1 The purpose of the EIR
1.2 Use of the terms client, client's representative and contractor

2. Client BIM and asset management strategy and objectives
3. Project details
3.1 Project information
3.2 Project contact list

4. Management Requirements	*5. Technical requirements*	*6. Commercial Requirements*
4.1 Applicable standards and guidelines	5.1 Software	6.1 Exchange of information in line with *RIBA* project stages
4.2 CIC BIM protocol	5.2 IT and system performance constraints	6.2 Supplier BIM assessment form
4.3 Project roles and responsibilities	5.3 Data exchange formats	6.3 BIM tender assessment
4.4 Existing client CAFM/IWMS or enterprise asset management systems	5.4 Common co-ordinates system	
4.5 Model creation and ongoing management	5.5 Levels of definition	
4.5.1 Planning the work and data segregation	5.6 Specified model and information formats	
4.5.2 Model management plan	5.7 Site information, floor and room data information	
4.5.3 Collaboration process		
4.5.4 Model size		
4.5.5 Model viewing		
4.5.6 Volumes, zones and areas		
4.5.7 Naming conventions		
4.5.8 Model co-ordination, quality control and clash-detection process		
4.5.9 Use of BIM to help health and safety		
4.5.10 Delivery of asset information to the client		
4.5.11 Information publishing process		
4.5.12 Security of model information		
4.5.13 Training		
4.5.14 Model audits by the client		

Figure 6.10: Overall structure of IWFM EIR guidance – (Ashworth et al., 2018)

The UK BIM Framework (2020a) noted the principle of cascading the information requirements (in a back-to-back way) to all appointed parties. **Note**: they might add their own requirements when passing the EIR to their supply chain as illustrated in Figure 6.11.

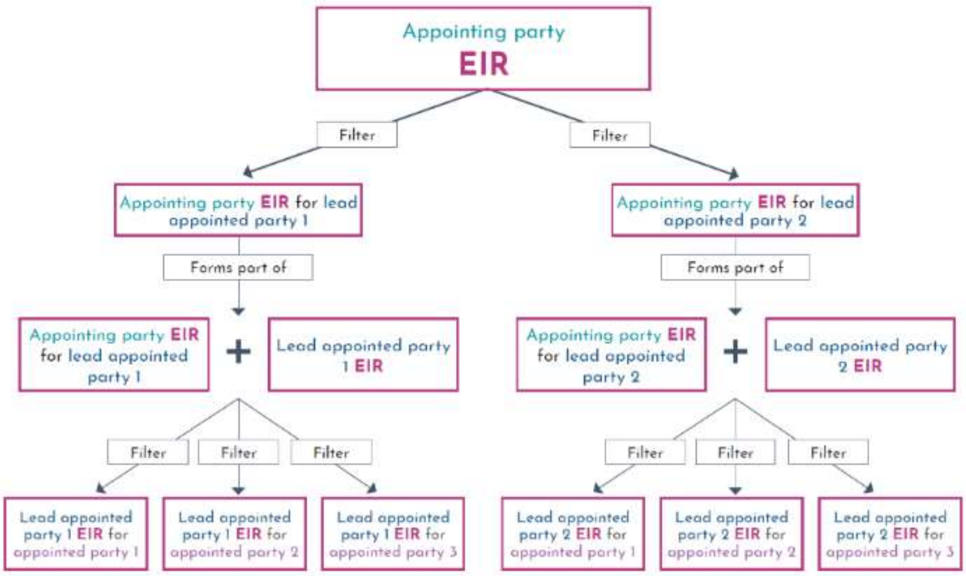


Figure 6.11: Cascading information needs using the EIR (UK BIM Framework, 2020a)

The EIR should be included in tender documentation. A BIM 'competence assessment' should be completed by the delivery parties to ensure a clear picture of their BIM competence with respect to IT capabilities, expertise, resources, BIM approach etc. Ashworth, Tucker and Druhmann (2018) stated this will help the client assess whether they have the adequate experience to meet the requirements of the EIR. It should confirm and specify aims regarding the transition of information into CAFM and other FM systems. This leads us into specific guidance for FMs in BIM projects.

6.3 Key standards and guidance for facility managers

Before starting a BIM project, clients/FMs should read the key guidance documents and standards listed in Table 6.3, specifically developed to help FMs engage in BIM projects.

Table 6.3: BIM standards and IWFM guidance for FMs (various 2014-2020)

Guidance / standard title	Aim of guidance
IWFM: '*The role of FM in BIM projects*' (Thomas, 2017)	To help (FMs) understand BIM and support them in their role as a productive member of any project or design team that is using BIM.
IWFM: '*Operational readiness guide*' (Beadle et al, 2017)	To aid FMs (FM professionals) in their role as a key stakeholder in the design and construction process. It aims to provide the perspective of the operational end user and offers advice on the processes, activities, tools and frameworks applied to deliver and operate buildings that are fit for purpose, operate optimally and provide a high level of occupant satisfaction.
IWFM: '*Employer's information requirements (EIR) Template and Guidance*' (Ashworth and Tucker, 2017)	To assist FM professionals and clients by providing an EIR template which can be edited and amended by the client or facility manager to meet individual requirements for a project that is using the BIM process.
IWFM: '*BIM Data for FM Systems: The facilities management (FM) guide to transferring data from BIM into CAFM and other FM management systems*' (Ashworth et al, 2020)	To help teams to think ahead when planning BIM projects and to be clear about what they want and how to get it smoothly into their CAFM and other asset management systems.
'BS 8536-1:2015 - Code of practice for facilities management (Buildings infrastructure)'	To include the operations team and their supply chain in the design process. It also aims to extend the involvement of the supply chain for the project's delivery through to operations and defined periods of aftercare. It gives recommendations for briefing design and construction teams to ensure that designers consider the expected performance of a building in use. The standard applies to all new building projects and major refurbishments. It also includes briefing requirements for 'Soft Landings', BIM and Post Occupancy Evaluation (POE).
'BS 8536-2:2016 - Code of practice for asset management (Linear and geographical infrastructure)'	gives recommendations for briefing design and construction teams in relation to energy, telecommunication, transport, water and other utilities' infrastructure. It aims to ensure that design considers the expected performance of the asset in use over its planned operational life. It is applicable to the provision of documentation supporting this purpose during design, construction, testing and commissioning, handover, start-up of operations and defined periods of aftercare. It incorporates the principles of briefing associated with BIM Level 2 and GSL.
BS 1192-4: 2014 Collaborative production of information. Fulfilling employer's information exchange requirements using COBie. Code of practice	defines a methodology for the transfer between parties of structured information relating to Facilities, including buildings and infrastructure. It assists the demand side, including employers with portfolio managers, asset managers and facility managers, to specify their expectations while helping information providers, including the lead designers and contractors, to prepare concise, unambiguous and accessible information.
'BSRIA Soft Landings' (2018)	To help the project team focus more on the client's needs throughout the project, to smooth the transition into use and to address issues that post-occupancy evaluation (POE) has shown to be widespread.
'Government Soft Landings - Revised guidance for the public sector on applying BS8536 parts 1 and 2 (updated for ISO 19650)'	It encourages designers and constructors to stay involved with buildings beyond practical completion. This will assist the client during the first months of operation and beyond, to help fine-tune and de-bug the systems, and ensure the occupiers understand how to control and best use their buildings.

There is not space in this work to cover these documents comprehensively. However, a few key issues are highlighted here. *'The role of FM in BIM projects'* (Thomas, 2017) and the *'Operational readiness guide'* (Beadle et al., 2017) provide a general overview of the BIM process and make detailed suggestions about: when FMs should get involved, roles of FMs and other specific BIM project team members, maturity levels, soft landings, Post Occupancy Evaluation (POE), etc.

'*BS 8536'* promotes the important principle of "design and construction for operability" (BSI, 2015a, p. 18). A detailed list in Appendix B highlights primary FM activities in preparation for a BIM project. '*BS 8536-1 Annex G'* (ibid, p75) provides a list of typical PLQ which can help the construction and operations teams. The standard uses an evidence-based approach with the focus on preparing a brief for the design team from a client/FM perspective. Before a project even begins there should be discussion of FM, operator and operation teams appointments. It notes the importance of building a link between construction and operations teams:

> The emphasis is upon greater involvement of the design and construction team with the operations team (or with the facility manager) acting on behalf of the owner and/or operator and end-users before, during and after completion of construction, with the aim of improving operational readiness in the expectation of a flawless start-up and sustained operational performance in use (ibid, p14).

It also suggests the D&C team appoints a person "responsible for coordinating all transition-related activities with the owner's representative" (ibid, p17). A key task set out in clause 4.3 requires setting 'target performance outcomes'. These should be defined at the project start and include categories shown in Table 6.4 with KPIs for checking compliance which are "digitally checkable" (ibid, p10):

Table 6.4: Key performance targets required by '*BS 8536-1'* (BSI, 2015a)

Target area	**Aim of performance outcome (from BS 8536-1: 2015, p10)**
Environmental	the asset/facility should meet performance targets such as those for energy use, CO2 emissions, water consumption and waste reduction and/or others defined by the owner and operator [see BS EN 15643-2 and Annex B (of BS8536-1) for an approach and typical measures forming a part of POE].
Social	(i.e. functionality and effectiveness) – the asset/facility should be designed and constructed to meet the functional and operational requirements of the owner such as the overall concept, context, uses, access, visual form, space, internal environment, durability and adaptability, and in operation should meet the operator's and end-users' requirements, such as utility, usability, safety, maintainability, security, inclusiveness and comfort [see BS EN 15643-3 and Annex C (of BS8536-1) for an approach and typical measures forming a part of POE].
Security	the asset/facility and the creation, use, storage and disposal of asset/facility-related information and data should meet the security requirements of the owner, operator, operations team or facility manager, as appropriate, and end-users (see PAS 1192-5 for the development of an appropriate security-minded approach).
Economic	the asset/facility should meet performance targets for capital cost and operational cost, which should be considered side-by-side to enable whole-life costs to be calculated [see BS EN 15643-4 and Annex D (of BS8536-1) for an approach and typical measures forming a part of POE].

'*BS 8536-1'* also suggests commissioning, training and handover need to be jointly planned between the 'delivery' and 'operations' teams.

The '*Soft Landings Framework*', co-authored by BSRIA and the Usable Building Trust was first published in 2012 (BSRIA, 2012) to compliment the design process and suggests providing an aftercare period for up to three years after project handover. It was recently revised by Agha-Hossein (2018, p. 1) restating the aim of "helping the project team focus more on the client's needs throughout the project, to smooth the transition into use and to address issues that post occupancy evaluation (POE) has shown to be widespread". *'Government Soft Landings'* (GSL) is similar but described by BIM Wiki (2019) as "more prescriptive in relation to the BIM process being checked against project targets". In the revised UK BIM Framework guidance '*Government Soft Landings: Revised guidance for public sector on applying BS8536 parts 1 and 2 - Updated for ISO 19650'* Philp, Churcher and Davidson (2019) observed GSL aims to enable "a smooth transition from construction to operation" in line with '*BS 8536-1'*. Figure 6.12 shows the various elements that need to come together under GSL to produce good quality EIR.

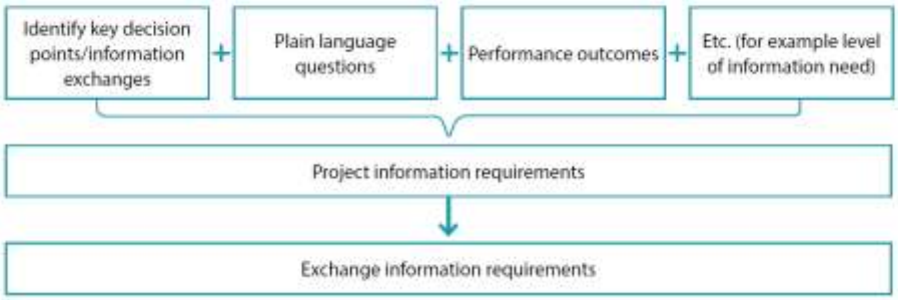


Figure 6.12: Information requirements led by GSL - Philp, Churcher and Davidson (2019)

GSL outlines tasks in line with '*BS 8536'*. A good example GSL roadmap illustrating the 'golden thread' concept is available from (NHSScotland, 2020). Figure 6.13 from '*BS 8536-1'* (BSI, 2015a, p. 13) illustrates the idea of the performance targets and POE periods (years 1-3).

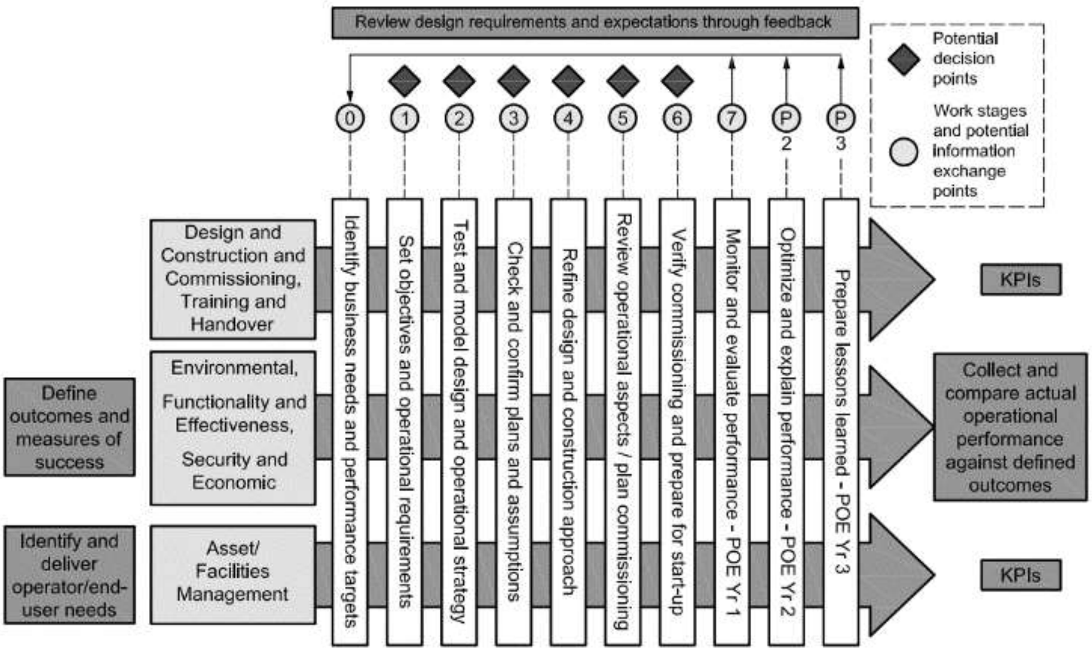


Figure 6.13: *'BS 8536-1*' importance of performance reviews/feedback (BSI, 2015a)

The PCSG online '*Step-by-step guide to using BIM on projects*' (Designing Buildings WiKi, 2019b) is a useful reference guide for using BIM on projects.

6.4 Wider benefits and challenges of building information modelling

Ashworth and Tucker (2017) suggested the role of FM in the BIM process is increasingly recognised as critical to realising the much talked about potential benefits of BIM. It is important to understand the potential benefits and challenges of BIM in order to set realistic expectations for project outcomes. Owners who understand and recognise the benefits of BIM-based FM will realise the potential, as long as it is instigated during a projects earliest stages argued Walasek and Barszcz (2017). Haines (2016) observed that the benefits across a BIM project are valuable to a wide range of participants similar to those highlighted by Butt el al. in Chapter 5.3, but with other interests in the life-cycle of BA, as illustrated in Figure 6.14.

Figure 6.14: Life-cycle participants benefiting from BIM (Haines, 2016)

The maturity and adoption of BIM (EU BIM Task Group, 2017) is now seen by many countries as the most promising catalyst to bring about change in the AEC. Governments around the world have recognised its strategic value to achieve significant economic, environmental and social benefits (ibid).

As a result, Sacks et al. (2018, p. 326) reported 15 countries worldwide have already mandated BIM for procuring their public assets. Further research by Charef et al. (2019, p. 8) shown in Figure 6.15 highlights the BIM status of the 28 EU countries as of 2017.

		Already Mandated countries						
Sources	Regulation/ Adoption State	Finland	Estonia	Luxembourg	Sweden	Denmark	Netherlands	UK
Questionnaire	Date of BIM mandate	2002/2007	2013	2016	2015	2012	2012	2016
	Early Adopters	✓✓✓				✓	✓	✓
	Late Adopters		✓✓	✓✓	✓✓			
	Very Late Adopters							
CitA Report	Date BIM adoption Verifications	2007			No Regulation	2007	No Regulation	2016

		Already planned countries						
Sources	Regulation/ Adoption State	Austria	Lithuania	Germany	Italy	Spain	Poland	Portugal
Questionnaire	Date of BIM mandate	2020	2018/2020	2016/2020	2016/2017	2018	2020	2020
	Early Adopters		✓✓					
	Late Adopters	✓✓✓	✓	✓	✓		✓	✓
	Very Late Adopters			✓		✓		
CitA Report	Date BIM adoption Verifications	2018		2020	2016	2018		No Regulation

		Will be planned countries					
Sources	Regulation/ Adoption State	France	Latvia	Slovakia	Croatia	Czech Republic	Ireland
Questionnaire	Date of BIM mandate	planned	planned	planned	planned	planned	planned
	Early Adopters		✓			✓	✓
	Late Adopters	✓✓		✓✓	✓	✓	
	Very Late Adopters	✓	✓✓	✓	✓		
CitA Report	Date BIM adoption Verifications	2017				No Regulation	

		Not yet planned countries							
Sources	Regulation/ Adoption State	Slovenia	Cyprus	Romania	Belgium	Bulgaria	Greece	Hungary	Malta
Questionnaire	Date of BIM mandate	×	×	×	×	×	×	×	×
	Early Adopters			✓					
	Late Adopters	✓✓	✓	✓	✓			✓	
	Very Late Adopters		✓✓	✓		✓	✓		✓
CitA Report	Date BIM adoption Verifications				No Regulation				

Figure 6.15: BIM implementation in EU countries in 2017 (Charef et al., 2019)

The EU BIM Task Group (2017) highlighted some key benefits from the social, environmental and economic perspectives for 'built-assets' and 'sectors' as shown in Figure 6.16.

Figure 6.16: Social/environmental/economic BIM benefits (EU BIM Task Group, 2017)

The wider 'benefits and challenges' of BIM are extensively discussed in the literature. Early examples include the *'Avanti Case Studies and Presentations*" (DTI, 2007). They concluded BIM could help "increase the quality of information, the predictability of outcomes and reduce risk and waste" (CPIC, 2013, p. para 4). Many other studies now exist considering the topics including; CRC (2007), Azhar (2011), Arayici, Onyenobi and Egbu (2012),Becerik-Gerber et al. (2012), Kelly et al. (2013), Brinda and Prasanna (2014), Korpela et al. (2015), Kensek (2015), Aziz, Nawawi and Ariff (2016), Mohanta and Das (2016), Zeiss (2018), PwC (2018), Matarneha et al. (2019) etc.

Yalcinkaya and Singh (2014) noted that the use of BIM for FM has gained global research interest. However, Sacks et al. (2018, p. 131) observed "most owners have yet to realize all the benefits associated with a life-cycle approach to BIM". Examples of key benefit areas identified in the literature with a direct impact on FM are shown in Table 6.5.

Table 6.5: Examples of key benefits of BIM to FM (various 2007-2018)

Examples of key benefits of BIM to FM from literature		
Benefit type	**Details of specific benefit**	**References**
Time and efficiency	BIM can reduce project execution time, improve faster & more effective processes, information is more easily shared, can be value-added and reused.	CRC Construction Innovation, (2007)
Performance Analysis	BIM can enable analysis for improving building performance.	Aziz et. Al, (2016)
Cost savings	BIM can reduce down time and associated costs by providing faster response times to emergency work orders.	Brinda & Prasanna, (2014)
Energy efficiency	BIM can be used to help reduce annual energy use and minimize environmental risks.	Shoubi, Shoubi, Bagchi, & Barough, (2015)
Increase business value	BIM can help reduce the probability of asset downtime due to more accurate understanding of asset condition and avoiding unpredictable component failure due to timely maintenance.	PwC, (2018)
Data accuracy /quality	BIM can empower better management and organization of information, reduce inaccuracy and incomplete information, empower the improvement of life cycle planning and improve durability and sustainability.	Mohanta & Das, (2016)
Interoperability	BIM exchange and transfer, reduces the need for major repairs and alterations, increasing the efficiency of work orders and decision-making process by access to real-time as well as previously stored graphical and nongraphical data.	Yalcinkaya & Singh, (2014)

The following summary highlights some of the key benefits for FM in operations from Saxon, Robinson and Winfield (2018, p. 8):

> Operation optimised, with likely reduction in energy use and maintenance costs; maintenance activity planning optimised; workplace planning and space management supported for occupant performance enhancement; efficiencies in safety management, remodelling and end of life; structured feedback for future projects. There is also potential for integration with digital building control systems.

During the PhD several research projects were undertaken to better understand the benefits and challenges of BIM from an FM perspective. An example was the early 'PhD pilot questionnaire' by Ashworth and Bryde (2015), which surveyed 52 IFMA members in Switzerland (See Appendix C for full write up). Several benefits were assessed and three stood out as shown in Figure 6.17:

1. Data transfer to FM management systems
2. Improved transition between construction and operation
3. Visualisation

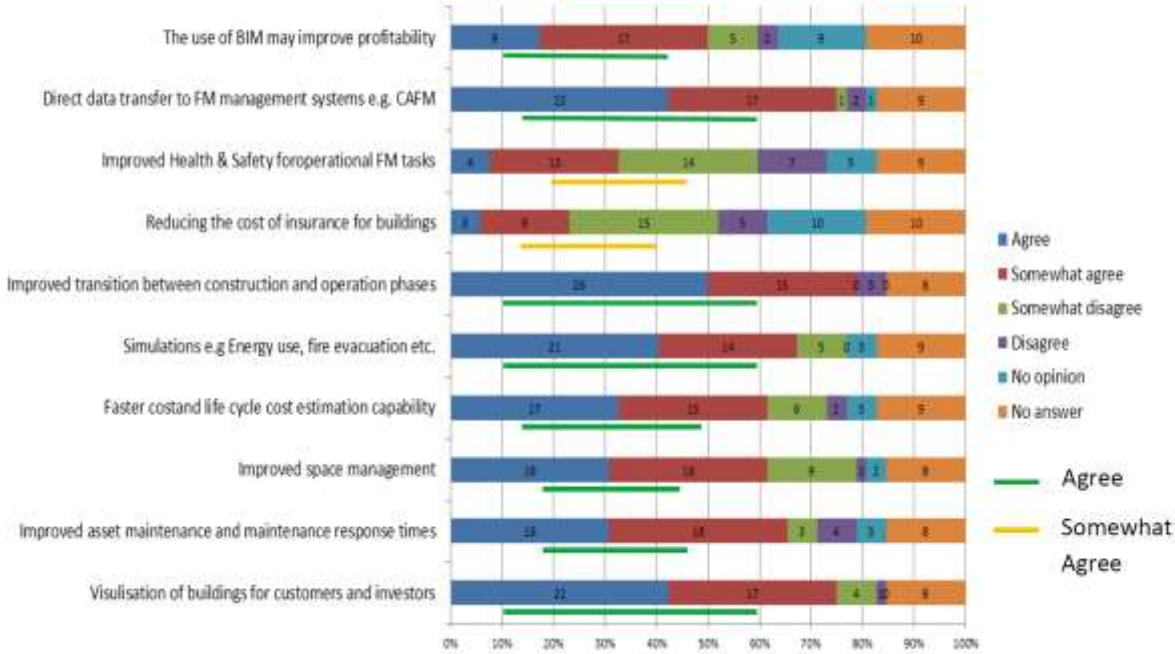


Figure 6.17: Pilot study: benefits of BIM to FM - Ashworth and Bryde (2015)

The study highlighted several key concerns shown in Figure 6.18. Ashworth and Bryde (2015, p. 3) noted the top three were: ‘data management’, ‘cost of implementation’ and ‘basic knowledge and training with respect to BIM and its benefit in operation’.

Figure 6.18: Pilot study: challenges of BIM - Ashworth and Bryde (2015)

The pilot study provided the initial guidance for the actual PhD questionnaire which was conducted in 2017. The findings were first published by Ashworth and Tucker (2017) with the BIFM in the ‘*FM Awareness of BIM survey’* and are detailed here in Chapter 13. Further research together with an MSc student, Tenny Streeter, took findings from her MSc thesis (Streeter, 2019) and expanded them, creating an online ‘*Benefits of BIM to FM Catalogue’* by Ashworth, Druhmann and Streeter (2019). The aim was to provide a catalogue of benefits for practitioners to refer to when creating business cases, and as a reference source for other researchers. A total of 373 occurrences of specific benefits of BIM to FM from literature were categorised into nine key groups. These were ranked based on the frequency of occurrence as shown in Table 6.6 with 'time savings' the most quoted category. The benefits were categorised as tangible/intangible in terms of how quantifiable they were. The findings indicated "42.35% of the benefits were quantitative (tangible) in nature and 57.64% were qualitative (intangible) in nature" (ibid, p8). The top three benefits category were: 1) time savings, 2) productivity and 3) cost savings.

Table 6.6: Benefits of BIM to FM by category - Ashworth, Druhmann and Streeter (2019)

Ranking of frequency	Type of benefits category	Percentage
1	Time savings	21.98%
2	Productivity	18.23%
3	Cost savings	16.62%
4	Business Values	14.21%
5	Data Accuracy / Quality	11.26%
6	Communication / Collaboration	7.77%
7	Energy Performance	4.02%
8	Improving safety and risk management	3.75%
9	Interoperability	2.14%
	Total	**100%**

A further list of specific benefits of BIM to FM was highlighted by Thomas (2017, p. 12) in the IWFM guide '*The Role of FM in BIM Projects'* as shown in Table 6.7.

Table 6.7: Benefits of BIM to FM identified by IWFM (Thomas, 2017)

Functional benefit	Detail of benefit of BIM to FM (Thomas, 2017)
Detailed information	About the assets installed in a property.
Centralised and up to date information	Up to date information in one place that can be shared with other systems, for example CAFM.
Cost certainty	Operational input and challenge to D&C to ensure that operational costs are fully understood and their impact to change is assessed.
Visualisation and life cycle costing	3D BIM model and its material properties enable FMs to achieve visualisation and life cycle model testing at different stages of a building's life cycle, which helps the FM demonstrate the business case for change.
Reduction of time and errors for transfer to FM systems	BIM provides a fully populated asset data set for either a CAFM or integrated workplace management system (IWMS) and reduces the time required to obtain information about assets and the cost of maintaining or replacing items. It also reduces the risk of input errors.
Avoiding loss of information	Eliminates the traditional loss of information between the construction and operational phase.
Ownership	Introduces clear ownership and a consistent change process for data management and synchronisation.
Use in tenders	Improves tender accuracy throughout the supply chain by eliminating judgement calls based on inaccurate data.

Some of the key benefits including ROI, sustainability and social outcomes and operational advantages are explored further in the next sections.

6.5 Financial benefits of building information modelling to facility management

A key question for most clients is; if we invest in BIM will it deliver a positive ROI? BIM was identified by the Government as a significant contributor to the savings of £804m in construction costs in 2013/14 (HM Government, 2015). However, one of the challenges with BIM is it is very difficult to compare 'with-and-without BIM' scenarios as buildings are usually only built once. A key issue highlighted by McGraw Hill Construction (2014) is that there are currently no standard metrics for measuring ROI on BIM. Cavka, Staub-French and Pottinger (2013) noted that BIM migration is not necessarily apparent to many, specifically large, owners. Cost modelling delivers significant benefits during the D&C project stages Eadie et al. (2015) noted, but also that there is little use through into the operational phase. However, there is a growing body of case study examples of ROI and tangible and intangible benefits which come in many forms. BIM enables FMs to perform financial forecast accurately and efficiently using cost data if it is included in the models. In terms of possible ROI of BIM Teicholz (2013, p. 1) suggested a conservative estimate of "about 64 percent, with a payback period of 1.56 years". Zeiss (2018) later reported a case study by George Broadbent using a combination of BIM & FM which estimated on average 5% of operation expenditures were saved per annum. Dodge Data & Analytics and the McGraw Hill Group have produced a series of reports which reflected on the possible ROI of BIM as shown in Table 6.8.

Table 6.8: ROI benefits to industry of BIM (various 2009-2017)

Report name	Reflections on ROI with BIM
'Leading the future of building: connecting teams' (Dodge Data & Analytics, 2017, p.7)	• "About 30% of contractors perceive high ROI (more than 25%) versus only about 11% of design firms." • "Many more architects (27%) and engineers (31%) are unsure about their ROI that general contractors (12%) or trade contractors (10%)."
'The Business Value of BIM for Owners' (McGraw Hill Construction, 2014, p.37)	In the UK two key types of ROI measured are used: • Organisations established process for measuring ROI • Comparing specific results from BIM projects to non-BIM projects
'The Business Value of BIM for Construction in Major Global Markets' (McGraw Hill Construction, 2014, p.22)	• "Companies in their early years of BIM adoption exhibit negative or break-even ROI on BIM." • "Contractors generally reach positive ROI more quickly than design professionals." • "Users with the deepest BIM engagement, as represented by their skill, years of experience and level of BIM implementation, report the highest ROI on their BIM investment."
'The Business Value of BIM in Europe' (McGraw Hill Construction, 2010, p.8)	• "Only 18% of beginners report formally measuring ROI and only 46% report that they perceive ROI to be better than break even."
'The Business Value of BIM: Getting BIM to the Bottom Line' (McGraw Hill Construction, 2009, p.10)	• "Two-thirds of BIM users say they see positive ROI on their overall investment in BIM." • "93% of BIM users believe there is potential to gain more value form BIM in the future."

Possibly the most thorough ROI research regarding BIM was the report '*PwC BIM Level 2 Benefits Measurement*' (PwC, 2018). They identified potential savings to the UK Government of around £400m a year. They also described several case studies highlighting possible ROI. Table 6.9 shows the '39 Victoria Street office refurbishment' project which reported a "3.0% savings in total" (against the 'without BIM' cost).

Table 6.9: PwC ROI case study - 39 Victoria Street office refurbishment (PwC, 2018, p. 3)

Lifecycle phase	All	Design	B&C + Handover	Operation
Time period over which benefits are realised	**4 July 2016 – 30 Sep 2029 (~13.33 years)**	4 July 2016-30 Nov 2016 (~5 months)	24 Oct 2016-20 Sep 2017 (11 months)	20 Sep2017-30 Sep 2029 (~12 years)
Est. cost of refurbishment (without BIM)*	**£22,526,574**	£1,163,406	£12,462,844	£8,900,325#
% Est. cost by lifecycle phase (without BIM)	**100%**	5%	55%	40%
Est. PV benefit from BIM L2	**£676,907**	£42,366	£141,872	£492,669
PV benefit as % of cost	**3.0%**	3.6%	1.1%	5.5%
Estimated benefits by category (% of total benefits estimated)				
Time savings in design (6.3%)	£42,366	£42,366		
Time savings in build and commission (15.3%)	£103,872		£103,872	
Time savings in handover (12.5%)	£84,520		£38,000	£46,520

A second example; 'The Foss Barrier Upgrade' (ibid, p5) reported "1.5% savings in total" as per Table 6.10.

Table 6.10: PwC ROI case study - Foss Barrier Upgrade (PwC, 2018, p. 5)

Lifecycle phase	All	Design	B&C + Handover	Operation
Time period over which benefits are realised	**April 2016 – June 2043 (27+ years)**	April 2016-May 2018 (26 months) Design and B&C undertaken in parallel		July 2019-June 2043 (~24 years)*
Est. cost of Upgrade (without BIM)*	**£23,748,302**	£2,632,317	17,683,400	£3,432,584#
Est. cost by lifecycle phase (%) (without BIM)	**100%**	11%	75%	14%
Est. PV benefit from BIM L2	**£367,693**	£132,317	£12,257	£223,118
PV benefit as % of cost	**1.5%**	5.0%	0.1%	6.5%
Estimated benefits by category (% of total benefits estimated)				
Time savings in design (36%)	£132,317	£132,317		
Time savings in build and commission (1.6%)	£5,757		£5,757	
Cost savings in clash detection (1.8%)	£6,500		£6,500	
Cost savings in asset maintenance (60.7%)	£223,118			£223,118
% benefits estimated in each phase of lifecycle	**100%**	36%	3%	61%

Following a recommendation to the Scottish Government to use BIM on public sector projects from April 2017 (The Scottish Government, 2013), the Scottish Futures Trust (SFT) developed a 'BIM Guidance Portal which provides guidance on BIM best practice and includes an evolving suite of online tools with an 'ROI calculator' (SFT, 2020).

6.6 Using building information modelling to improve sustainable and social outcomes

The cdbb (2020) note the importance of digital transformation as key to unlocking much greater value from the built environment. However, during the early years of BIM most of the focus was on its use in the design and build stages. Hosseini et al. (2018, p. 2) observed an "increasing realisation amongst practitioners that the majority of BIM benefits reside within the whole-life-cycle management". The main reason is "the phases from design to construction might typically last about 2–5 years, whereas the overall life span of the building is conservatively 20 years, probably much more" (Kensek, 2015, p. 900). Figure 6.19 (updated to include RIBA 2020 stages) illustrates how exclusively focusing on stages 0-6 might not be so sensible when we consider the relative duration of the much longer stage 7 'Use' where most of the life cost of the asset is (Thomas, 2017).

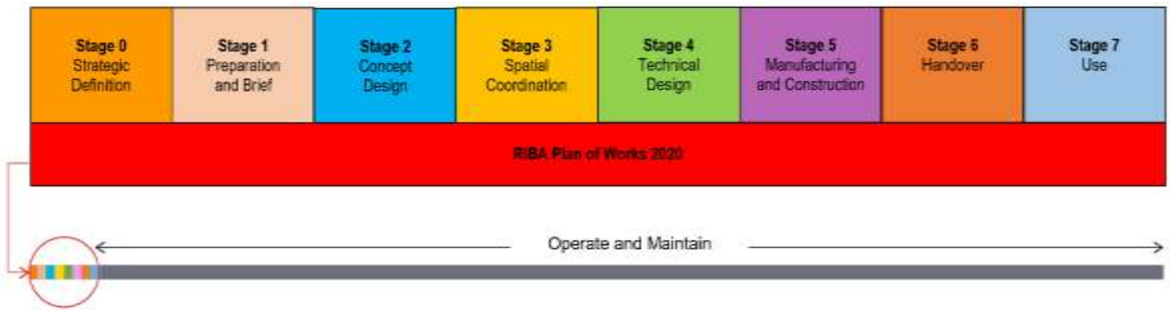


Figure 6.19: Timeline of 'use' phase's importance (Thomas, 2017)

The use of BIM to try and improve sustainability is not new as Krygiel and Nies (2008) discussed in their book "*Green BIM: Successful Sustainable Design with Building Information Modeling*". They discussed using BIM tools, to enhance building performance and to achieve the sustainability objectives of a building. Other academics like Motawa and Carter (2013) observed the performance and design of a building using BIM can expedite maximum energy savings. Solla, Lokman and Yunus (2016, p. 2412) noted it can be used to help "assessment for green building certification". Rathnasiri, Jayasena and Madusanka (2017, p. 25) described "Green BIM technology is a part of BIM and a model-based process which undertakes generation and management of coordinated building data during the building life-cycle, to improve energy performance of buildings while facilitating the accomplishment of sustainability goals".

However, Wong and Zhou (2013) suggested that the unawareness of BIM by building stakeholders has led to a shortage of green building projects.. From a WLC perspective Meslec, Ashworth and Druhmann (2018, p. 1) noted that "environmental impact and life-cycle costs are often not seen as key factors in decision making about best value solutions, yet they have a significant influence over the entire life". Fadeyi (2017) argued BIM can help design teams choosing materials and buildings systems with a WLC approach focused on durability/reliability to deliver more sustainable buildings. Chong, Lee, and Wang (2017, p. 4123) suggested "new BIM tools need to be developed for assessing related sustainability criteria throughout the project's life-cycle, including the materials used and energy consumption aspects". Yuan, Yang and Xue (2019, p. 2) noted BIM is an ideal tool to:

> integrate the assessment of sustainable construction as well as resource management efficiently, such as benefit-cost analysis of economically sustainable design, energy-consumption analysis for a sustainable built environment assessment, architectural information sharing for sustainable facilities management and stakeholder relationship management.

BIM can also be used for various simulations including light, energy, evacuations, logistics etc. Kensek (2015, p. 902) noted an example of BIM used for energy simulations: "Harley Ellis Devereaux used models of several buildings on a campus to calculate energy use intensity". Figure 6.20 shows a visual representation of how "they were then able to advise their client which buildings might benefit from energy-saving upgrades" (ibid).

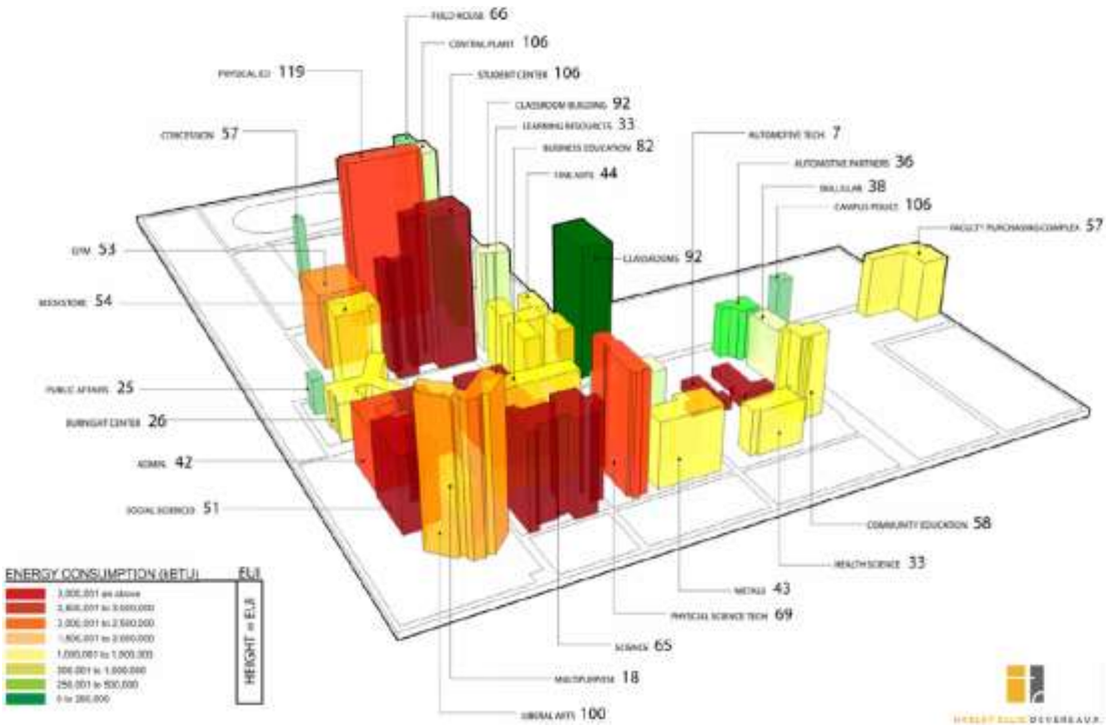


Figure 6.20: Harley Ellis Devereaux's building upgrades using BIM (Kensek, 2015)

Research by Wills and Diaz (2017, p. 3) suggested sensors will increasingly be "part of the installed real-time data systems". Connected to CAFM/BIM tools they will empower visualisation in real time for heating, cooling and lighting systems in buildings which are sensitive to the presence of people and so run to the minimal levels needed by the building occupants. However, Motawa and Carter (2013, p. 419) suggested in "the post-occupancy stage, there is a need for a proper and systematic methodology to monitor the behaviour of buildings and to make critical decisions to ensure that the energy criteria of the design are really met in practice". With respect to sustainable FM, Wills, Fauth and Smarsly (2018, p. 8) carried out a SWOT analysis which demonstrated "the applicability of using FM-relevant BIM applications for realizing sustainability objectives in FM". They used the '*GEFMA 160: Sustainability in Facility Management'* guidance (GEFMA, 2016) to show "the majority of sustainable FM criteria of GEFMA 160 exhibit opportunities and strengths using BIM for meeting the sustainability objectives" as shown in Table 6.1 by Wills, Fauth and Smarsly (2018, p. 6).

Table 6.11: GEFMA 160 FM sustainability criteria and BIM - Wills, Fauth and Smarsly (2018)

	No.	Sustainable FM criteria	Rating	Cat.	Description
Ecological quality	1	Energy management	100%	S	By installing sensors for measuring actual energy consumptions, energy consumption conditions can be monitored, reported, and controlled.
	2	Water management	75%	O	By installing sensors for measuring actual water consumptions, water consumption conditions can be determined and optimized if required. To this date, measurement methods are less detailed than in energy management.
	3	Waste management	60%	O	By installing sensors for measuring waste production, actual waste production within buildings can be determined. Until now, there are only a few possibilities for measuring user-specific waste production.
	4	Emergency management	70%	O	By installing sensors for measuring and monitoring disaster risk situations, e.g. failure of energy supply, flood or fire, accidents within the building maintenance phase can be prevented.
Econ. qual.	5	User cost management	95%	S	By analyzing data of maintenance measurements, e.g. energy consumption or water consumption, monitoring and reporting of user costs can enable an efficient cost management
Socio-cultural criteria	6	User satisfaction management	10%	T	By interviewing building users for satisfaction requirements, the user satisfaction of a building can be determined. No installation of sensors for measurements is possible.
	7	Fault and complaint management	50%	O	By collecting information concerning complaints through information management and by evaluating the complaints the elimination of potential consequences of the complaints can be achieved.
	8	Legal conformity	70%	S	By storing and by updating legal conformity information on sustainable facility management in the BIM database, legal requirements can be met.
	9	Indoor air and drinking water quality manag.	50%	O	By installing sensors for measuring toxic elements in air and water, elimination of toxic elements is possible.
	10	Building security management	80%	S	By collecting sensor data from technical installations and by reporting of building maintenance events, security can be enhanced.
	11	Occup. safety management	10%	T	By collecting data on occupational safety and by storing data to building elements relevant for maintenance, the occupational safety management can be improved.
Facility management organization	12	Operating strategy	70%	S	By storing and updating building-relevant and business-relevant objectives in the BIM database, operating strategies on sustainable facility management can be coordinated among stakeholders
	13	Personnel	10%	T	By storing data of employee qualification on each maintenance relevant task, personnel management can be supported.
	14	Procedural organization	50%	O	By storing data of sustainability management systems in BIM database, FM procedures can be organized.
	15	Documentation and reporting	90%	S	By collecting, reporting and storing all data of sustainable FM procedures, a documentation and reporting system can be developed.
	16	Procurement	80%	S	By storing information on building elements and products for building maintenance already in use, non-sustainable materials can be replaced.
Facility management service level agreements	17	Space management	80%	S	By using data from the planning phase and from the construction phase, space management can be facilitated.
	18	Operation acc. to DIN 32736	60%	O	By monitoring construction elements, agreement of operation requirements with DIN 32736 can be ensured.
	19	Maintenance acc. to DIN 31051	60%	O	By storing information on building elements concerning the period of repair and maintenance, conformity with DIN 31051 can be accomplished.
	20	Project monitorg.	80%	S	Determining and continuously controlling if sustainability objectives are met.
	21	Cleaning	95%	S	By storing data on area management, cleaning schedules and cleaning materials in use, the cleaning quality of a facility can be improved.
	22	Security	30%	W	By collecting and storing data on security services, e.g. by installing sensors to building elements measuring the quality and status of the element, security requirements can be met.
	23	Catering	20%	W	By collecting information and by storing data on the number of menus served within the maintenance phase, catering agreements can be fulfilled.
	24	Outside areas incl. winter services	50%	O	By installing temperature sensors collecting measurements of outside temperature, information pertinent to actions concerning winter services, e.g. snow removal, can be obtained.

Figure 6.21 from a presentation from Bew (2017) illustrates that BIM has the potential to deliver significant 'social performance' outcomes for society. Over time BIM is expected to reduce costs, produce better quality and smarter buildings, drive savings and improve overall usability and quality. Mark Bew as the then head of the UK BIM Task Group once commented in conversation "when BIM can deliver 5 schools for the price of 4 then politicians will also take it more seriously".

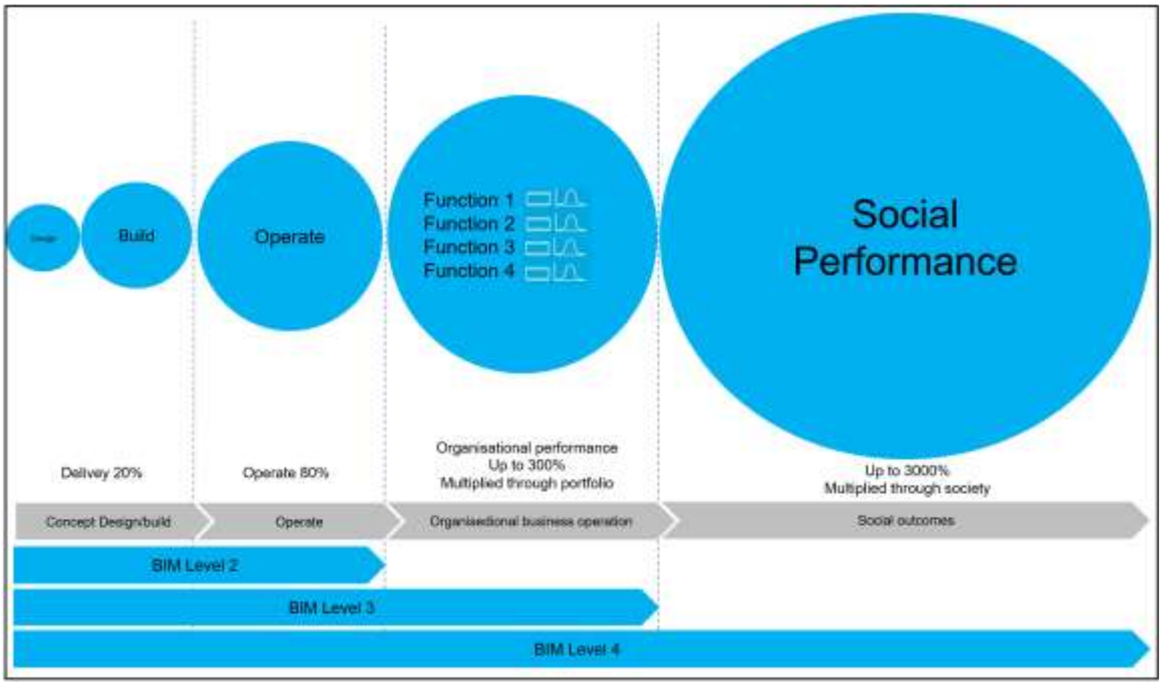


Figure 6.21: Social performance of BIM (Bew, 2017)

6.7 Operational benefits of building information modelling to facility management

Teicholz (2013, p. 2) argued in the IFMA book '*BIM for Facility Managers'* that BIM-FM integration "can provide very significant owner benefits". Zeiss (2018) noted that most of the essential data needed for daily FM operations can be captured from the BIM process including: manufacturer and purchase information, facility information, asset specifications, maintenance procedures, warranties etc. Ball (2018) agreed, adding that well-planned BIM projects with a focus on client/FM information needs will provide specific data that will help FMs make better informed decisions over the entire life-cycle of a property. They will be able to realise real benefits in many mays including; space planning, maintenance planning, energy consumption, creating cost efficiencies etc.

Another fundamental operational benefit of BIM for FM was highlighted by Kassem et al. (2015, p. 261) who argued there will be "improvement to current manual processes of information handover; improvement to the accuracy of FM data, improvement to the accessibility of FM data and efficiency increase in work order execution". From an operational perspective Teicholz (2013, p. 2) categorised benefits into three main areas; 'reducing cost', 'improving performance' and 'integrating systems as shown in Figure 6.22.

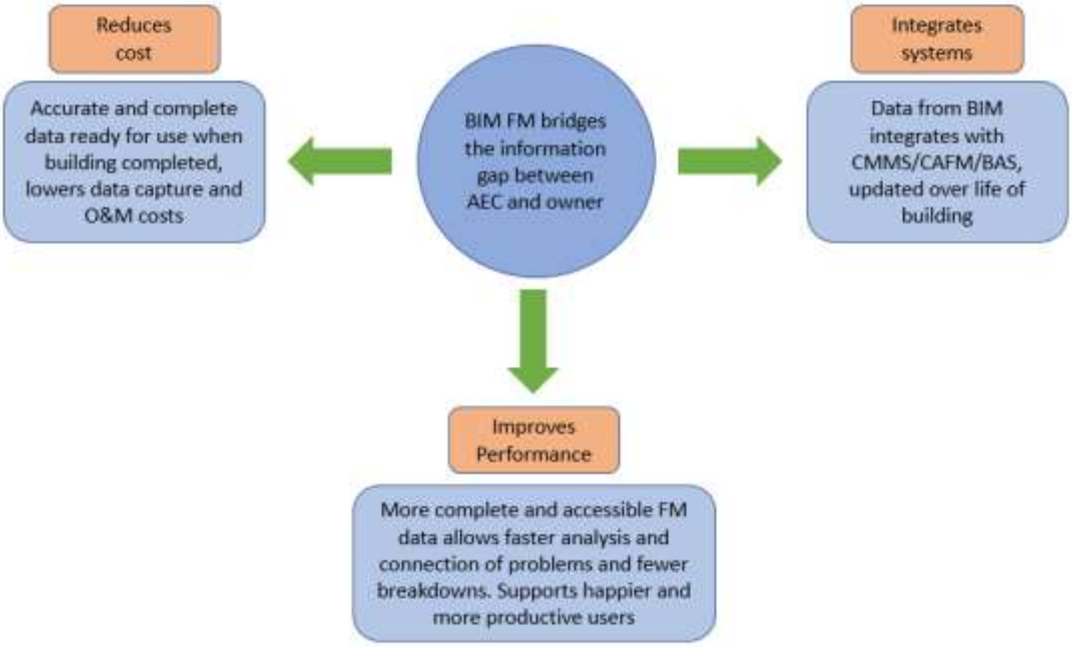


Figure 6.22: Main benefits to be achieved by BIM FM integration (Teicholz, 2013)

Another perspective suggested by Mohanta and Das (2016, p. 4), is that “BIM has the capability of acting as a FM tool”. Their model in Figure 6.23, based on earlier work by Arayici, Onyenobi and Egbu (2012), and Brinda and Prasanna (2014), highlights key FM tasks, which they argue will be made a lot easier if supported by good BIM models and data.

Figure 6.23: BIM as a tool supporting typical FM tasks Mohanta and Das (2016)

A similar model by Avsatthi (2018) considered how BIM models in Revit could support FM activities (Figure 6.24). He highlighted other key areas including ‘disaster planning’ and ‘energy efficiecy analysis’.

Figure 6.24: How FMs should use Revit BIM (Avsatthi, 2018)

Motamedi, Hammad and Asen (2014) observed visualisation through 3D models and data will empower FMs to better understand the root cause of building failure. However, Korpela et al. (2015, p. 16) noted that “FM and maintenance information systems are an essential part of building information management with their own functionalities and contents that differ from the models developed to be used in design and construction”. They added “partial, stepwise integration based on selective communication between systems may be the way forward” (ibid). Reid Cunningham, Strategic Development Director, BAM FM Ltd, observed “by combining 3D geometry with accurate data, instructions, and records for individual assets we can ensure that our employees have access to the information they need, where and when they need it” (Ashworth and Tucker, 2017, p. 5). Figure 6.25 from Codinhoto and Kiviniemi (2014) highlights the powerful visualisation aspect which enables easy access to operational information using BIM.

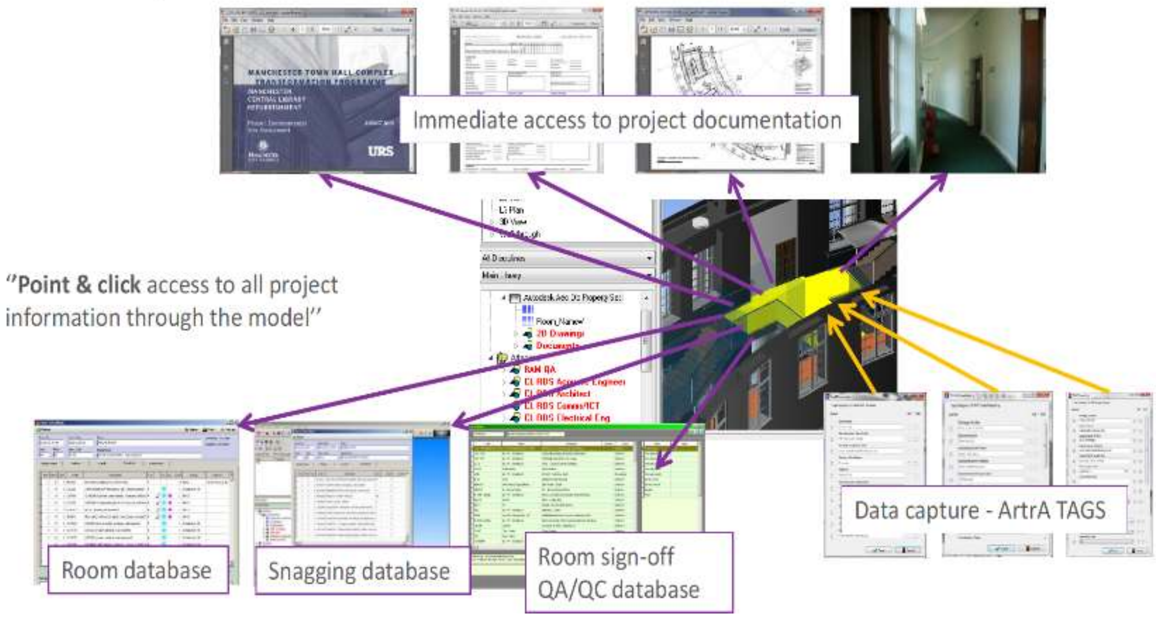


Figure 6.25: BIM visualisation within 3D models (Codinhoto & Kiviniemi, 2014)

Another good summary of operational benefits of BIM to FM is illustrated in the PwC report '*BIM Level 2 Benefits Measurement - Summary Guide'* (PwC, 2018a, p. 3). It identified eight key benefit categories showing the 'nature' and 'measurement' of the benefit as shown in Figure 6.26.

1 *Time savings* (Chapter 1; Sections 1.1-1.6)	**Nature of the benefit:** The use of BIM has the potential to result in time savings in a number of different ways, both in asset delivery throughout each stage of the asset lifecycle, and in service delivery (or business as usual) for a government organisation. For example, use of a Common Data Environment (CDE) enables easier ways of working and quicker information exchange. **Measuring the benefit:** Time savings resulting from BIM Level 2 can be monetised by calculating the corresponding reduction in (1) *direct labour cost*; or (2) *time-dependent recurring preliminary costs* (in the case of an overall reduction in the duration of a project). If time savings result in accelerated project delivery (and project benefits are brought forward in time), the net present value (NPV) of the project may also increase.
2 *Materials savings* (Chapter 2; Sections 2.1-2.2)	**Nature of the benefit:** Use of BIM Level 2 has the potential to result in materials savings in the 'build and commission' and 'operation and end of life' (maintenance, refurbishment, etc.) stages of the asset lifecycle, by reducing the volume of materials required (including reducing wasted materials). **Measuring the benefit:** Materials savings are estimated by calculating the change in the amount or type of materials used, and applying the cost of each type of material to the reduction in quantity. There may also be corresponding environmental benefits from using fewer materials. These are estimated by applying the 'embodied carbon value' as a proxy for the total environmental impact to the reduction in the material's quantity (in line with Green Book guidance).
3 *Cost savings* (Chapter 3; Sections 3.1-3.7)	**Nature of the benefit:** Application of BIM Level 2 has the potential to result in other, broader cost savings across the asset lifecycle where it is difficult to distinguish the component time and materials elements. The benefits framework includes for example, cost savings from fewer changes, better clash detection, and improvements in facilities management and maintenance. **Measuring the benefit:** Cost savings may be estimated in a number of ways, depending on the specific saving in question. In general, savings can be quantified by determining the change in the number of instances of a particular event attributable to BIM Level 2 (e.g. the number of changes); and monetised by applying the average cost of each instance (e.g. average cost of undertaking a change).
4 *H&S Improvement* (Chapter 4; Sections 4.1-4.2)	**Nature of the benefit:** The use of BIM Level 2 can contribute to health and safety improvements, throughout both the 'build and commission' and 'operation and end of life' stages of the asset lifecycle. For example, a 3D model provides the visual basis for improved staff briefing and training, with further potential provided through 4D-type simulations, (including construction and demolition activities), to optimise sequencing from a safety perspective. **Measuring the benefit:** Benefits from improved health and safety are quantified by determining the difference in the number of fatal and non-fatal injuries and work related illnesses attributable to BIM Level 2; and monetised by applying the cost to society per accident, incident or work related illness (using values published by the Health and Safety Executive (HSE)).
5 *Risk reduction* (Chapter 5; Sections 5.1-5.2)	**Nature of the benefit:** The use of BIM Level 2 has the potential to improve the accuracy of information about a project or asset, and improve visibility about associated costs, delivery timeline, and risks. Because of this increased certainty provided by BIM Level 2, there is a potential for a reduction in the variability of costs and time required for asset delivery and operation. This may result in the ability to reduce the contingency required against capital expenditure and/or operating expenditure, thus resulting in a reduction in costs associated with that contingency. **Measuring the benefit:** Benefits from reduced risk are quantified by determining the reduction in contingency attributable to BIM Level 2; and monetised by applying the opportunity cost of capital to the change in value of the contingency. *(UK Government opportunity cost of capital = social rate of time preference = 3.5% pa – Green Book).*
6 *Improved asset utilisation* (Chapter 6)	**Nature of the benefit:** The use of BIM Level 2 can improve the availability of an asset once it has been constructed: this means that it can potentially be used more productively over its lifetime to provide public services. Better space utilisation planning; faster maintenance and refurbishment through use of an asset information model; and faster BIM enabled response to incidents; can all improve asset availability, or reduce an asset's downtime. **Measuring the benefit:** Benefits of improved asset utilisation are quantified by determining the increase in productivity (%) or reduction in downtime attributable to BIM Level 2; and monetised by applying the relevant value for that productivity increase (either the avoided cost of downtime [*e.g. cost to rent an alternative classroom while regular classroom is unavailable*], or the social benefit that would be lost through downtime [e.g. *cost to society of students foregoing education while classroom is unavailable – more difficult to measure*]).
7 *Improved asset quality* (Chapter 7)	**Nature of the benefit:** Use of BIM Level 2 brings improved visibility over the process of design and construction, which can enable improved quality of the asset for the end-user. For example, BIM's 3D and 4D visualisation capabilities may result in a building being better laid out, or more pleasant to be in (the building may be angled to get more sunlight for example). **Measuring the benefit:** The impact of improved quality depends on the asset, what it is used for, and how improved quality can directly affect user outcomes. Examples of direct quality effects that may be quantified are reduction in staff turnover as a consequence of improved staff morale or satisfaction with the working environment; or reduction in the length of hospital stays due to improved building amenity contributing to quicker recovery times.
8 *Improved reputation* (Chapter 8)	**Nature of the benefit:** The application of BIM Level 2 could potentially improve the reputation of government construction clients and asset owners, and the supply chains involved in asset delivery; by improving the experience of those associated with asset delivery and service delivery. For example, in asset delivery, use of BIM Level 2 may result in better site layout and improved logistics. This could reduce (or avoid) negative impacts on residents, businesses and customers who reside near the construction site. **Measuring the benefit:** Improved reputation is difficult to quantify, and often intangible. It may be possible to quantify through use of surveys, however difficulty arises in attributing reputational improvements to BIM Level 2 because many factors contribute to reputation, and it is difficult to isolate the extent to which each is responsible.

Figure 6.26: PwC BIM Level 2: benefits summary (PwC, 2018a)

What is clear is that in order to realise the operational benefits we need to plan what data to capture and how to structure it so it can be used over BAs' whole-life.

6.8 The importance of well-structured data

Mark Bew (who was the Head of the UK BIM Task Group) observed,

> the data created as part of the design and construct process is of vital importance to the safe and effective delivery of an operational strategy. The value of data derived from BIM is rich in detailed content, which in future will provide insights previously un-thought of as we start to integrate active sensor and condition monitoring strategies and the potential disruptive maintenance opportunities this will provide (such as the concept of Uber FM) (Ashworth & Tucker, 2017, p. 1).

The importance of data to organisations today was highlighted by Pettey (2017) who observed "the emergence of a chief data officer (CDO) in many organizations and across industries indicates a growing recognition of information as a strategic business asset". Findings from CBRE (2017, p. 5) confirm this trend: "75% of occupiers cite data as key to achieving strategic real estate goals". Hollander (2019) further underlined data's importance suggesting "the success of your organization probably depends on the information you need to store, protect, and of course, access when you need it". However, Blueberry Consultants (2020) noted: "information is only a valuable commodity if it can be used effectively". The National Infrastructure Commission (2017) argued high-quality data, used efficiently is the key, allowing it to be distributed and easily understood. The UK BIM Alliance (2018, p. 5) agreed, noting that "structured data is the essential element to enable communication in a digitally built environment" and Saxon, Robinson and Winfield (2018, p. 8) added it will allow "a 'single source of truth' for everyone and a 'golden thread' of continuity across the life-cycle".

In order to efficiently share/use data between stakeholders and their management systems projects need to have well-defined information requirements and consider using a classification system to standardise the data format from the outset. However, ABAB (2017) suggested this can be challenging for clients/FMs as it's not a question they regularly have to think about. Chen, Mao and Liu (2104) observed another challenge, the sheer quantity of data people need to manage; and Assunção et al. (2014) that complexity of data use quickly increases where several data types are combined for interpretation. The UK BIM Framework (2020a, p. 6) suggested information must be structured "using industry standards to help improve interoperability so that information can be joined-up by people and technology. This enables us to extract more valuable knowledge from it". Kelly (2018) agreed adding "we need standardised data libraries and open systems that can be utilised by any CAFM or asset management systems".

The UK BIM Alliance (2019) argued the client and project team need to ensure the right approach from the start and set clear objectives to help the project outcomes. Table 6.12 highlights their suggested list of 'factors' and appropriate 'target outcomes' in line with the '*ISO 19650'* series' which teams should adopt.

Table 6.12: Setting successful BIM project objectives (UK BIM Alliance, 2019)

Factor	ISO 19650 and (UK BIM Alliance, 2019) suggestions for successful project outcomes
Clear definitions	"Clear definitions for the information needed by the project client or asset owner, and for the standards, methods, processes, deadlines and protocols that will govern its production and review" (p.13).
Quantity/quality of information	"The quantity and quality of information produced being just sufficient to satisfy the defined information needs, whilst not compromising health and safety or security. Too much information represents wasted effort by the supply chain and too little means clients/owners take uninformed decisions about their projects/assets" (p.13).
Transfer of information	"Efficient and effective transfer of information between those involved in each part of the life cycle – particularly within projects and between project delivery and asset operation" (p.13).
Decision making	"Informed and timely decision making" (p.13).

In summary the (UK BIM Alliance, 2018, p. 7) suggested data should be structured and:

1. Defined in a standardised way, i.e. identified by naming conventions
2. Presented in a standardised format
3. Transferrable and translatable between users of the data and their software choices, i.e. interoperable

However, they highlighted a problem; "there is no universally agreed definition of what structured data is within the built environment" (ibid). The situation is not helped by the fact that even when data is structured, people in the same project teams often use different dictionaries, classification systems and terminology to often refer to the same thing. This can lead to confusion and often wasted time and effort. As discussed in Chapter 5.3, to try and help this situation the Government adopted Uniclass 2015 as its chosen classification system for its projects together with COBie to try and ensure project teams have a common frame of reference for structuring and exchanging data. The UK BIM Framework (2020a, p. 6) added an important thought for the future; it will become even more important to structure data in the future to ensure it is 'machine interpretable'.

A recommendation is that project teams hold 'exploratory discussions with client operational departments (FM, IT, core functions etc.) to establish what they really need; explain the process; and ensure expectations are managed. In these first steps it should be clear how the BIM models, information and documents will be used in operation. Law (2017, p. para 5) argued that adopting this type of reverse engineering approach (discussed in Chapter 5.6) will help "define what the 'I' is that you need to put into your model". Other important aspects to the 'I' in BIM are; 'interoperability', to ensure seamless use of data across different software systems (cobuilder, 2016); and as Cantrill and McCombe (2018) stated, checking 'intellectual property rights' to ensure clients have access to and can use their data.

The RIBA 2020 PoW adopts a similar approach: "the most effective means of collating this information is to make sure that the BIM model includes the relevant data structure from the outset and that the information is added as the design progresses" (RIBA, 2020, p. 120). It suggests where data/documents are to be provided separately or at a later stage e.g. O&M manuals etc. then "the client needs to clearly specify their requirements so that the necessary data are compiled as the design and construction phases progress" (ibid) which should be done in the EIR.

Level of information Need (LOIN) is another important topic and '*ISO 19650-1'* suggests "each information deliverable should be determined according to its purpose. This should include the appropriate determination of quality, quantity and granularity of information" (ISO, 2018b, p. 23). The standard recommends the LOIN "should be determined by the minimum amount of information needed to answer each relevant requirement, including information required by other appointed parties, and no more" (ibid). **Note**: previously the UK used the term LOD (as the aggregate of level of detail and level of information).

In an ideal world, the delivery team would develop BIM models using quality 'BIM-objects'. These are created by manufacturers and come with well-structured information based on standards like the '*NBS BIM Object Standard'* (NBS, 2019). Such objects will increasingly be the norm in the future as object libraries become common place. They are already available from various pre-defined online libraries such as the NBS National BIM Library (NBS, 2020b) or BIMobject (bimobject, 2020). A list of free object library suppliers is available from cad-addict.com (CAD Addict, 2020).

A key question to which there is currently no standard answer is 'what FM criteria should organisations capture from the BIM process and how should this be defined in the AIR?' A common demonstration of BIM models involves people clicking on BIM objects which then opens up a list of fields that could have data in them. But usually the fields are empty, as such they are useless. The key is planning what fields (criteria) should be included in the model(s) and how does the right data get there. The author suggests a 'minimal useful' approach is taken (similar to the Pareto 80:20) to identify what is really useful. For example, if a lift breaks down FMs do not need long lists of criteria to get it fixed. They probably just need 4-5 criteria to resolve the situation e.g. the lift's make/model, serial or asset number and a service-contract phone number. Further information can usually be obtained from the manufacture's product data sheet. A significant challenge has been identifying a 'minimal useful' list of FM criteria for a typical BIM project. Together with Professor Hubbuch (2020) at the Institute for Facility management (IFM) in Wädenswil Switzerland a suggested list was drawn up as shown in Appendix D. Project teams should take a similar approach and meet with the operational teams to clearly define exactly what is needed.

6.9 The importance of data transfer into facility management systems

From the FM perspective Hampl (2016) noted that the lifeblood of BIM methodology is data, which, if realised in the early stages can provide financial benefits to investors. Ultimately BIM projects are only successful if the delivery teams final collated PIM is handed over successfully to become the AIM (the 'single source of truth': documents, 3D models and alphanumeric data) and that it "supports the client's strategic and day-to-day AM/FM processes" (ABAB, 2017, p. 5). Indeed, "the entire theoretical framework of BIM data being used for facilities management is predicated on the assumption that data can be exchanged easily between software programs, specifically BIM and FM" (Kensek, 2015, p. 904). Where this is done well it will ensure "accurate information that can be used to improve the operation and maintenance of the asset over its whole-life" (Ashworth et al., 2020). The ideal solution is an AIM with 'bi-directional' data exchange links with other enterprise management systems as illustrated in Figure 6.27 from '*PAS 1192-3'* (BSI, 2014a, p. 13).

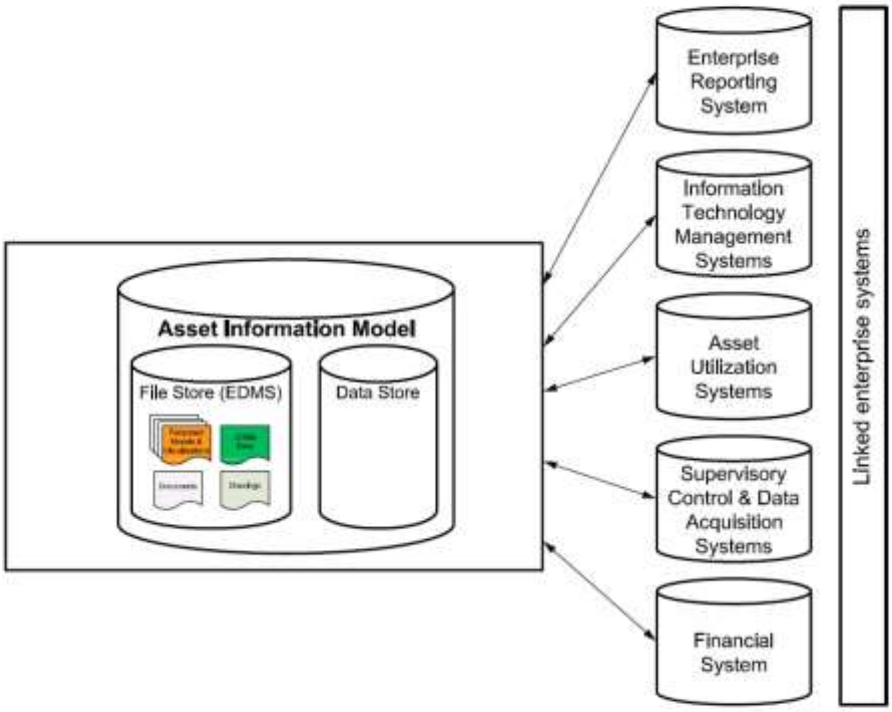


Figure 6.27: Interface between AIM and other management systems (BSI, 2014a)

Saxon, Robinson and Winfield (2018, p. 8) noted a key benefit of BIM is "the as-built O&M information can be loaded into the client's Computer Aided Facility Management (CAFM) system and managers trained before handover on the virtual building". Time reduction in acquiring relevant information relating to assets, and maintenance/replacement costs and the reduction of input errors are also key elements added Thomas (2017) However, in reality Clayton, Ozener and Nome (2009, p. 2) noted it's a major challenge to "link the complex and information rich BIM models to CAFM systems for simplified and applicable information for FM". Even in 2020 the RIBA 2020 PoW noted, "many CAFM systems are not currently capable of managing BIM information, but this will happen in time" (RIBA, 2020, p. 107). As such it is important clients/FMs consider if there is a target CAFM/Integrated Workplace Management System (IWMS); if it is capable of accepting BIM data; and how the AIM will be accessed/used by the operations team in practice.

Another important aspect to consider is that BIM projects will often just be a part of a FMs day-to-day management activity. Key to FMs is establishing how the BIM models, data and documents will actually be accessed and used by the operational teams in practice. This is important to ensure positive engagement as FMs and their operational staff will generally not use native BIM software such as Revit or ArchiCAD. Unless a way is found to make the information accessible, there is a danger it will not get used to its fullest potential (resulting in a data cemetery) as was discussed in the focus group. We need to accept that until the AIM (final as built models/data/documents) are more integrated (with bi-directional exchange capability) the AIM will likely be used either:

1. As a static repository and accessed when information is needed to support tasks, or
2. Transferring one-way transfer into other management systems (or hopefully bi-directional linking)

In reality project teams must remember FMs will need a BIM viewer tool to visualise 3D models, but they will not be likely to amend or alter the native models. It is also important for FMs to note that the alphanumeric data and documents are often the most useful part of the 'I' in BIM, and normally they would look to transfer or use such data in their CAFM/IWMS and other management tools.

Gnanaredam and Jayasena (2013, p. 20) noted BIM helps "promising integration of BIM with CAFM" for the future, and Naghshbandi (2016, p. 683) argued, "integration of BIM and FM systems is an inevitable event". Integration will improve with the growth of digital twins. Innovative companies such as Ecodomus are providing middleware solutions which can bring data together from various sources (arguably providing an aggregated single source of truth) and interfacing between different tool as shown in Figure 6.28 from (Starkov, 2020).

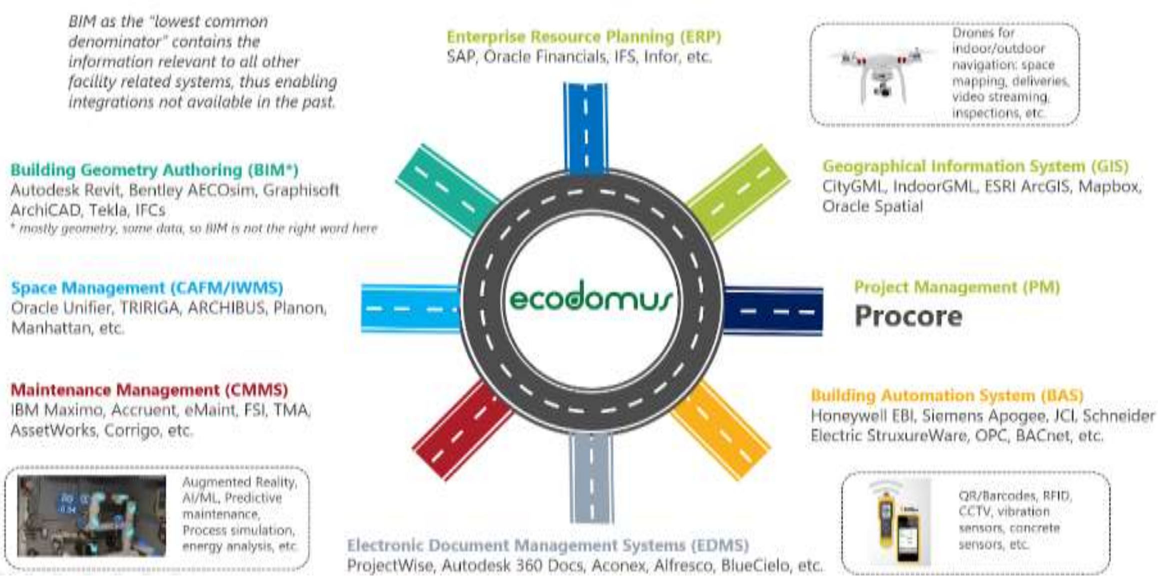


Figure 6.28: Integration of information systems – Ecodomus example (Starkov, 2020)

CAFM/IWFM systems are key to many FM activities. To understand why they are so important to FMs one can refer to the articles '*The Business Benefits of a CAFM Solution – 65 reasons you need CAFM'* (Idox, 2015) and '*31 Reasons Why You Need A Computerized Maintenance Management*

System' (Christiansen, 2019). Clarke (2018) argued that such systems deliver significant value in terms of ROI for organisations. Some of the benefits she identified are shown in Table 6.13.

Table 6.13: ROI business case benefits for CAFM/IWMS (Clarke, 2018)

IT	**System spend**	**Eliminate multiple licences & system sustainment fees for legacy systems**
Staff time	Real estate and lease management	• Reduce time on reporting • Reduce time abstracting lease information into IT systems • Reduce time on lease compliance activities
	Space management	• Reduce time on space surveys and data gathering • Reduce time on space utilization reporting • Reduce time on employee move management
	Room booking	• Reduce time on meeting room monitoring • Reduce administrator time to book rooms
	Maintenance management	• Reduce time spent on reporting • Reduce time spent inputting data and eliminate duplicate data entry • Reduce time managing contractors • Reduce time maintaining an asset inventory • Avoid wasted reactive maintenance spend
	Energy management	• Reduce time on utility bill management • Reduce time on energy reporting
	IT	• Reduce IT staff time maintaining multiple legacy systems • Avoid wasted time responding to system crashes
Operational costs extended savings	Energy costs	• Savings from reducing energy wasted during out-of-hours consumption
	Occupancy costs	• Savings from eliminating wasted real estate space or avoiding taking on new space as a business expands
	Outsourced contracts	• Savings achieved by negotiating better terms for facilities management and maintenance contracts based on facility data

FMs are recommended to read the IWFM guidance '*BIM Data for FM Systems: The facilities management (FM) guide to transferring data from BIM into CAFM and other FM management systems'* (Ashworth et al., 2020, p. 3). It "provides advice regarding planning what data requires collection, by whom and when in the BIM process". The CAFM/IWMS supplier should also be involved to discuss how the data will be transferred/linked to the proposed tool in operation, noting this may involve some mapping of data.

In a BIM project there may be a need to tender for a new CAFM if the client organisation does not already have one. Figure 6.29 provides a flow chart to help FMs decide if a CAFM is needed (Thomas, 2017, p. 34). He recommended '*BS 8587:2012*' (BSI, 2012) which lists requirements that should be considered when choosing a CAFM.

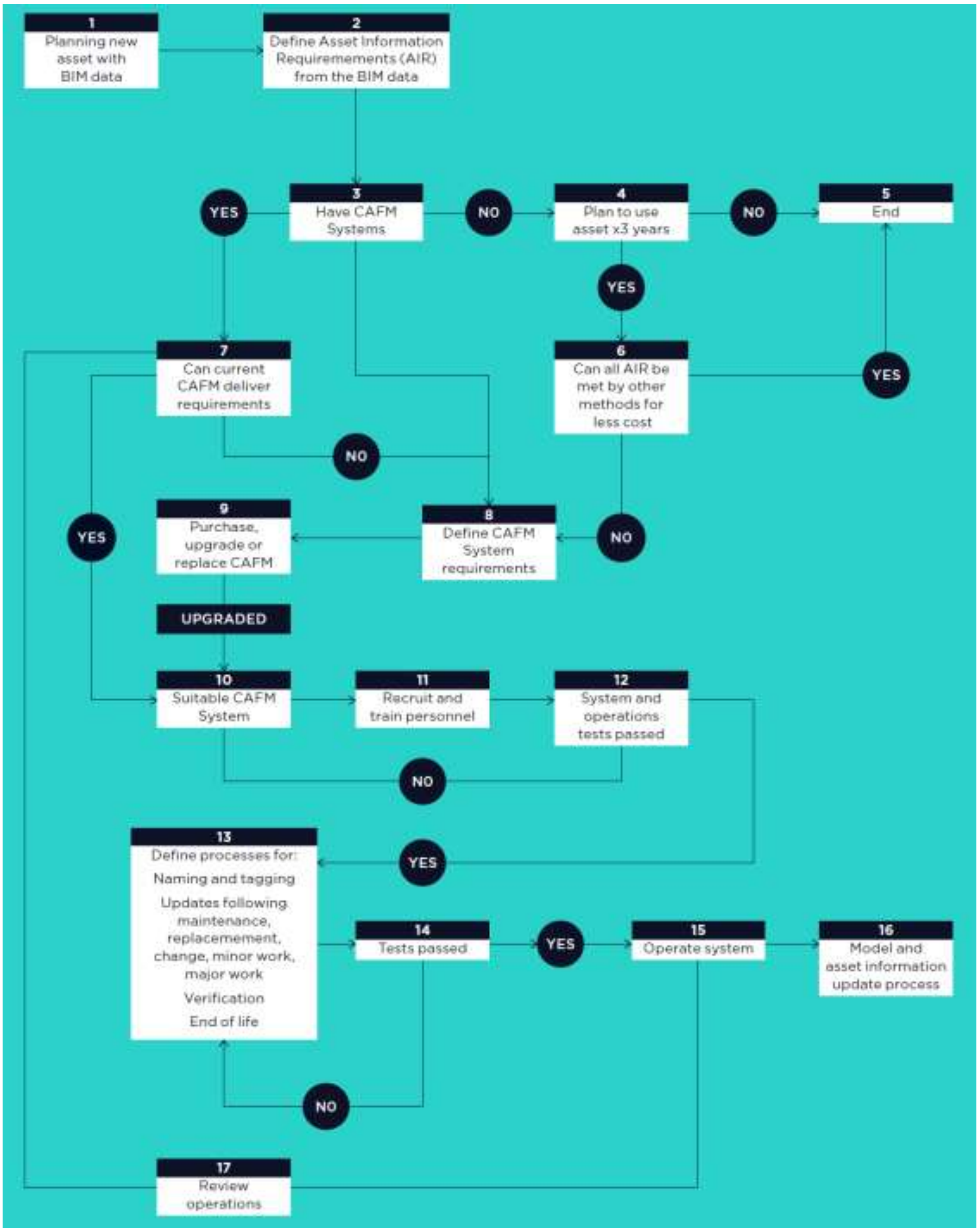


Figure 6.29: Flowchart – Determining if a CAFM system is required (Thomas, 2017)

As discussed in Chapter 5.10 COBie is important to consider as there is a high possibility it might be used to transfer data between BIM models and CAFM/IWMS. “Until the integration of 3D files becomes common across FM information systems, it is likely that the COBie will be the default basis for the data environment within the BIM model” (Ashworth et al., 2020, p. 17). Florez and Afsari (2018, p. 7) argued it will help “deliver accurate information to the owner in a format that can be used for facilities management". Clients and FMs are recommended to familiarise themselves with '*BS 1192-4:2014'* for COBie, providing guidance for its use in "defining expectations for the exchange of information throughout the life-cycle of a facility" (BSI, 2014, p. 1).

Yalcinkaya and Singh (2016, p. 2) noted COBie is the UK Government's nominated information exchange schema for federated building information management to meet the requirements of BIM UK level 2 together with 3D BIM models and PDF documents. Due to the need for humans to be able to read the files a "spreadsheet has become the most common way to represent COBie". They added however, that "depending on the delivery phase and the project size, a COBie spreadsheet can include thousands of rows of facility data" (ibid), and often regarded as being user hostile. It has "weaknesses and FMs believe if they ask for COBie they get everything they need. This may not be the case for sophisticated assets" (Ashworth et al., 2020, p. 17).

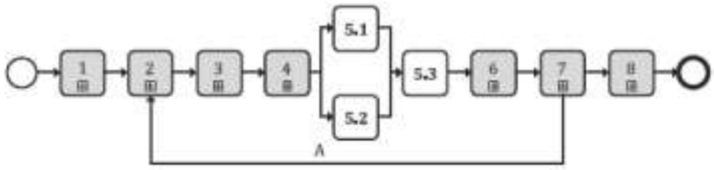
As a possible alternative Hosseini et al. (2018, p. 11) proposed the idea of a 'COBie-Lite' to "establish the appropriate type of data and information, depending upon their business case and goals vis-à-vis blindly adopting COBie in its entirety". Whatever approach is adopted it is important FMs work with their operations teams to "specify key fields that must be included in the COBie or IFC export" (Ashworth et al., 2020, p. 20), and remember that "COBie can only export data that is already within the model(s)" (ibid). The IWFM guidance provides two case studies about use of COBie and data mapping, and Lavy and Jawadekar (2014) have three case studies which can be referred to. Thomas (2017, p. 17) recommends that a "manager should be appointed who is responsible for control and verification of the data". This is discussed in the next section.

6.10 The role of the information manager in quality control of information handover

The role of 'Information Manager' is becoming more important in BIM projects. Davies, Wilkinson and McMeel (2017) noted the role should support the client in having an "oversight of the information requirements of the entire project". However, Mosey et al. (2016, p. 28) noted there "remains a lack of clarity as to who should take on the role of BIM Information Manager and how this interfaces with the role of the design lead as party responsible for BIM model coordination".

Croft, Winfield and Lewis (2020) suggested clients should consider using a BIM protocol in their contracts, e.g. the new UK BIM Framework '*Information Protocol to support BS EN ISO 19650-2 the delivery phase of assets'*. Note: this will replace the '*CIC BIM Protocol*' (CIC, 2018a). Parties should be aware that they are obliged to appoint a person to undertake and manage information. Responsibilities for information management should be clear for both the 'appointing' and the 'appointed' stakeholders in a BIM project. Clause 5.1.1 of '*ISO 19659-2'* suggests "nominating individuals from within the appointing party's organization to undertake the information management function on behalf of the appointing party" as well as possible other arrangements (ISO, 2018d, p. 3). An 'Information management assignment matrix, as per Annex A (Ibid, p24) of the same standard should be used to clearly define responsibilities.

Teams can refer to Figure 6.30 from the standard which shows key steps which should be taken for the mobilisation of the information management process (ibid, p18).



Key

5.1 mobilize resources

5.2 mobilize information technology

5.3 test the project's information production methods and procedures

A information model progressed by subsequent delivery team(s) for each appointment

NOTE Activities shown in parallel are to highlight that these activities can be undertaken concurrently.

Figure 6.30: Information management process mobilisation steps (ISO, 2018d)

The standard provides guidance in section 5 on the "information management process during the delivery phase of assets" including what appointed parties have to do during the project to undertake quality assurance checks'' (ibid, p3). Section 5.8 specifically addresses 'project close out' actions including "which information containers will be needed as part of the asset information model" (ibid, p22).

Before any exchange of information it is imperative that acceptance and approval procedures within the verification and validation methods is established and recorded and that the information received is fit for purpose (ISO, 2018b). This will involve "a mixture of manual and automated methods" (UK BIM Alliance, 2019, p. 21).

There are various tools being developed which aim to check data quality automatically, e.g. LIBAL (LIBAL, 2020), EcoDomus (EcoDomus, 2020), BIMQ (AEC3, 2020), BIMspot (bimspot, 2020), Plannerly (plannerly, 2020), Onuma COBie checker (Onuma, 2020), IFC Check (IFC Check, 2020) and Sglr (Singular, 2020). There will always be an element of 'human checking' needed to verify the actual quality of what is provided.

6.11 Updating and archiving BIM models and data

Each appointed party in the delivery team must use the CDE to review and provide the most up to date BIM models and information (UK BIM Framework, 2020a). However, with respect to updates after handover some important aspects often get forgotten.

- Model updating: a policy should be established to determine how models are maintained over their life and to ensure this is viable to meet the ongoing needs of the organisation.

- Archiving: it is very important that a process is in place to enable the continued availability of information that is archived, otherwise there is a risk that this information will be lost.

Suerth (2018, p. para 12) suggested clients/FMs should think about certain questions at the start of a project, including, "who will be updating the Building Information Model? Will you hire staff in-house? Will you contract out to a third party? If a piece of equipment needs to be replaced, who will update that data in the system?"

Importantly, Sacks et al. (2018) noted that small works or renovation projects will generate changes which need to be updated in BIM models. They suggested any changes are detailed and amassed to allow periodic updates to the BIM models. The need to "create workflows in order to manage the update process continuously so that the model remains a reliable source of information" is cited by archidata (2020).

The NBS offers tutorial video advice to clients whose BIM models were created using Revit on keeping objects up to date (NBS, 2017). BIM can be perceived similarly to CAD drawings, in the sense that they both need to be updated by professionals. Kerosuo et al. (2015, p. 294) noted a similar issue with BIM; that FMs probably will not have/ lack the "competence to update the as-built models or designs". As a result, it is likely that clients/FMs will need the services of professional BIM modellers if they are making significant changes to the BIM model(s).

From a legal perspective Winfield and Rock (2018) suggested contracts need to specifically cover the rights to use of project native models after handover, i.e. to allow clients to edit designs which otherwise might be protected under intellectual property rights. This is important if clients are to manipulate data and keep BIM models up to date.

6.12 Legal issues

Clients should allow adequate time to ensure any legal issues are properly discussed before detailed work starts on a BIM project. Udom (2012) argued this is important to avoid any "adverse legal consequences" and might require specialist legal advice. As BIM developed there have been several academic reviews of the key legal issues including; Udom (2012), Eadie, McLernon and Patton (2015a), who surveyed the top 100 UK construction companies, and Fan et al. (2018, p. 2100) who reviewed 55 journal articles. Table 6.14 shows the key issues they found.

Table 6.14: Key legal issues with BIM (various 2012-2018)

Udom (2012) – not ranked	Eadie et al (2015) - ranked	Fan et al, (2018) – not ranked
Ownership of BIM process, risk management during model transfer and model ownership (final product).	Model ownership.	Model ownership and IPR.
Contractual framework for incorporating BIM.	Incorporation of BIM into the contractual relationship of the parties involved.	Incompatibility of procurement systems with BIM.
Liabilities.	Design liability, Reliance on data and the Evolution and responsibility of model.	liabilities arising from BIM use.
Model Management and other roles.	Design responsibility, Lack of standardisation, litigation and protocols.	Unclear rights and responsibilities.
Reliance on data.	Collaborative working, the Role of BIM co-ordinator and Sharing of copyrighted data.	
Intellectual Property Rights (in parts or elements of the model) and Data Management.		

'*The Winfield Rock Report*' is recommended reading for clients and FMs. It sets out the "present understanding of BIM legal and contractual issues among the legal community and those who instruct them" (2018, p. 9). It also highlighted that a "common issue appears to arise as a result of parties failing to set out the BIM specifications and expected deliverables and roles in sufficient (or, at times, any) detail at the outset".

A key issue from a legal perspective is confirming at the start of the project the issues of ownership of data/models and Intellectual Property Rights (IPR). Larson and Golden (2007) noted in the absence of contract terms to the contrary "the party that creates the model owns it". Eadie, McLernon and Patton (2015a) noted the position of the legal issue on ownership is difficult to determine because there is little case law to establish a precedent. However, obviously owners want to be able to use and possibly amend models in the future for renovations etc. As such, Fan et al. (2018) noted this is especially important to clients and FMs as the models can be utilised by employers for FM purposes. This applies to a project CDE and Winfield and Rock (2018, p. 33) suggested careful thought is given to "which party is best positioned to host the CDE and to therefore effectively act as gatekeeper for the design for the entire project". They go on to observe, "the underlying contract needs to ensure that the parties are adequately protected, and that data contained in the CDE cannot be used to hold other parties to ransom at a later stage" (ibid). Fan et al. (2018, p. 2126) noted the need to refer to the local countries legal system as "legal issues and their solutions can vary across localities".

Winfield and Rock (2018, p. 22) suggested a way to minimise legal uncertainty is to use one of the standard forms of contract: "there already exists a well-established body of case law surrounding standard forms and their use arguably minimises the time and cost of negotiations as the terms and conditions are well known to players in the market”. Figure 6.31 shows their findings regarding percentage of use of the common contract forms for BIM design/construction projects.

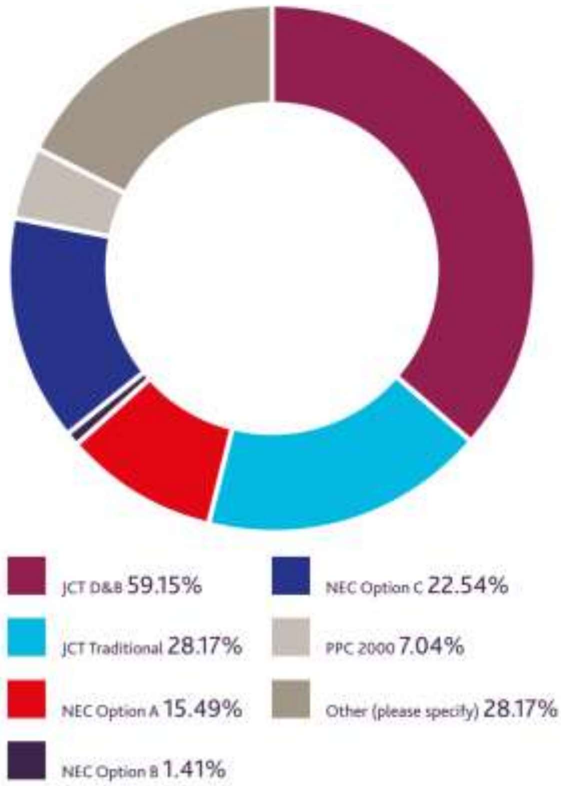


Figure 6.31: Legal procurement routes used for BIM projects – Winfield and Rock (2018)

They discussed two common approaches to covering the legal aspects in BIM projects as shown below. Their research also indicated 83.56% of respondents have used a BIM protocol (ibid, p29).

1. Include a BIM Protocol
2. Include the BIM specific clauses in the contract itself

The UK BIM Framework recently published the ‘*Information protocol to support BS EN ISO 19650-2 the delivery phase of assets*’ by Croft, Winfield and Lewis’ (2020). It requires an ‘*Information Protocol Template’* to be competed (one is included) and recommends the inclusion of an “incorporation clause” (ibid, p6) and “appointment specific Information Particulars” (ibid).

6.13 Upskilling people for engagement with the BIM process

It is important to recognise BIM is not just about technology and processes but also people. Davies, McMeel and Wilkinson (2015, p. 116) agreed noting “technology alone does not deliver collaboration, and communication, conflict management, negotiation, teamwork and leadership are all required within a BIM project team”. Dawood and Vukovic (2015, p. 2) described BIM as being made up of "four pillars: processes, technology, policy and people". They went on to note "these are developed concurrently and are highly dependent on each other". They added the 'people pillar' includes "training, competency assessment standards for both, people and organisations, leadership, teamwork and others" (ibid). They then made a very important point that "the people pillar cuts across all three other pillars, as technology, processes and policy will not operate properly unless well-trained and developed human resource are available" (ibid). It is imperative that for BIM to succeed there is investment in collaboration, training and new technology, noted Kivits and Furneaux (2013).

Therefore, if people are not equipped with the right skills and competencies we should not be surprised if BIM projects have poor outcomes. Wijekoon, Manewa and Ross (2018, p. 819) remind us that simply "demanding 'all the information' is not helpful" in BIM projects and clients/FMs need to understand how to order BIM projects and the associated information requirements. As such the 'people factor' is an essential CSF to realising the benefits that most stakeholders hope to achieve by investing in BIM. The need for good quality training and familiarisation was highlighted in research by Amuda-Yusuf (2018, p. 63) who considered 28 CSF for BIM implementation. His findings ranked "education and training" as the third most important factor, and Mordue, Swaddle and Philp (2016, p. 221) observed "BIM processes can fail because end users don't have the right level of support and training".

The best project outcomes occur when teams take the effort to integrate people, process and technology in a collaborative non-confrontational atmosphere that allows for good information exchange. Otherwise many of the potential benefits may be lost due to confusion and misunderstanding. Ernst (2016, p. para 8) noted the growing importance of 'digital literacy' and that new roles will also appear:

> New professions will emerge as BIM FM takes hold, including BIM FM manager (ensuring the validity of data for the FM, owners, and occupants), BIM FM modeller (overseeing updates to the digital model), and assistant to the BIM FM project owner (responsible for integrating BIM in the property management process and in pre-project phases).

Morlhon, Pellerin and Bourgault (2014, p. 1126) highlighted that this will happen gradually and that we need to remember BIM is relatively new and as such the "recent introduction of BIM does not allow organizations to build their experience on acknowledged standards and procedures". There are some examples of H2020 projects e.g. '*BUILD UP skills to business'* (CORDIS, 2017) and '*BIMplement*' (CORDIS, 2017a) which have targeted the construction digital skill shortages. However, there has been little done to date to help upskill people from the operational phase of the BIM process i.e. clients, FMs and operational teams. This issue must be addressed as the whole premise of BIM is 'to start with the end in mind' - in other words with the clients who will order BIM projects and FMs as the people who will maintain them. Saxon, Robinson and Winfield (2018) suggested that clients who want to gain the most benefit from digitisation need to invest in awareness training, set up a BIM strategy, equip teams, set up legal instructions and a CDE to manage the BIM process. They recognise that this will result in consultants' costs being front-loaded as they create the digital model meaning that the cash flow for these skills needs to be brought forward.

Taking all this into account, it would seem obvious that clients/FMs should be heavily involved. However, as highlighted in Chapter 6.2 the NBS reported the greatest barrier (64%) to using BIM as "no client demand" (NBS, 2020c, p. 24). There may be various reasons for their lack of engagement: Kelly et al. (2013) suggested it might be down to challenges of proving the added value for clients in the O&M phase; Mordue, Swaddle and Philp (2016, p. 83) suggested "BIM-wash and posturing about BIM competency has a negative impact on trust and relationships". Heaton, Parlikad and Schooling (2019a, p. 172) suggested it may be linked to when "asset owners, maintainers and operators fail to address their information requirements, resulting in BIM models that generate little value for the O&M phase".

Whatever the reason, a key CSF in making BIM successful is overcoming this challenge and getting positive client/FM engagement at the start of the process. Ashworth et al. (2016, p. 1) suggested "the need for further education regarding BIM guidelines and standards. In particular, new and more FM/client-focussed BIM strategy documents, EIR and other templates". Without their engagement, we should not be surprised they often have the perception BIM projects do not deliver against their needs and that the data that is delivered is often unstructured and do not align with their business needs. This prevents easy transfer to and use in management systems and is bound to cause a negative impression. These perceptions need to be addressed if clients are to positively engage with BIM.

Therefore, we can see why clients/FMs need a good overview of key BIM standards/guidance in order to be able to competently order BIM projects. Chapter 6.3 provides a good starting point with the IWFM BIM guides and guidance from the UK BIM Framework. The BIM standards themselves should be referred to for further detail and used for key definitions, common language terminology etc. Networking with other BIM practitioners is recommended to help clients/FMs understand how the standards/guidance are being used in practice. Another resource includes online videos and seminars which can be helpful, as are several books including: '*BIM for Facility Managers'* (Teicholz et al., 2013)*,* '*The BIM Handbook: A Guide to Building Information Modeling for Owners, Designers, Engineers, Contractors, and Facility Managers'* (Sacks et al., 2018), and '*Building Information Modeling For Dummies'* by Mordue, Swaddle and Philp (2016).

Simpson and Carlton (2019, p. 2) from the UK BIM Alliance noted: "A fair description of current BIM training provision would be that it is variable". Several professional associations are already offering various BIM training courses. These included: buildingSMART (buildingSMART, 2020c), BRE (BRE, 2020), BSI (BSI, 2020a), BSRIA (BSRIA, 2020) and RICS (RICS, 2020a). In terms of further education there are a range of bachelor and master courses with BIM content which can be found online. These are often tailored around stakeholder group's needs. Some other courses include modules about BIM alongside the main topic. The Chartered Institute of Building (CIOB BIM+, 2016a) website provides some advice on BIM degrees. Ultimately organisations need to satisfy themselves that whatever training they choose it is appropriate and of high quality.

6.14 Chapter summary

The literature demonstrated how the BIM landscape of standards/guidance is developing extremely fast. It highlighted how clients/FMs stand to benefit most from BIM in terms of ROI, sustainable and social outcomes and operational benefits. However, to realise the benefits, FMs need to be involved early to support clients set up their BIM strategy and clearly define the information requirements. There is a gap of understanding of the information requirements with many people overcomplicating them or asking for information that is not required or will never be used. Instead a ‘minimal useful’ approach should be adopted, and information logically structured e.g. using a classification approach. The client’s OIR/AIR should drive the EIR which should be cascaded to all project appointed parties. There is also a lack of understanding around how to structure data using recognised classification systems to ensure it can be easily transferred into operational management software at handover. We are gradually seeing more alignment between BIM and CAFM/IWMS tools, but until they can easily exchange information bi-directionally careful consideration needs to be given to planning the transfer/linking of information into FM management systems. Legal issues around data ownership should be discussed and finally the ‘people factor’ is essential to engage and upskill clients/FMs and ensure they can competently order BIM projects.

Chapter 7: Critical success factors and frameworks

This Chapter discusses the background of CSF and specific examples from applications in the context of the ACE and FM industries. It also explores example frameworks from practice which were used as inspiration to develop to address the objective (e) to identify a suitable format for the '*FM-BIM Mobilisation Framework*' and incorporate the final list of CSF (from d) into a draft framework.

7.1 Incorporating critical success factors into the framework

The ultimate aim of the research was to create a '*FM-BIM Mobilisation Framework'* to help people better engage with the BIM process and optimise built assets in operation.. The literature review in Chapters 2-6 highlighted potential CST which could be used in the interviews and the questionnaire to establish the CSF. The following sections highlight possible approaches from practice examples and explores how these formed the basis of the proposed framework to include both UK specific and more generic advice for international users.

7.2 Background to critical success factors

Rockart (1979, p. 84) observed the "concept of the 'success factors' was first discussed in management literature" by Daniel (1961). He went on to note "a research team at MIT's Sloan School of Management" came up with the term CSF and reported the "approach suggests that it is highly effective in helping executives to define their significant information needs" (ibid). He also suggested a definition of CSF: "a limited number of areas in which results, if they are satisfactory, will ensure successful competitive performance for the individual, department or organization" (ibid). Further research by Bullen and Rockart (1981) suggested that in order for a business to expand and thrive there are key CSF it must achieve in order to reach its goals. Milosevic and Patanakul (2005, p. 183) later suggested they could be viewed as "characteristics, conditions, or variables that can have a significant impact on the success of the project when properly sustained, maintained, or managed". Alias et al. (2014) suggested such CSF can contribute to the success or failure of a project.

Munro and Wheeler (1980, p. 37) were some of the first researchers to investigate CSF for 'information requirements'. Their findings concluded: "attending to those factors critical to the achievement of the organization's goals results in more effective management. Senior and middle management's information needs for control are defined by identifying critical success factors within the context of corporate planning processes". This aligns with much of the BIM literature which argues successful projects start by reviewing the organisation's corporate policy and objectives.

Their approach suggested five major activities (ibid):

1. Understand business unit objectives
2. Identify CSF
3. Identify specific performance measures and standards
4. Identify data required to measure performance
5. Identify decisions and information required

The approach above overlaps closely with many of the CSF in the BIM literature. Munro and Wheeler (1980, p. 34) proposed the model shown in Figure 7.1 for linking the business plan to objectives, CSF, measurement standards and data.

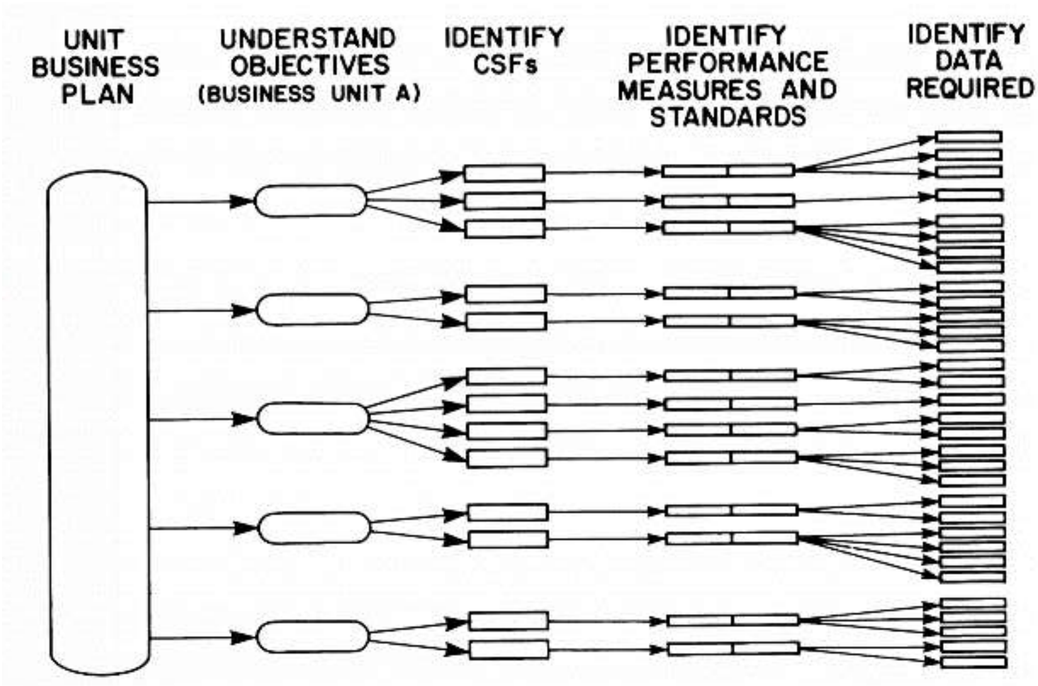


Figure 7.1: CSF approach – Munro and Wheeler (1980)

Research by Bullen and Rockart (1981, p. 12) highlighted a principle idea behind CSF which aligned with the intention of the '*FM-BIM Mobilisation Framework',* i.e. to help managers focus on "their most limited resource (their time) on those things which really make the difference between success and failure".

Table 7.1 illustrates the '*Ten Factor Model',* by Slevin and Pinto (1986), whereby experts considered which CSF would drive successful projects.

Table 7.1: *'Ten Factor Model'* for successful projects - Slevin and Pinto (1986)

No	Factor (CSF)	Detail of why the factor (CSF) is important
1	Project Mission	Initial clarity of goals and general directions.
2	Top Management Support	Willingness of top management to provide the necessary resources and authority/power for project success.
3	Project Schedule/Plan	A detailed specification of the individual action steps required for project implementation.
4	Client Consultation	Communication, consultation, and active listening to all impacted parties.
5	Personnel	Recruitment, selection and training of the necessary personnel for the project team.
6	Technical Tasks	Availability of the required technology and technical steps to accomplish the specific technical action steps.
7	Client Acceptance	The act of "selling" the final project to its ultimate intended users.
8	Monitoring and Feedback	Timely provision of comprehensive control information at each stage in the implementation process.
9	Communication	The provision of an appropriate network and necessary data to all key actors in the project implementation.
10	Troubleshooting	Ability to handle unexpected crises and deviations from plan.

Other aspects from research were also considered for the development of the PhD framework, including Pinto and Prescott (1988), who suggested CSF can have a different impact over various stages of a projects life (like the RIBA PoW stages).

Another idea highlighted by Pinto and Prescott (1990) was that certain CSF are directly under individual manager's control; however, others are environmental and therefore outside their control. Similarly, BIM projects have many stakeholders who need to collaborate. This means some CSF are in the control of other team members.

The author's own experience in mobilising large FM contracts led him to develop 'mobilisation checklists', which proved a simple and effective way of checking essential actions had been taken to maximise the success of projects. Belassi and Tukel (1996, p. 141) suggested a similar approach; that managers need a "compressive list" of CSF to help evaluate projects. Their research on CSF in construction projects found the top three were: 'top management support', 'project management performance' and 'availability of resources' (ibid, p146). They also confirmed another link between CSF; that "the availability of resources is directly related with top management support for the project" (ibid).

Interestingly Baccarini (1999, p. 30) suggested 'success' has 'hard' and 'soft' dimensions. Some project success criteria are 'hard', i.e. objective, tangible and measurable, whilst others were 'soft referring to "such aspects as happiness, job satisfaction, enhanced reputation, and attention to detail" (ibid). He also argued CSF "support the attainment of organizational goals. Goals represent the end points that an organization hopes to reach. Critical success factors, however, are the areas in which good performance is necessary to ensure attainment of those goals".

Chan, Scott and Chan (2004, p. 153) observed “project success is a function of project-related factors, project procedures, project management actions, human-related factors and external environment”. Müller and Jugdev (2012, p. 762) noted that between 1990 and 2000 CSF started to be linked to “integrated frameworks on project success”. These approaches inspired ideas regarding how CSF for FMs working in BIM projects could be presented in a framework.

7.3 Different approaches to identifying critical success factors

In terms of how CSF can be identified Amberg, Fischl and Wiener (2005, p. 5) highlighted several methods as shown in Table 7.2.

Table 7.2: Research methods - CSF identification by Amberg, Fischl and Wiener (2005)

Research Method	Examples (from literature)
Action research	Jenkins et al. (1999)
Case studies	Gibson et al. (1999), Summer (1999)
Delphi technique	Atthirawong and McCarthy (2001), Brancheau et al. (1996)
Group interviewing	Khandewal and Miller (1992)
Literature review	Esteve and Pastor (2000), Umble and Umble (2001)
Multivariate analysis	Dvir et al. (1996)
Scenario analysis	Barat (1992)
Structured interviewing	Rockhart and Van Bullen (1986)

Unlike some of the approaches, focused exclusively on a quantitative approach to CSF a more qualitative approach was taken as it was believed in depth interviews with FM/BIM experts would lead to the identification of more precise CSF.

Other examples of CSF research with a qualitative approach include Tucker, Turley and Holgate (2014, p. 233). They used “a thematic analysis approach” in line with guidance from Grbich (2007) to establish CSF for effective repairs and maintenance service for social housing in the UK. Pakrudin et al. (2017, p. 69) adopted a qualitative approach to investigate CSF for FM in the healthcare industry with a “content analysis methodology and an inductive coding technique”.

7.4 Examples of critical success factors from practice

Dahlan and Zainuddin (2018, p. 1) investigated CSF applying to FM in low-cost high-rise residential buildings. They observed, “before implementing CSFs, an FM organisation must identify the key areas where things must be done properly to enable the business to flourish”. Their research shown in Table 7.3 grouped 34 factors (bullet points) under five main CSF: ‘financial’, ‘customer’, ‘internal process’, ‘learning & growth’ and ‘design & construction defects’.

Table 7.3: CSF of FM - Dahlan and Zainuddin (2018)

No	Critical Success Factors (CSFs)	AUTHORS
1	Financial	
	• Cost efficiency/ value for money	Kalumbu, Mutingi, & Mbohwa[19], Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [23]
2	Customer	
	• Communication between organization and customers	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Relationship with customers	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Customer expectation	Yongtao, Liyin, Craig, Weisheng, and Michael [20], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Reliability of service	Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Quality standards/certification	Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Quality resources	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Responsiveness to incidents	Yongtao, Liyin, Craig, Weisheng, and Michael [20], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
3	Internal Process	
	• Top management support	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Clear policy, strategy & planning	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19]Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [23], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Experience in maintenance business/familiarity with maintenance & other maintenance plan	Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Adequate resources/dedicated resources	Zushi and Sohal [24], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Appointment of capable manager	Zushi and Sohal [24], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Staff qualification & experience	Yongtao, Liyin, Craig, Weisheng, and Michael [20], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Reference to industry guideline/standards	Zushi and Sohal [24]
	• General training & awareness for suppliers & other stakeholders	Zushi and Sohal [24]
	• Necessity & usage of audits/monitor performance/quality assessment	Zushi and Sohal [24], Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [23], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12],Abdul Mutalib, M. Sapri, and I. S. Mohammad [26]
	• Document control system (hard or soft version)/ IT &Technology	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12],Abdul Mutalib, M. Sapri, and I. S. Mohammad [26]
	• Company reputation/certification	Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Member of professional organizations	
	• Working condition/effective working practice/good communication	Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [23], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Contract and risk management	Yongtao, Liyin, Craig, Weisheng, and Michael [20]
	• Lesson learnt	Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
4	Learning & Growth	
	• Employee training	Zushi and Sohal [24], Kalumbu, Mutingi, & Mbohwa [19], Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [17], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12]
	• Cultural changes/innovativeness	Zushi and Sohal [24], Yongtao, Liyin, Craig, Weisheng, and Michael [20], Tucker, Turley, and Holgate [23], Ganisen, Mohammed, Jawahr Nesan, Kanniyapan [12], Abdul Mutalib, M. Sapri, and I. S. Mohammad [26]
	• Learning from other organisations' experiences and benchmarking	Zushi and Sohal [24]
5	Design & Construction Defects	
	• Defective construction materials	Waziri [28]
	• Poor supervision	Waziri [28]
	• Defects due to specification	Waziri [28]
	• Poor quality control on site	Waziri [28]
	• Incompetent workforce	Waziri [28]
	• Architectural defects	Waziri [28]
	• Use of new & untested materials	Waziri [28]
	• Incompetent workforce for construction	Waziri [28]

They suggested the CSF be used to “provide a useful guideline and can be used as a benchmark for the efficiency of FM” (ibid, p5). Other CSF studies using a grouping approach include Lok, Opoku and Baldry (2018) who identified five main categories for 36 CSF for outsourcing strategies in local FM practice. Other research by Antwi-Afari et al. (2018, p. 100) explored CSF in BIM from different countries. They noted “some countries (e.g. USA, UK and South Korea) have developed clear CSFs for measuring successful BIM implementation”. They went on to note;

> each country implements a different sets of CSFs, some universal CSFs are shared between these countries, namely: collaboration in design, engineering, and construction stakeholders; earlier and accurate 3D visualisation of design; coordination and planning of construction works; enhancing exchange of information and knowledge management; and improved site layout planning and site safety (ibid).

Their work identified five key CSF; “i) collaboration in design, engineering and construction stakeholders, ii) earlier and accurate 3D visualisation of design, iii) coordination and planning of construction works, iv) enhancing exchange of information and knowledge management, and v) improved site layout planning and site safety”. A summary of the sources used for the identification of CSF is shown in Table 7.4 (ibid).

Table 7.4: CSF literature for implementing BIM (Antwi-Afari et al., 2018)

Item	CSFs	References
1.	Earlier and accurate 3D visualisation of design	Fox and Hietanen [37], Olatunji and Sher [38]
2.	Enhancing exchange of information and knowledge management	Pektas and Pultar [39], Chiu and Lan [40], Ozkaya and Akin [41]
3.	Collaboration of simultaneous access of construction work	Ohsuga [42], Dean and McClendon [43]
4.	Better design/multi-dimensional design alternatives/applications	Aranda-Mena et al. [44], Sacks et al. [35,45]
5.	Design coordination on various elements/components	Eastman et al. [1]
6.	Predictive analysis of performance (energy analysis, e.g. CO_2)	Lee et al. [46], Taylor and Bernstein [28], Bynum et al. [47], Li et al. [48]
7.	Thermal energy analysis and simulation	Azhar [2], Sebastian and Van Berlo [49], AGC BIM Guide [23]
8.	MEP analysis and simulation (HVAC)	Eastman et al. [1], Azhar [2], NIBS NBIM Standard [50]
9.	Structural analysis and design	AGC BIM Guide [23], Hartmann et al. [51], Arayici et al. [8]
10.	Predicting environmental analysis and simulation (airflow, weather)	Eastman et al. [1], Azhar [2], NIBS NBIM Standard [50], Sebastian and Van Berlo [49]
11.	Acoustical analysis and simulation (sound)	Eastman et al. [1], Azhar [2], NIBS NBIM Standard [50], Sebastian and Van Berlo [49]
12.	Verification of consistency to the design intent	Eastman et al. [1]
13.	Ensuring effective communication among project participants	Acharya et al. [25]
14.	Collaboration in design, construction, engineering and facility management stakeholders	Lu et al. [52], Wu and Issa [53]
15.	Providing BIM models for shop drawings	Eastman et al. [1], AGC BIM Guide [23], Hartmann et al. [51], Arayici et al. [8]
16.	Providing BIM models for offsite prefabrication	Eastman et al. [1], Azhar [2], NIBS NBIM Standard [50], Sebastian and Van Berlo [49]
17.	Providing better implementation of lean construction, green sustainability and integrated project delivery	Eastman et al. [1], NIBS NBIM Standard [50], Hartmann et al. [51], Arayici et al. [8]
18.	Reducing construction project duration	Bynum et al. [47], CURT [54], Khanzode et al. [55]
19.	Reducing construction project cost	McGraw-Hill Construction [56]
20.	Model checking and validation (reviewing code)	Azhar [2], NIBS BIM Standard [50,120], AGC BIM Guide [23], Hartmann et al. [51]
21.	Improved construction project performance and quality	Khanzode et al. [55], Suermann and Issa [57]
22.	Accuracy and reliability of data (less reworking and fewer document errors and omissions)	Barlish and Sullivan [3], Boktor et al. [58], Hanna et al. [59]
23.	Improved site layout, planning and site safety	Li et al. [60], Vacharapoom and Sdhabhon [61]
24.	Reduced claims or litigation (risks)	Aranda-Mena et al. [44], CURT [54]
25.	Improved operations and maintenance (facility management)	Azhar [2], Eastman et al. [1]
26.	4D construction scheduling and sequencing (3D + time)	Eastman et al. [1], NIBS NBIM Standard [50], Sebastian and Van Berlo [49]
27.	5D cost estimation and scheduling (3D + time + cost)	AGC BIM Guide [23], Hartmann et al. [51]
28.	Coordination and planning of construction works	Eastman et al. [1], Azhar [2], Arayici et al. [8]
29.	Integrating project documentation/bid preparation	Olatunji and Sher [38]
30.	Synchronization of procurement with design and construction	Eastman et al. [1], NIBS NBIM Standard [50], Sebastian and Van Berlo [49]
31.	Integrating design validation (clash detection)	Eastman et al. [1]
32.	Extracting cost estimation and quantity take off	Azhar [2], Gallello et al. [62]
33.	Remodeling and renovation	Azhar [2], Hartmann et al. [51], Arayici et al. [8]
34.	Photorealistic rendering for marketing purposes	NIBS NBIM Standard [50], Sebastian and Van Berlo [49], Hartmann et al. [51]

However, most of these CSF related to the AEC industry except minor aspects of (iv). In this CSF the observation highlighted that BIM can help to share and exchange data in an open way and improve collaboration among project participants.

Other research on CSF in BIM include Olawumi and Chan (2018) who considered 30 CSF specific to ‘sustainability principles’ in construction projects. The top three ranked CSF were; “1) early involvement of project teams, 2) more training programs for cross-field specialists in BIM and sustainability, and 3) technical competence of project staff. Badrinath and Hsieh (2018) explored CSF for BIM projects in Taiwan. Their findings, some of which include specific CSF to FMs (operational), are shown in Table 7.5.

Table 7.5: Operational CSF for BIM projects in Taiwan (Badrinath & Hsieh, 2018)

Category	FG No.	Factor group	Competency area	OCSF rank	OCSF	OCSF definition
Project resources	1	BIM technology	Implementation	1	Physical and knowledge infrastructure	The primary BIM facilities and knowledge needed for the operation of an AECO organization
	1		Technical	2	Technical tasks	Availability of the required technology and expertise to accomplish specific technical steps
	2	Stakeholder skills and competencies	Operational	3	General model use	Using model-based deliverables to improve design, construction and operation of facilities
	2		Functional	4	BIM Project management	Managing the BIM projects where BIM workflows are used and BIM deliverables are specified
	3	Project teams and organizations	Functional	5	Stakeholders and project teams' roles and responsibilities	Different AECO stakeholders are assigned specific activities for which they are held accountable, i.e., their roles on a project. Moreover, responsibilities are the specific set of duties that AECO stakeholders are expected to complete as a function of their roles.
	3		Administrative	6	Allocation of budget toward BIM	AECO organizations willing to deliver BIM projects have to allocate budget toward BIM resources
Project collaboration	4	Project coordination and collaboration	Functional	7	Integrated BIM meetings	AECO stakeholders involved in delivering BIM projects need to make combined decisions and also resolve several issues, and this can happen in integrated meetings during project planning, design, construction and handover stages.
Project life-cycle stages	5	Planning stage (RIBA stage 0–1)	Administrative	8	Documented BEP	Document BEP-BIM execution plans including, but not limited to, project information, project organizational chart, project schedule, BIM process, and contracts.
	5		Managerial	9	Definition of BIM project goals	It is essential to define the project goals before forming the BIM project teams.
	6	Design stage (RIBA stage 2–4)	Operational	10	3D detailing in design stage	A model use representing how three-dimensional details are extracted from information-rich BIM models; 3D detailing typically includes hybrid 2D and/or 3D annotated views.
	7	Construction stage (RIBA stage 5)	Operational	11	BIM/FM integration in construction stage	A model use representing the integration of BIM technologies and processes in the construction stage with facility management deliverables, databases, and workflows
	8	Handover and closeout stage (RIBA stage 6)	Operational	12	Space management data requirements	Delivering the BIM data that are associated with space management
	9	Operations and maintenance stage (RIBA stage 7)	Operational	13	BIM/FM integration in operation stage	A model use representing the integration of BIM technologies and processes in the operation stage with facility management deliverables, databases, and workflows

More recently Sinoh, Othman and Ibrahim (2020) explored CSF for 'BIM implementation'. They discovered, as previous literature had suggested, the importance of early engagement of managers and other key stakeholders, who ultimately play an important part in the successful implementation of BIM within different levels of the organisation.

The literature review revealed that although some papers discuss CSF in BIM, and more recently some in FM, no papers were found which focused on combining them.

7.5 Background to frameworks

A framework can be defined as "the ideas, information, and principles that form the structure of an organisation or plan" (Cambridge Dictionary, 2020), or "a set of principles, ideas etc. that you use when you are forming your decisions and judgments" (macmillian dictionary, 2020). As stated earlier in Chapter 7.1 the research aim was to combine the CSF into a 'framework'. The design approach explained in Chapter 9 took an inductive approach. In line with suggestions from Imenda (2014, p. 185) this meant the work tended more towards "the development of a conceptual framework". Adom, Hussein and Adu-Agyem (2018, p. 440) observed conceptual frameworks often deliver outcomes "useful to practitioners in the field". This resonated strongly with the research aim to deliver something for FMs to use in practice. They suggested such a framework might be based on an existing model "which a researcher adapts to suit his/her research purpose" (ibid). This led to the consideration of whether there were existing frameworks in practice, associated with BIM and FM, which could be used as inspiration.

7.6 The RIBA Plan of Work

Probably the best-known framework used in practice which can be associated with FM and BIM is the '*RIBA PoW 2020'*. It is the UK framework which "organises the process of briefing, designing, constructing and operating building projects into eight stages and explains the stage outcomes, core tasks and information exchanges required at each stage" (RIBA, 2020, p. 1). However, at the start of the PhD the RIBA PoW (2013) version was in place. At this time there was a fundamental recognition that BA have a continuous cyclic life from conception to refurbishment/re-use and recycling, rather than the traditional linear approach.

The recognition that how we procure BA was changing, largely driven by BIM as outlined in the '*BIM Overlay to the RIBA Outline Plan of Work'* (RIBA, 2012)*,* which highlighted the need for change. This resulted in the 2007 version being updated in 2013 with new cyclic numbered stages rather than linear letters as shown in Figure 7.2.

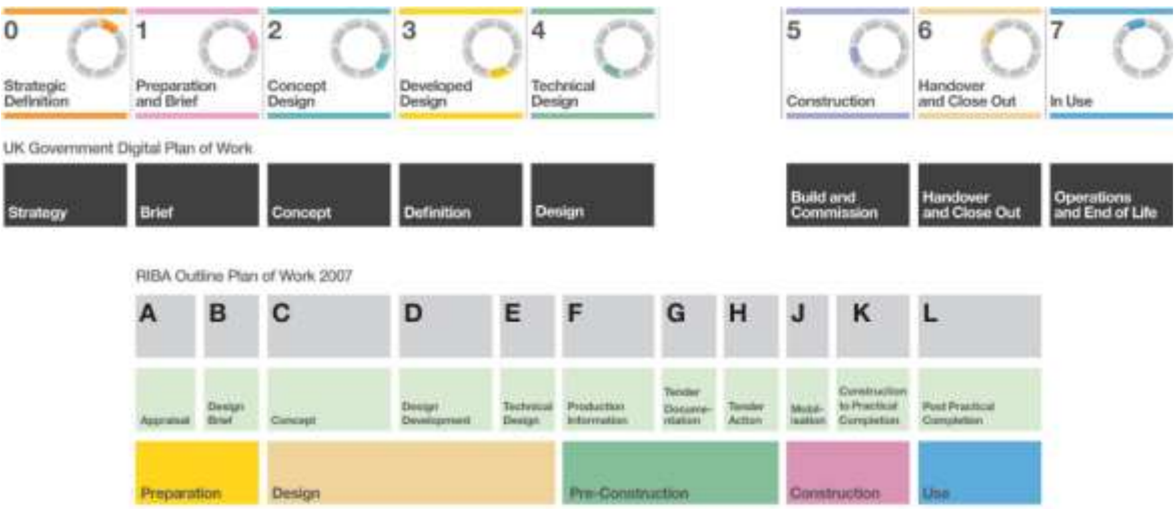


Figure 7.2: Overlay showing the update of the RIBA PoW (2007 and 2013)

Sinclair and Clark (2019, p. para 1) reported the change saw the creation of two new stages (0 and 7) at the beginning and end; "stage 0, which ensures a building project is the best means of achieving the client requirements, and stage 7, to acknowledge the life of a building in use until a new stage 0 – and project – begins". The new stages were very significant to FM and BIM as stage 0 requires the project to be 'strategically appraised and defined' before work commences, and stage 7 includes the requirement for POE and project reviews to ensure a continuous feedback loop for improving the design of future assets.

As the research reached its conclusion the PoW was again updated in 2020. This was driven by the "UK Government committed to be net zero carbon by 2050" (RIBA, 2020, p. 1), and the target to "design and construct new projects and undertake refurbishments that do not need to be retrofitted again before 2050" (ibid). Sinclair and Clark (2019, p. para 4) noted the 2012 BIM overlay document has been replaced by "a section looking at the increasing complexity of information requirements" and a "glossary of current BIM terms".

This resulted in changes to the naming and content of stages 3, 5 and 6 as illustrated in Figure 7.3. Note: full details of the PoW and downloads can be found on the RIBA website.

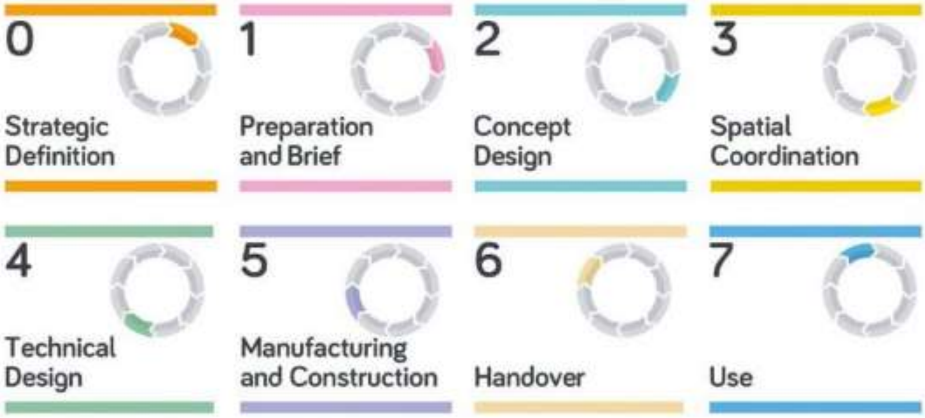


Figure 7.3: RIBA 2020 PoW stages (RIBA, 2020)

The importance of a framework like the PoW to track information was highlighted by the Grenfell Tower fire report: '*Building a safer future: independent review of building regulations and fire safety: final report*'.

The findings by Hackitt (2018) highlighted the necessity to ensure that future owners of buildings are passed the essential key information in order to provide safe and effective management for the rest of the buildings life.

The NBS highlighted BIM is critical to achieve this "as a shorthand for an accurate and up-to-date record of building data" (NBS, 2020). The RIBA PoW 2020 framework is supported by several sustainability initiatives.

The '*RIBA Sustainable Outcomes Guide*' (RIBA, 2019) outlines how the framework will deliver sustainable outcomes which align with the UN SDG outlined in Chapter 2.1 and as shown in Figure 7.4.

Figure 7.4: RIBA Map of UN SDG to RIBA SDG by Garry Clarke (RIBA, 2019)

7.7 Other frameworks which inspired the '*FM-BIM Mobilisation Framework'*

Several frameworks were considered when thinking about the proposed design. One of the main drivers was to include a mobilisation checklist which could be reviewed at the start of a project and which would capture CSF across all the stages of a project. An inspiring example was the SFT framework 'BIM portal' (SFT, 2020).

It was "developed to support the Scottish Public Sector implement BIM within the built environment" (ibid). It uses the RIBA PoW as a framework with specific tasks teams should address, related to each stage, to result in better project outcomes as shown in Figure 7.5.

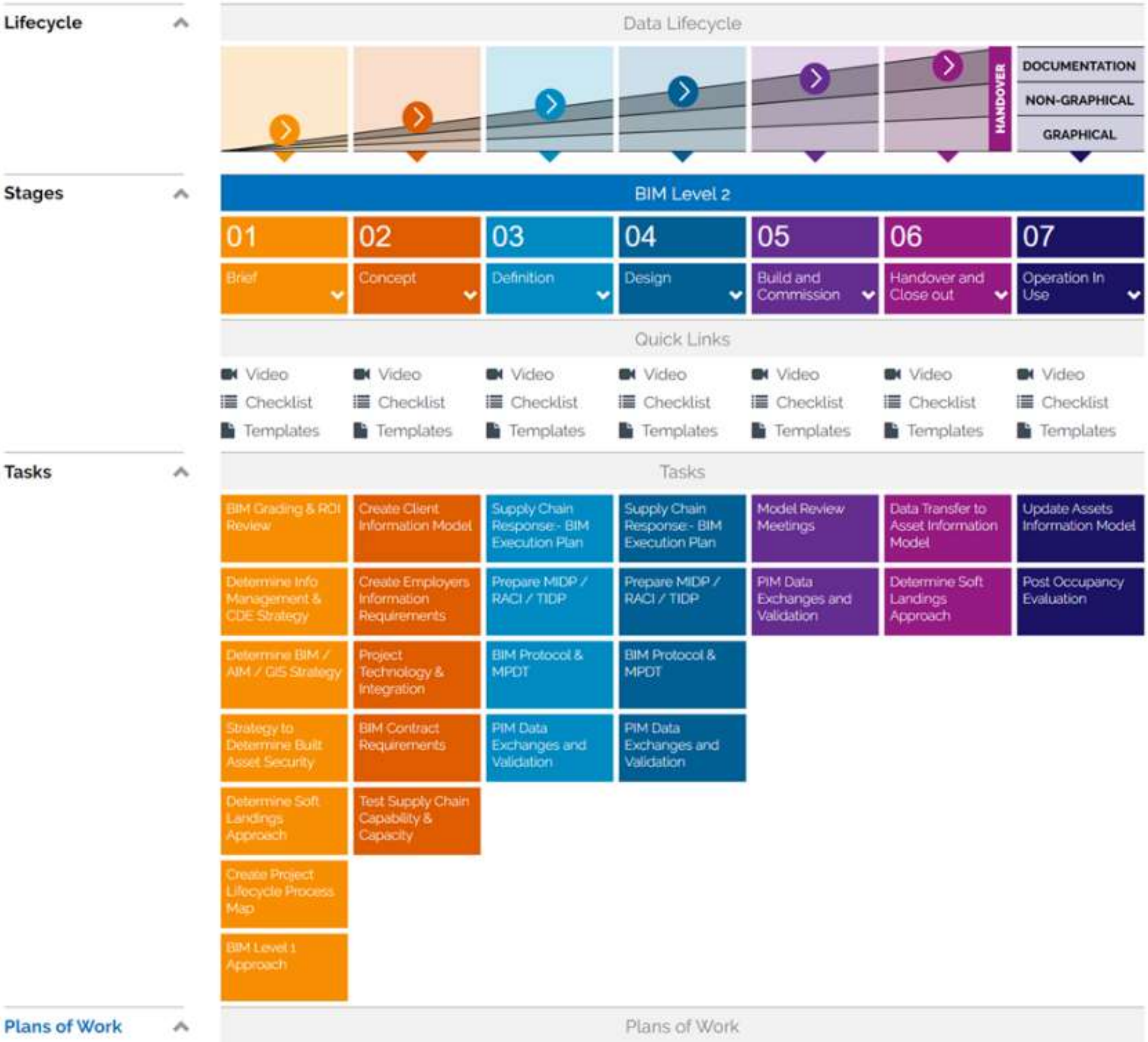


Figure 7.5: SFT BIM portal framework (SFT, 2020)

During the research ideas were explored of using the PoW stages to present CSF for FMs in the BIM process. However, it became obvious that many of the key decisions that have the most significant impact in the 'use stage' need to be taken right at the start of process. Consequently, a decision was taken not to tie CSF to specific stages. The overall conclusion was the best project outcomes would be delivered through earlier engagement.

Another inspiration was the PhD framework idea developed by Aderiye (2015): the '*Guide to Facilities Management – Cultural Fit Framework'.* She used a checklist type approach to consider the 'cultural fit' of FM and the socialisation of external service provider employees in client organisations. An example of the format is shown in Figure 7.6.

Contract Definition

This is a subsection of **clarity** and lays out what should be included in the contract agreement signed by the client organisation and the service provider. It brings up issues that could be potential causes for dispute after the contract has been established and proffers solutions.

Action	Explanation	Examples	Self-Assessment		
			FI	PI	NI
Strategic information and compatibility	✓ Provide information about the core business and the goals of the organisation to the other party to foster understanding of your needs. ✓ Be sure of a reasonably equal stand on ethics of the other organisation, their mode of operation and how this might help or deter you from achieving your goals.	✓ Vision, strategic goals, clear contract requirements. ✓ Check for compatibility of vision and the ability to adapt to the client's business mode			
Lessons learned	✓ Discuss with your service provider issues that led to the decision to outsource or problems with the last outsourced contract	✓ Clarify these issues once you have decide to employ their services			
Realistic expectations	✓ Discuss clearly the services you require without becoming bogged down with detail. This will help the other party plan human and financial issues better and lead to less dissent later on in the contract. ✓ Finances are typically one of the top reasons contracts go awry. Be prepared to determine how certain payments should be structured or who bears the burden for an aspect of the contract.	✓ Expansion plans that will affect the partnership as a proviso in the contract. Include a clear process in the contract. ✓ E.g. do social occasions count as overtime for the outsourced staff?			
Future strategy	✓ The other party is better able to plan their services to, or requirements from your organisation when they are aware of plans that will affect the effective and efficient delivery of those services.	✓ Expansion plans that will affect the partnership as a proviso in the contract.			
Compliance and restrictions	✓ The client organisation should confirm that the service provider is aware of legal restrictions such as employment law or even financial restrictions. In certain situations, service delivery might be in another town or in an area where the service provider is not established which may lead to difficulty in securing staff or expensive rates for scarce skills.	✓ Employment law ✓ Awareness of services delivered in areas with limited resources/ offsite locations leading to increased expenses.			
Service measurement	✓ This is quite common in contracts now and the methods by which services will be measured should be clearly stated in the contract to make each party aware of what is at stake. This is due to the different standards of performance accepted by various organisations and industries.	✓ Periodic meetings, KPI's and SLA's.			

Figure 7.6: Example: '*Guide to FM – Cultural Fit Framework'* (Aderiye, 2015)

Another inspiring approach was a later paper '*Critical Success Factors for Building Information Modelling Implementation*' (Amuda-Yusuf, 2018) which presented a list of 28 CSF with an 'explanation and 'authors' (literature sources). An example of one CSF is shown in Figure 7.7.

Critical Success Factors	Explanation	Authors
Clear definition and understanding of users' requirements	There is need for end-user driven system development to ensure that user requirements are correctly captured. User needs would need to be simplified after they are presented with various available options, possibly with unbiased guidelines to help them towards realistic choices.	(Ugwu & Kumaraswamy, 2007); (Morlhon, et al., 2014)

Figure 7.7: CSF structure - 'explanation' and 'literature source' (Amuda-Yusuf, 2018)

7.8 Chapter summary

The literature identified a significant research gap in that there was no evidence of frameworks which combine CSF specific to BIM for FM. However, it did highlight that both qualitative and quantitative approaches can be used to establish CSF and several frameworks which were used as inspiration for the PhD framework:

1. BIM portal: client actions for BIM projects aligned with RIBA PoW stages (SFT, 2020)
2. A mobilisation tick list (using a traffic light approach) with explanations (Aderiye, 2015)
3. A useful list of authors/sources that people could use for reference (Amuda-Yusuf, 2018)

These examples and feedback from the 'FM/BIM expert' interviews enabled a structure to be developed for the PhD framework. The aim was to also incorporate the final list of CSF (Established in Chapter 14). These would be based on the CST from the literature (Chapters 2-6) and subsequent analysis of data from the qualitative interviews (Chapters 10/11) and quantitative questionnaire (Chapters 12/13). Together these provided a solid basis for the development of the unique '*FM-BIM Mobilisation Framework*'. The process of identifying and incorporating the CSF is explained in the following Chapters.

Chapter 8: Summary of the literature review

The purpose of this chapter was to reflect on the literature review (objective a) and how the CST were identified and subsequently explored with FM/BIM experts in the interviews and with the wider industry in the questionnaire. It also reflects on the speed with which the topic has developed and the impact this had on the literature at the point of write up.

8.1 Reflection and update of literature

Since the PhD start in December 2014, a snowball effect was observed in terms of both the number of academic papers on various BIM topics, as well as significant changes made to the BIM process in practice i.e. standards, terminology and guidance. The result was that at times it was difficult to keep up to date as there seemed to be new publications almost every week. There was a concern that by the time of the write-up parts of the initial literature review would be largely out of date with what was happening in practice. This was in stark contrast to the first visit to LJMU library to investigate the role of FMs in preparing input for the EIR in the BIM process. At this time search engines returned zero hits against these key words (FM, EIR and BIM) combined.

However, with the explosion of new BIM literature, standards and guidance, it was clear a significant update would be required at the point of writing up to ensure the work would be still current at the point of completion. This was a valuable lesson learnt and what Pautasso (2013) referred to as “the nature of science”. He suggested changes in the real world often lead to the need to revisit one’s own reviews. Ridley (2012, p. 175) also observed “the literature review process is a continuous one which begins when you first start to develop an idea for your research and does not end until the final draft of your dissertation or thesis is complete”. This led to a decision to carry out an evaluation of the literature chapters as part of the final write up. Ridley added its “quite natural to revise your literature review in light of your own research findings” (ibid). As such it is important the readers note the CST described in the following sections reflect findings from the initial literature review, whereas Chapters 2-6 have been appropriately updated to ensure the literature and PhD work as a whole are current at the point of write up in 2020.

8.2 Identification of critical success themes

The main aim of the literature review in Chapters 2-6 was to identify CST which could then be used in the concurrent mixed methodology design as follows:

- **Interviews:** ‘FM/BIM experts’ were interviewed with questions developed using the CST. Their opinions were then used to establish specific CSF to help FMs better engage with, and benefit from the BIM process.

- **On-line questionnaire**: developed using CST to gauge the general level of awareness of BIM by the 'general FM industry'. The feedback would be used to establish wider CSF to help improve FM industry engagement in the BIM process.

8.3 Initial literature review

The initial research identified a total of 13 CST MT, and 33 CST ST. These were broadly grouped into four 'key areas': policy, technology, processes, and people using areas from the well-known FM '*3P model'* (EuroFM, 2020a) and *'FM beyond buildings: FM interfaces FM*' (McGregor and Then, 1999). The grouping of CST into key areas is shown in Tables 8.1-8.3.

8.4 Key area: 'policy'

Two MT and five ST were highlighted as shown in Table 8.1.

Table 8.1: CST: key area – 'policy' (various)

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
Policy	1. Government construction and procurement strategy and policy	1.1 CST: understanding impact of BIM on AEC & FM (government policy, timescales etc.)	Cabinet Office (2011), HM Government (2013), Cabinet Office (2014), HM Government (2015), IPA (2016).
		1.2 CST: FM industry readiness for BIM	Moody and Walsh (1999), Newton (2004), Eadie et al. (2013), Lavy and Jawadekar (2014), Beadle (2017).
		1.3 CST: how can FM industry help support government 2025 strategic targets?	Higson and Waltho (2010), Akcamete, Akinici and Garrett (2010), Hansen and Damgaard (2011), Ashworth (2013, 2013a), Cavka, Staub-French and Pottinger (2013), ISO (2017).
	2. Paradigm change towards a whole-life cycle thinking approach	2.1 CST: to realise best value over the WLC	Paulson (1976), CURT (2004), Hughes et al. (2004), Flanagan and Jewell (2005), Saxon (2005), Eastman et al. (2011), MacLeamy (2010, 2012), Langston (2011), Davis (2013), Kovacic and Zoller (2015).
		2.2 CST: for FM to use a WLC approach and use of BIM to help deliver long-term value	Bogenstätter (2000), Bourn (2001), OGC (2007), Krygiel and Nies (2008), Mitchell, Swann and Poli (2009), Ashworth (2013), Carter (2013), ISO (2017).

8.5 Key area: 'technology'

One MT and two ST were highlighted as shown in Table 8.2.

Table 8.2: CST: key area – 'technology' (various)

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
Technology	9. Impact of digitalisation and technology on FM and BIM	9.1 CST: Importance of technology links with BIM which might be important for the FM industry	Buckman, Mayfield and Beck (2014), IBM (2017), WEF (2016), JLL (2016), Stoddart (2016), Berger (2016), Panetta (2016), Bowers et al. (2016), Gartner (2017), CBRE (2017), Ebbesen (2016), Parrott and Warshaw (2017), (Marr, 2017), Deloitte (2017), Ahmed et al. (2017).
		9.2 CST: to ensure FMs are prepared for BIM and the change digitalisation will bring about	Patel and Veira (2014), Goldman Sachs (2014), Bauer, Patel and Veira (2014), Yeates (2015), HM Government (2015), McKinsey Global Institute (2015), Teuteberg (2016), Gerbet et al. (2016), IPA (2016), HM Government (2017), EU BIM Task Group (2017), IPA (2017), Araszkiewicz (2017).

8.6 Key area: 'processes'

Six MT and sixteen ST were highlighted as shown in Table 8.3.

Table 8.3: CST: key area – 'processes' (various)

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
Processes	3. Strategic planning using BIM to support Asset Management (AM)	3.1 CST: understanding the link between strategic AM planning and BIM to optimise AM in operation	Barret and Baldry (2003), Savitz and Weber (2006), Chotipanich (2006), IFMA (2009), White (2013), Roper and Borello (2014), Rondeau, Brown and Lapides (2017).
		3.2 CST: in producing good OIR and AIR	Eadie et al. (2013), Haines (2016), Ashworth (2016), Thomas (2017).
	4. FM engagement in the BIM process	4.1 CST: understanding the importance of early FM involvement in BIM process	DTI (2007), Kensek (2015), Arayici, Onyenobi and Egbu (2012), Becerik-Gerber et al. (2012), Thomas (2017).
		4.2 CST: how to bring FM expertise into relevant stages of the design (BIM) process	BSRIA (2012), Eadie et al. (2013), BSI (2015, 2015a), Beadle et al. (2017).
		4.3 CST: defining the role and key tasks for FM in the early stages of a BIM project	BSRIA (2012), BSi (, 2015, 2015a, 2016), Haines (2016), Thomas (2017), Beadle et al. (2017).
	5. Employer's information requirements (EIR)	5.1 CST: defining key information needed by FM from the BIM process (CAPEX to the OPEX phase)	Saxon (2005), Schley (2011), Ashworth (2013), BSi (2014, 2014a), Kovacic and Zoller (2015), Grzyl, Miszewska-Urbańska and Apollo (2017).
		5.2 CST: how to setup/use EIR guidance documents	BSi (2014a), Ashworth (2016), Thomas (2017), Beadle et al. (2017).
		5.3 CST: to creating a useful and appropriate EIR	BSi (2015), Ashworth (2016), Ashworth and Tucker (2017), Thomas (2017).

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
	6. Benefits of BIM	6.1 CST: to making benefits of BIM to FM credible, understandable and transparent	Teicholz (2013), Kensek (2015), Aziz, Nawawi and Ariff (2016), Mohanta and Das (2016), Walasek and Barszcz (2017), EU BIM Task Group (2017), Dodge Data & Analytics (2017).
		6.2 CST: understand possible benefits of BIM to FM	Becerik-Gerber et al. (2012), Kelly et al. (2013), Teicholz (2013), Brinda and Prasanna (2014), HM Government (2015), Korpela et al. (2015), Haines (2016).
	7. Barriers to BIM adoption & use	7.1 CST: understand negative perception about BIM	McGraw Hill Construction (2009), Cavka, Staub-French and Pottinger, (2013) Eadie et al. (2015).
		7.2 CST: what are key barriers to be overcome?	DTI (2007), Azhar (2011), Arayici, Onyenobi and Egbu (2012), McGraw Hill Construction (2014) Ashworth and Bryde (2015).
		7.3 CST to overcome the possible barriers.	McGraw Hill Construction (2010), Teicholz (2013), Thomas (2017).
Processes	8. Knowledge management and data transfer to operation	8.1 CST: FMs readiness to plan the information needed from the BIM process in the operation phase	ISO (2015a), Hampl (2016), Mosey et al. (2016), Ashworth (2106), Beadle et al. (2017), Thomas (2017), Davies, Wilkinson and McMeel (2017).
		8.2 CST: transferring information into FM systems using COBie or other mechanisms	Clayton, Ozener and Nome (2009), Idox (2015), Hampl (2016), Naghshbandi (2016), ABAB (2017).
		8.3 CST: for data/information capture/transfer to benefit FM in the operational phase including: a) the key information needed and b) quality of information	Gnanaredam and Jayasena (2013), BSi (2014a), Kensek (2015), Thomas (2017), Walasek and Barszcz (2017).

8.7 Key area: 'people'

Four MT and ten ST were highlighted as shown in Table 8.4.

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
People	10. Changing perception of FM	10.1 CST: understanding the perception of FM involvement and capability in the BIM process	Volk, Stengel and Schultmann (2014), Thompson et al (2014), Bsi (2015a).
		10.2 CST: how FM can strategically support organisations and use BIM to help them	Then (1996), IFMA (2009), White (2013), Teicholz et al. (2013), Jensen (2014), Volk, Stengel and Schultmann (2014).
		10.3 CST: realising the strategic impact of BIM on organisations and their people	Shepard (2015), Khaddaja and Srourb (2016), Khaddaja and Srourb (2016).
	11. Collaboration (the people factor)	11.1 CST: which enable FM engagement and contribution to a team on a BIM project	BIM Working Party (2011), Philip (2014), Preidel et al (2016), Burgess (2016).
		11.2 CST: in understanding what people skills are important to make BIM successful in projects	Teicholz et al. (2013), Davies, McMeel and Wilkinson (2015), Dawood and Vukovic (2015).

CST Key Area	Main Theme	Sub-Theme	Examples from literature (see references)
	12. Competence and knowledge about BIM	12.1 CST: closing the knowledge gap between FM and other industry professionals	Mordue, Swaddle and Philp (2016), Ernst (2016), CIOB (2016a), IWFM (2017), Beadle et al. (2017).
		12.2 CST: how FMs can gain competence and knowledge with respect to BIM	Kelly et al. (2013), Morlhon, Pellerin and Bourgault (2014).
	13. Specific FM/BIM guidance and training	13.1 CST: understanding and awareness of BIM standards and guidance	Cabinet Office, 2011, BSRIA (2012), Teicholz et al. (2013), BSi (2015, 2015a), Ashworth et al. (2016).
		13.2 CST: for FMs use and benefit of BIM guidance documents including: • Specific important documents to FMs • Level of detail of familiarity with documents • Use of documents in practice • Absorbing the critical information for FMs	Korpela et al. (2015), Kensek (2015), Aziz, Nawawi and Ariff (2016), Mohanta and Das (2016), IWFM (2017).
		13.3 CST: understanding key gaps in BIM guidance	The Scottish Government (2013), Thomas (2017), Beadle et al. (2017), SFT (2017).

8.8 Research gaps in the literature

The literature exposed many gaps which were subsequently explored in the interviews and questionnaire to establish the CSF in BIM projects. Some of the key gaps are summarised below:

Policy: the UK Government has championed BIM which has driven a paradigm change in considering the value of BA over their whole life-cycle. The research highlighted a need for more focus on the OPEX phase which represents a much higher percentage of the overall costs. However, many projects are still driven by ways of working which focus on short term CAPEX costs. The research indicated BIM can contribute significantly to the Government's 2025 construction targets (and wider UN SDGs). However, to achieve this, ways need to be found to better engage client/FMs early in the process so they understand how to competently order BIM projects. They have also been instrumental in developing the essential framework of BIM standards/guidance to help the parties involved. Significant gaps in competencies between the various stakeholders involved were also highlighted. D&C teams are already using BIM as part of their day job but clients and FMs have been, to a degree, side-lined and yet their needs represent the main reason for starting a BIM project. The benefits of BIM also need to be made more transparent to ensure all parties understand how it will contribute to cost savings, sustainability and better places for us all to live and work.

Technology: the research highlighted a poor record of productivity in the AEC industry. In order to change, the whole industry must adapt to the worldwide digital revolution which has already driven change across many other business sectors. Traditional barriers which have often stopped early FM involvement in the creative process have also resulted in a growing digital gap in terms of understanding the digital technologies including BIM, digital twins etc. These are radically changing the way clients/FMs will receive and use information and BIM models from construction projects. The research indicated a need for organisations to prepare themselves for the digital transformation that is facing us all; accentuating a general need for more awareness of, and digitalisation competency.

Processes: the research highlighted gaps in understanding that digitalisation will significantly impact and change the processes used by organisations to manage their RE portfolios and the services that support the users. It emphasised a lack of clarity around how clearly defined information requirements (OIR, AIR and EIR) will support organisations' wider corporate and AM strategies. In order to properly 'start with the end in mind', clients/FMs need to understand how they can better brief and instruct D&C teams to ensure they get the project outcomes they desire. BIM is now the chosen workflow for construction projects but the research highlighted a need to find ways to help the quality transfer of data and models for use in FM systems, and thus to extend its benefits into processes over the longer operational phase. This includes how to overcome the challenges around keeping BIM models and data valid and up-to-date.

People: Although BIM is meant to help people work more collaboratively, the research indicated the focus of BIM has been largely on technology and processes, and that there is also a need ensure people are empowered to succeed with access to adequate training and competencies. It highlighted that in order for people to work more collaboratively, they need to have adequate digital competencies. Project teams need a better understanding of how clients/FM teams will use information/data both strategically and operationally over the life of projects, especially to reduce overall waste.

Chapter 7.4 noted a significant gap in the literature with respect to research specifically considering how CSF apply to both FM and BIM together. This formed a central pillar of the research and even at the point of writing up in 2020 some evidence of CSF was found with respect to either topic but nothing combining the two.

8.9 Chapter summary

The literature review in Chapters 2-7 was successful in identifying CST which could be used in the subsequent interviews and questionnaire to establish both qualitative and quantitative CSF respectively. The ongoing literature review also provided a valuable 'lesson learnt'. This came in the form of recognising the importance of regularly and iteratively reviewing the literature in order to stay up to date; especially with respect to a very popular topic like BIM where literature, standards and guidance can go out of date very quickly. The benefit of this became very apparent when updating the sources in the final version of the '*FM-BIM Mobilisation Framework*'. As the subject area is evolving at a considerable pace, by revisiting the literature it was possible to improve the framework. This was in alignment with advice from Ridley (2012, p. 176) who observed it is only by "redrafting of your literature review that you are able to fine-tune your arguments". We need to be mindful that FMs need to clearly understand what CSF they need to be aware of when engaging in a BIM project. The literature redrafting process helped in refining argumentation and the final framework content to ensure that as of June 2020 it was up to date.

Chapter 9: Research design and methodology

The literature review clearly established the need for a framework for FMs engaging in BIM projects which combines CSF for both FM and BIM. The purpose of this chapter is to explain the overall research design and philosophical approach as well as to introduce several research frameworks which were used as inspiration.. In doing so it explains the logic of the chosen research design to establish the CSF and refine them into the much needed '*FM-BIM Mobilisation Framework'.*

9.1 Research design

A 'convergent design' mixed methods approach using 'side-by-side' narrative analysis was adopted to develop the framework. This approach was chosen as Creswell and Clark (2018, p. 65) recommend the design: "when a researcher intends to bring together the results of the quantitative and qualitative data analysis". It was then validated using a two-stage process with 'FM/BIM experts'. The following sections explain the philosophical approach and the steps that were taken to ensure the final data collection and analysis techniques and procedures were appropriate.

9.2 Reference research frameworks

Crotty (1998) observed that in order to develop a credible design, researchers should be able to explain their findings. Saunders, Lewis and Thornhill (2016, p. 12) noted a "well-thought-out and consistent set of assumptions will constitute a credible research philosophy, which will underpin your methodological choice, research strategy and data collection techniques and analysis procedures".

Creswell and Clark (2018, p. 34) suggested that "a framework is needed for thinking about how philosophy fits into the design of a mixed methods study". Three reference frameworks were considered as follows to reflect on the philosophical approach and the research design:

1. The 'framework: worldviews, design and research methods' (Creswell, 2014)
2. The 'four level research approach' Creswell and Clark (2018)
3. The 'research onion' Saunders, Thornhill and Lewis (2007)

The first framework shown in Figure 9.1, suggested by (Creswell, 2014, p. 5), aims to help researchers "think through the various philosophical worldview assumptions and to make an assessment of which ones they might bring to the study. It illustrates the important "intersection of philosophical worldviews, research designs and research methods" (ibid) with the possible research approaches shown in the centre.

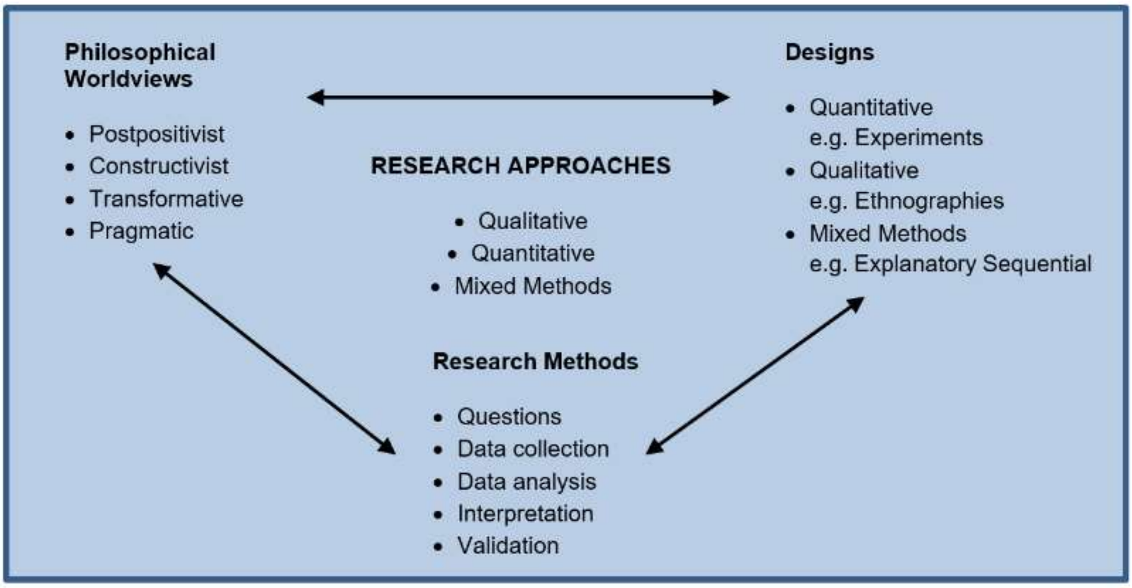


Figure 9.1: Framework: worldviews, design and research methods (Creswell, 2014)

The second framework shown in Figure 9.2 was based on earlier work by Crotty (1998) and proposed by Creswell and Clark (2018, p. 34). It has four levels which researchers should consider when “developing a proposal or designing a study”.

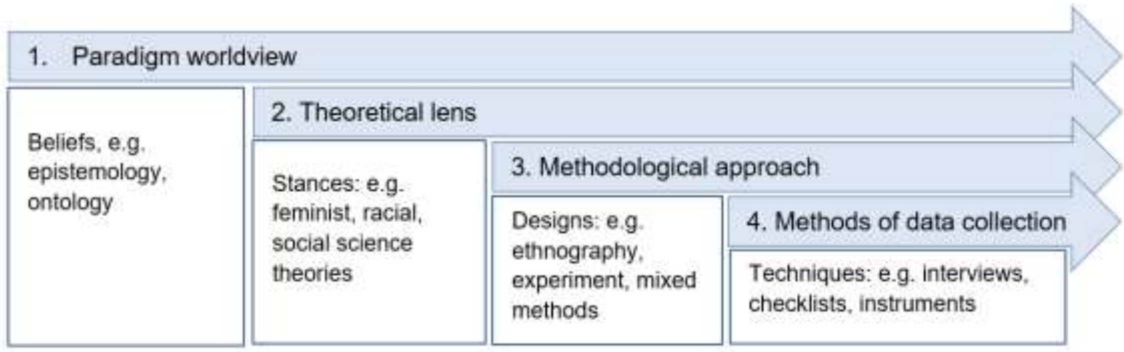


Figure 9.2: Four level research framework - Creswell and Clark (2018)

They summarised the levels as follows (ibid, p35):

1. **Paradigm worldview:** requires the researcher to consider their own beliefs and ‘philosophical assumptions’ including epistemology and ontology with respect to how they acquire knowledge
2. **Theoretical lens:** the assumptions inform the adoption of a theoretical stance
3. **Methodological approach:** describes the overall research design
4. **Methods of data collection**: selection of appropriate methods for data collection and analysis

The third framework used for reference was the ‘research onion’. First developed by Saunders, Thornhill and Lewis (2007), it provides a well-known framework which many researchers have used to explain philosophical assumptions and the underlying issues as to their decisions about how they collect and analyse data. Figure 9.3 illustrates the version from Saunders, Lewis and Thornhill (2016).

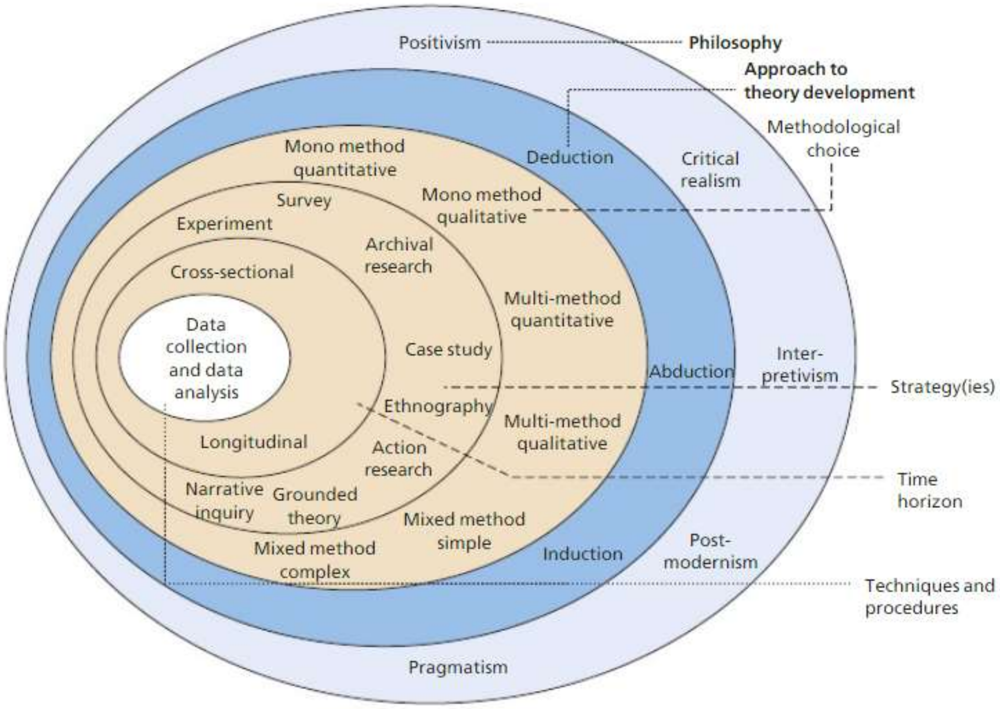


Figure 9.3: The research onion framework - Saunders, Lewis and Thornhill (2016)

The following sections discuss each of the research onion's layers, making reference to the previous two frameworks, to explain the philosophical approach and the steps taken to ensure the study's research design and collection methods were appropriate.

9.3 Philosophy and worldviews

The first onion layer relates to the researcher's philosophical approach. To ensure they have a credible design, researchers must first be aware of their own beliefs and how they shape the choices they make. Creswell (2014, p. 6) went further, arguing researchers should be able to "make explicit the larger philosophical ideas they espouse". Begoray and Banister (2012, p. 790) noted that this process is often referred to as 'reflexivity' and requires "critical reflection of his or her own biases and assumptions and how these have influenced all stages of the research process".

As research involves the creation of new knowledge, Patton (2002, p. 92) argued philosophical assumptions are critical, as they involve "examining the nature of knowledge itself, how it comes into being and is transmitted through language". Saunders, Lewis and Thornhill (2016, p. 89) suggested they can be perceived as "a system of beliefs and assumptions about the development of knowledge". Creswell and Clark (2018, p. 34) highlighted their underlying importance: "inquirers should be aware of assumptions they make about gaining knowledge during their study. These assumptions shape the processes of research and conduct of inquiry". However, Saunders, Lewis and Thornhill (2016, p. 127) recommended that before discussing different research philosophies researchers "should be able to distinguish between them". They need to consider and understand their ontological, epistemological and axiological assumptions, and suggested objectivism and subjectivism can be seen as two extremes. Table 9.1 shows how they illustrated the assumption types in relation to typical questions and the continua of objectivism and subjectivism.

Table 9.1: Philosophical assumptions - Saunders, Lewis and Thornhill (2016)

Assumption type	Questions	Continua with two sets of extremes		
		Objectivism	⇔	Subjectivism
Ontology	• What is the nature of reality? • What is the world like? • For example: – What are organisations like? – What is it like being in organisations? – What is it like being a manager or being managed?	Real External One true reality (universalism) Granular (things) Order	⇔ ⇔ ⇔ ⇔ ⇔	Nominal/decided by convention Socially constructed Multiple realities (relativism) Flowing (processes) Chaos
Epistemology	• How can we know what we know? • What is considered acceptable knowledge? • What constitutes good-quality data? • What kinds of contribution to knowledge can be made?	Adopt assumptions of the natural scientist Facts Numbers Observable phenomena Law-like generalisations	⇔ ⇔ ⇔ ⇔ ⇔	Adopt the assumptions of the arts and humanities Opinions Narratives Attributed meanings Individuals and contexts, specifics
Axiology	• What is the role of values in research? How should we treat our own values when we do research? • How should we deal with the values of research participants?	Value-free Detachment	⇔ ⇔	Value-bound Integral and reflexive

Ontology: derived from the Greek; 'onto' = existence/or being real, and 'logia' = science/study (Löfgren, 2013, p. 2). Creswell and Clark (2018, p. 37) stated, it "refers to the nature of reality (and what is real)". In simpler terms Saunders, Lewis and Thornhill (2016) suggested "your ontological assumptions shape the way in which you see and study your research objects". Löfgren (2013, p. 7) noted the concept is used "to discuss challenging questions to build theories and models, and to better understand the ontological status of the world".

Epistemology: derived from the Greek; 'episteme' = knowledge/understanding and 'logia' = science/study (Löfgren, 2013a, p. 2). According to Burrell and Morgan (1979, p. xii), it refers to assumptions about the study of knowledge: what constitutes valid and legitimate knowledge and how do we obtain and "communicate it to fellow human beings". They went on to add that it addresses ideas like "what forms of knowledge can be obtained, and how one can sort out what is regarded as 'true' from what is to be regarded as 'false'" (ibid). With respect to what knowledge can be considered legitimate, Saunders, Lewis and Thornhill (2016, p. 127) argued within the context of business and management there are many valid knowledge sources e.g. "numerical data to textural and visual data from facts to interpretations, and including narrative, stories and even fictional accounts".

Axiology: derived from the Greek; axios = strong/worthy (Hiles, 2012). Saunders, Lewis and Thornhill refer (2016, p. 128) to the "roles of values and ethics within the research process". Herron (1996, p. 126) maintained axiological skills are demonstrated when researchers can "articulate a set of shared values as a basis for making judgements of relevance about what they are doing and how they are doing it". Saunders, Lewis and Thornhill (2016, p. 128) argued that "your choice of philosophy is a reflection of your values". Therefore, it is very important to have an "awareness of value judgments you are making in drawing conclusions from your data" (ibid). It also has an impact on ensuring an ethically appropriate approach to research.

Other terms have been used to describe philosophical assumptions. Guba (1990, p. 17) suggested 'paradigms' (the 1st level in the second framework). He defined these as "a basic set of beliefs that guide action". Lincoln and Guba (2005) wrote extensively about the landscape of paradigms and social scientific inquiry. Importantly, they argued that it is probably unrealistic to expect a "single 'conventional' paradigm to which all social scientists might ascribe in some common terms and with mutual understanding". Instead they proposed that it is more likely multiple possibilities exist.

Creswell and Clark (2018, p. 35) suggested the term 'worldviews' (shown in the first two frameworks), arguing they "provide a general philosophical orientation to the research". They recommended researchers consider the four key worldviews shown in Table 9.2, noting that different worldviews can be "combined or used individually" (ibid).

Table 9.2: Four world views used in mixed methods research – Creswell and Clark (2018)

Postpositivist World view	Constructivist Worldview	Transformative Worldview	Pragmatist Worldview
Determination	Understanding	Political and activist	Consequences of actions
Reductionism	Multiple participant meanings	Empowerment, human rights, social justice oriented	Problem cantered
Empirical observation and measurement	Social and historical construction	Collaborative	Pluralistic
Theory verification	Theory generation	Change, emancipatory oriented	Real-world practice orientated

They suggested:

- The **postpositivist**: leans more towards quantitative approaches, often adopting "cause-and-effect thinking" (ibid, p36) with elements of reductionism, to select specific variables to investigate and consider the continual refinement and testing of theories. They "tend to view 'the reality' as singular and independent from the researcher" (Ibid, p37).

- The **constructivist:** is often associated with qualitative approaches seeking understanding from phenomena and participant's subjective views with a 'bottom-up' approach (ibid, p36). They "tend to view reality as multiple and actively look for multiple perspectives from participants" (ibid, p37)
- The **transformative**: tends to focus on "social justice and pursuit of human rights" (ibid).
- The **pragmatist:** often leans towards the use of mixed methods combining "multiple methods of data collection". They often take a pluralistic view of using "what works" and "real-world practice" (ibid).

Considering the four worldviews observations were:

- The researcher perceived the 'postpositive' worldview as more relevant to natural sciences. Creswell (2014, p. 7) noted, "postpositivists hold a deterministic philosophy, in which causes (probably) determine effects or outcomes". It was felt that this area of science relies on the fundamental belief that "there are laws or theories that govern the world" (ibid). However, where people's opinions or actions are involved these may not fit such natural laws and therefore other approaches might be more appropriate.
- The researcher felt the 'constructivist' worldview, is more affiliated to social sciences. It is associated with qualitative research as highlighted in works such as; '*Naturalistic Inquiry',* Lincoln and Guba (1985), and '*The Social Construction of Reality',* Berger and Luckmann (1967). He was very interested in the 'social constructivist' view, which Saunders, Lewis and Thornhill (2016, p. 568) observed, tries to "make sense of subjective and socially constructed meanings expressed by those who partake in the research" Other worldview's which appealed came from Denzin (2012); taking a 'bottom-up approach' which considers the participants perspectives and then broadens to lead to more detailed understandings; and Creswell (2014, p. 8), that its key aim was to rely "as much as possible on the participants views of the situation being studied". This allows researchers "to make sense of (or interpret) the meanings others have about the world" (ibid).
- These assumptions were important to the researcher who was interested in understanding phenomena and different perspectives regarding the subjective views of FM/BIM experts in interviews about what are the CSF in practice. This was achieved by mainly open-ended qualitative questions to generate meaning from data captured from participants, as suggested by Crotty (1998).
- The 'transformative' worldview was perceived as not relevant to this particular research, as its focuses on the central importance of specific communities and groups of individuals who may not be so well represented (Mertens, 2009).
- The researcher strongly related to the 'pragmatist' worldview, in which Kelemen and Rumens (2008) asserted that concepts need to support action in research. Saunders, Lewis and Thornhill's (2016, p. 142) observation was of interest; "if you would rather get on with research

that would focus on making a difference to organisational practice you may be leaning towards the philosophy of pragmatism". This aligned with the aim to develop a framework providing direct and practical benefits from the research to practitioners. Another aspect of this approach observed by Creswell and Clark (2018, p. 37) is that in general pragmatists are more interested in "the consequences of research, on the primary importance of the question asked rather than the methods used". This aligned with the researcher's view that the most appropriate method should be used, and as Tashakkori and Teddlie (2003) noted, that the pragmatic worldview is typically associated with mixed methods.

In summary; the researcher's philosophical approach is that his ontology views lean more towards the belief that there is 'no objective reality' and his epistemological views lean towards the 'subjectivist', 'constructivist' and 'pragmatist' approaches.

9.4 Research approach

The second layer of the research onion considers the theoretical lens (shown in the 2nd framework) and whether an abductive, deductive or inductive approach is taken. The following section gives an overview of each term and the reasoning behind the adopted choice:

- **Abduction:** Saunders, Lewis and Thornhill (2016, p. 145) suggested the approach is appropriate where "you are collecting data to explore a phenomenon, identify themes and explain patterns, to generate a new or modify and existing theory which you subsequently test through additional data collection".
- **Deduction**: The approach commonly "starts with a theory, often developed from your reading of the academic literature" (ibid). Used in quantitative studies it usually has "the objective of testing or verifying a theory rather than developing it" (Creswell, 2014, p. 59). He suggested a typical approach as per Figure 9.4.

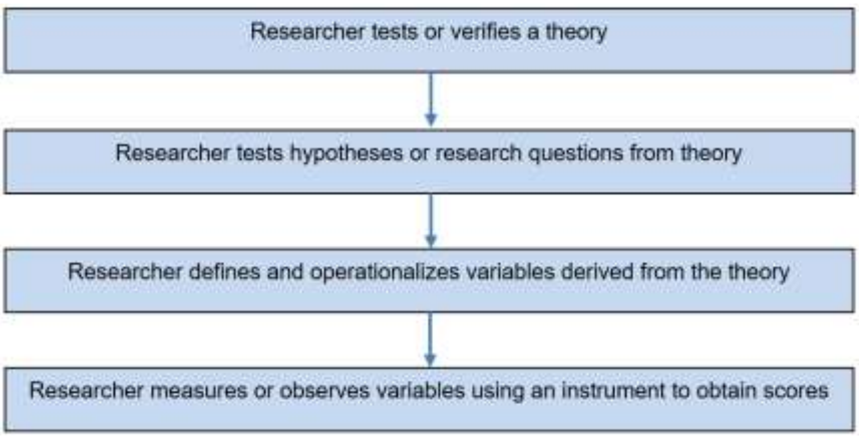


Figure 9.4: Typical deductive approach (Creswell, 2014)

- **Induction:** Saunders, Lewis and Thornhill (2016, p. 145) suggested the approach is appropriate where "your research starts by collecting data to explore a phenomenon and you generate or build theory (often in the form of a conceptual framework)". The approach shown in Figure 9.5 typically "begins by gathering detailed information from participants and then forms this information into categories or themes" (Creswell, 2014, p. 65).

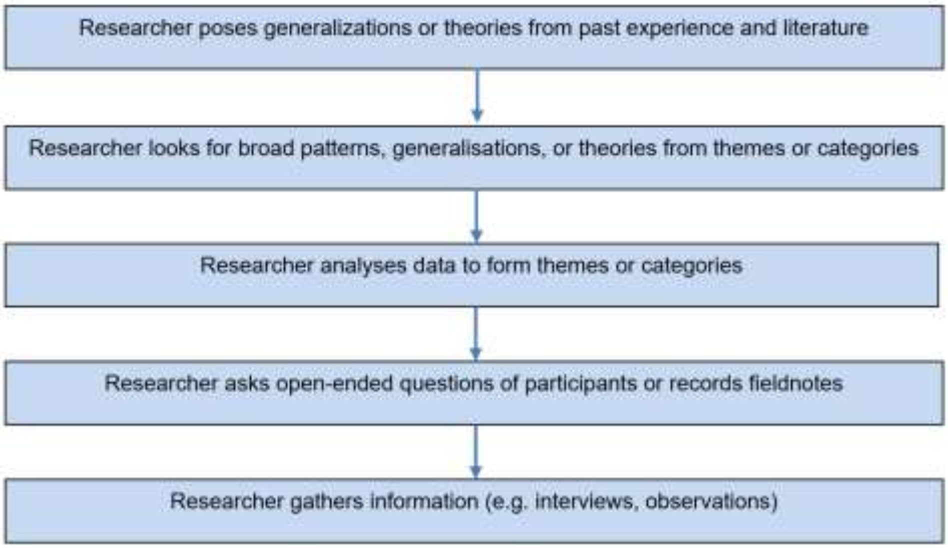


Figure 9.5: Typical inductive approach (Creswell, 2014)

Overall an inductive approach was favoured. This relates to the topic and the researcher's belief that when one is observing a unique phenomenon (people's opinions and actions) that a more open, inductive and qualitative approach would lead to richer knowledge about what was being studied (defining the CSF for the framework). However, for the general views of the FM industry he recognised a more deductive approach with a survey would be needed.

9.5 Methodological choice

David and Sutton (2011) stated the third layer of the research onion considers the methodological approach which should be selected to best suit a particular study. Saunders, Lewis and Thornhill (2016) suggested it needs to take account of the researcher's own philosophical approach, the theory development and research questions. The three main approaches are summarised at a very broad level by Creswell (2014, p. 4):

- **Qualitative**: "approach for exploring and understanding the meaning individuals or groups ascribe to a social or human problem"
- **Quantitative**: "approach for testing objective theories by examining the relationship among variables"

- **Mixed methods**: ”approach to inquiry involving collecting both quantitative and qualitative data, integrating the two forms of data”

Note: Further details of each methodological approach and their appropriate use are provided in the relevant chapters.

Figure 9.6 from Curry and Nunez-Smith (2017, p. 4) illustrates some of the key differences between qualitative and quantitative approaches, highlighting typical examples of the goal, setting, sampling, data collection/analysis and products for the different approaches. Saunders, Lewis and Thornhill (2016, p. 165) stated that it demonstrates that qualitative and quantitative approaches “may be viewed as two ends of a continuum”. The mixed method lies somewhere in the middle and uses elements of both approaches. **Note**: the design can lean more towards one approach or the other depending on the chosen research design.

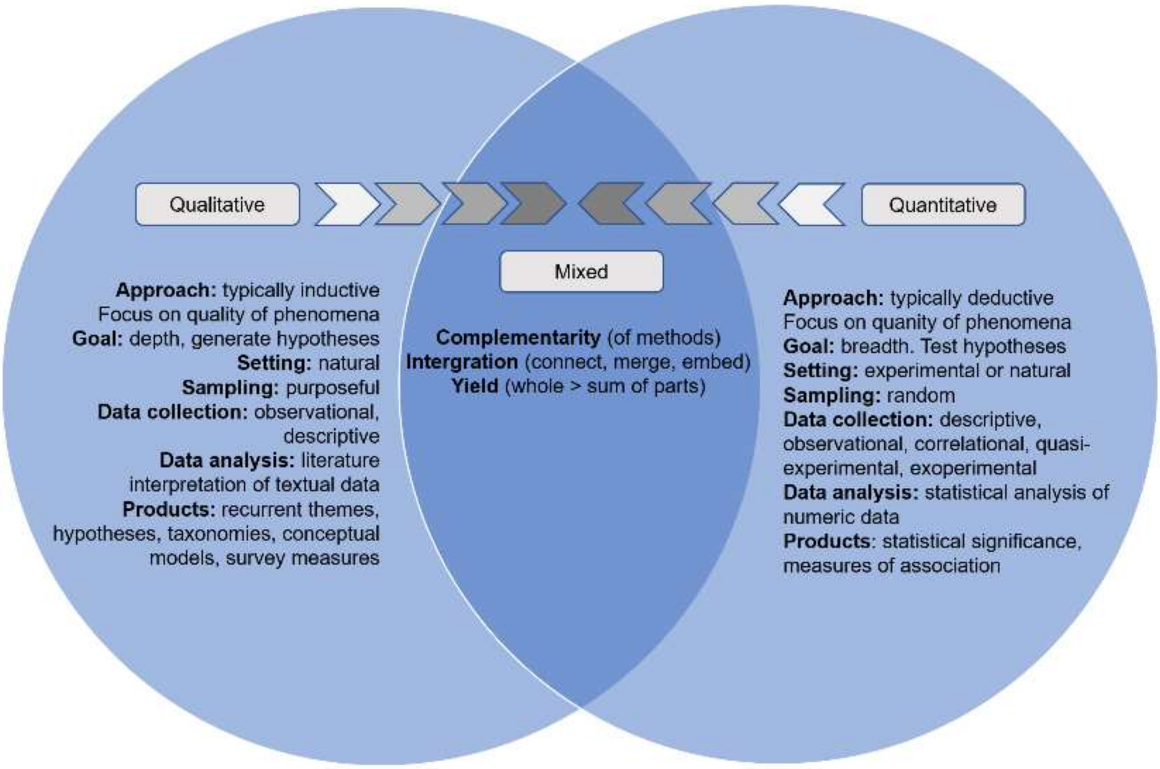


Figure 9.6: Characteristics of different research types – Curry and Nunez-Smith (2017)

It was decided to use a mixed method approach. This related to views expressed by Creswell and Clark (2018, p. 13) when they observed that “by combining the approaches, researchers gain new knowledge that is more than just the sum of the parts”. They “recommend three core mixed methods designs” shown in Figure 9.7 which researchers might consider.

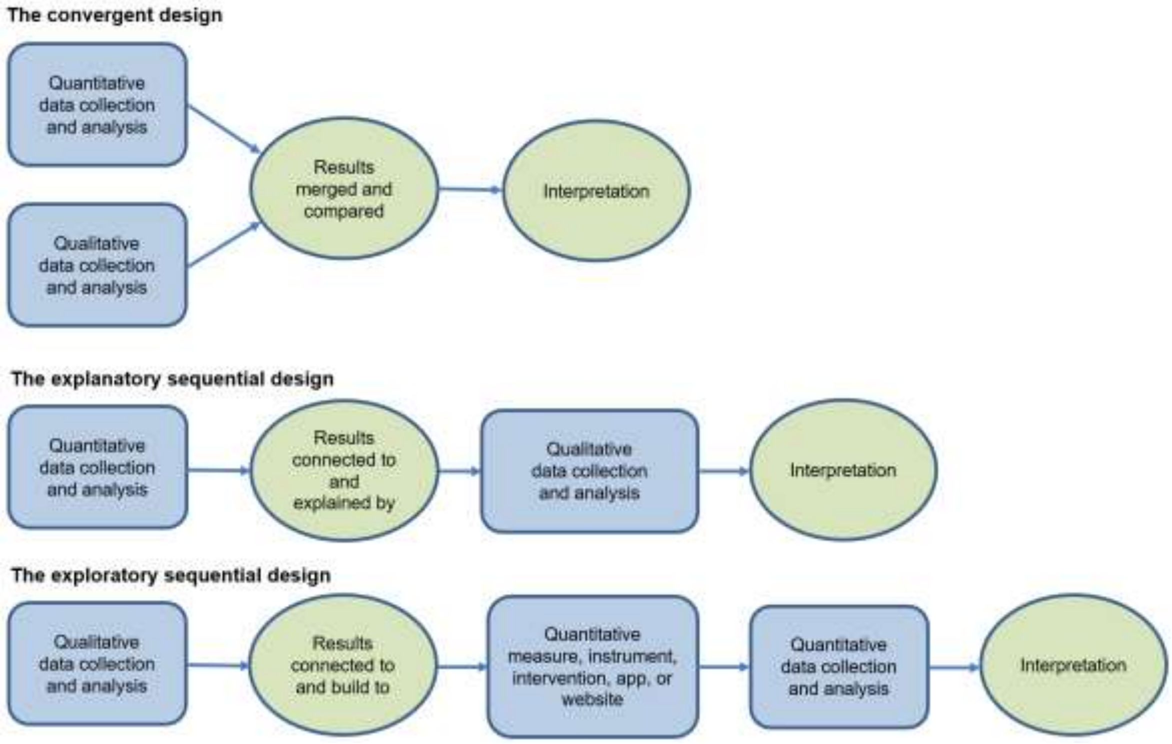


Figure 9.7: Three core mixed method designs – Creswell and Clark (2018, p. 66)

The three designs were summarised as follows (ibid, p65):

- **Convergent design:** quantitative and qualitative data collection/analysis are carried out concurrently "so they can be compared or combined". The aim is "to provide a more complete understanding of a research problem" (ibid). In the design the two databases are combined and then compared to see if the findings 'converge' or 'diverge'.
- **Explanatory sequential design:** has two distinct sequential phases, starting with quantitative data collection/analysis, then followed by qualitative collection/analysis which is used to expand on findings from the first phase.
- **Exploratory sequential design:** uses sequential timing, but usually uses qualitative data collection/analysis in the first phase. This is followed by "a development phase by designing a quantitative feature based on the qualitative results" (ibid). There is then a third phase in which the researcher "quantitatively tests the new feature" (ibid).

The 'convergent design' was deemed as the most appropriate. The research design intent is "to obtain different but complementary data on the same topic" (Morse, 1991). It is a well-known mixed method approach discussed and established in the early 1970s (Jick, 1979). The design was referred to as 'simultaneous triangulation' (Morse, 1991) or 'parallel study' by Tashakkori and Teddlie (1988). Creswell and Clark (2018, p. 68) observed that it was "conceptualised as a 'triangulation design' in which different methods were used to obtain triangulated (quantitative and qualitative) results about a single topic". It was also decided to use 'narrative text' to bring together and compare qualitative text from both the interviews and the questionnaire using a “joint display table”, as recommended by Creswell (2014, p. 71). This is explained in detail in Chapter 14.

9.6 Research strategy

The fourth layer of the research onion concerns selecting “a type of study” from the qualitative, quantitative or mixed methods (Creswell, 2014, p. 4), or as Denzin and Lincoln (2011) called them ‘strategies of inquiry’. Saunders, Lewis and Thornhill (2016, p. 177) defined the research strategy as “a plan of action of how the researcher will go about answering her or his research question”. A wide range of possible strategies have evolved over time. Table 9.3 shows some key stratagems discussed by Saunders, Lewis and Thornhill (2016) for a better understanding of the various approaches.

Table 9.3: Alternative research strategies (various authors)

Research strategy	Observations about the individual research strategies - based on list in (Saunders, et al., 2016)
Experiment	"Seeks to determine if specific treatment influences an outcome" (Creswell, 2014). Has its roots in "natural science" (Saunders, et al., 2016, p.178). Purpose is "to study probability of change in an independent variable causing a change in another, dependant variable" (ibid). Includes 'true experiments' with "random assignment of subjects to treatment conditions, and 'quasi-experiments' that use nonrandomized assignments" (Creswell, 2014, p.13).
Survey	"Provide quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of the population" (Creswell, 2014, p.13). The intention is to answer questions " what, who, where, how much and how many" (Saunders, et al., 2016, p.181). Easy to administer to a high number of people and can be "analysed with descriptive and inferential statistics" (ibid, p.182). Usually done anonymously with controlled number of questions . However, questions need careful thought as there is no second chance to query the results.
Archival and documentary Research	Uses many online sources and databases. There are a bewildering range of possible sources. Usually referred to as secondary sources of data thus care needs to be taken as usually the documents were not specifically developed for the research (Saunders, et al., 2016, p.183). Some documents may also be missing or omit certain key data (ibid).
Case study	In-depth study of a topic within a real-life setting (Yin, 2014). Understanding context is fundamental" (Saunders, et al., 2016, p.185). They can be used to support a wide range of philosophical approaches. Can involve single or multiple case studies. (Yin, 2014) noted four strategies: single case vs. multiple cases and holistic case versus embedded case. Can generate "rich, empirical descriptions and the development of a theory" (ibid).
Ethnography	"Used to study the culture or social world of a group" (Saunders, et al., 2016, p.187), has its roots in anthropology. Several possibilities including realist , interpretive and critical ethnography. Also often used in market research (ibid, p.189). Requires fieldwork and also trust if working with people in the field. Studies common patterns of behaviour, language etc.
Action research	First described by Lewin in 1994. "It uses an emergent and iterative process of inquiry" (Saunders, et al., 2016, p.189). It is used in organisations to produce practical outcomes (planning, taking and evaluating action). It starts with a certain question and context and then works through iterations to find facts and enable actions to be taken (ibid).
Grounded	Developed by Glaser and Strauss (1967). Researchers derive a general, abstract theory of a process, action, or interaction grounded in the views of the participants. Its aim is to help "make sense of that social actors construct to make sense of their everyday experiences" (Creswell, 2014, p.13). Can take an inductive or abductive approach, researches collect/analyse data simultaneously using coding and comparison and self-memos. Literature can be used as a complementary source. Development of a theory grounded in the data (Saunders, et al., 2016, p.197).
Narrative enquiry	Based on storytelling by participants usually in interviews. "Seeks to preserve chronological connections and the sequencing of events" (Saunders, et al., 2016, p.198). Where more than one account is used, they can be compared and triangulated. Can be used with small or larger samples of people.

‘Surveys’ were favoured for the deductive quantitative elements of the research, and ‘grounded’ and ‘action research’ with respect to the inductive qualitative approaches. The researcher also felt ‘case studies' could provide interesting results regarding how FMs use BIM in practice. However, there were no suitable case studies available at the time.

9.7 Time horizon

Research can either be 'cross-sectional' i.e. done "at one point in time" (Wood, 2015) or longitudinal when you want to "observe changes over a long period of time" (ibid). As already discussed, the three main mixed methods have different approaches with respect to the time horizon and sequence of research. Table 9.4 from Creswell (2009) provides some guidance on aspects to consider for each approach.

Table 9.4: Considerations for mixed method designs (Creswell, 2009)

Timing	Weighting	Mixing	Theorizing
No sequence – concurrent	Equal	Integrating	Explicit Implicit
Sequential – qualitative first	Qualitative	Connecting	
Sequential – quantitative first	Quantitative	Embedding	

The chosen concurrent convergent design involves data collection/analysis in a 'concurrent' way i.e. as Wisom and Creswell (2013, p. 2) observed: "at roughly the same time; assessing information using parallel constructs for both types of data". The researcher related to Saunders, Lewis and Thornhill (2016, p. 170) who suggested that data collection/analysis in a concurrent 'single phase' has the benefit that it allows "both sets of data to be interpreted together to provide a richer and more comprehensive response to the research question". This approach was favoured as it was important to consider at the start, with equal weighting, CSF both from an expert and the general FM industry perspective.

9.8 Techniques and procedures

For the design, the individual qualitative/quantitative techniques and approaches are explained in detail in the following chapters. A brief summary is given below:

- **Interviews:** with BIM/FM experts – qualitative semi-structured interviews were used as they would provide rich data regarding the CSF. The aim was to achieve this using open "emerging questions and procedures" (Creswell, 2014, p. 4). The advantage of interviews is that they would allow open discussion to help really identify the issues from practice. Thematic coding analysis was used to establish the CSF following procedures recommended by Saldaña (2016) .
- **Questionnaire:** of the general FM industry - to benchmark the level of awareness of BIM, a quantitative approach was deemed appropriate to explore what FMs across the industry knew about BIM. This used both descriptive and inferential statistics to determine if there were any

significant “relationships between variables” e.g., levels of knowledge of BIM and confidence in BIM projects.

In the final stage of the convergent design the CSF, established from the separate qualitative and quantitative analysis, were analysed using the “side-by-side comparison” using qualitative “narrative discussion” as recommended by Wisom and Creswell (2013, p. 2). By qualitatively merging the findings the researcher could then determine whether various CSF “tended to converge or diverge” as defined by Creswell and Clark (2018, p. 65). This formed the basis to establish a final list of CSF for the framework.

- **Focus group:** with ‘BIM/FM experts’ - a qualitative approach allowed detailed discussion to get feedback to validate the CSF and framework before the final version was completed.

9.9 Validity strategies to ensure reliability and void bias

To ensure validity Creswell (2014, p. 201) suggested “the researcher actively incorporates validity strategies”. The advice of Barbour (2009, pp. 27-31) was used as a reference when considering quality issues around validity, reliability and bias. He reminds us to consider three important areas:

- **Truth is relative**: what is the truth to one person may not be to another. We each have our own perception of the truth. This can have profound impacts on views expressed, for example in interviews.
- **There are multiple realities**: people use different reference criteria depending on their involvement in the reality. Hence the context of the research is crucial to get a full understanding.
- **Views are not static**: people often change their view with time and circumstances. This means that researchers may be faced with changing opinions and views during the research process.

Validity and reliability are very important in qualitative research. Guba and Lincoln (1994) noted four criteria which should be taken into account in the research design:

- **Credibility:** equivalent to validity in quantitative research and shows whether the results of the research are credible and is judged by the similarities between the results from the interview participants.
- **Transferability:** extent to which the results can be used or generalised in other frameworks or backgrounds.
- **Dependability:** similar to reliability in quantitative research and shows the same results can be acquired if we study the same thing repeatedly i.e. stability.
- **Confirmability:** shows the objectivity of the results.

Creswell (2014, p. 201) argued that validity strategies can be strengthened by “the use of multiple approaches”. He went on to note eight different approaches which can be used; triangulation, member checking, use of thick rich description, clarifying the bias, presenting possible negative information that runs counter to the themes, spending prolonged time in the field, using peer debriefing, and use of an external auditor.

Several of the approaches recommended by Creswell (2014), and Creswell and Clark (2018) were used. The techniques selected and notes about how these were incorporated are shown in Table 9.5.

Table 9.5: Validity strategies to improve validity, reliability and bias (self-study)

Validity strategy	Ways in which validity strategies were used in the research
Triangulation	Can be used "to conform the validity, credibility /authenticity of research data, analysis and interpretation" (Saunders, et al., 2016, p. 207), "By triangulating different evidence from different data sources, a more coherent justification can be formed. This can be argued to "adding to the validity of the study" (Creswell, 2014, p. 201). A triangulation strategy was incorporated into the design by using qualitative and quantitative data sources as well as the secondary data from the literature review.
Member checking	Used to "check accuracy of the qualitative findings" (Creswell, 2014, p. 201). This is done by taking the "themes back to participants and determining whether these participants feel they are accurate" (ibid). Mainly used to check findings from interviews but can be used to discuss "quantitative survey findings also with sample of your respondents" (Saunders, et al., 2016, p. 207). It provides the opportunity for participants to check and comment on findings to improve their accuracy. Member checking was incorporated where findings from the BIM/FM experts were checked with them also in the follow up focus group discussions.
Clarify the bias	Researchers naturally bring their own bias to a study. "Self-reflection creates an open and honest narrative that will resonate with the readers" (Creswell, 2014, p. 202). Researchers need to acknowledge how aspects of their background i.e." gender culture, history and socioeconomic origin" impact on their interpretation of the findings (ibid). Researchers should consider both their own and participant bias to ensure the work is reported "in a fully transparent way to allow others to judge for themselves and replicate your study" (Saunders, et al., 2016, p. 203). The author went to length to review his own philosophical approach and during the coding the author observed how his own bias might impact on the findings. Care was also taken in interview and focus groups to avoid bias from outside influences.
Negative findings	It is important that "negative or discrepant information that runs counter to the themes" is also reported. Adding such information "adds to the credibility of the report" (Creswell, 2014, p. 202). By presenting "contradictory evidence, the account becomes more realistic and valid" (ibid). The negative findings were transparently reported – sometimes these presented some of the most interesting and thought-provoking findings.
Peer Debriefing	Involves using a second person who "reviews and asks questions about the qualitative study so that the account will resonate with people other than the researcher". (Creswell, 2014, p. 202). This can be seen as "adding validity to an account" (ibid). Elements of debriefing were used in different ways – feedback was sought from the author's supervisor and colleagues from his institution.

9.10 Ethical considerations

Saunders, Lewis and Thornhill (2016, p. 184) noted that researchers must "ensure that the way you design your research is both methodologically sound and morally defensible to all those who are involved". Creswell (2014, p. 95) argued that all researchers should use the "code of ethics" from their research institute. As such all aspects of the research were planned in line with the established ethical guidelines of Liverpool John Moores University (LJMU, 2020). Each step of the research was developed in discussion with the PhD supervisor and through formal ethical approval from the University's ethics committee.

During the research all participants were fully advised of the aim of the research, and the process and risks involved, using appropriate means. Informed consent was sought and received from all interview/focus group participants ahead of discussions in person. This was done by using the relevant ‘information sheets’ and ‘consent forms’ as listed in the appendices. Details of additional ethical considerations are included in the relevant qualitative and quantitative chapters.

9.11 Chapter summary

The philosophical views and the approach to the design have been explained illustrating how the decision to combine both qualitative and quantitative methods was reached. The mixed method approach was deemed most appropriate to ensure “a more complete understanding of a problem”. In this case the problem being the main research question: *What are the CSF in terms of relevant knowledge, skills and competences, which will empower FMs to fully engage with the BIM process and ensure that built assets can be optimised in operation*? The literature review (Chapters 2-6) and Chapter 7 (CSF/Frameworks) provided the basis to bring together CSF for FMs regarding BIM into one framework. The mixed method ‘convergent design’ recommended by Creswell and Clark (2018, p. 65) with side-by-side narrative text provided an appropriate way of bringing together qualitative/qualitative CSF. This would help answer the secondary questions and lay the groundwork for the development of the ‘*FM-BIM Mobilisation Framework’.* The following chapters explain how the research design was implemented and the associated data collection/analysis methods in detail.

Chapter 10: Qualitative methodology and approach

This chapter describes the logic for the use of the qualitative interviews with ‘FM/BIM experts’. The principle aim was to better understand their view of how BIM impacts on FM and to establish CSF from practice which could help other FMs engage in the BIM process. It addresses the objective (c) to specifically establish critical qualitative CSF in the BIM process.

10.1 Nature and logic of the selected approach

A key reason for using a qualitative approach was highlighted by Kumar (2010, p. 104) who described the focus of qualitative research as “to understand, explain, explore, discover and clarify situations, feelings, perceptions, attitudes, values, beliefs and experiences of a group of people”. Another reason was described by Saunders, Lewis and Thornhill (2016, p. 568) who observed “qualitative data are likely to be characterised by their richness and fullness” and stated interviews provide “an opportunity to explore a subject in as real a manner as is possible”. However, they also noted:

> in qualitative research, meanings are principally derived from words and images, not numbers. Since words and images may have multiple meanings as well as unclear meanings. It is necessary to explore and clarify these with great care. This indicates the quality of qualitative research depends on the interaction between data collection and data analysis to allow meanings to be explored and cleared (ibid, p.567).

They went on to describe the qualitative research process as similar to “completing a jigsaw puzzle in which the pieces represent data”. Their analogy suggested one can think of the relationships between pieces of data in a similar way as jigsaw pieces. Like the jigsaw, when one carries out research, it brings together the pieces and slowly a picture emerges which we naturally try to interpret, i.e. what the data is telling us. However, when building a jigsaw, one usually has a picture to start the process. Whereas, with research it’s like having no picture at the start and letting one form as we put the pieces together. This process involves categorising and organising the pieces in ways that help us fit them together and build a picture. In a similar way the research intended to identify the CSF in the wider BIM process would help FMs understand the bigger picture when working in BIM projects.

Patton (1990) observed that the analytical approach for each research project should be distinctive to reflect the uniqueness of the research conditions. Frechtling and Sharp (1997, pp. 4-3) observed such a qualitative approach often produces large amounts of data which “has to be organised and somehow meaningfully reduced or reconfigured”. Creswell (2014, p. 183) observed this requires “using specific protocols for recording data, analysing the information through multiple steps of analysis, and mentoring approaches for documenting the accuracy - or validity - of the data collected.”

10.2 Interview design

As discussed in Chapter 9, interviews were seen as appropriate for collecting CSF from 'FM/BIM experts'. This was in line with Qu and Dumay (2011, p. 238) who noted "the research interview, one of the most important qualitative data collection methods, has been widely used in conducting field studies and ethnographic research". Saunders, Lewis and Thornhill (2016, p. 388) described the essential purpose of interviews as "about asking purposeful questions and carefully listening to the answers to be able to explore these further". However, on the webpage 'General Guidelines for Conducting Interviews' McNarma (2014), suggested "before you start to design your interview questions and process, clearly articulate to yourself what problem or need is to be addressed using the information to be gathered by the interviews. This helps you keep clear focus on the intent of each question". Turner (2010, p. 754) suggested researchers consider key steps to take when planning interviews. These "provide the researcher with the tools needed to conduct a well-constructed, professional interview with their participants". A self-study was carried out of various authors to define eight steps to follow as illustrated in Table 10.1.

Table 10.1: Preparation steps for interviews (self-study - various authors)

Interview steps	Study of issues that are important for each step
1. Preparation for interview	Turner (2010, p.757) stress this steps importance: it "can help make or break the process and can either alleviate or exacerbate the problematic circumstances that could potentially occur once the research is implemented. According to McNarma (2014) this should include: 1) A setting with little distraction, 2) Explaining the interviews purpose, 3) Confidentiality, 4) interview format, 5) length of interview, 6) contact details, 7) process for questions, and 8) recording of interview.
2. Selecting interviewees	Springer (2018) observed that interviewees should be selected based on their appropriateness (specialist knowledge etc.) and their ability to answer the researcher's questions.
3. Decide on interview type	McNarma (2014) suggest considering: 1) informal, conversational interviews, 2) general interview guide approach, 3) standardized, open-ended interviews, or 4) closed, fixed-response interview. Saunders, et al (2016) suggested: structured, semi-structured and unstructured or in-depth interviews.
4. Constructing questions	Saunders, et al (2016, p.408) argued "formulating appropriate questions to explore areas in which you are interested is critical to achieving success". Turner (2010, p.757) suggested they should "allow the examiner to dig dip into the experiences and/or knowledge of the participants in order to gain maximum data from the interviews". McNarma (2014) note the sequence and wording are also very important to ensure the interview follows well.
5. Pilot Testing	Turner (2010, p.757) suggested implementing a pilot test to "determining if there are flaws, limitations, or other weaknesses within the interview design". It also helps establish the suitability of the compiled questions and to determine the flow of questions.
6. Interview protocol, Information sheets and consent forms	Creswell (2014) argued an interview protocol is important to manage the interview and will act as a guide to smooth the process. Turner (2010, p.754) note the protocol will help ensure "effective ways to conduct in-depth, qualitative Interviews". Saunders, et al (2016, p.252) observed the need for 'participant information sheets' to ensure prospective participants can "reach a fully informed decision" about whether to take part. Consent forms should then be sent to and recorded for each person.
7. Carrying out and recording the interview	There are lots of considerations here which Saunders, et al (2016) suggested should include: location, appearance, opening comments, listening skills, reducing bias in questioning, summarising key issues etc. Each interviewee should be informed of the intent to record the interview and this should be re-confirmed as part of the interview.
8. Transcribing	Saunders, et al (2016, p.416) note the importance of considering how the interview will be transcribed in preparation for analysis and if this is verbatim or if paraphrasing is acceptable.

The following sections explain how each step was implemented in more detail.

10.2.1 Preparation

This involved preparing the overview already highlighted in Table 10.1 using eight recommendations from McNarma (2014). These are covered in the following sections.

10.2.2 Selecting interviewees

The aim was to target 'FM/BIM experts' who would be able to review the CST from literature, reflect on these and perhaps other factors with their practical experience perspective, to provide feedback and help establish the CSF for FM engagement to achieve the best outcomes in BIM projects. A sampling procedure based on the advice of Saunders, Lewis and Thornhill (2016, p. 275) was established to select appropriate interviewees; i.e. the sample should be "related to the population highlighted in the research questions and objectives". This involved reducing the focus from an overall 'population' to a 'sample' within a 'target population' as illustrated in Figure 10.1.

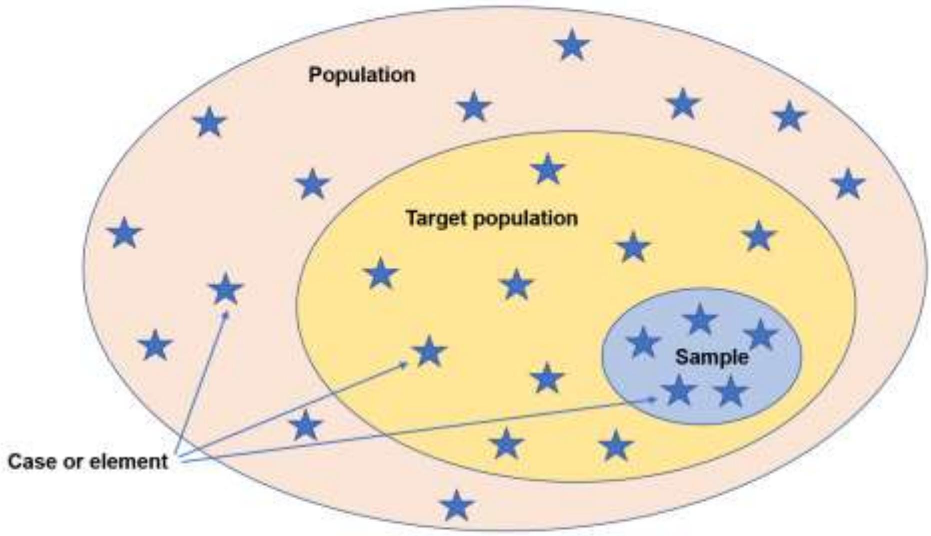


Figure 10.1: Defining a sample within a population (Saunders, Lewis and Thornhill, 2016)

An objective was to reduce interviewer/interviewee 'response bias' in line with the advice of Easterby-Smith et al. (2015, p. 221) who suggested using a 'sampling frame'. This should help achieve a low bias meaning "that conclusions from a specific sample can reasonably be applied to a larger population, and high precision means that the margin of error in the claims that are made will be low" (ibid, p.224).

The research required representation from various stakeholders in the BIM process. As such, the wider 'population' was defined as professionals from the wider AEC/FM industries. The 'target population' was the experts who had experience of working on BIM projects. To narrow the selections further the final 'sample' of selected interviewees would target experts with relevant experience and know-how based on a series of defined criteria as shown in Table 10.2.

Table 10.2: Interviewee selection criteria

Selection criteria	Detail
1. Stakeholder role	Interviewees should be one of the key stakeholders in the BIM process
2. RIBA PoW process	Interviewees should be familiar with the RIBA PoW
3. Relevant experience	Interviewees should have a minimum of 3-5 years relevant FM and/or BIM experience
4. BIM knowledge	Interviewees should have a good knowledge of the BIM process
5. Professional membership	Interviewees should ideally have membership of a professional institution e.g. ➢ BIFM: British Institute of Facilities Management ➢ RIBA: Royal Institute of British Architects ➢ RICS: Royal Institution of Chartered Surveyors ➢ CIOB: Chartered Institute of Building ➢ CIBSE: Chartered Institute of Building Service Engineers

Based on discussions with the researcher's supervisor and taking into consideration similar studies a sample size was set of 15-20 FM/BIM experts to provide good generalisation within the limitations of the sample size. The researcher then used his extensive network of contacts to select appropriate interviewees. In some cases advice was also taken from the BIFM regarding appropriate experts. Each person was then approached in person to ask if they were interested to partake in the research. All those approached agreed and were then sent the more formal paperwork as outlined in Section 10.2.6. Table 10.3 shows the stakeholder groups who were considered during the selection process.

Table 10.3: Interviewee selection criteria

Stakeholder group	Job role/function
1. Investors and owners	• Investors • Owners (buildings and RE portfolios) • Clients and client representatives (agencies)

2. Planning and design	• Planners
	• Architects and design specialists
	• Consultants:
	  ○ Financial/cost advisors
	  ○ FM
	  ○ BIM advisors
	  ○ IT (including CAFM, IFC, COBie etc.)
	  ○ Legal (BIM issues)
	  ○ Safety, environment, sustainability
	• SMEs (Subject Matter Experts):
	  ○ Electrical
	  ○ Civil
	  ○ Mechanical
	  ○ Structural
	  ○ Other (HVAC, Fire, BMS etc.)

Stakeholder group	Job role/function

3. Construction	• Construction managers
	• Project managers
	• Quantity and building surveyors
	• General contractors
	    o Suppliers/fabricators
	    o Installation companies
	• Surveyors (QS/building)
	• BIM managers
	• Commissioning managers

4. Operations and end of Life	• End users • Facility managers • FM providers (internal and external) • Information Managers • CAFM consultants and providers

The criteria were used to help improve the credibility/reliability. Ensuring candidates had relevant work experience, in terms of FM/BIM across the stages of the RIBA PoW, allowed a link to be created between theory and practice. Their expert knowledge was key to establishing the CSF in the BIM process. Membership of professional institutions who were helping establish/develop BIM best practice guidance was also seen as important.

Based on the selection criteria, 19 interviewees were interviewed between 8.5.17 and 17.6.17. The final interviewee representation made up from the relevant stakeholder groups is shown in Table 10.4 **Note**: names are anonymised for confidentiality.

Table 10.4: Profile list of FM/BIM experts

No	Role/Function	Location	Gender	Age	Stakeholder	Work experience	Type of organisation	Interview
1	Director	UK	Female	52	Client and FM consultant	FM, BIM and WLC	FM supplier	08.05.2017
2	Facility Manager	UK	Male	41	Client	FM and BIM	Local government	08.05.2017
3	Director and IT & BIM Consultant	UK	Male	57	BIM consultant & standards advisor	AEC consultancy BIM	AEC & BIM consultancy	09.05.2017
4	Architect & BIM Coordinator	UK	Male	37	Architect & BIM advisor for design teams	Architecture, BIM	Architectural design house	09.05.2017
5	Senior Solicitor	UK	Female	39	Legal advisor & BIM consultant	Legal advice and BIM consultancy	Construction company	10.05.2017
6	BIM Technologist	UK	Female	33	Lead BIM modeler information management	BIM and BIM modelling	Architect practice	10.05.2017
7	Managing Director	UK	Male	53	FM consultant, BIM & CAFM expert	FM, CAFM and BIM software	FM, CAFM & BIM software consultants	11.05.2017
8	Global BIM & Information Director	UK	Male	54	Client advisors for WLC project delivery	WLC projects, BIM, standards	Consultancy, civil and infrastructure	12.05.2017
9	Director for BIM Strategy	UK	Male	50	Advisor for OPEX and CAPEX clients	AEC, BIM policy and standards	All aspects of built environment	12.05.2017
10	Director & Head of Property Management	UK	Male	47	Client, FM and BIM expert and champion	FM, BIM and project management	Financial services and banking	15.05.2017
11	Director Asset Strategy and Maintenance	Australia	Male	59	Client and FM/AM management	FM, BIM, AM and AM strategy	Health (previous Sydney Opera House)	16.05.2017
12	Director of Research and Innovation	UK	Male	42	Advisor for the AEC technical design	BIM, architect, engineer	Information delivery to the AEC industry	17.05.2017
13	Director	UK	Male	50	Advisor to clients & AEC companies	BIM and standards developer	Consultancy to the built environment companies	17.05.2017
14	Strategic Development Director	UK	Male	48	FM and BIM consultant/advisor	FM, BIM, PFI, construction, WLC	Construction company with FM division	19.05.2017
15	Managing Director	UK	Female	50	Client agent, FM advisor and provider	FM, BIM, WLC, construction	FM services globally for private/public clients	08.06.2017
16	Director/Management Consultant	UK	Male	65	FM consultant and service operations	FM, WLC, BIM	Public sector health and education projects	14.06.2017
17	National Acc Director	UK	Male	50	Design consultants	FM, AM, WLC, projects	Higher and further education	15.06.2017
18	Chief Executive	UK	Male	50	AEC design advisors	BIM, information management	AEC industry	16.06.2017
19	Associate	UK	Male	33	Consultant and client advisor	BIM, FM and project management	BIM advisors to clients and AEC professionals	17.06.2017

10.2.3 Deciding on interview type

When selecting the appropriate interview type the advice of Saunders, Lewis and Thornhill (2016) as well as Young, Bell and Fristad (2016) was followed. This involved deciding on whether to use:

- Structured interviews
- Semi-structured interviews
- Unstructured or in-depth interviews

Figure 10.2 based on their observations, highlights different aspects of each interview type.

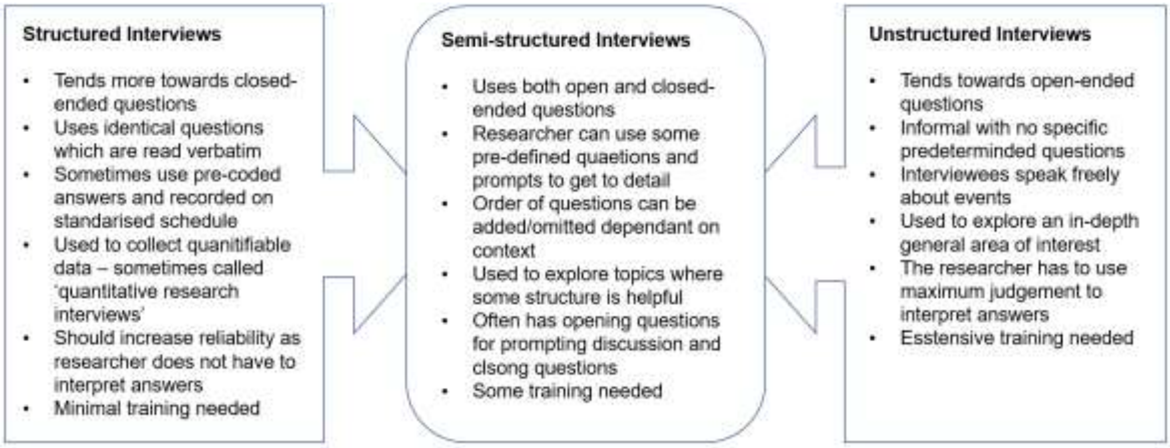


Figure 10.2: Different interview procedures (self-study based on various authors)

The 'semi-structured' approach was deemed most appropriate as this aligned with the aim of presenting semi-structured ideas (based on CST established from literature) and asking interviewees their opinions. Saunders, Lewis and Thornhill (2016, p. 394) argued this approach was appropriate where the study "includes an exploratory element", and where the researcher wants to "probe answers, where you want your interviewees to explain, or build on, their responses". This was the case for establishing what might constitute the CSF through discussion and follow up probing questions.

10.2.4 Constructing questions

In order to compare the theory from the literature with the experts practice perspective, a series of questions were developed which focused on the CST themes identified (Chapters 8.4-8.7 - policy, technology, processes, people). Themes around standards/guidance and mobilisation in BIM projects were also represented in the questions. The advice of Saunders, Lewis and Thornhill (2016, p. 408) was followed to ensure an appropriate balance of question types, including; open, probing, specific and closed. Most of the questions were open in nature with follow up probing questions to get the interviewees to describe their experience as richly as possible.

The questions were grouped in the 'interview protocol' as shown in Table 10.5.

Table 10.5: Question logic for interviews

Part	Study of issues that are important for each step
Part A: Background information	These questions were used to establish and record the contextual information about each of the interviewees including details of their background and experience, stakeholder status as well as Information regarding gender, age and education.
Part B: Experience of FM, WLC and BIM	These questions allowed the researcher to establish a context in terms of what level of experience each interviewee had with respect to certain key areas in the BIM process including WLC, FM and the BIM process itself.
Part C: CSF for FMs in the BIM process	These questions helped explore the CST main and sub-themes established during the literature review in detail to compare theory with practice and to provide data for identifying key CSF.
Part D: Current industry BIM standards/guidance	These questions were used to explore the levels of awareness of BIM standards and guidance in practice. They helped establish CSF in relation to the use of and development of standards/guidance and also to establish where the experts felt further guidance was required.
Part E: Mobilising for BIM projects	These questions were aimed at establishing CSF that would help FMs involved in the mobilisation of BIM projects It also helped the author establish some CSF for the structuring and appearance of the study's *'FM-BIM Mobilisation Framework'*.
Part F: Closing the interview	The interviewees were asked if there was any other relevant information that had been missed or anything that they felt was a CSF which had been missed.

10.2.5 Pilot testing

Two stages were involved; firstly, early in the research a '*BIM and FM Research & Practice Workshop'* was organised which was held on 1.6.15 as a side event at the 'EuroFM 2015 Conference'. A group of 20 researchers, FM practitioners and construction professionals came together from the UK, Switzerland, Germany, Denmark, Norway, Netherlands and the US to discuss how BIM was impacting on FM. The aim was to have a broad discussion and get an early feel for developing themes that could be discussed in the planned interviews with FM/BIM experts and the concurrent quantitative questionnaire. The write up of the pilot workshop can be found in Appendix E.

Secondly; several pilot interviews were held with colleagues from IFM to test the proposed questions and ensure they were clear. This allowed the questions to be fine-tuned based on their feedback before the actual interviews.

10.2.6 Interview protocol, information sheets and consent forms

Creswell (2014, p. 194) suggested researchers should "plan to develop and use an interview protocol for asking questions and recording answers during a qualitative interview". However, a first step to ensure compliance with LJMU ethical guidelines was to produce a pack of information to send to potential interviewees before an interview to ensure they were fully informed of the research aim and gave consent to be involved. This was then combined with the interview protocol. The list of documents included:

- **Interview participant email:** to invite possible participants to take part (Appendix F)
- **Interview participant information sheet**: giving a full overview of the research (Appendix G)
- **Interview consent form:** to record willingness to participate in the research (Appendix H)
- **Interview Protocol:** the detailed list of questions for the interview (Appendix I)

The interview protocol and associated documents were used to help manage the interviews. It included all the questions and an 'introduction and scene setting' section to:

- Confirm the interview format and briefly explain the research aim
- Explain the expected benefits to academia and FMs in practice
- Confirm permission to record the interview and that the data would remain confidential

Each potential interviewee was contacted initially by phone to gauge if they would be interested to participate. For those who were; a formal email invitation was sent together with the information sheet and consent form. The interviewees were then given several weeks to review the information before checking if they were happy to proceed by returning the signed consent form.

10.2.7 Carrying out and recording the interviews

The advice of Saunders, Lewis and Thornhill (2016) was followed regarding the logistics planning for interviews. As there was a lot of content to cover, each interview was planned in two stages: a first 1.5-hour slot, with a follow-up slot if required. In line with advice from Sullivan (2012, p. 59) the online Zoom tool (2019) was deemed appropriate for interviews, to keep cost to a minimum, and due to the researcher being based in Switzerland. Test sessions were offered to those unfamiliar with the tool. A link was sent out in advance of the interview date and people were asked to find a quiet place away from disturbances. For each interview a few minutes were planned at the start to go over the process and ensure the interviewees were comfortable. Permission was then confirmed for recording and the interview protocol used to guide the interviewee through each question.

Note: An online folder for each interviewee was set up to store soft copies of all the relevant interview information:

- Invitation to participate in the interview (recording date and time)
- Information and consent forms
- Interview recordings (mp4 files)
- Final interview transcripts

Note: a similar process was set up for the focus group.

10.2.8 Transcribing interviews

The interviews were transcribed using the services of a touch typist. A secure online folder was set up to share the interview recordings immediately after completion. As the proposed analysis would not focus on speech mannerisms the advice of Rubin and Rubin (2012) was followed omitting specific pronunciation, frequent repetition, pauses and grammatical errors. After each transcription was completed a 'data cleaning' check was carried out whilst the content was still fresh in the mind as recommended by Saunders, Lewis and Thornhill (2016, p. 572). Transcription file names and content were anonymised for confidentiality. A sample transcript can be found in Appendix J.

10.3 Coding method of interviews

Thematic coding analysis was chosen for the interviews. Braun and Clarke (2006) observed it as a systematic, flexible and accessible approach for qualitative analysis. Gläser and Laudel (2013) argued that "qualitative content analysis requires a precise research question from which a clear understanding of the data we need from our texts can be derived prior to the analysis". It was deemed appropriate in line with advice from Saunders, Lewis and Thornhill (2016, p. 579) who noted its essential purpose "to search for themes, or patterns, that occur across a data set".

Grbich (2013) described how the process uses 'codes' which can be single words or short phrases to allow the reduction of data into meaningful groups. According to Saunders, Lewis and Thornhill (2016, p. 580) the coded extracts of data or 'units of data' can range from a few words to whole paragraphs. These are used to help analysis of the data in relation to the research questions and objectives. Maguire and Delahunt (2017) argued thematic analysis done well is much more than just a summary of the data; it interprets and makes sense of it. Clarke and Braun (2013) noted it is a method rather than a methodology, and as such not confined to one philosophical position. Saunders, Lewis and Thornhill (2016, p. 579) suggested this allows it to be used as a standalone technique "irrespective of whether you are adopting an objectivist or subjectivist position" or "a deductive or inductive approach" (ibid). Braun and Clarke (2006, p. 77) noted it is "important to be clear about the theoretical approach" and suggested two avenues:

1. A 'top-down' or theoretical thematic analysis driven by the specific research questions and/or the analyst's focus
2. A 'bottom-up' or inductive one that is more driven by the data itself.

It was decided the appropriate approach was an inductive, exploratory and bottom-up one. Braun and Clarke (2006, p. 77) suggested using the "experiences, meanings and the reality of participants", with the aim of "deriving themes based on what interviewees actually said" (ibid). Saunders, Lewis and Thornhill (2016) were referred to, who noted the importance of considering how the codes are derived. Figure 10.3 highlights their suggestions as to possible approaches.

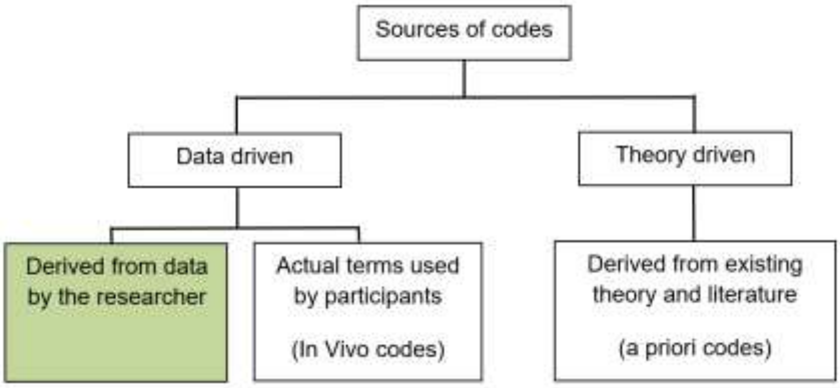


Figure 10.3: Sources/types of thematic codes - Saunders, Lewis and Thornhill (2016)

Based on the research objectives it was decided the most appropriate sources of codes were 'data' driven by the researcher. 'In Vivo' coding was considered but the aim was not to specifically use the exact words of participants, but rather the wider CSFs meaning (derived by the researcher).

10.3.1 Selection of coding methods

Saldaña (2016, p. 69) observed with respect to selecting the appropriate method(s) that researchers should consider which methods are most appropriate. He added "depending on the nature of your study, you may find that one coding method alone will suffice, or that two or more are needed to capture the complex processes or phenomena in your data". However, he cautions against "muddying the analytic waters, by employing too many methods for one study" (ibid).

The researcher agreed with the stance taken by Saldaña of 'pragmatic eclecticism' (ibid). He suggested the researcher remains "open during the initial data collection and review before determining which coding method(s) – if any – will be most appropriate and most likely to yield a substantive analysis" (ibid, p.70). Saunders, Lewis and Thornhill (2016) noted there are many coding techniques that could be used and highlighted eight to consider:

1. Thematic analysis
2. Template analysis
3. Explanation building and testing
4. Grounded theory
5. Narrative analysis
6. Discourse analysis
7. Content analysis
8. Data display and analysis

Based on several recommendations, it was decided to use the book by Saldaña (2016) '*The coding manual for qualitative researchers'* as a principle guide for the detailed coding work. His work highlighted even more: 32 techniques in total. He categorised them into 26 'first cycle' and 6 'second cycle' methods. The "first cycle methods are those processes that happen during the initial coding of data" (ibid, p.68) and are used as a first stage to sort the data. The 'second cycle' methods go deeper and "require analytical skills as classifying, prioritising, integrating, synthesizing, abstracting, conceptualizing, and theory building" (ibid, p.69). These are used to further refine the analysis of the data. The 32 codes are shown in Table 10.6 (ibid, p.68). **Note**: one additional method 'eclectic coding' is described as a hybrid method between first and second cycle. As part of the research design each one was reviewed to see which would be best suited for the research.

Table 10.6: First and second cycle coding methods (Saldaña, 2016)

First cycle coding methods	
1. **Grammatical Methods** Attribute Coding Magnitude Coding Sub-coding Simultaneous Coding	4. **Literary and Language Methods** Dramaturgical Coding Motif Coding Narrative Coding Verbal Exchange Coding
2. **Elemental Methods** Structural Coding Descriptive Coding In Vivo Coding Process Coding Initial Coding Concept Coding	5. **Exploratory Methods** Holistic Coding Provisional Coding Hypothesis Coding
3. **Affective Methods** Emotion Coding Values Coding Versus Coding Evaluation Coding	6. **Procedural Methods** Protocol Coding OCM (Outline of Cultural Materials) Coding Domain and Taxonomic Coding Causation Coding
7. Theming the data	
First to second cycle coding methods Eclectic coding	
Second cycle coding methods Pattern Coding Focused Coding Axial Coding Theoretical Coding Elaborative Coding Longitudinal Coding	

When reviewing which method(s) were appropriate the advice laid out in the book was followed. This included reviewing the following issues:

- **Level of detail of coding:** 'line-by-line In Vivo' coding was deemed not appropriate, as the main aim was to establish 'MT' (topics) and 'ST' (within the topics) to help identify CSF for FM involvement in the BIM process, rather than specifically considering the language used.
- **Selection of coding methods:** Saldaña suggests avoiding "descriptive statistics' as a default method" (ibid, p.76). He noted this tends to produce a long list of topics and subtopics, but

generally does not offer analytical insights about the perspective of the participants. This was especially relevant when the aim was to benefit from the FM/BIM expert's experiences. Other coding methods were considered to extract more from the analysis.

- **Code Proliferation:** avoid creating more codes than needed making analysis impractical. Searching for 'commonality' within the data was fundamental to avoiding proliferation. Initial themes were developed during the 'first cycle' coding. A 'second cycle' coding process then identified the specific key MT and ST to help establish relevant CSF.
- **Alignment of coding with research aims and questions:** the nature of the research question(s) influenced the researcher's coding choice(s). As such, each of the 26 'first cycle' methods were reviewed to check their appropriateness and alignment with the research objectives.
- **Code organisation and subsuming codes:** an open mind was kept during the coding process towards "subsuming codes into broader codes or categories" (ibid, p.79) to streamline the process and avoid proliferation. This included a 'clean up' and 'recoding' approach from the start, using the first few transcriptions as pilot tests as the process was gradually refined.
- **Code only the most essential parts of your data corpus**: this principle was adopted to help focus on analysing text portions deemed relevant to the study.

The following coding methods as described by Saldaña (2016) were deemed appropriate:

<u>First cycle</u>

- **Descriptive coding:** was used to organise and manage the data and help code basic descriptive information about the interviewees. This included information such as; age, gender, stakeholder status, industry sectors etc. this data would then be available to provide context for the further analysis of data (ibid, p.292).
- **Structural/Theming**: the coding looks for codes/themes applied to specific phrases/segments of data to "code and categorise the data corpus" (ibid, p.297). "Similarly-coded segments are then collected together for more detailed coding and analysis" (ibid). This approach is especially recommended for "semi-structured data-gathering protocols" (ibid) where the aim is to "gather topics lists or indexes of major categories or themes" (ibid).

<u>Second cycle</u>

- **Pattern coding:** organises the corpus into sets, themes, or constructs to develop major themes from the data. In this case the final list of qualitative CSF from the practice FM/BIM expert perspective.

10.3.2 Coding procedure

Strauss (1987, p. 27) argued "any researcher who wishes to become proficient at doing qualitative analysis must learn to code well". The success of the research depends largely on the excellence of the coding (Charmaz, 2001). Rubin and Rubin (2012, p. 238) noted there is a critical link between data collection and the explanation of meaning; coding is “the process of grouping interviewees' responses into categories that bring together the similar ideas, concepts, at themes you have discovered, or steps or stages in a process”. According to Saunders, Lewis and Thornhill (2016, p. 580) the process is “concurrent and recursive” and Saldaña (2016, p. 68) observed “data is not coded, they’re recoded”. He argued this is done in a cyclic nature by progressive “refinement of the codes in a study as stages, levels or feedback loops” (ibid).

Clarke and Braun (2013) argued the importance of having clear guidance on the practical aspects of how to do qualitative research; and Nowell et al. (2017) observed that having a clear process is very important to ensure credibility of the research. Maguire and Delahunt (2017, p. 3353) suggested following the framework of phases recommended by Braun and Clarke (2006), and applying it in a systematic manner, as “it is arguably the most influential approach, in the social sciences at least, probably because it offers such a clear and usable framework for doing thematic analysis”. As such the six steps of the framework shown in Table 10.7 were used to guide and structure the main coding process.

Table 10.7: Six key phases in thematic analysis (Braun and Clarke, 2006)

Phase	Description of the process
1: Familiarizing yourself with your data	Transcribing data (if necessary(, reading and re-reading the data, noting down initial ideas.
2: Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code.
3: Searching for themes	Collating codes into potential themes, gathering all the data relevant to each potential theme.
4: Reviewing themes	Checking if themes work in relation to the coded extracts (level 1) and the entire data set (level 2), generating a thematic 'map' of the analysis.
5: Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells, generating clear definitions and names for each theme.
6: Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis.

10.3.3 Familiarising yourself with your data

Maguire and Delahunt (2017) suggested researchers should become familiar with the entire data corpus (i.e. all interviews and any other data being used) before progressing with coding. As such, familiarisation with the interview data was seen as critical. This was achieved in three stages:

- Firstly, during the transcription process itself
- Secondly, by revisiting each transcript in a ‘data cleaning’ process to re-read the content and correct any transcription errors
- Thirdly, by re-reading to decide any final edits before analysis commenced

As part of the ongoing familiarisation process 'self-memos' about key thoughts and ideas were recorded directly in NVivo.

10.3.4 Generating initial codes

The purpose of coding is to reduce the large sections of data in interview answers into small portions with clear meaning.

NVivo was selected as the Computer Aided Qualitative Data Analysis Software (CAQDAS) to carry out the thematic analysis and coding. The software, stated Bazeley and Johnson (2013), is a powerful tool that can be used to manage data and ideas, run queries and generate reports. Whole transcripts can be imported and stored for review and analysis. The transcripts can be viewed at any time in their original context and are coded into 'nodes'. Relevant sections of text can be highlighted and copied into the nodes, maintaining a record of the original source and location. They are like a filing system which can be organised and named in a hierarchical way to reflect codes or themes in terms of ideas. Bazeley and Johnson (2013) noted the nodes can be renamed, reorganised, merged or grouped at any time in the analysis.

Clarke and Braun (2013) observed a common mistake is using the main interview questions as the codes and themes. Maguire and Delahunt (2017) argued that this constitutes summarising and organising the data, rather than analysing it. Consequently, before the transcriptions were undertaken the 'import-formatting' capabilities of NVivo were checked to ensure relevant formats and colours used in the initial transcripts would be successfully replicated. Each interview was imported into NVivo and the first cycle coding techniques of 'descriptive coding', and then 'structural/theming coding', were applied. These identified relevant segments of text that suggested interesting ideas or possible themes. The inductive approach taken meant using 'open-coding', i.e. no pre-set codes were used, or presumptions were made about relationships or connections.

As the process developed notes were taken and ideas for developing the nodes iteratively for further themes. The initial data from all the interviews was coded using codes and sub-codes. These were then grouped together into categories and sub-categories.

As the analysis developed the categories where gradually compared and then consolidated into more general main themes. This idea was described by Saldaña in his book (2016, p. 14) and is shown in Figure 10.4.

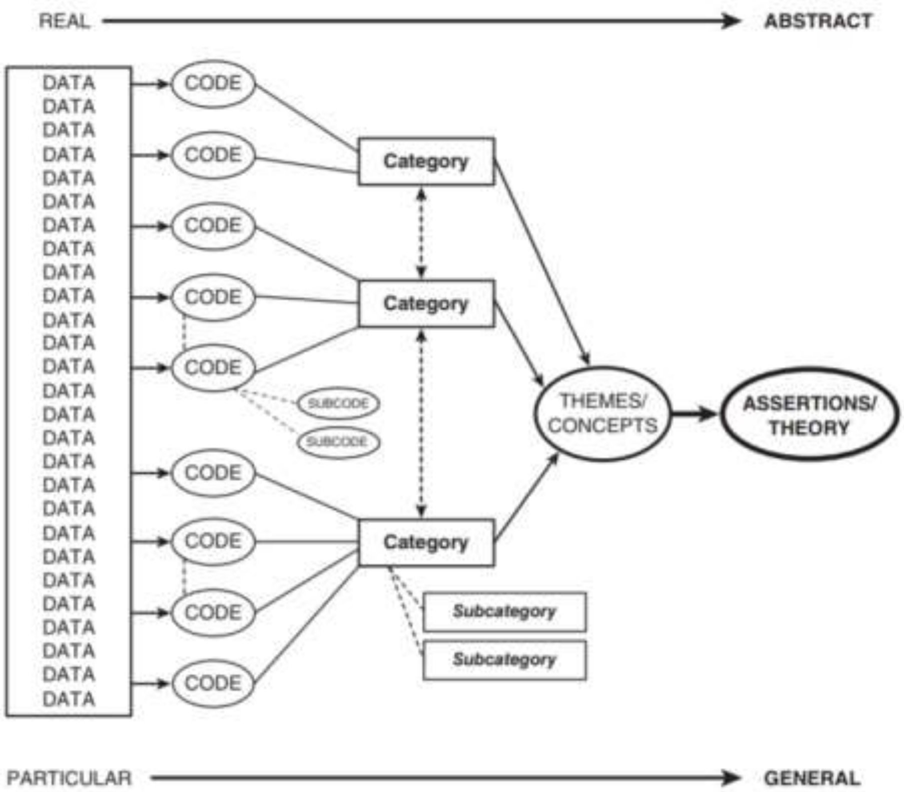


Figure 10.4: Codes-to-category-themes theory model (Saldaña, 2016)

10.3.5 Reviewing themes

Saunders, Lewis and Thornhill (2016, p. 584) noted "the search for themes fully begins when you have coded all your data set and is a distinct stage". At this point the aim is to search for patterns (hence the second cycle pattern coding).

The advice of Maguire and Delahunt (2017) and Braun and Clarke (2006) was followed, and the following points deliberated when developing themes, and considering whether they worked in the context of the entire data set:

- Do the themes make sense?
- Does the data support the themes?
- Am I trying to fit too much into a theme?
- If themes overlap, are they really separate themes?
- Are there themes within themes (subthemes)?
- Are there other themes within the data?

They noted that themes can be 'semantic' i.e. "based on the explicit or surface meanings of the data" (ibid, p.84); or latent i.e. "based on identifying or examining the underlying ideas, assumptions, and conceptualisations – and ideologies - that are theorised as shaping or informing the semantic content of the data " (ibid).

Occurrence (and non-occurrence) were used to identify major themes, and where appropriate, were then divided into sub-themes. During the overall process some themes were merged with others, or deleted as the analysis progressed. As recommended by Saunders, Lewis and Thornhill (2016, p. 584) this had the "effect of reducing and rearranging your data into a more manageable and comprehensible form". This aligned with the aim: to examine and organise the codes into the broader themes that constituted the qualitative CSF.

10.3.6 Defining and naming themes

In the final step the themes were further 'refined and renamed' as the researcher sought to understand what each theme was revealing, as well as the relationships between MT and ST. The key aim here was to "identify the 'essence' of what each theme is about" Braun and Clark (2006, p. 92) commented. This then allowed the development of what would form the basis of the final list of qualitative CSF MT and ST.

10.3.7 Producing the report

As part of the analysis a series of thematic maps were developed to represent the hierarchy and relationships between the CSF MT and ST.

10.4 Chapter summary

The logic for the chosen qualitative approach and subsequent interview design has been clearly explained. The adopted procedure resulted in 19 qualitative semi-structured interviews from a wide range of 'FM/BIM experts' with knowledge across every stage of the RIBA PoW. Their experience and know-how were probed to provide an extremely rich data set with over 110,000 words of transcribed text. The data set was subsequently iteratively coded using thematic analysis in NVivo. This allowed the fulfilment of research objective (c) to establish qualitative CSF from 'FM and BIM experts' to understand their view of how BIM is impacting on FM and what would help FMs best engage in the BIM process (using semi-structured interviews). Input will be mainly based on the UK but may include international experts.. This step in the concurrent convergent design provided a clear link between the theory and practice, by comparing the CST from the literature (Chapters 8.4-8.7), with the views of the 'FM/BIM experts' and their direct experience of how BIM is impacting on FM in practice. The review process to rename and reorganise the themes resulted in a series of thematic maps which are presented in Chapter 11.

Chapter 11: Qualitative analysis and findings

This chapter presents the findings from the analysis of the interviews with 'FM/BIM experts', which used NVivo and thematic analysis to achieve research objective (c) defined in Chapter 1:

> To establish qualitative CSF from 'FM and BIM experts' to understand their view of how BIM is impacting on FM and what would help FMs best engage in the BIM process (using semi-structured interviews). Input will be mainly based on the UK but may include international experts.

11.1 Analysis of the FM/BIM experts' interviews

An overview is provided of the interviewee profiles and how NVivo was used to develop the CSF MT and associated ST. The identified themes are presented using a series of bubble diagrams and then discussed in detail using quotes from interviewees.

A summary list of the qualitative CSF is presented at the end of the chapter. These were subsequently used in the CSF merging process (Chapter 14) to produce a final CSF list for the '*FM-BIM Mobilisation Framework'.*

11.2 NVivo thematic analysis

The interview transcripts were uploaded in NVivo and thematic analysis applied to identify key MT/ST. This was done by coding passages of text and then developing emerging themes. Background data about gender, job function, experience, etc. was also collected.

The analysis identified interesting topics which were coded as 'free nodes' at a low level. These were then gradually and iteratively organised and grouped using a hierarchical 'tree node' system.

Figure 11.1 shows a screenshot from NVivo illustrating the coding. Nodes A and B include interviewees background data. Node C includes the final identified high-level MT. The figure shows MT1 expanded with its (mid-level) ST. Beneath these are the low-level 'free nodes'.

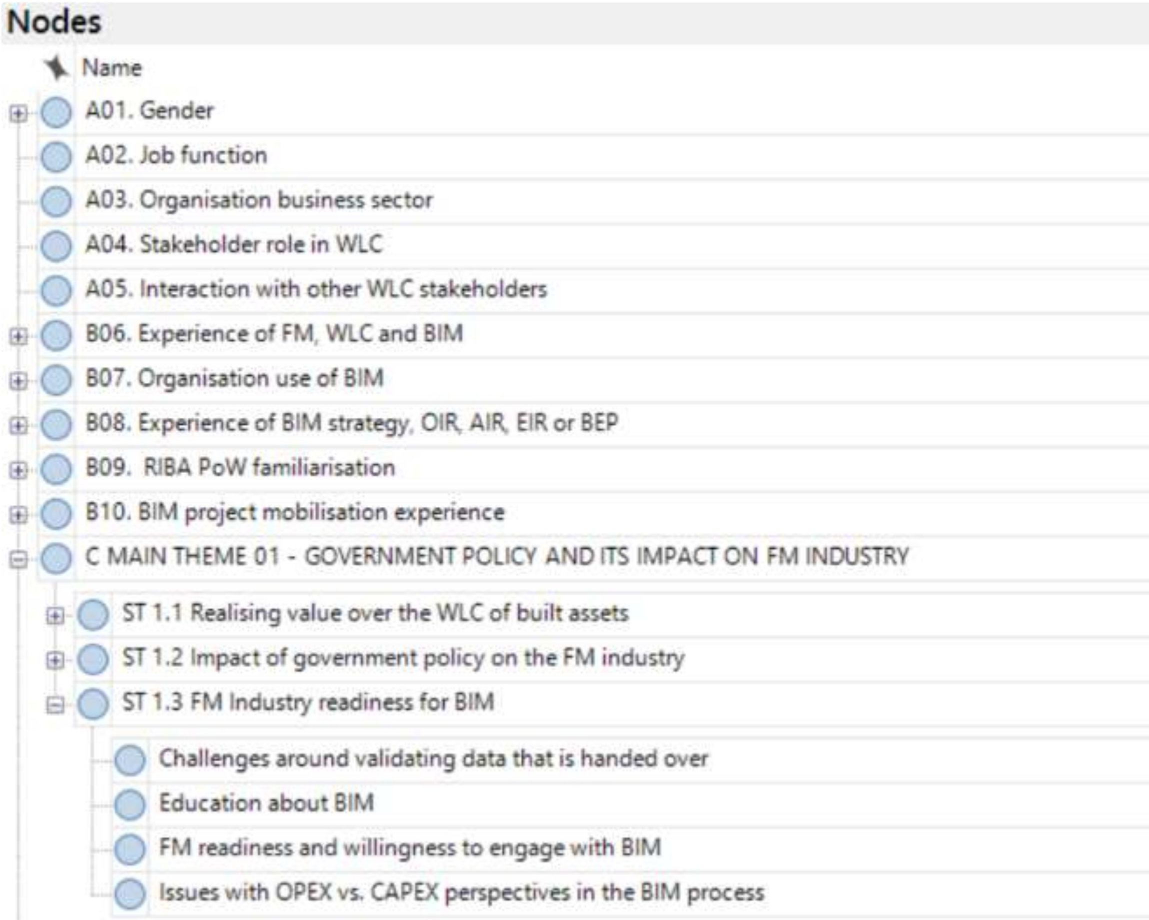


Figure 11.1: NVivo 'tree node' system used in thematic analysis

11.3 Qualitative CSF themes

The CSF are presented as a series of thematic maps. Each MT was highlighted in blue e.g. **CSF_QUAL_MT1** (the first qualitative MT). Associated ST are shown in green using similar notation e.g. **ST_QUAL-T1.1** (qualitative ST1.1 under MT1). The number of passages of text from NVivo appear in brackets to illustrate the thematic analysis profile.

Narrative text is then used to highlight themes for each ST using interviewee quotes. These appear in "*italic quotation marks*" referencing the interviewee quoted e.g. (I-1). Topics deemed interesting/important appear in **bold**. These would then be used to compare key issues also from the quantitative CSF using the 'side-by-side' narrative comparison and where appropriate included in the '*FM-BIM Framework*'.

11.3.1 CSF_QUAL_MT1: Government policy impact on the FM industry

240 passages of text were divided into three ST as illustrated in Figure 11.2.

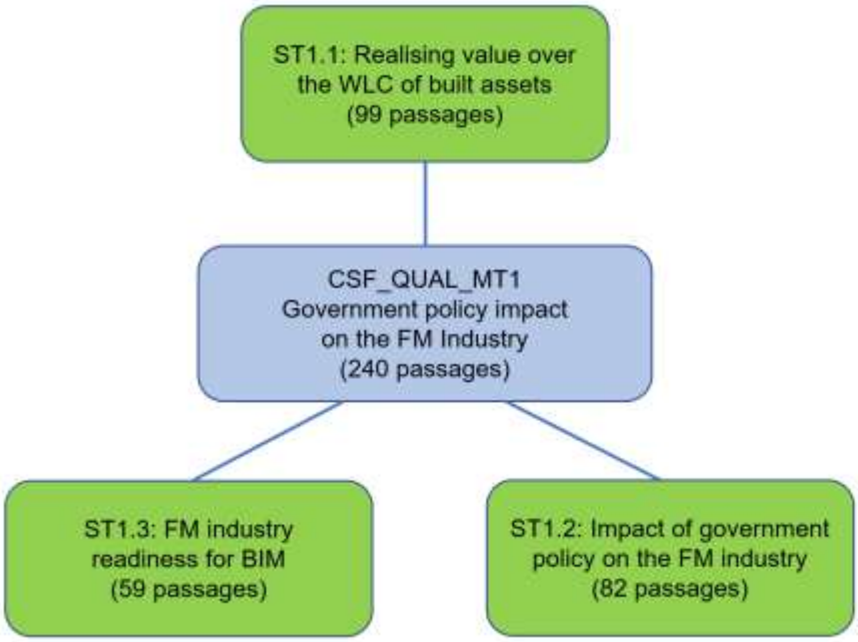


Figure 11.2: CSF_QUAL_MT1: Government policy and its impact on the FM industry

ST_QUAL_T1.1-Realising value over the WLC of built assets

(**I**-7) noted the need for a **WLC cradle-to-cradle approach**: "*designing sustainable equipment and items that can then be reused and reworked."* Achieving **best value** was raised by (**I**-15): "*we should be advising clients that focusing on short term costs, is not the best measure by which long-term value is determined."* (**I**-17) suggested BIM can **improve procurement**: "*FMs could use BIM to improve their tendering strategy and drive down WLC for clients.*" (**I**-16) discussed **quality/life-longevity**: "*in a 25-30-year PFI, replacing floor coverings causes significant inconvenience and disruption. A cheaper product with a 10-year life may be replaced twice, whilst a more expensive 15-year life once".* (**I**-6) noted **feedback loops** can help: **"***if designers know about typical everyday maintenance problems, we can change the design to avoid long-term problems."* (**I**-6) discussed conflicts between **CAPEX and OPEX budgets**: "*clients are often driven by CAPEX budgets".* (**I**-19) discussed **value engineering**: "*It's an uncomfortable truth that value engineering is mainly about reducing the CAPEX expenditure, with little real consideration of the downstream impact on WLC.* (**I**-1) suggested '***Soft Landings'*** will help "*improve usability, sustainability, etc. as it drives BIM projects to be aligned with and follow the FM process"*. (**I**-17) suggested ***'BS-8536'*** *was "key guidance for getting FM input at the right time*". **Performance targets** were highlighted by (**I**-13) "*upfront performance targets should be set and systematically assessed to ensure they are met*".

ST_QUAL_T1.2-Impact of government policy on the FM industry

(I-18) noted "*government vision and policy mandating people to use BIM has been fundamental in galvanising BIM's success in the UK*". (I-12) discussed **government construction strategy targets**: "*their 'Construction 2025' and the 'Construction Strategy' set clear and challenging targets"*. (I-2) suggested more **FM-BIM leadership** was needed: "*more publicised examples of successful BIM best practice will help contribute towards the Government's strategic targets.*" (I-4) believed FMs should help **clients drive change** and "*push FM contractors and their own teams to look at BIM*". (I-5) observed "*we're already seeing client requirements for BIM models, their use and handover to the FM teams*". (I-17) discussed **FM incentivisation**: "*they've provided an opportunity for early FM involvement and to get the right data in the right format.*" However, (I-2) felt "*it will take a decade until FM fully grasp the potential of BIM, then it will be the norm"*. (I-3) discussed the **digitalisation of Britain's assets** and BIM Levels 3+: "if *BIM Level 2 was about capital cost and making the best of current mechanisms, the next levels will include OPEX and probably carbon sustainability and the circular economy."* (I-12) suggested "*the next logical step is using cloud technologies, big data and other emerging technologies*". (I-6) believed this will lead to ***smart cities***: "*BIM is the start of smart cities in which FMs will have a massive role to play.*" (I-3) agreed but cautioned "*the technology is some way off everyday implementation yet*". The need for **young people in FM** was raised by (I-14): "*digital technology is a powerful way of attracting young people to join our industry.*"

ST_QUAL_T1.3-FM industry readiness for BIM

(I-7) believed "*most FMs don't really understand what BIM is*". (I-2) agreed "*the FM industry is not prepared. It does not really understand how BIM benefits FM*". However, others like (I-14) were more confident: "*FMs are already focused on cost, sustainability, diversity, etc., it's part of our day job. Most people would be confident with implementing 'Soft Landings'.*" (I-18) highlighted the key was **FM industry education regarding BIM**: "*A massive education exercise is required within the FM industry to explain BIM.*" (I-7) observed "*using mobile technology and linking the data sets together will be transformational in the terms of the profitability of organisations*". (I-7) observed "*Although FMs have valuable knowledge about processes and WLC, in other areas such as adopting BIM standards and grasping the process there's lots of work to do".* (I-11) noted the importance of understanding **BIM is not just about software**: "*many people think Revit is BIM. They need to understand it's not just about the software but the overall process.*" (I-4) highlighted the need for **FMs to engage clients**: "*to contribute, FMs should be to be informed so they can help their clients*". (I-9) believed **evidence of the benefits of BIM** was important: "*to encourage clients to join the BIM journey, we need to provide hard evidence.*"

11.3.2 CSF_QUAL_MT2: Barriers and challenges to the adoption and use of BIM

221 passages of text made up one main ST, broken down into 22 SST.

ST_QUAL_T2.1-Key barriers and challenges to the adoption and use of BIM

Table 11.1 shows the 'key barriers/challenges' ranked to help visualise which have more impact.

Table 11.1: ST_QUAL_T2.1: Ranked barriers/challenges to the adoption of BIM

ST_QUAL_T2.1-Key barriers/challenges to the adoption and use of BIM	Rank	Passages	Sources
SST_QUAL_T2.1.1-Lack of digital and BIM skills, experience and training	1	36	17
SST_QUAL_T2.1.2-Lack of FM industry readiness and willingness to engage in BIM	2	25	11
SST_QUAL_T2.1.3-Cost of implementing BIM and achieving a ROI from BIM adoption	3	19	10
SST_QUAL_T2.1.4-Articulating the value benefit of BIM to FM	4	14	9
SST_QUAL_T2.1.5-False perceptions and expectations about what BIM can and should deliver	4	14	10
SST_QUAL_T2.1.6-Pessimism about BIM and what it can deliver	5	12	9
SST_QUAL_T2.1.7-Quality and accessibility of data vs quantity of data	5	12	8
SST_QUAL_T2.1.8-BIM is perceived as complex and only beneficial for larger projects	6	10	5
SST_QUAL_T2.1.9-Lack of FM industry leadership and ability to convince clients to use BIM	6	10	5
SST_QUAL_T2.1.10-Software driving solutions rather than using it to directly meet clients' needs	6	10	5
SST_QUAL_T2.1.11-Lack of case studies evidencing the benefits of BIM to FM	7	9	6
SST_QUAL_T2.1.12-CAPEX vs. OPEX budgets and not seeing the bigger WLC picture	7	9	5
SST_QUAL_T2.1.13-Legal and contractual issues	8	6	3
SST_QUAL_T2.1.14-Silo mentality and lack of early engagement of FM	8	6	3
SST_QUAL_T2.1.15-Security, risk and insurance associated with BIM information	9	5	4
SST_QUAL_T2.1.16-Too many acronyms causes confusion for people	9	5	4
SST_QUAL_T2.1.17-Perceived complexity prevents more use of BIM standards in practice	10	4	3
SST_QUAL_T2.1.18-Concerns about using BIM for existing RE as well as new builds	11	3	2
SST_QUAL_T2.1.19-Confusion between CAFM and BIM	11	3	2
SST_QUAL_T2.1.20-Lack of standardisation and classification to structure information properly	11	3	3
SST_QUAL_T2.1.21-Involvement of FM in BIM process by other stakeholders	11	3	2
SST_QUAL_T2.1.22-Short term FM and maintenance contracts hinder full engagement with BIM	11	3	3
Total passages of text		**221**	

The **top five** ranked barriers/challenges were:

1) SST_QUAL_T2.1.1-Lack of digital and BIM skills, experience and training (36)

(I-7) observed "*education about BIM is the key barrier to be addressed"*. (I-14) noted the need for **upskilling people**: "*people need to feel more secure about using digital technology. We shouldn't underestimate how important the people factor and having skills is.*" (I-16) discussed **BIM knowledge and skills**: "*I think they are like the Ten Commandments; you need to know to what to do, but also how to do it.*" (I-10) discussed **age profiles**: "*some of the older generation struggle with the technology. BIM is a good way to connect generations.*" (I-18) noted **adequate resources** (money and time) were essential: "*it's like learning to drive, initially it's quite expensive and time consuming; but once you've learnt it, it opens up a host of possibilities.*"

2) SST_QUAL_T2.1.2-Lack of FM industry readiness and willingness to engage in BIM (25)

(I-1) observed: "*the lack of understanding of the benefits of BIM to FM and clients, has hampered engagement.*" (I-5) believed **early FM involvement** was critical: "*in the past getting was a challenge.*

Early FM involvement is very important for success." (I-6) agreed **involving people** was important: "*it's about behaviour, attitude, motivation, and trying to change ways of thinking.*"

3) **SST_QUAL_T2.1.3-Cost of implementing BIM and achieving a ROI from BIM adoption (19)**

(I-10) highlighted the importance of **transparency of benefits**: "*I struggle to see where some of the projected savings will come from.*" (I-12) believed **ROI of BIM** was critical: "*with FM it's about demonstrating ROI and quality of what you deliver, BIM is no different.*" (I-1) believed **investment in BIM** as critical to success: "*a barrier often put forward is cost, which is a fallacy; there are no real additional costs specific to FM. BIM or not.*" (I-11) discussed **complexity**: "*for single buildings it's harder to prove the cost benefits than for multi-building sites as the cost per building is lower."* (I-11) noted *"people perceive BIM as expensive because someone has to pay to update models. However, it's no different from projects without BIM*".

4) **SST_QUAL_T2.1.4-Articulating the value benefit of BIM to FM (14)** and **T2.1.5-False perceptions and expectations about what BIM can and should deliver (14)**

(I-15) saw the inability to **articulate value proposition** *"as the number one reason BIM will fail*". (I-7) suggested "*we need to articulate the benefits of BIM and its value proposition to help convince clients to invest in BIM*". (I-11) proposed people **link benefits to organisation's needs**: "*the challenge is understanding the vision, goals and business strategy before delivering what clients need.*" (I-5) saw **over-selling BIM as** "*having negative results as people's expectations are set so high*". (I-15) added "*some people sell the idea you can somehow buy Level 2 BIM, but you can't buy one holistic end-to-end solution*". (I-7) suggested problems stem from people perceiving **BIM as just software**: "w*e need to dispose of that idea, it's about the information and quality of data.*"

5) **SST_QUAL_T2.1.6-Pessimism about BIM and what it can deliver (9)** and **T2.1.7-Quality and accessibility of data vs. quantity of data (9)**

(I-8) discussed **realistic expectations**: "*some people doubt the potential of BIM.*" (I-7) agreed "*potential barriers and pessimism exist, and need to be taken seriously, especially to convince people BIM is worth adopting*". (I-19) believed **poor data quality** "*at handover s still a key issue*", and discussed **quality vs quantity**: "*what's important is quality not quantity of data, especially with respect to what goes into BIM models.*" (I-16) discussed **data relevance**: "*when construction teams ask FMs what they want and they say everything, that does not help, Data should be relevant, well-structured and useful for FM management systems.*" (I-5) noted "*where people say models are not in formats that they can use, or don't contain the right information at handover, it's usually because no one took the time to find out what was needed at handover".*

For the remaining barriers/concerns some interesting observations were:

SST_QUAL_T2.1.8-BIM is perceived as complex and only beneficial for larger projects

(I-13) discussed **added complexity**: "*people blow BIM out of proportion, making it more complicated and scarier than it is. We survived without BIM for many years. People need to understand it's just a new approach.*"

SST_QUAL_T2.1.9-Lack of FM-industry leadership and ability to convince clients to use BIM

(I-2) discussed **FM-industry leadership** as "*key to overcoming barriers and helping FMs understand BIM*". (I-19) highlighted the contradiction that "*clients need to drive the process, but they often ask for a BIM building with no understanding of what that means".*

SST_QUAL_T2.1.10-Software driving solutions rather than using it to directly meet clients' needs

(I-12) discussed the **IT landscape**: "*decisions about IT are critical to the success of data exchange in projects.*" (I-19) saw **openBIM** as important: "*people should adopt an openBIM approach and consider how BIM software interfaces with or feeds data into FM software.*"

SST_QUAL_T2.1.11-Lack of case studies evidencing the benefits of BIM to FM

(I-4) believed **documented evidence** *"of improved performance and ROI is critical as clients sometimes need a leap of faith to invest in BIM*". (I-13) observed "*More case studies are needed to promote BIM based on evidence*". (I-7) believed "*when FMs can prove we get really good quality data from the BIM process to optimise operations the argument will be over*".

SST_QUAL_T2.1.12-CAPEX vs OPEX budgets and not seeing the bigger WLC picture

(I-7) noted the importance to WLC of **CAPEX/OPEX decisions:** *"decisions usually are 'value-engineered' in favour of CAPEX savings without any real thought for the much larger OPEX costs."* (I-4) believed "CAPEX*/OPEX teams need more communication, otherwise it's a recipe for disaster*". (I-2) suggested "*the future operating costs should define decisions in CAPEX planning.*"

SST_QUAL_T2.1.13-Legal and contractual issues

(I-5) discussed **legal implications of BIM** suggesting *"it must be clear contractually at what point a party hands over responsibility for models and data, as they can then say it's no longer my responsibility, it's FMs*".

SST_QUAL_T2.1.14-Silo mentality and lack of early engagement of FM

(I-14) discussed **silo-mentality working-approach:** "*stakeholders need to talk the same language as terminology can be"* (I-14) suggested "*adversarial behaviour needs to be removed*".

SST_QUAL_T2.1.15-Security, risk and insurance associated with BIM information

(I-6) noted the importance of **digital security**: *"it's a ticking time bomb, people are lax in the construction industry about digital security.*" (I-8) agreed believing "'*PAS 1192-5' and BIM online access will become a bigger security issue in the future*".

SST_QUAL_T2.1.16-Too many acronyms cause confusion for people

(I-15) believed **BIM terminology and acronyms** can be alienating and suggested "*all stakeholders should use language that others can understand*".

SST_QUAL_T2.1.17-Perceived complexity prevents more use of BIM standards in practice

(I-5) observed **complexity** as an issue: "*a 'keep-it-simple' approach is needed where people know what they need to do.*" (I-15) suggested "*BIM standards can be quite complicated*". However, (I-7) observed "*often people overuse standards, they're not used in the spirit with which they were intended*".

SST_QUAL_T2.1.18-Concerns about using BIM for existing RE as well as new builds

(I-1) discussed **BIM and data capture for existing buildings**: "*in real-life we need to remember most RE already exists; we need to address how we deal with retro-BIM for existing buildings.*"

SST_QUAL_T2.1.19-Confusion between CAFM and BIM

(I-14) discussed the **link between BIM, CAFM and FM management systems**: "*sometimes there is confusion. Some people don't understand that BIM models and data are a static data repository, whilst CAFM is the operational process tool FMs use*".

SST_QUAL_T2.1.20-Lack of standardisation and classification to structure information properly

(I-19) discussed **classification systems**: *"often structuring information and data is not discussed in projects and then people are surprised at handover when they can't find things*".

SST_QUAL_T2.1.21-Involvement of FM in BIM process by other stakeholders

(I-19) saw **stakeholder engagement of FM** as an issue: "*many BIM training schemes don't include FM-operations, so it's not surprising we are rarely invited to be involved by other stakeholders.*"

SST_QUAL_T2.1.22-Short term FM and maintenance contracts hinder full engagement with BIM

(I-16) saw **supplier contracts and data ownership** as an issue: "*a building's life span maybe 50 years; whilst most FM-contracts are outsourced every 3-5 years. FM suppliers may change several* *times over a building's life.* (I-16) suggested *"data ownership and obligations to maintain must be clear, or client is open to significant risk*".

11.3.3 CSF-QUAL_MT3: Benefits of BIM to FM

380 passages of text were divided into two ST as shown in Figure 11.3.

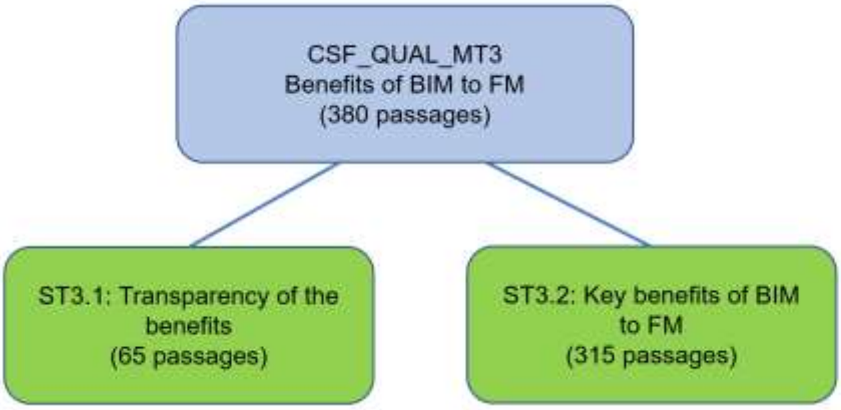


Figure 11.3: CSF_QUAL_MT3: Benefits of BIM to FM

ST_QUAL_T3.1_Transparency of benefits: this ST had five SST as shown below:

SST_QUAL_T3.1.1-Need for case studies, websites and lessons learnt for reference (24)

(I-2) discussed **evidence of BIM benefits**: "*we need case studies and literature evidence to show the benefits helpful to FM.*" (I-7) saw **BIM buy-in** as critical: "*it's difficult to convince people to engage with and pay for BIM upfront without solid reference examples"*. (I-9) saw **case studies and standardisation** as important: "*examples to help FM better price models would be a big benefit for FM.*" (I-12) added "*We need to improve our OIRs, AIRs, EIRs etc. to avoid repeating the same mistakes.*" (I-8) suggested more **guidance and ROI tools** were "*needed to help people estimate ROI.*"

SST_QUAL_T3.1.2-Need to make benefits transparent and clear (17)

(I-1) discussed **transparency and credibility**: "*needs must be described in FM language*". (I-15) observed "*BIM should be in a transparent and believable. Making promises which don't materialise won't sell BIM to potential users*". (I-17) added "*some benefits are overhyped, without evidence showing they exist.*" (I-19) agreed stating "*benefits must be credible as well as transparent*". Good **BIM books** might improve transparency: (I-3) suggested "*Eastman's 'BIM handbook', and Richard Saxon's, 'BIM for Construction Clients' to understand benefits from the client's point of view*". (I-8) discussed **benchmarks and ROI**: "*industry needs good BIM benchmarks, and evidence about ROI.*"

SST_QUAL_T3.1.3-Need to think about BIM from a WLC perspective in order to realise the full potential of BIM (9)

(I-9) discussed the **link between WLC and OPEX costs**: "*CAPEX savings focus on short term savings but considering OPEX savings will deliver the most benefit over the long term. As BIM develops the OPEX focus will become much more important.*" (I-3) saw **ROI over the long-term** as critical: "*delivering 10-20% savings aren't possible just by tweaking things in design, it needs long-term thinking.*"

SST_QUAL_T3.1.4-Need for the benefits of BIM to be measurable (6)

(I-13) discussed **measuring benefits**: "*We need to find ways to measure the benefits to win the WLC arguments.*" (I-19) gave an example: "*our Hong Kong 'MTR case study' modelled stations and track and linked data to FM systems. The improved integration saved time finding information and highlighted possibilities to increase workloads or employ less people. With a half-hour/per work-order saving, with 60,000 orders/month there was the potential to save 30,000 hrs through better information retrieval.*"

SST_QUAL_T3.1.5-Time needed to be able to realise the benefits (9)

(I-14) noted operational benefits need **time to be realised**: "*benefits in operation are often not instantaneous but generated over time.*" (I-17) agreed: "*we have a few years before the real benefits of BIM are realised from an FM perspective, then cost savings will be realised downstream.*"

ST_QUAL_T3.2-Key benefits of BIM to FM

17 SST (one per 'key benefit of BIM to FM') are shown in Table 11.2. They were ranked to help visualise importance.

Table 11.2: ST_QUAL_T3.2: Key benefits of BIM to FM (ranked by frequency)

ST_QUAL_T3.2: Key benefits of BIM to FM (ranked by frequency)	Rank	Passages	Sources
SST_QUAL_T3.2.1-Access to accurate quality information in one place	1	54	14
SST_QUAL_T3.2.2-Improved efficiency, maintainability, optimisation and ability reducing time to carry out tasks	2	36	17
SST_QUAL_T3.2.3-Improved strategic planning to ensure better usability of assets and availability of information	2	36	14
SST_QUAL_T3.2.4-Improved visualisation to improve FM operations and communication with user groups	3	34	13
SST_QUAL_T3.2.5-Providing a ROI and better ability to predict maintenance costs and analysis	4	27	16
SST_QUAL_T3.2.6-Improving sustainability, energy monitoring and WLC	5	23	14
SST_QUAL_T3.2.7-Improved collaboration between stakeholders in designing, building and managing built assets	6	18	9
SST_QUAL_T3.2.8-BIM helps facility managers improve health, safety and risk management	7	15	9

ST_QUAL_T3.2: Key benefits of BIM to FM (ranked by frequency)	Rank	Passages	Sources
SST_QUAL_T3.2.9-BIM brings new possibilities for innovation, services and improving added value for FM to organisations	8	14	11
SST_QUAL_T3.2.10-Improving procurement, tendering and commercial models for FM	9	13	9
SST_QUAL_T3.2.11-Improved handover from construction to operation, ability to monitor and POE	10	11	5
SST_QUAL_T3.2.12-Improving data transfer and reducing costs to populate CAFM and FM management systems	10	11	8
SST_QUAL_T3.2.13-Avoiding abortive, disruptive or wasteful work	11	7	5
SST_QUAL_T3.2.14-Improving the benchmarking and marketing of real estate	12	6	5
SST_QUAL_T3.2.15-BIM forms a basis for better integration with other technology e.g. sensors, BMS, CAFM etc	13	5	3
SST_QUAL_T3.2.16-Improve information about existing buildings and assets with retro-BIM processes	14	3	1
SST_QUAL_T3.2.17-Better ability to carry out quality checks and monitoring of as built vs. what was planned	15	2	1
Total passages of text		**315**	

The **top five** ranked ‘benefits of BIM to FM’ were:

1) SST_QUAL_T3.2.1-Access to accurate quality information in one place (54)

(I-7) noted **BIM provides accurate information**: “*it gives you the richest picture of your asset that you’re likely to get.*” (I-9) suggested “*BIM helps people visualise what assets they need to maintain, all from one place; where are they; how many; and how they can be maintained*”. (I-19) added “*BIM will help with quality and the time transferring data into CAFM*”*.* (I-9) discussed **asset replacement**: “*BIM provides you with accurate service life and replacement costs for replacement*”. (I-15) discussed **tenders**: “*most tenders add additional cost against unknown risk due to poor information. Having to resurvey buildings and reprice should be a thing of the past.*”

2) SST_QUAL_T3.2.2-Improved efficiency, maintainability, optimisation and ability reducing time to carry out tasks (36), and **T3.2.3-Improved strategic planning to ensure better usability of assets and availability of information (36)**

(I-4) believed **time/cost savings** were key: “*BIM allows things to be found quicker, improves response times and lower costs.*” (I-9) noted “*early discussion before designs are finished will ensure final decisions avoid creating long-term expensive operational costs*”. (I-6) believed **linking BIM to mobile devices** as critical in the future: “*it will empower people to assess task requirements e.g. special access equipment or spares before they travel, avoiding travel; it’s a huge benefit*”. (I-8) discussed **strategic asset management**: “*BIM empowers the digitisation of an organisation’s AM* *strategy. This will lead to better strategic asset planning and improvements around how assets are managed.*" (I-8) discussed **improving cost planning** and **business intelligence**: "*BIM will provide FMs with critical business intelligence."* (I-9) added "people *can visualise how to manage the assets before they are created*". (I-15) discussed BIM as **digital twins** "*they will be used to compare scenarios, planning events and building diagnostics without the cost risks of doing it for real.*" (I-18) saw **future flexibility** as important: "*BIM will help planning future flexibility into buildings.*"

3) **SST_QUAL_T3.2.4-Improved visualisation for FM operations and communication with user groups (34)**

(I-6) discussed **visualisation**: "*BIM viewing tools provide a huge benefit to FM; what's behind ceilings and information and operation manuals etc.*" (I-7) saw **easier fault analysis/reporting** as important: "*people can access models on tablets and easily photograph and send faults to CAFM systems as they find them"*. (I-9) added: "*operations teams can use models to understand if they need special access equipment.*" (I-11) believed models **improve communication**: "*most people can't read a 2D plan, but a 3D model empowers good visualisation for most people."* (I-14) discussed **business opportunities**: *"increasingly people are using visualisation tools like AR, VR and MR for business opportunities like remote working."*

4) **SST_QUAL_T3.2.5-Providing a ROI and better ability to predict maintenance costs and analysis (27)**

(I-1) suggested a big **prediction** advantage: "*full access to technical details enables accurate pricing of FM maintenance.*" (I-8) added "*FMs can mine rich data sets to get real business intelligence*".

5) **SST_QUAL_T3.2.6-Improving sustainability, energy monitoring and WLC (23)**

(I-3) discussed **WLC and sustainability**: "*FMs will save money by using BIM models with the project teams to review designs and think ahead to what will make the building function better*". (I-4) added: "*BIM will help WLC planning which has to be good for sustainability.*"

For the remaining 'benefits of BIM to FM' some interesting observations were:

SST_QUAL_T3.2.7-Improved collaboration between stakeholders in designing, building and managing built assets

(I-5) suggested BIM will improve **decision-making**: "*empowering intelligent discussion between stakeholders by using digital twins*". (I-3) believed *"well-coordinated 3D models help us review and discuss issues quickly*". (I-10) suggested "*it's FMs opportunity to become a professional stakeholder in the construction process*".

SST_QUAL_T3.2.8-BIM helps facility managers improve health, safety and risk management

(I-3) discussed **health and safety**: *"access to better information will enable safer planning."* (I-15) observed: "*BIM models empower safer maintenance. If BIM could help provide data needed to understand what went wrong in events like the Grenfell Tower, then indirectly that would be a big benefit to society.*"

SST_QUAL_T3.2.9-BIM brings new possibilities for innovation, services and improving added value for FM to organisations

(I-5) believed BIM will help **innovation**; "*like automated checking processes to make construction and handover more efficient.*" (I-9) discussed **commercial models**: "*people will innovate around their commercial models and find new ways to benefit from BIM.*" (I-14) observed: "*people are using AR/VR/MR applications with BIM for remote maintenance and other business opportunities.*"

SST_QUAL_T3.2.10-Improving procurement, tendering and commercial models for FM

(I-17) believed BIM will **improve procurement**: "*BIM can be used to proactively tender, even before a building is completed."* (I-10) agreed suggesting **tenders with WLC solutions** "*will be empowered by BIM so procurement is not based just on the cheapest CAPEX cost*".

SST_QUAL_T3.2.11-Improved handover from construction to operation, ability to monitor and POE

(I-9) discussed **handover**: "*BIM will improve quicker and more accurate handover.*" (I-15) noted the impact on **POE**: "*BIM will be used to validate if buildings are performing as designed and provide avenues to go back to the contractor if there are discrepancies.*"

SST_QUAL_T3.2.12-Improving data transfer and reducing costs to populate CAFM and FM management systems

(I-9) discussed **CAFM/FM-management systems**: "*BIM is a golden opportunity to get what FMs need in their CAFM*". (I-17) added: "*BIM can save clients a huge amount of time and money to transfer into their CAFM system.*"

SST_QUAL_T3.2.13-Avoiding abortive, disruptive or wasteful work

(I-5) discussed **variations**: "*we should achieve near zero variations at handover, reducing FM wasted time and money chasing up snags.*" (I-7) added: "*a great benefit is taking models to site on a tablet to enable locating objects.*"

SST_QUAL_T3.2.14-Improving the benchmarking and marketing of real estate

(I-17) discussed **benchmarking**: "*standardised data from BIM will help enable comparisons and performance benchmarks of assets."*

SST_QUAL_T3.2.15-BIM forms a basis for better integration with other technology e.g. sensors, BMS, CAFM etc.

(I-1) discussed **integration of technology**: *"in the near future BIM models will merge or link directly with CAFM and BMS systems. Companies like EcoDomus are already on this path.*" (**I**-7) added: **sensors** "*connected to equipment can now be visualised in BIM models enabling direct monitoring of assets, new innovative services etc.*"

SST_QUAL_T3.2.16-Improve information about existing buildings and assets with retro-BIM processes

(I-11) discussed **existing assets/buildings**: "*we created retro-BIM models at the Sydney Opera House. There are many advantages to retro-BIM, but you must be clear about objectives; what is and is not modelled. We also linked data together with the 3D-model."*

SST_QUAL_T3.2.17-Better ability to carry out quality checks and monitoring of as built vs. what was planned

(I-7) discussed **quality checks**: "*FMs can carry out quality checks if they have received the data specified in their EIR. COBie exports and a simple checking mechanism can do that in the software. However, people still need to check the actual quality of what's being handed over.*"

11.3.4 CSF-QUAL_MT4: Digitalisation and technology

206 passages of text were divided into seven ST as shown in Figure 11.4.

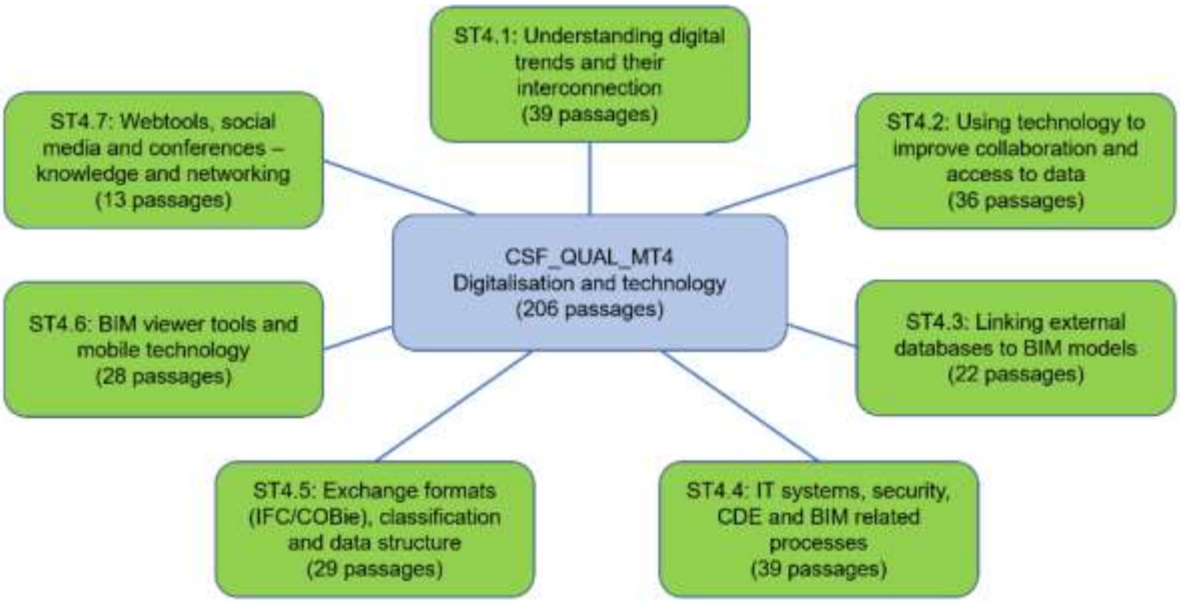


Figure 11.4: CSF_QUAL_MT4: Digitalisation and technology

ST_QUAL_T4.1-Understanding digital trends and their interconnection

(I-1) discussed **digital trends**: "*FMs should have a general understanding of the digital trends impacting their industry.*" (I-14) highlighted **smart buildings**: "*there will be a digital explosion over the next 2-4 years around data sensors and smart buildings.*" (I-3) believed: "*big data and the IoT are very useful and important, but BIM itself isn't big data. It is however the big model on which other data hangs.*" (I-15) discussed **BIM as an ecosystem**: "*BIM is part of the 'prop-tech' ecosystem*" and (I-2) observed "*IoT is just the technology side, we shouldn't forget the process and people*". (I-15) saw **PropTech** as *"the next massive trend. RICS are pushing it on their website as part of their 2020 Vision.*"

ST_QUAL_T4.2-Using technology to improve collaboration and access to data

(I-6) noted: "*the whole building process from creation to handover and onwards needs digitising.*" (I-8) discussed **usability**: "*digital technology needs to be easy for people to access, use and share.*" *(I-17) discussed* **operability**: "*it's so important but like with a car, you don't want to worry about what's under the bonnet, you just want to get from A to B.*" (I-12) discussed **online collaboration tools:** "*today there's so many free software tools to help the collaboration process".* (I-12) mentioned **accessing data**: "*The EIR should suggest address how e.g. BIM viewers".* (I-14) noted: *"on site our team are using BIM 360 field, with iPads and QR codes which work very effectively."* (I-16) discussed 'room data' tools such as **dRofus**: *"it can be used to provide RDS from the start of a BIM project helping to track assets through the BIM process."*

ST_QUAL_T4.3-Linking external databases to BIM models

(I-2) discussed **linking databases with BIM models**: "y*ou don't have to include everything. Information such as the installation dates, warranty information etc., could be held in external databases and hook into native software.*" (I-15) highlighted considering **which FM systems should be linked to BIM models**: "*CAFM, BMS, fire alarms, access controls and finance systems; BIM and digitalisation will help linking these systems."* (I-1) believed **CAFM providers** need to "*improve links between CAFM and BIM, with bi-directional exchange of data between systems*". (I-7) added: "*EcoDomus is providing leading-edge approaches to information integration, allowing linking of different systems.*" (I-17) believed **IFC and BIM servers** are the future: "*you can have data effectively joined up and looked at in just one place.*"

ST_QUAL_T4.4-IT systems, security, CDE and BIM related processes

(I-10) discussed **BIM/IT security risks**: "*the security risks need to be assessed and addressed in line with 'PAS1192-5'.*" (I-8) noted the importance of setting up the **CDE**: "*it's critical at the start of a project to think about the CDE functional requirements and how the security of data will be managed and controlled.*" (I-15) suggested "*the EIR should layout the CDE process*". (I-19) suggested organisations need **BIM processes** "*to receive and store asset and geometric information safely and update it. They should be simple but effective, focusing on key issues e.g. what CDE will be used? Is there a BIM protocol, who is setting up the OIR, AIR and EIR etc.*".

ST_QUAL_T4.5-Exchange formats (IFC/COBie), classification and data structure

(I-15) noted the importance of **classification systems**: "*project members must use the same approach to structure data to ensure easy exchange and transfer into FM systems.*" (I-17) noted *"Uniclass is the UK's chosen system".* (I-4) suggested: **data exchange formats** need to be "*defined early to facilitate the interoperability and transfer of data between systems, making the process easier and giving people confidence in the process.*" (I-8) discussed **openBIM**: *"IFC, openBIM and COBie help share models between software packages and import data into CAFM.*" (I-17) debated **data mapping**: "*COBie and a 'field-mapping exercise' can get the right data in the right place in CAFM.*" (I-18) discussed **Product Data Templates (PDT):** "*in the future the 'FM property-sets' will already be defined in templates for products and systems."*

ST_QUAL_T4.6-BIM viewer tools and mobile technology

(I-1) noted **BIM viewers** "*are needed as FMs can't open and use BIM software"*. (I-10) agreed: "*FMs need model visibility and access to the data.*" (I-4) noted: "*they need just basic training, but it's important all users are trained.*" (I-6) observed: "*viewers let you hide elements, create saved views and walk around the model".* (I-15) discussed **accessing BIM models on mobile devices**: "*operations staff need to visualise plans, 3D models and data in the field. A user-friendly solution is critical to success. We adopted 'Autodesk 360 field".*

ST_QUAL_T4.7: Web-tools, social media and conferences for knowledge and networking

(I-6) recommended online **BIM communities**: "*social media, LinkedIn and Twitter are all useful tools. People wanting to keep themselves updated should consider joining conversations. I use the 'UK #BIMcommunity and #theUKBIMcrew"*.

11.3.5 CSF_QUAL_MT5: Strategic management and use of information

359 passages of text were divided into 4 sub-themes as displayed in Figure 11.5.

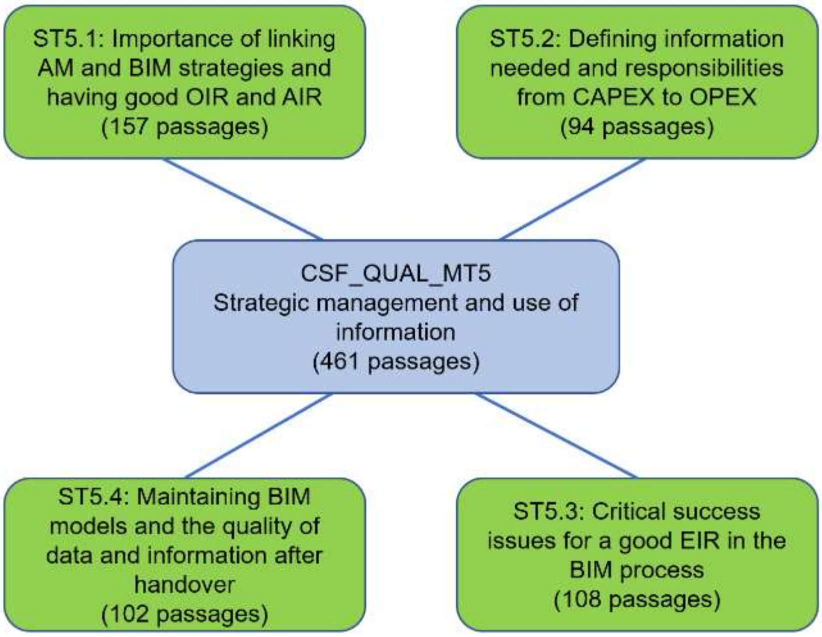


Figure 11.5: CSF_QUAL_MT5: Strategic management and use of information

ST_QUAL_T5.1-Importance of linking AM and BIM strategies and having good OIR and AIR

(I-4) discussed **taking time to define OIR/AIR**: (I-11) suggested: "*they should reflect the organisation's corporate goals*". (I-5) continued: "*they should be specific to organisations helping to cascade board policy into FM and AM strategy.*" (I-11) suggested key BIM documents are **written/owned by clients/FM-teams**: "*the worst people to write OIRs and AIRs are external consultants who don't understand the internal running of the organisation".* (I-19) believed "*the MoJ examples are the best so far*". (I-13) noted the important link with **business strategy and risk management**: *"FMs need to review organisations' strategic business objectives and translate these into opportunities for providing data and intelligence*."

ST_QUAL_T5.2- Defining information needed and responsibilities from CAPEX to OPEX

(I-16) suggested a **minimum useful** approach: "*it's a really good philosophy.*" (I-9) added: *"avoid things that create cost or lock you into unnecessary costs. Instead aim to minimise long term costs."* (I-1) discussed **OPEX thinking**: "*knowing your operational budget helps understand the impact of CAPEX decisions on the OPEX phase."* (I-15) suggested reducing **attributes in BIM models**: "*they should be minimal and clearly articulated in the EIR".* (I-17) recommended *'**SFG20**'*: "*as a possible frame of reference*". (I-16) believed: "*FMs need to distinguish what alphanumeric data needs to go* *into the BIM model vs what will come over as separate PDFs, such as building user guide, drawings, RDS, O&M manual and H&S file etc*." (I-19) suggested using "**W-questions** i.e. "*What assets are managed and matter? What level of information do you need? Who is responsible for supplying data and managing the model/data? Where is it managed and stored? Who owns it, Where/how do you find data? If we can answer those questions, we are already on the path to success*". (I-15) suggested "*using CAFM and maintenance suppliers to help configure the list of what to collect for FM systems*". (I-9) highlighted **critical systems**: "*they must be considered, together with the data required to manage them.*" (I-17) highlighted **contractual responsibilities**: "*it must be clear who is responsible for what.*" (I-2) recommended '**example information schedules**' **"***from MoJ and the UK BIM Alliance*" and (I-7) discussed **LOD/LOI**: "*FMs need to consider the required LOD and LOI at an element level.*"

ST_QUAL_T5.3-Critical success issues for a good EIR in the BIM process

(I-3) discussed **cascading information**: "*the OIR must highlight the information needed to run the business and AIR, the asset information needed to support operations. Good EIRs cascade these in a lean way.*" (I-14) highlighted **clarity and simplicity**: "*avoid a 'copy-paste' approach and adapt EIRs for each project.*" (I-6) added: "*EIRs should be proportionate".* (I-4) warned: "*asking for 'everything' only increases costs and produces information you don't really need*". (I-16) suggested the **end repository** "*must be identified early for BIM data*". (I-2) suggested **FM knowledge** "*should guide the development of OIRs, AIRs, and EIRs.*" (I-5) insisted **roles and responsibilities** *"need to be clearly defined*". (I-16) added: "*the EIR should be a document for discussion.*" (I-4) discussed **quality checking**: "*the contractors BEP and delivered data and models should be quality checked to see they are as defined in the EIR.*" (I-16) recommended an **EIR template** to: *"help FMs get a head start; the BIFM EIR template helps provide clarity*".

ST_QUAL_T5.4-Maintaining BIM models and the quality of data and information after handover

(I-15) discussed **change control process**: "*a process is required to periodically update the model and ensure reliability.*" (I-7) believed **professional BIM services** maybe required: "*as FMs are not modelling experts, usually updating will be outsourced to professional architects.*" (I-9) warned: "*changes should only be made by qualified experts, otherwise models will quickly be out of data or unreliable.*" (I-16) discussed **model ownership and update responsibility**: "*clients need to clarify who owns and controls their models and who pays for updates.*" (I-12) suggested the **EIR** covers "*ownership and updating as part of the contract*". (I-10) discussed **validation**: "*as-built models and data should be validated before handover possibly using software like Solibri for detailed model checking.*" (I-6) noted: "*simple checks initiated against required data fields tell you if something is missing. However, a human should be involved to validate the content-quality of what's handed over.*" (I-9) suggested **COBie drops**: *"to get a high level of certainty about data handed over.*"

11.3.6 CSF_QUAL_MT6: People in the BIM process and improving collaboration

273 passages of text were divided into five ST as shown in Figure 11.6.

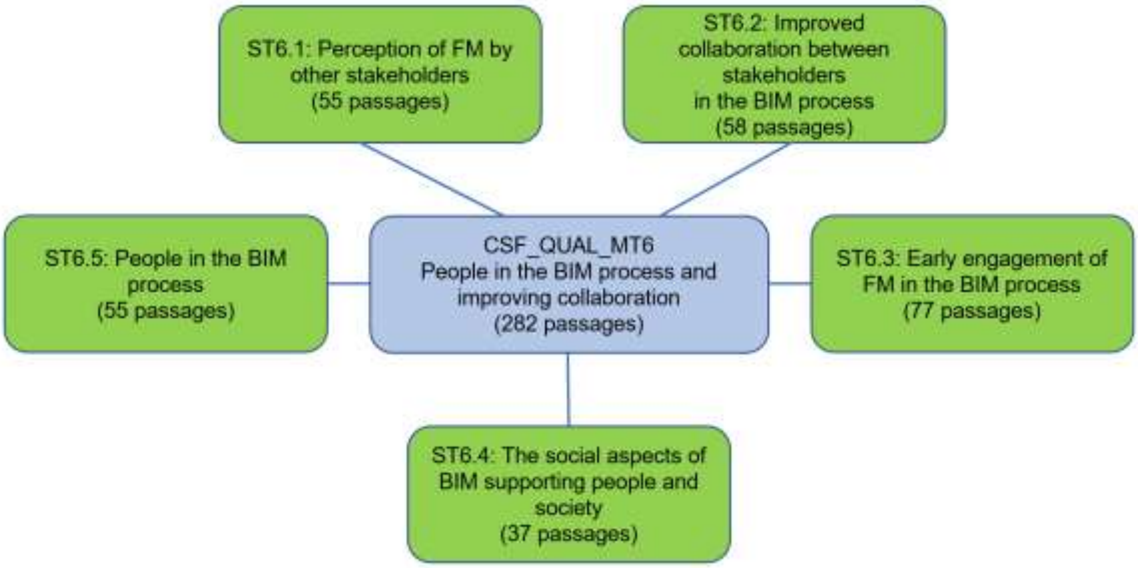


Figure 11.6: CSF_QUAL_MT6: People in the BIM process and improving collaboration

ST_QUAL_T6.1-Perception of FM by other stakeholders

(I-7) discussed **FM professionalisation**: (I-1) added: "*FM organisations need to raise the bar with respect to the professionalisation of FM especially when engaging in construction and BIM projects.*" (I-13) observed: "*if FMs do their job well they save a lot of money over the whole-life of an asset, but they need to be perceived that way in order to confirm the value FM adds.*" (I-4) discussed **communication**: "*many FMs and clients have no construction or design process experience"* and (I-13): "*stakeholders must speak the same language so they can ask each other relevant questions."*

ST_QUAL_T6.2-Improved collaboration between stakeholders in the BIM process

(I-10) discussed **collaboration**: "*BIM forces people to collaborate.*" (I-1) believed: "*working with 'one version of the truth' results in better teamwork*". (I-9) saw **empowering people** as "*vitally important in the BIM process*". (I-18) added "*people should feel confident in their roles, it leads to much more success*". (I-19) discussed **design briefing using BS 8536**: "*it supports the design briefing process.*"

ST_QUAL_T6.3-Early engagement of FM in the BIM process

(I-2) discussed **organisations vision and mission**: "*the FM role is key, as they can translate these into BM speak.*" (I-7) suggested '***Soft Landings'*** "*is a good grounding for early FM engagement*" and (I-4) added: "*FM teams have lots of experience to help define the BIM strategy at the beginning.*" (I-

16) saw **assisting design-teams** as important: "*FM can gather relevant data to support BIM teams,*" and (I-14) suggested: "*inviting FMs to walk through 3D models to help identify potential problems*".

ST_QUAL_T6.4-The social aspects of BIM supporting people and society

(I-12) discussed the associated **social impact**: "*it has the potential to be transformational to people in society.*" (I-9) observed "*ultimately it's people who benefit from built-assets, they underpin our social fabric.*" (I-15) believed: "*When the benefit is four schools for the price of five, then we will have reached the social level.* (I-6) discussed BIM as a **research backdrop**: "*it provides a digital backdrop for researchers.*"

ST_QUAL_T6.5-People in the BIM process

(I-8) discussed **motivating people**: *"the 'people success factor' is when everyone understands what the value proposition is and what we are trying to achieve."* (I-10) believed: *"enthusiasm to deliver BIM is a vital human factor", and* (I-14) suggested: *"the most important CSF is changing people's behaviour to want to engage."*

11.3.7 CSF_QUAL_MT7: Role of FM in the BIM process

299 passages of text were divided into ten ST as shown in Figure 11.7.

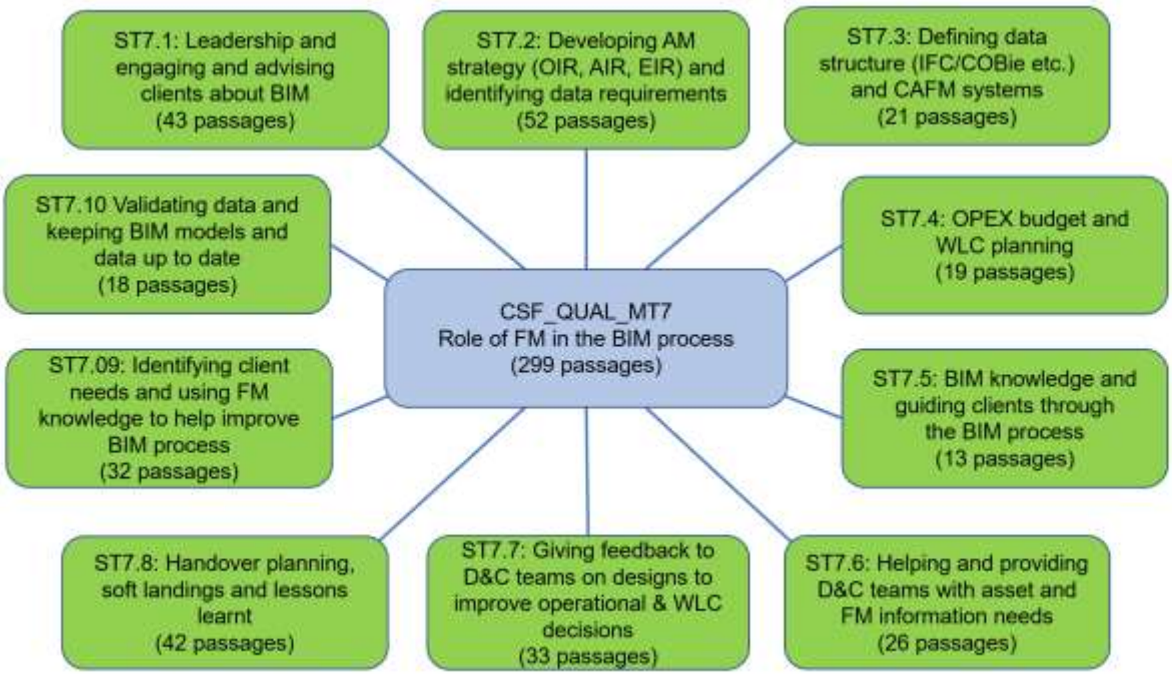


Figure 11.7: CSF_QUAL_MT7: Role of FM in the BIM process

ST_QUAL_T7.1-Leadership and engaging and advising clients about BIM

(I-15) suggested: "*FMs need to help client articulate their needs for other stakeholders. This will help achieve the benefits BIM can bring to the organisation.*" (I-14) discussed **articulating the ROI/benefits**: "*FMs should advise on measuring improvements and benefits of BIM to indicate the ROI value*". (I-4) discussed **managing client information**: "*sometimes those assets are worth millions of pounds.*" (I-12) highlighted **BIM champions**: "*they're needed both at mid and senior-level to drive BIM through the business. Without them it's a struggle.*" Also, **senior buy-in** suggesting: "*many operational people are frustrated at the BIM passion at a lower level, but where it's not being treated seriously by senior-levels*."

ST_QUAL_T7.2-Developing AM strategy (OIR, AIR, EIR) and identifying data requirements

(I-9) discussed **information strategy**: *"without a good AM strategy based on solid OIR and AIR, it's likely BIM will deliver you a failure."* (I-8) suggested: *"if clients need to procure their OIR and AIR from a consultant, there is something fundamentally wrong with their strategy"* (I-15) discussed **relevant data**: (I-9) added: *"asking for 'everything' is unrealistic and wasteful. It's like asking for a library when you just need a book. The chance of getting to grips with all that information is just not realistic".* (I-15) highlighted **templates:** "*to help capture critical asset information based on your OIR."*

ST_QUAL_T7.3-Defining data structure (IFC/COBie etc.) and CAFM systems

(I-11) discussed **standards for structuring data**: "*project teams should ensure consistent use of BIM standards, classification systems, numbering and naming disciplines; to ensure everyone is structuring data in the same way.*" (I-12) highlighted **IFC/COBie**: "*FMs need to understand the structure of COBie as they will often get data via COBie drops.*" (I-12) mentions **workshops with operational/FM teams:** *"they're a good idea to discuss what useful information can be extracted from BIM models using the COBie data-schema.*" (I-10) suggested an awareness of **Uniclass**: "*it's the preferred UK government classification system for structuring data.*" (I-10) recommended the **NBS-Digital-Toolkit**: "*assets can be linked with levels of information and detail required"*.

ST_QUAL_T7.4-OPEX budget and WLC planning

(I-8) believed "*a huge challenge is organisations having CAPEX and OPEX departments which don't communicate.*" (I-2) recommended **BIM to improve WLC**: "*models can capture information about numbers of components, life periods etc. which can be used to calculate life costs.*" (I-7) agreed "*BIM can capture critical sustainability, energy and WLC information data."*

ST_QUAL_T7.5-BIM knowledge and guiding clients through the BIM process

(I-15) noted: *"people shouldn't assume clients understand BIM, it's FMs job to guide them."* (I-12) discussed **writing BIM documents**: "*it's important the team have competent FMs who can clearly define and articulate their client's needs.*" (I-13) believed **using FM knowledge,** "*can help project teams understand the information needs and what should be prioritised*". (I-17) highlighted **FM, BIM and people skills**: "*good BIM, FM and people skills are essential to assist clients in defining their needs.*"

ST_QUAL_T7.6-Helping and providing D&C teams with asset and FM information needs

(I-4) discussed **demands on assets**: "*FMs need to communicate what's operational day-to-day and what's critical at an early stage."* (I-10) mentioned **reviewing design team inputs**: *"suggesting how to reduce service costs for equipment located in awkward locations, like the top of an atrium.*" (I-4) noted: "*designers need to know what information FMs currently use, to run, maintain and optimise assets in operation.*" (I-16) discussed **understanding users' needs**: (I-8) added: "*the design team need good information like occupancy level data, performance requirements etc. to help better decision making.*"

ST_QUAL_T7.7-Giving feedback to D&C teams on designs to improve operational & WLC decisions

(I-11) discussed a **WLC approach**: "*people who design and construct buildings usually don't operate them. Without a WLC focus designs often introduce cheaper solutions that create increased long-term operating costs.*" (I-16) agreed quoting ***'ISO1586-5'***: *"it states 80% of assets' costs over their life are fixed in the first 20% of design, so more focus is needed on long-term solutions that deliver best value over assets whole-life."* (I-2) highlighted **energy efficient solutions**: "*buildings often use more energy than predicted; due to poor design or people changing the building.*"

ST_QUAL_T7.8-Handover planning, *'Soft Landings'* and lessons learnt

(I-16) discussed **early planning for handover**: "*the earlier 'Soft Landings' outcomes are considered, the more chance we have of a successful project.*" (I-4) highlighted **defining model and information formats**: "*Clarity is needed around required formats i.e. native, IFC etc."* (I-4) suggested: "*the quality control process should compare actual data handed over against expected.*" (I-8) discussed **lessons learnt**: "*it's important to know what worked, or didn't, on previous projects.*" (I-19) discussed **experience in BIM projects**: *"a key success factor is employing people with both BIM experience and an FM understanding."* (I-7) **using BIM to improve handover:** "*People can use models for training and commissioning can be videoed and made available via the BIM.*"

ST_QUAL_T7. 9-Identifying client needs and using FM knowledge to help improve the BIM process:

(I-4) discussed **setting project/performance outcomes**: "*clients and FMs need to clearly define expected outcomes in line with 'BS8536' at the start of BIM projects.*" (I-2) saw **providing data** as critical: "*providing operational data will help the design teams make better informed decisions.*" (I-15) discussed **workplace productivity targets**: "*BIM should support workplace effectiveness and productivity.*" (I-19) discussed **best value solutions**: "*It's important to include operational expertise in any value-engineering decisions.*"

ST_QUAL_T7.10-Validating data and keeping BIM models and data up to date

(I-6) discussed the **client information manager** role: "*someone on the client side must be involved in checking the handover quality.*" (I-18) discussed the **BIM project responsibility matrix**: "*it needs to be crystal clear who is responsible for what.*"; (I-8) mentioned **project data drops**: "*people still need to be involved to check quality during the BIM process.*" (I-16) mentioned **updating BIM models/data**: "*clients need to agree how models and data will be recorded, maintained and kept up to date.* (I-9) suggested: "*clients need to consider their training process for keeping the model up to date.*" (I-16) discussed **data for future projects**: "*how do we keep data valid from old projects to start new ones? People are still figuring out what that mechanism is."*

11.3.8 CSF_QUAL_MT8: Key standards and guidance for FM

194 passages of text were included in one key ST:

ST_QUAL_T8.1-Key standards/guidance perceived as useful to FM (ranked by frequency)

The passages were split across 21 standards/guidance, shown as individual STT in Table 11.3. They were ranked to show which documents were perceived as most useful to FM.

The top five were:

1. *'BS 8536-1&2'* and *'Soft Landings'*
2. *'PAS 1192-3'*
3. *'PAS 1192-2'*
4. *'ISO 55000'*
5. BIFM (IWFM) guides

Reflecting on **international and local BIM standards** (I-11) noted: "*every country is developing their own BIM standards and guidance to suit local markets.*" (I-12) added: "*what would help FMs is more succinct FM orientated summaries of BIM documents.*"

Table 11.3: ST_QUAL_T8.1: Key standards/guidance most useful to FM (ranked)

No	ST_QUAL_T8.1 Key standards/guidance perceived most useful to FM (ranked)	Rank	Passages	Sources
1	SST_QUAL_T8.1.1-BS 8536 - Part 1: Briefing for design and construction. Code of practice for facilities management (Buildings infrastructure) and Part 2: Design and construction : Code of practice for asset management (Linear and geographical infrastructure)	1	30	14
2	SST_QUAL_T8.1.2-Government and BSRIA Soft Landings	1	30	14
3	SST_QUAL_T8.1.3-PAS 1192-3 BIM specification for information management for the operational phase of assets using building information modelling	2	26	12
4	SST_QUAL_T8.1.4-PAS 1192-2 Specification for information management for the capital/delivery phase of construction projects using building information modelling	3	17	10
5	SST_QUAL_T8.1.5-ISO 55000 Asset management. Overview, principles and terminology	4	15	10
6	SST_QUAL_T8.1.6-BIFM (IWFM) BIM guidance series	5	13	8
7	SST_QUAL_T8.1.7-SFG 20 - planned maintenance	6	10	4
8	SST_QUAL_T8.1.8-BS 1192-4 Collaborative production of information. Fulfilling employer's information exchange requirements using COBie. Code of practice	7	9	7
9	SST_QUAL_T8.1.9-NBS BIM Toolkit, BIM Object standard	8	7	5
10	SST_QUAL_T8.1.10-BS 1192: Collaborative production of architectural, engineering and construction information. Code of practice	9	6	3
11	SST_QUAL_T8.1.11-PAS 1192-6 Specification for collaborative sharing and use of structured Health and Safety information using BIM	10	5	3
12	SST_QUAL_T8.1.12-PAS 1192-5 Specification for security-minded building information modelling, digital built environments and smart asset management	11	4	4
13	SST_QUAL_T8.1.13-PAS 1192-7: Specification for defining and maintaining structured digital product information used for the design, construction and use of a product or built asset (STOPPED)	11	4	3
14	SST_QUAL_T8.1.14-RIBA Plan of Work	11	4	4
15	SST_QUAL_T8.1.15-Uniclass 2015 : Classification system	11	4	3
16	SST_QUAL_T8.1.16-CIC BIM Protocol	12	3	3
17	SST_QUAL_T8.1.17-BS 8541: Library objects (BIM)	13	2	1
18	SST_QUAL_T8.1.18-ISO 15686 Buildings and constructed assets - Service life planning - Part 5: Life-cycle costing	13	2	2
19	SST_QUAL_T8.1.19-ISO Environmental management – Life-cycle assessment - Requirements and guidelines	14	1	1
20	SST_QUAL_T8.1.20-ISO 55001 Energy management	14	1	1
21	SST_QUAL_T8.1.21-Non UK standards	14	1	1
	Total Passages of text		**194**	

The following points address general observations about the key standards/guidance

Industry standards/guidance directed at FM: (**I**-1) noted, "*people wanting to improve their competency with respect to BIM should start with 'BS 8536', because it's written for FMs*". (**I**-13) agreed: "*FMs should be aware of; 'PAS1192-3' and 'BS 8536' as a minimum as they are key.*" (**I**-19) felt: *"'Soft Landings' is an important piece of the jigsaw that gets forgotten. It should be used together with 'BS 8536'.*" (**I**-11) highlighted the importance of *'ISO 55000'*: *"it's a good basis for asset management and guideline to understand the full life-cycle of the asset*". (**I**-6) suggested the "*BIFM (now IWFM)* **BIM guidance documents***:* "*they are a must read for FMs involved in BIM.*"

11.3.9 CSF_QUAL_MT9: Training and competence

679 passages of text were divided into eight ST as shown in Figure 11.8.

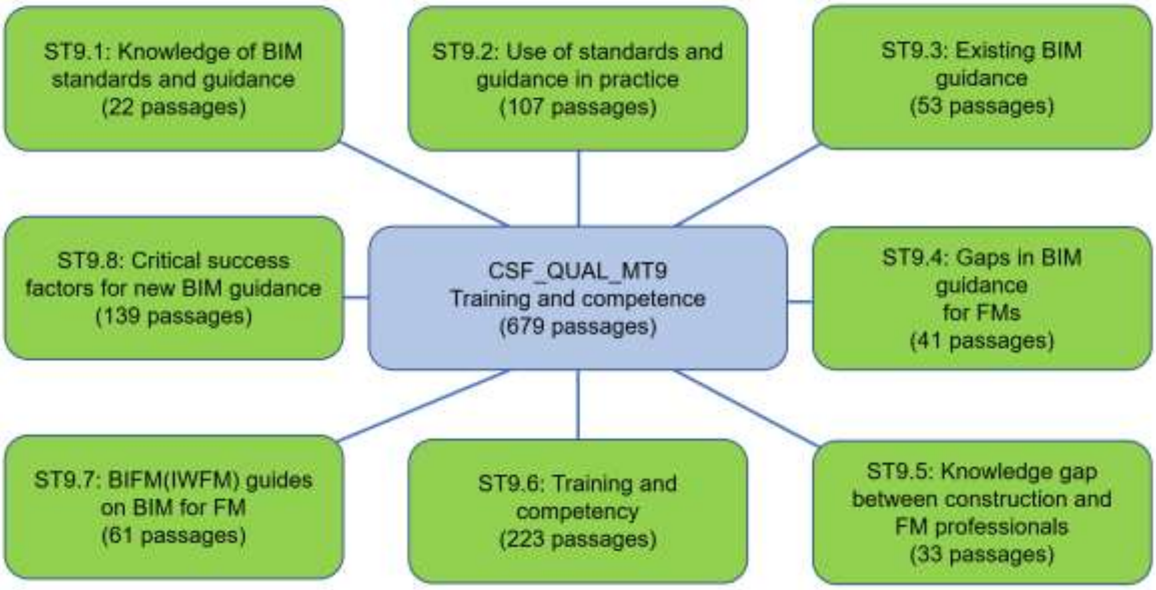


Figure 11.8: CSF_QUAL_MT9: Training and competence

ST_QUAL_T9.1-Knowledge of BIM standards and guidance

(I-14) highlighted the **IWFM BIM guidance documents**: "*they help FMs understand BIM from an FM perspective.*" (I-18) discussed **asset management strategy**: "*FMs should know 'ISO 55000', especially where a strategy needs developing.*" Regarding **familiarisation with BIM standards**, views varied. (I-16) believed: "*FMs need a working knowledge without having to be experts*" and (I-11): "*as a minimum you need an overview of what each one contains.*"

ST_QUAL_T9.2-Use of standards and guidance in practice

(I-4) believed **adopting standardisation** *"will deliver significant benefits in BIM and ongoing asset management"*. (I-8) debated **BIM standards in practice**: *"they are used, but often not used as a cohesive suite."* (I-19) believed: "*people are making it too complex; our focus should be on input and output deliverables.*" (I-9) recommended **websites for BIM standards**: "*use government websites. The SFT's website helps people understand their inputs at different RIBA stages.*"

ST_QUAL_T9.3-Existing BIM guidance

(I-8) suggested useful **example EIRs**: *"the NHS and MoJ had good quality early EIR examples."* (I-5) discussed **FM orientated EIRs**: "*the BIM Task Group's EIR and others were not so client focused."* (I-18) observed: *"Good examples I have seen are the BIFM and the BIM Academy ones.*" (I-3) believed "*bad quality EIRs from consultants vary from damaging through to pointless*". (I-19) felt **clear and unambiguous guidance** was needed: "*EIRs can't be fluffy, they need to clearly tell the supply chain what is needed.*" **Other BIM guidance** discussed included, (I-12): "*the 'NBS's BIM Toolkit',* (I-18): "*the* 'NRM3 *Digital Life-Cycle Toolkit' from Faithful+Gould*"; and (I-11): "*the US 'NBIMS' guidance*'. (I-15) recommended certain **BIM books**: "*the* '*BIM for Dummies', the 'BIM Handbook' and 'BIM for Facility Managers' sponsored by IFMA are worth a read.*"

ST_QUAL_T9.4-Gaps in BIM guidance for FMs

(I-19) felt **practice-orientated BIM guidance** was necessary: *"what's missing is pragmatic advice around how FMs and clients can really utilise BIM in practice."* (I-4) mentioned **OIR and AIR guidance:** "*FMs would benefit from templates or good guidance.*" (I-18) highlighted the need for **BIM-2-CAFM guidance**: *"to enable the movement of information from one to the other."* (I-10) discussed **Level of Information Need (LOIN)**: "*we need clearer guidance around LOIN"* (I-15) discussed **data analytics:** "*FMs need to think about the future and analysing data to make informed decisions.*"

ST_QUAL_T9.5-Knowledge gap between construction and FM professionals

(I-9) observed: "*the knowledge gap between construction and FM is made worse by the speed of technological change".* However, (I-2) believed: "*the gap is decreasing as FMs start engaging more.*" (I-9) felt **technology skills** (I-1) noted "*there's little guidance about transferring data i.e. BIM-2-CAFM".* (I-6) discussed **practical experience**: "*BIM familiarisation comes down to practical experience.*" (I-18) highlighted **client and FM support and engagement**: "*clients are not taking enough responsibility in the procurement of BIM and involving their FM team."*

ST_QUAL_T9.6-Training and competency

(I-17) noted a need for **FM-BIM training**: "*I don't see enough FM people with adequate BIM competency skills.*" (I-10) discussed **BIM training courses**: "*educational bodies should embed qualifications at university, college, secondary school and even earlier.*" (I-12) added: "*good case studies are also critical to BIM adoption.* (I-4) noted *"training is needed to help people understand how BIM might work with linked databases, mobile devices etc."* (I-7) agreed: "*FMs need to understand what can and can't be done and who will keep models up-to-date*. (I-5) argued a **budget for training** was important: "*adequate funds are needed in project budgets to cover training for operational teams."* (I-10) discussed **time for training**: "*FMs will probably do BIM alongside their day job.*" (I-18) suggested a **step-by-step approach**: *"we should approach training like the BIM wedge, learn to walk before you try to run.*"

(I-3) discussed **case studies/FM use cases**: **"***people learn by example," and* (I-13): "*they should show BIMs practical value on the asset owning organisation."* (I-18) highlighted **networking** as useful: "*talk to others to find out what their experiences are; what they would or wouldn't do again.*" (I-14) suggested **CPD events**: *"for networking and seeing worked examples.*" (I-16) discussed **software and mobile devices**: "*FMs need to have a basic overview of what can be achieved with BIM software. Viewing tools like Solibri, Tekla's, Autodesk's A360, etc."*

(I-2) recommended **BIM training videos**: "*we now ask for videos where client BIM demonstration are recorded.*" (I-8) suggested **mobilisation checklists**: "*people may read standards but in terms of mobilisation thereafter you want a checklist.*" (I-11) felt **handover training** was critical: "*FMs need good handover training so that they are well prepared.*" (I-6) felt the **Information Manager** role was important: *"this new role has emerged both on the construction and client sides."* (I-12) believed the **people element** was important: *"you need willing, experience, trained and engaged people to make it work, like any project.*" (I-18) noted **age** is a concern to some but felt: "*being successful with BIM is a state of mind, it's not about age.*"

ST_QUAL_T9.7-BIFM (IWFM) guides on BIM for FM

(I-2) highlighted the ***'EIR Template and Guidance'***: *"I trialled the final version, it's a great document."* (I-16) discussed the '***Operational Readiness Guide'*** and *'The* ***Role of FM in BIM Projects'***: "*we use them with 'Soft Landings'. The guides include a list of useful reference documents."* However (I-18) noted **lack of exposure**: *"I wasn't aware of the guidance. Maybe they are not being marketed to clients."* (I-16) added: *"clients need to use them with their supply chain."*

ST_QUAL_T9.8-CSF for new BIM guidance

(I-18) observed: "*to be useful, guidance must be able to be utilised straight away.*" (I-19) felt **practical tools** were needed "*to allow people to get on with the job*". (I-1) discussed **essential reading:** "*an overview of essential BIM reading for FMs, with links would be very helpful.*" (I-19) highlighted **reference frameworks**: "*like the 'RIBA PoW' that everyone else in industry is using and can understand.*" (I-1) discussed **online learning**: "*many people use YouTube to research subjects*."

11.3.10 CSF_QUAL_MT10: Data and information transfer in the BIM process

427 passages of text were divided into four ST as shown in Figure 11.9.

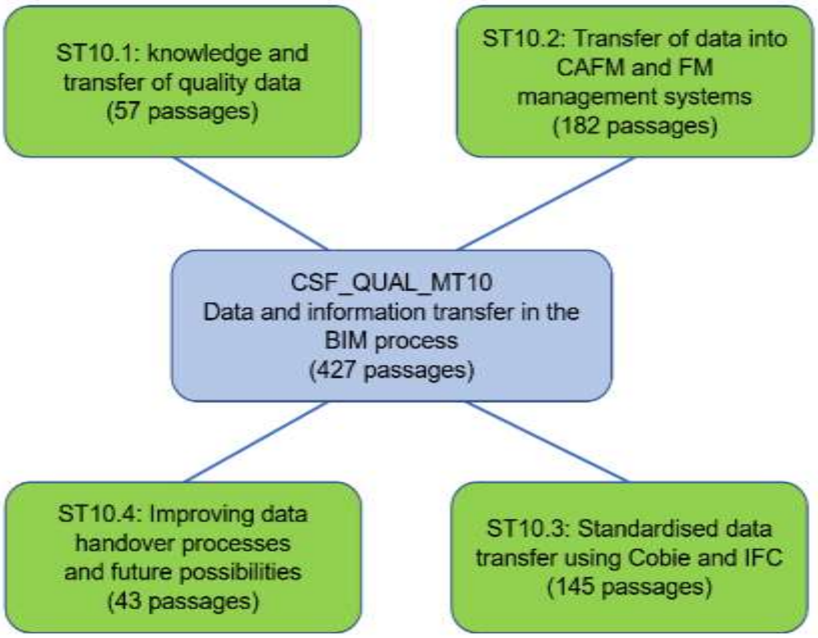


Figure 11.9: CSF_QUAL_MT10: Data and information transfer in the BIM process

ST_QUAL_T10.1-Knowledge and transfer of quality data

(I-11) noted **information/data** transfer will include: "*a rich set of 3D models, PDF documents and alphanumeric data".* (I-8) suggested for planning keeping **the end in mind**: *"start by identifying what target systems need data, then work back on how to get it there."* (I-9) discussed **quality checks**: "*COBie can help validate the required data is transferred.*" (I-6) mentioned **linking documents**: *"PDFs; like O&M manuals can be accessed by clicking on objects in the model.*" (I-19) raised **ongoing management**: "*the top five issues are: 1) which assets matter?, 2) what level of information is needed?, 3) how do you find it?, 4) where is it stored?, and 5) what are the critical elements?*"

ST_QUAL_T10.2-Transfer of data into CAFM and FM management systems

(I-4) discussed **target FM systems**: "*FMs should establish the proposed systems and if they are IFC compatible. CAFM supplier know-how can help here.*" (I-8) mentioned a '**minimal useful'** approach: "*people need to ask; why do I need this data, and will it benefit FM in operation?*" (I-16) suggested: "*the plan should be to have the data in the CAFM from day one of operation.*" (I-9) discussed **time/cost savings**: "*at the MoJ, a 16-month process was reduced down to 6-weeks.*" (I-6) felt **workshops with FM teams** were important: "*We go through the COBie-structure sliming it down to what clients really need. Keeping it simple saves time and money during data collection.*"

ST_QUAL_T10.3-Standardised data transfer using Cobie and IFC

(I-15) discussed **classification**: "*fundamental to BIM-2-CAFM data transfer are taxonomy classification systems and IFC.*" (I-2) highlighted **data mapping**: "*middleware software may be needed to move data from the CAFM supplier".* (I-19) mentioned **IFC compatibility**: "*many CAFM systems can't import IFCs, so this needs checking.*" (I-11) mentioned **COBie-Lite**: "*you don't need all the information possible in COBie, we shortened it down to about 30 fields, which was still too much.*" (I-5) added **linked databases,** were important: "*data can be linked from other databases.*" (I-11) discussed **required FM attributes**: "*The EIR should specify the required level of detail within COBie*, *we aim for about 30 key attributes for FM.*"

ST_QUAL_T10.4-Improving data handover processes and future possibilities

(I-16) suggested a '**BIM-2-CAFM guide'** was needed: "*there's no standard for receiving data from BIM models.*" (I-2) discussed **bi-directional data transfer**: "*currently it's mostly one-way; it should be bi-directional."* (I-6) felt **OpenBIM** was critical: *"to empowering the exchange of data between different software."* (I-4) discussed **BIM servers**: "*industry should move to an IFC approach with BIM servers.*" (I-15) suggested **early supplier engagement**: "*they can help you get the data you need and should be encouraged to join the team effort to produce the data we need at the end.*"

11.4 Qualitative CSF (MT/ST) identified from BIM/FM experts

In total 3380 passages of text were identified and used in the qualitative analysis. Table 11.4 shows the final list of qualitative CSF. This comprised of 10 MT and 45 ST identified from the qualitative NVivo analysis of the interviews with FM/BIM experts.

Table 11.4: Summary-list of identified qualitative CSF MT and ST

Qualitative CSF MT and ST	Passages
CSF_QUAL_MT1: Government policy impact on FM industry	240
ST_QUAL_T1.1 Realising value over the WLC of built assets	99
ST_QUAL_T1.2 Impact of government policy on the FM industry	82
ST_QUAL_T1.3 FM Industry Readiness for BIM	59
CSF_QUAL_MT2: Barriers and challenges to the adoption and use of BIM	221
ST_QUAL_T2.1 Key barriers and concerns to the adoption and use of BIM	221
CSF_QUAL_MT3: Benefits of BIM to FM	380
ST_QUAL_T3.1 Transparency of benefits	65
ST_QUAL_T3.2 Key benefits of BIM to FM	315
CSF_QUAL_MT4: Digitalisation and technology	206
ST_QUAL_T4.1 Understanding digital trends and their interconnection	39
ST_QUAL_T4.2 Using technology to improve collaboration and access to data	36
ST_QUAL_T4.3 Linking external databases to BIM models	22
ST_QUAL_T4.4 IT systems, security, CDE and BIM related processes	39
ST_QUAL_T4.5 Exchange formats (IFC, COBie etc.), classification and data structure	29
ST_QUAL_T4.6 BIM viewer tools and mobile technology	28
ST_QUAL_T4.7 Webtools, social media and conferences for knowledge and networking	13
CSF_QUAL_MT5: Strategic management and use of information	461

Qualitative CSF MT and ST	Passages
ST_QUAL_T5.1 Importance of linking AM and BIM strategies and having good OIR and AIR	157
ST_QUAL_T5.2 Defining information needed and responsibilities from CAPEX to OPEX	94
ST_QUAL_T5.3 Critical success issues for a good EIR in the BIM process	108
ST_QUAL_T5.4 Maintaining BIM models and the quality of data and information after handover	102
CSF_QUAL_MT6: People in the BIM process and improving collaboration	273
ST_QUAL_T6.1 Perception of FM by other stakeholders	55
ST_QUAL_T6.2 Improved collaboration between stakeholders in the BIM process	58
ST_QUAL_T6.3 Early engagement of FM in the BIM process	77
ST_QUAL_T6.4 The social aspects of BIM supporting people and society	37
ST_QUAL_T6.5 people in the BIM process	46
CSF_QUAL_MT7: Role of FM in the BIM process	299
ST_QUAL_T7.01 Leadership and engaging and advising clients about BIM	43
ST_QUAL_T7.02 Developing AM strategy, (EIR, OIR,AIR) and identifying data requirements	52
ST_QUAL_T7.03 Defining data structures (IFC/COBie etc.) and CAFM systems	21
ST_QUAL_T7.04 OPEX budget and WLC planning	19
ST_QUAL_T7.05 BIM knowledge and guiding people through the BIM process	13
ST_QUAL_T7.06 Helping/providing D&C teams on designs to improve operational & WLC decisions	26
ST_QUAL_T7.07 Giving feedback to D&C teams to improve operational & WLC decisions	33
ST_QUAL_T7.08 Handover planning, soft Landings and lessons learnt	42
ST_QUAL_T7.09 Identifying client needs and using FM knowledge to help improve BIM process	32
ST_QUAL_T7.10 Validating data and keeping BIM models and data up to date	18
CSF_QUAL_MT8: Key BIM standards and guidance for FM	194
ST_QUAL_T8.1 Key standards/guidance perceived as useful to FM (ranked by frequency)	194
CSF_QUAL_MT9: Training and competency	679
ST_QUAL_T9.1 Knowledge of BIM Standards & Guidance	22
ST_QUAL_T9.2 Use of standards and guidance in practice	107
ST_QUAL_T9.3 Existing BIM guidance	53
ST_QUAL_T9.4 Gaps in BIM guidance for FMs	41
ST_QUAL_T9.5 Knowledge gap - construction and FM	33
ST_QUAL_T9.6 Training and competency	223
ST_QUAL_T9.7 BIFM -IWFM guides on BIM for FM	61
ST_QUAL_T9.8 CSF for new BIM guidance	139
CSF_QUAL_MT10: Data and information transfer in the BIM process	427
ST_QUAL_T10.1 Knowledge and transfer of quality data	57
ST_QUAL_T10.2 Transfer of data into CAFM and FM systems	182
ST_QUAL_T10.3 Standardised data transfer using COBie and IFC	145
ST_QUAL_T10.4 Improving data handover processes and future possibilities	43
Total passages of text used in the qualitative analysis	**3380**

11.5 Chapter summary

The qualitative thematic analysis of the interviews with ‘FM/BIM experts’ resulted in the identification of the qualitative CSF comprising 10 MT and 45 associated ST. These were then used in the convergent design ‘merging process’ using ‘side-by-side narrative text to bring qualitative and quantitative CSF together as explained in Chapter 14.

Chapter 12: Quantitative methodology and approach

This chapter describes the approach used to address research objective (b) from Chapter 1: to establish quantitative CSF based on a 'general FM industry' awareness of BIM considering benefits and barriers to FM involvement in the BIM process (using an online questionnaire). This will include inputs from the UK and other countries.

12.1 Nature and logic to the selected approach

The chapter outlines the quantitative element of the 'convergent design' approach which used the '*FM Awareness of BIM'* questionnaire to analyse the general view of FM industry professionals and their levels of awareness of BIM. The aim was to establish quantitative CSF from the industry perspective which could help other FMs involved in the BIM process.

With respect to quantitative research, Yilmaz (2013, p. 1) suggested it "can be defined as research that explains phenomena according to numerical data which are analysed by means of mathematically-based methods, especially statistics". Saunders, Lewis and Thornhill (2016, p. 166) noted that it "examines relationships between variables, which are measured numerically and analysed using a range of statistical and graphical techniques". The techniques include "true experiments and the less rigorous experiments called quasi-experiments" (Creswell, 2014, p. 12).

Normally a quantitative approach is associated with a deductive approach and positivist philosophy. However, Saunders, Lewis and Thornhill (2016, p. 166) argued an interpretivist philosophy could fit where the research uses "data based on opinions, sometimes referred to as 'qualitative' numbers". They added, it can "incorporate an inductive approach, where data are used to develop theory" (ibid). This aligned with the researcher's pragmatist philosophical approach using mixed methods. The aim was to include some statistical analysis, but also descriptive qualitative feedback against specific questions, which would be important to help explain some of what the numbers revealed.

Creswell (2014) noted that quantitative designs have developed in recent years to become very elaborate, but recommended novice researchers consider two designs; 'surveys and 'experiments'. He defined these as follows (ibid, p.13):

- Surveys: provide "numeric description of trends, attitudes, or opinions of a population by studying a sample of that population".
- Experiments: "seeks to determine if a specific treatment influences an outcome … by providing specific treatment to one group and withholding it from another and then determining how both groups scored on an outcome"

Regarding terminology, deVause (2002) observed the terms 'survey' and 'questionnaire' can both be used in research, and involve techniques of data collection in which people are asked to respond to similar questions in a predetermined order.

Note: for the purpose of clarity, the term 'questionnaire' is used in this work.

As the research aim was to gather general information about levels of awareness about BIM from the 'general FM industry', a questionnaire approach was deemed more appropriate. This aligned with Saunders, Lewis and Thornhill (2009, p. 361) who observed "the questionnaire is one of the most widely used data collection techniques within the survey strategy". They added it "provides an efficient way of collecting responses from a large sample prior to quantitative analysis" (ibid). Fowler (2013) suggested the main objective is to collect data that can be used to provide numerical descriptions, and conduct statistical analysis about certain aspects of the study population. Creswell (2014, p. 157) agreed, noting researchers can "generalise from a sample to a population so that inferences can be made about some characteristic, attitude or behaviour of this population". As such, the approach would support the research aim to establish quantitative CSF from the target population (FM industry) and allow the collection of data to test hypotheses to establish if there were any significant relationships. The next step was to consider the design.

12.2 Questionnaire design

The book '*Conducting Online Surveys*' by Sue and Ritter (2012) was used as a general guide for designing the questionnaire. They observed that when considering the design, the "research objectives guide questionnaire format; questionnaire format determines the types of questions that may be used; the types of questions used determine data analysis; data analysis reflects research objectives; and all this is bound by time, budget, and ethical considerations" (ibid, p.15). The eight-step process they suggested and shown in Figure 12.1 was used to ensure a rigorous design.

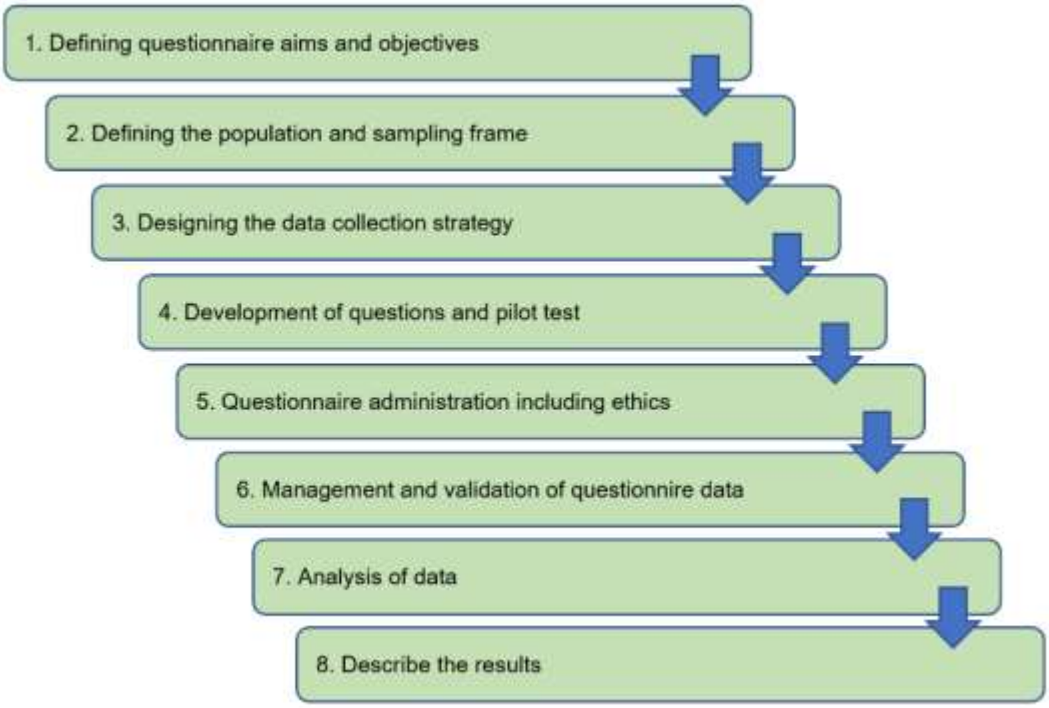


Figure 12.1: Design of questionnaire (Sue and Ritter, 2102)

Advice was followed from Fowler (2013), who argued a good design requires a good combination of sampling, designing questions and data collection. Saunders, Lewis and Thornhill (2016, p. 449) added, "the internal validity and reliability of the data you collect and the response rate you achieve depend, to a large extent, on the design of your questions, the structure of your questionnaire and the rigour of your pilot testing".

12.2.1 Defining the questionnaire aims and objectives

The '*FM Awareness of BIM*' questionnaire was a cross-sectional approach (i.e. at a fixed point in time) to collect a wide range of views from 'general FM industry' professionals about their awareness of BIM. The objective was to gather data to enable both 'descriptive' and 'inferential' statistical analysis, to generalise and draw inferences from the population, to help identify a series of quantitative CSF.

The researcher was interested in establishing whether having specific BIM training and/or experience would increase people's confidence levels to engage with BIM. The hypothesis shown in Table 12.1 were derived to ascertain whether there were any statistically significant relationships between the data. The testing is explained further in Chapter 12.2.7.

Table 12.1: Hypotheses tested using the questionnaire (self-study)

No	Hypotheses to be tested (to establish if there are any significant relationships)
H0:	People who have had some BIM training have higher: levels of confidence and higher levels of belief that 'BIM can support FM delivery' and have a 'significant impact on the FM industry'. They would also be more likely to agree with the 'benefits of BIM to FM' and disagree with the barriers to BIM adoption/use'.
H1:	People who have some BIM experience have higher: 'levels of confidence to engage in a BIM project'; higher 'levels of knowledge of BIM standards/guidance' and higher levels of belief that 'BIM can support FM delivery' and have a 'significant impact on the FM industry'. They would also be more likely to agree with the 'benefits of BIM to FM' and disagree with 'the barriers to BIM adoption/use'.
H2:	People based in the UK will be 'more familiar with UK 'BIM standards/guidance', 'the government's targets with respect to BIM', 'the BIM level 3 strategy' and 'BIM websites'.
H3:	Respondent's beliefs that 'BIM will help support FM delivery', and 'BIM will have an impact on the FM industry'; would have an impact on their 'level of agreement of possible benefits of BIM to FM'.
H4:	Where respondents have some 'experience of using/preparing BIM documents' this will have an impact on their 'confidence levels engaging in BIM projects'
H5:	Respondents 'confidence of engaging in a BIM project' is influenced by; 'experience of preparing and using BIM documents', 'barriers to BIM adoption/use', 'use of BIM in their organisations', 'knowledge of BIM standards/guidance' and 'knowledge of BIM websites'

12.2.2 Defining the population and sampling frame

Sue and Ritter (2012, p. 2) noted the critical importance of sampling in relation to the research objectives. They suggested "a good sample is representative of the population from which it is drawn". The 'target population' for the research were FM professionals from the 'general FM industry'. However, as Field (2009, p. 34) noted "scientists rarely, if ever have access to every member of a population". Saunders, Lewis and Thornhill (2009, p. 214) suggested researchers use a "representative sample" as a 'census', i.e. collecting data from every member of the population is usually not feasible. Creswell (2014) described this as 'clustering'. This is where organisations are identified who have access to people within the main population. Sampling then takes place "within those clusters" (ibid, p.158).

It was decided the most logical approach to accessing a 'representative sample' of the general FM industry was to approach an appropriate professional organisation whom could be deemed as best representing the targeted sample. The BIFM (since rebranded as IWFM) was chosen as they were the main professional body promoting FM in the UK and their members met the 'eligibility criteria' as a good representation of the general FM industry.

Other organisations like RICS and BICS were also considered but it was decided to approach BIFM as they had higher number of FM specific professional members whereas the other organisations focus was often in other disciplines or specific in the case of BICS to one focused sector. The BIFM research department was contacted, and they agreed to make the questionnaire available to their members (UK and worldwide) via their IT/BIM blog. The sampling process is represented in Figure 12.2.

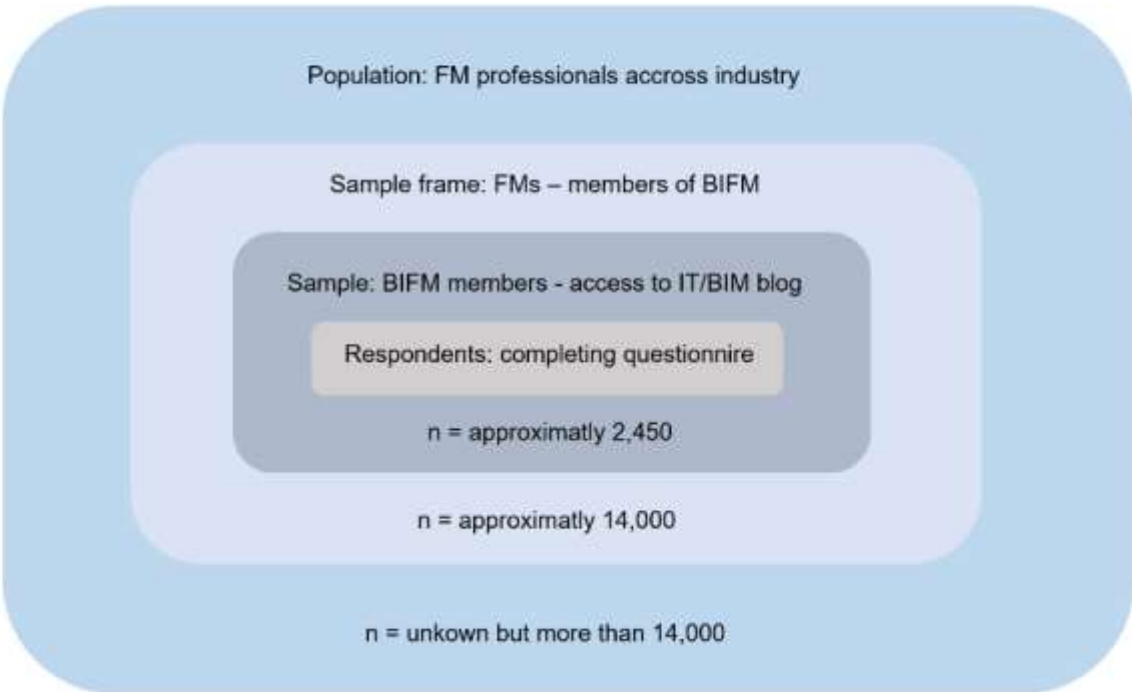


Figure 12.2: Sampling process for questionnaire (self-study)

The precise sample size or response rate could not be calculated as it was impossible to clearly state how many members actually accessed the blog. However, the BIFM research team estimated approximately 15-20% of their 14,000 members (at the time) would receive the blog, equating to a potential sample size of approximately 2,100-2,800 (a figure of 17.5% or 2,450 was estimated as the representative sample). As an estimation, the response rate would not accurately determine the views of the total population (including non-participation).

Instead, the advice of Sue and Ritter (2012) was to achieve this by gauging the 'margin of error' and 'level of confidence' using a 95% confidence level. In terms of appropriate sample size, Stutley (2003, p. 117) recommended "a sample of just 30 items is often adequate" and suggested this will usually result in a sampling distribution for the mean that is very close to 'normal distribution', i.e. "in which the data can be plotted as a bell-shaped curve". As BIM was relatively new at the time, it was expected there would be some dropouts (incomplete responses). After discussion with his supervisor, a target response rate of 8-10% was set. This equated to a sample size of around 196-245. The final figure of fully completed responses was very close to this at 254, around 10.36%.

12.2.3 Designing the data collection strategy

Saunders, Lewis and Thornhill (2009, p. 440) noted data collection for questionnaires/surveys can utilise several approaches as shown in Figure 12.3.

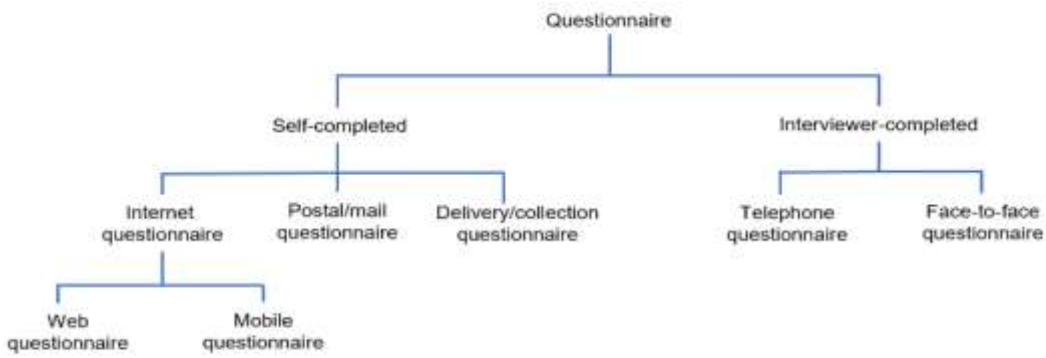


Figure 12.3: Types of questionnaire (Saunders et al., 2016)

Sue and Ritter (2012) recommended identifying the most appropriate design, and to consider appropriate factors which might have an influence. To do this the Table 12.2 was drawn up (based on various researchers' observations) to justify how the questionnaire would be used.

Table 12.2: Design of online questionnaire (self-study using various authors)

Consideration factor	Notes ref online questionnaires	Justification for use
Population's characteristics for which suitable	Computer literate individuals contactable by email or online	Respondents should be computer literate and easily contactable through web using BIFM blog
Confidence that right person has responded	High if using email	Email can help target specific people where they fit the profile and have good knowledge
Likelihood of contamination of respondent's answers	Low	Contamination likelihood (effecting reliability) low due to anonymous completion
Size of sample	Tend to be large, the web means they can be geographically dispersed	Aim is to get input from UK and a range of other countries using or considering use of BIM
Likely response rate	Variable, 30% reasonable within organisations/via intranet, 11% or lower using web/internet	Due to BIM being relatively new, response rate expected to be low – 10% would be good. Target set at 250
Flexible length of questionnaire	Conflicting advice; however, fewer "screens" probably better	Questionnaire developed to ensure questions and clear and moving between questions/screens is easy
Suitable types of question	Closed questions but not too complex, complicated sequencing fine if uses IT, must be of interest to respondent	Some closed questions but Linkert scale approach used where measurement is required.
Time taken to complete collection	2-6 weeks from distribution (depending on the number of follow-ups)	Questionnaire targeted to be live for data collection for 6 weeks
Main financial resource implications	Web page design. Although automated expert advice helps reduce cost	Partnership approach with BIFM ensured administrated online and at zero cost
Role of the interviewer	None	Intention was self-completion anonymously
Data input	Usually automated	Web based questionnaire enables automated data collection.

In line with the intention to use the BIFM IT/BIM blog a 'self-completed online web questionnaire' design was the most appropriate approach. This would address the objective of capturing a good cross-sectional snapshot of awareness of BIM in the FM industry in line with recommendations from Thomas (2013). This was appropriate as the researcher was based in Switzerland. Saunders, Lewis and Thornhill (2009) and Nair and Adams (2009) argued such a design is easy and cheap to administer at low cost; can run over a relatively short time frame; and is an efficient when the aim is to collect data from a specifically targeted cluster group who may be geographically dispersed.

12.2.4 Development of questions and pilot test

Saunders, Lewis and Thornhill (2009, p. 361) advised researchers should "collect the precise data that you require to answer your research question(s)". This approach was taken to determine which questions would provide the best data. Developing clear and relevant questions was seen as essential, especially with the cross-sectional design giving only one chance to collect data.

The primary aim was to assess and benchmark the level of awareness of BIM by the 'general FM industry', so questions were developed using the CST established during the literature review (Chapters 8.4-8.7). It was deemed important to include questions assessing; the awareness and knowledge of key BIM standards/guidance which were fundamental to BIM projects; and the industry perception of the benefits and challenges of BIM.

Previous surveys relevant to the topic were considered, including:

- *'BIFM4FM Overview of Survey Results'* (BIM4FM, 2013)
- '*Annual National BIM Report'* (NBS, 2014), (NBS, 2015)
- *'Common Knowledge in BIM for Facility Maintenance'* by Liu and Issa (2015).

However, the CSF which were central to answering the research questions were not addressed or mentioned. This highlighted a gap in the literature and it was decided a new and more detailed set of questions were needed.

To help improve the design a 'pilot-test questionnaire' was conducted early in the process with a small target group (n=52) from IFMA-Switzerland in March/April 2015. This enabled several proposed formats for questions to be trialled and the results used to help inform the development of the PhD questionnaire. The write up of the pilot test by Ashworth and Bryde (2015) can be found in Appendix C.

To develop and refine the questions Wilson's (2012) five-step process shown in Figure 12.3 was followed.

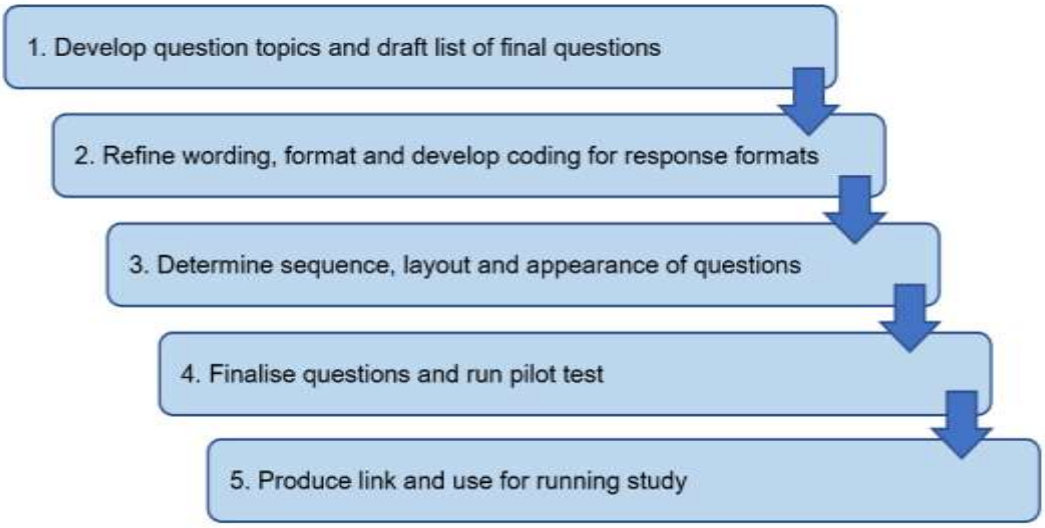


Figure 12.4: Process steps - questionnaire question development (Wilson, 2012)

In line with each step, the following actions were taken:

Step-1: The 'question topics' were developed based on the literature CST, and lessons learnt from the 2015 pilot-test questionnaire were used to draft a final list of questions.

Step-2: The 'wording/coding/format' was then refined following advice from Sue and Ritter (2012). This involved using various question formats including; 'open', 'closed' and 'dichotomous questions' (presenting two possible response options e.g. yes/no, male/female, etc.). Other formats included 'multiple-choice, ranked and rated scale' questions (unipolar/bipolar). Saunders, Lewis and Thornhill (2009, p. 378) suggested checking 'validity' and reducing 'social desirability-bias'. This required formatting questions to make it socially acceptable for respondents to say they were unfamiliar with certain topics. They also recommended "Likert-style rating scales in which the respondent is asked how strongly she or he agrees or disagrees with a statement". These used 'construct-specific questions' in line with Dillman (2007) who suggested these would help reduce 'acquiescence response bias' i.e. a tendency to agree regardless of content. 'Demographic' questions were included to collect background information about respondents such as age, gender etc. for descriptive statistics.

Thinking ahead to the analysis phase, the type of data, or "scale of measurement" for the questions was considered as suggested by Saunders, Lewis and Thornhill (2009, p. 416). This helped ensure the right type of data was captured to allow the analysis intentions of the design and to test hypotheses. The following data types were considered when designing the questions:

- **Descriptive/nominal:** not associated with any numerical values or ordered in any way (numbers can be associated with response options but are arbitrary and have no inherent meaning).
- **Ranked/ordinal data:** which can be ranked with a reason behind the ranking. These can be ranked using a number system but the distances between the attributes are not equal.
- **Interval data:** with interpretable relative position or distance between values e.g. age or height.

Step-3: The question sequence/layout/appearance was finalised, to ensure a logical flow from start-to-finish. The layout was finalised using appropriate buttons, visual cues, logos etc. Questions were then coded into the 'SnapSurvey' tool (SnapSurveys, 2018) which allowed for the chosen question styles. It also provided a hyperlink to access the questionnaire. On doing so the respondent was guided through the various question screens by using prompts in the software. At the final screen a submit button was used to complete the process.

Step-4: Thomas (2013, p. 215) suggested "one should always pilot a draft questionnaire on a small group of people who can give you feedback". Bell (2005, p. 147) agreed noting "without a trial run you have no way to know whether your questionnaire will succeed". Sue and Ritter (2012) recommend trying to use people who are representative of the final intended population. As such, a small group of eight members of 'BIFM Operational Readiness Working Group' and three research colleagues from the IFM research institute were chosen to make up a small group of 'peer-feedback reviewers'. The researcher's personal contact with the group ensured he got direct feedback. Their expertise was seen as representative of the general FM industry. Their feedback helped confirm the 'face validity' as recommended by Saunders, Lewis and Thornhill (2009, p. 394). They added, this helps "establish whether the questionnaire appears to make sense", and to "refine the questionnaire so that the respondents will have no problems in answering the questions and there will be no problems in recording the data" (ibid). The feedback led to some minor improvements in wording and helped refine the appearance, cognition and establish time for completion (5-10 minutes).

Step-5: After the final amendments were made, SnapSurvey generated a link to directing people to the questionnaire.

Note: The final format of the questionnaire is shown in Appendix L.

12.2.5 Questionnaire administration and ethics

All aspects of administering the questionnaire were controlled via the SnapSurvey software (2018). There were several other tools e.g. SurveyMonkey and KwikSurveys which were considered, but SnapSurvey was selected as it was the preferred survey tool of BIFM. These tools can provide outputs which are formatted for use in other analysis software.

The hyperlink to the questionnaire was posted in the BIFM IT/BIM blog on 31st January 2017 to disseminate it to their members and it was live for 6 weeks until 15th March 2017. SnapSurvey automatically kept a track of the collected data in a central database. **Note**: this ensured anonymity of the data as responses were automatically coded using predefined codes. On closure of the questionnaire, an Excel data sheet for data analysis was produced.

LJMU's ethical guidelines were implemented, and the advice of Sue and Ritter (2012) followed regarding the following important aspects:

1. **Informed consent:** a specific introductory text was included to advise possible respondents of the overall purpose of the questionnaire, as recommended by Dillman (2007), and Creswell (2014). This described how data would be used, and that completion was voluntary, to enable people to freely decide whether they wished to complete the questionnaire.
2. **Ensuring respondent confidentiality/anonymity**: the questionnaire was configured in SnapSurvey to ensure all data would be kept confidential and aggregated so there was no way of revealing anyone's identity.
3. **Ethical interpretation of results**: the SnapSurvey software ensured an unbiased way of collecting results with automatic data coding of responses based on pre-determined codes. This minimised any bias from the researcher.

12.2.6 Management and validation of questionnaire data

The first step of the data validation process was to conduct an initial review and data cleaning exercise on the excel spreadsheet from SnapSurvey. All fields were checked to see if they were completed with valid data entries. Those that were not fully or correctly completed were omitted.

The data was then imported into the well-established 'Statistical Package for Social Sciences' (SPSS) which was used for the data analysis (IBM, 2015). A further step to ensure clarity and validity of the data for the analytical stage was to 'recode' the data in SPSS. This involved manually checking the coding labels to ensure the data was valid for all questions and associated variables. Some of the variables were recoded, where necessary, to ensure the accuracy of the categorical data analysis, where selected variables were tested against each other to see if there were any significant relationship between the two variables.

12.2.7 Statistical analysis of data

The aim of the data analysis was to carry out 'descriptive' and 'inferential' statistical analysis to support answering the research questions and objectives. These could be used as follows:

Descriptive statistics: Field (2009) noted they provide a good way of getting an instant picture of the distribution of your data. Landers (2013) added they allow researchers to describe, illustrate and explain the data by organising and summarising it in a way to establish whether there are significant patterns in the responses of people from the given sample. Examples include; graphical displays showing distribution of data; central tendency (mean, median, mode); measures of spread (range and validity of data such as standard deviation); and measures of location.

Inferential statistics: Saunders, Lewis and Thornhill (2016, p. 280) noted they "allow you to calculate how probable it is that your result, given your sample size , could have been obtained by chance". Field (2009) observed they can be used to investigate whether there are significant patterns in the data sample and find out if these are statistically significant in terms of being representative for the population from which they were drawn. SPSS was used to test the hypotheses and investigate any statistically interesting relationships in the data. Kerr, Howard and Kozub (2002) noted inferential statistics can indicate if patterns described in the data sample are likely to apply across the population from which it was drawn. Field (2009, p. 49) noted statistical analysis can "tell us whether the alternative hypothesis is likely to be true" and help to "confirm or reject our predictions" (ibid).

Tests for normality: before analysis of the relationships could start, standard statistical tests were carried out to check if the data was normally distributed or not. The outcome helped determine whether to use 'parametric' or 'non-parametric' testing for further analysis. Saunders, Lewis and Thornhill (2016, p. 533) noted several standard statistical tests require that the 'dependant variable' is normally distributed for 'each category of the independent variable'. Where the data was shown to be normally distributed (resulting in the classic bell-shaped curve) then parametric tests could be used; if not, non-parametric tests would need to be used. Therefore, it was necessary to consider the 'dependant' and 'independent variables' described by Field (2009) as:

- '**Dependant variables'**: depend on other variables (e.g. someone's weight may change with their height)
- '**Independent variables'**: do not change depending on other factors (e.g. someone's sex is not dependant on their weight or height)

SPSS was used to determine if the data had a normal distribution. However, a perfect normally distributed bell-curve was not expected, as it was quite normal to have small deviations. This was deemed acceptable as long as these were within the acceptable limits (shown by the tests).

Common statistical practice, as noted by (Fisher, 1990), is that an acceptable level of significance is $p < 0.05$, where p means probability. Field (2009) noted standard tests can be used to check for normality including:

- **Shapiro-Wilk** and **Kolmogorov-Smirnov***:* p-value should be above 0.05 according to Shapiro and Wilk (1965)
- **Skewness and Kurtosis:** z-values should be between -1.96 and +1.96 according to Doane and Seward (2011)
- **Visual tests***:* histograms, Q-Q plots and boxplots can be used as visual indicators according to Cramer and Howitt (2004)

For the 'one sample Shapiro-Wilk' and 'Kolmogorov-Smirnov' tests, where the significance produced a 'p value' between 0.01 and 0.05, this indicated the distribution of the sample was not significantly different from a normal distribution. Consequently, parametric tests could be used to understand the differences between variables in the data. However, where the test was significant (i.e. $p<0.05$) then the distribution of the sample was shown to be significantly different from a normal distribution and non-parametric tests had to be used.

A test of normality indicated in all but one case that the data is significantly divergent and therefore is not normally distributed $P<0.05$.

12.2.8 Describe the results

The findings from the descriptive and inferential analysis are described in Chapter 13.

12.3 Chapter summary

The logic for the chosen qualitative approach, and the use of SPSS to produce the descriptive and inferential statistics with data collected from the *FM Awareness of BIM'* questionnaire, has been clearly explained. The questionnaire produced 254 competed responses from the 'general FM industry'. This allowed the fulfilment of research objective (b) and to establish a series of themes (MT/ST) which would form the basis for the quantitative CSF.

This step in the concurrent convergent design enabled benchmarking of levels of awareness from industry. The findings allowed a comparison to be made and to consider links between the theory (CST from the literature, Chapters 8.4-8.7) and practice. The data also facilitated testing of the hypothesis discussed in Chapter 12.2.1. The detailed findings from the descriptive and inferential statistics are presented in Chapter 13.

Chapter 13: Quantitative analysis and findings

This chapter presents the findings from the analysis of the '*FM Awareness of BIM*' questionnaire, which used descriptive and inferential statistics to achieve the research objective (b) to establish quantitative CSF based on a 'general FM industry' awareness of BIM considering benefits and barriers to FM involvement in the BIM process. This will include inputs from the UK and other countries.

13.1 Comparing literature findings with general FM industry views

In order to carry out the quantitative analysis 'descriptive' statistics were used to describe the respondent's profiles and the ten quantitative CSF identified. **Note:** the 'convergent design' approach required that the quantitative findings were described using 'narrative text' (combining descriptive statistics and 'additional comments' from respondents). A 'side-by-side' comparison analysis then compared CSF with a merging process as described in Chapter 14. Inferential statistics were used to investigate the hypothesis described in Chapter 12.2.1 and findings presented in Chapter 13.3 . A summary list of the quantitative CSF is presented at the end of the chapter.

Note: The '*FM Awareness of BIM*' report published with BIFM is included in Appendix M.

13.1.1 Respondent's profiles

The questionnaire delivered 254 responses. Respondent's profiles are described below:

Gender profile: 22.4% female and 72.4% male (5.2% did not respond).

Age profile: was fairly evenly balanced as shown in Figure 13.1.

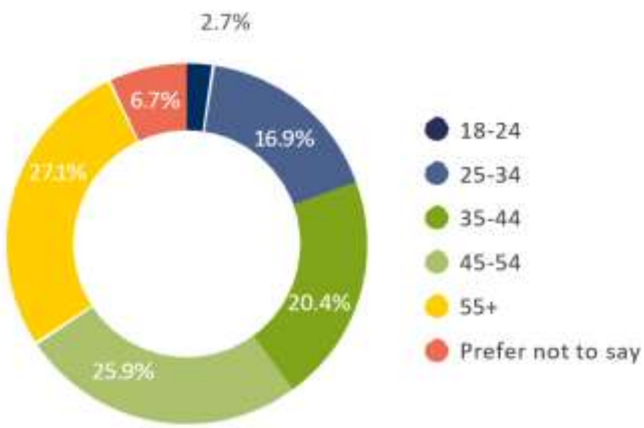


Figure 13.1: Respondents' profile – age

Academic profile: the most prevalent qualification was a Masters (42.1%) as shown in Figure 13.2.

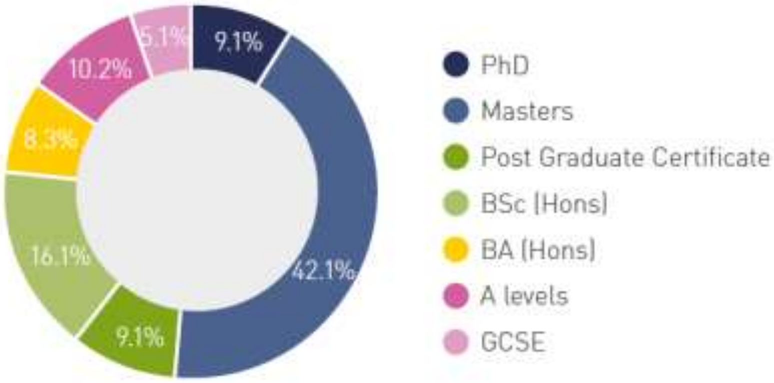


Figure 13.2: Respondents' profile – academic qualifications

Organisation size: there was representation from all sizes (no employees): 1-9 (16.1%), 10-49 (8%), 50-99 (7%), 100-249 (9%), 250-499 (6%), 500-999 (7%), 1,000-4,999 (23.2%) and 5,000+ (23.6%).

Industry sectors: the highest response was from the 'property sector (including RE)' and 'education sector' (both 27.2%). Then 'engineering, construction and manufacturing' (23.2%), and 'management consultancy' (18.1%).

Stakeholder/industry groups: FM-in-house (31.1%) and FM-consultants (19.7) made up the majority. However, 'others' (19.7%) were significant including; 'academics, researchers, BIM consultants/managers and FM students/multi-disciplinary consultants' as shown in Figure 13.3**.**

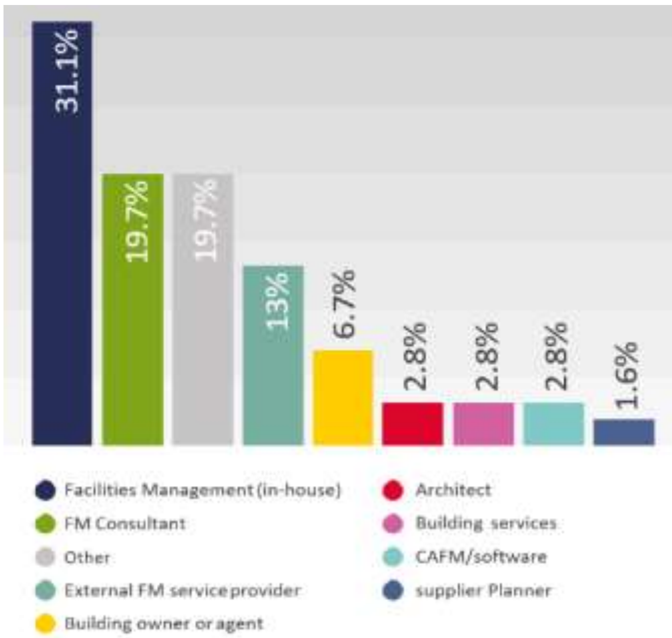


Figure 13.3: Respondents profile – stakeholder participation

Geographic distribution; 127 (46.1%) of respondents were UK based: 16.1% operated UK wide, 7.9% in London, 6.3% South East, 3.5% South West, 3% Scotland and 9.2% across the rest of the UK. The remaining 53.9% of respondents came from 28 other countries as indicated in Figure 13.4.

Figure 13.4: Respondents profile – geographical distribution

13.2 Quantitative CSF findings

The follow sections list the quantitative CSF identified from the analysis. **Note:** the following notations were used: **CSF_QUAN_MT1** (QUAN=quantitative, MT1=Main-Theme 1). **ST_QUAN_T1.1** refers to the first ST of MT1. Occasionally **SST** were used e.g. **SST_QUAN_T5.1.1** described the first benefit under ST5.1.

Note: **bold text** was used to highlight specific **topics** of interest for the 'narrative text analysis' using the side-by-side convergent design and also for the development of the '*FM-BIM Mobilisation Framework*'.

13.2.1 CSF_QUAN_MT1: General awareness of BIM and impact on FM

This MT highlighted general awareness levels of BIM:

ST_QUAN_T1.1-Awareness of existence of BIM: 91.7% had "*heard of BIM before completing the questionnaire",* whilst 6.7% said *"no",* and 1.6% *"didn't know"* as shown in Figure 13.5. This indicated the majority were familiar with the existence of BIM.

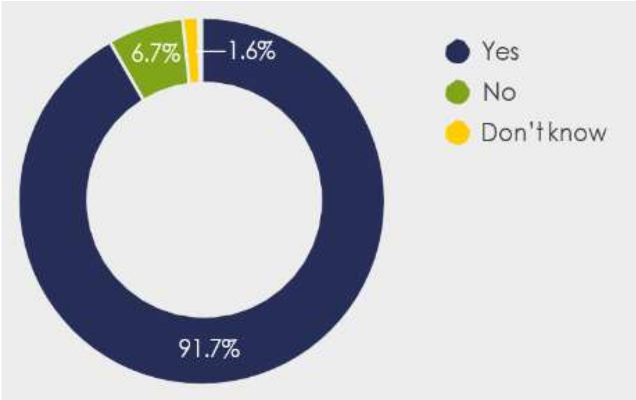


Figure 13.5: CSF_QUAN_T1.1 Respondents - general awareness of BIM

ST_QUAN_T1.2-Impact of BIM on FM industry: 74.0% believed "*BIM will have a significant impact on the FM industry*", whilst 19.7% said "*no*" and 6.3% were *"unsure" as* shown in Figure 13.6. This indicated the majority believed BIM will have a significant impact.

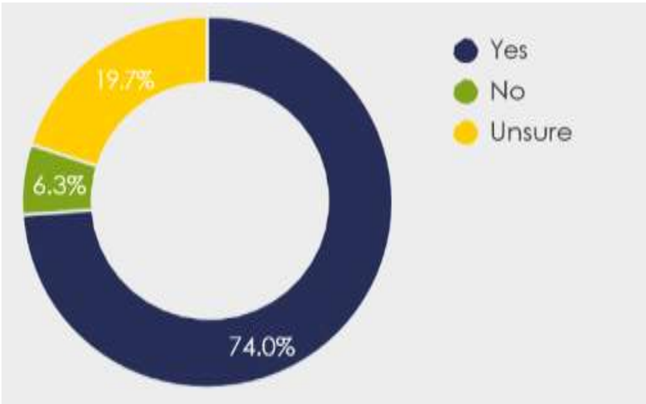


Figure 13.6: SF_QUAN_T1.2 Respondents – impact of BIM on FM

ST_QUAN_T1.3-BIM supporting FM: 83.5% believed "*BIM will help support the delivery of Facilities Management",* whilst 12.6% were "*unsure",* and 3.9% said *"no" as* shown in Figure 13.7. This indicated the majority perceived BIM as supporting FM.

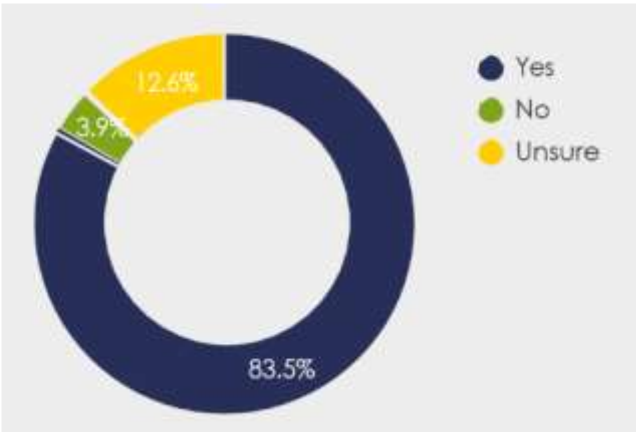


Figure 13.7: SF_QUAN_T1.3 Respondents - perception of BIM supporting FM

ST_QUAN_T1.4-Timescales for BIM to impact on FM: 29.5% believed "*BIM is already having an impact*", 23.2% believed in "*1-2 years*", 31.1% in "*3-5 years*" and 16.1% in "*more than 5 years*" as shown in Figure 13.8. This indicated that the impact of BIM on FM will mature over the next 5 years.

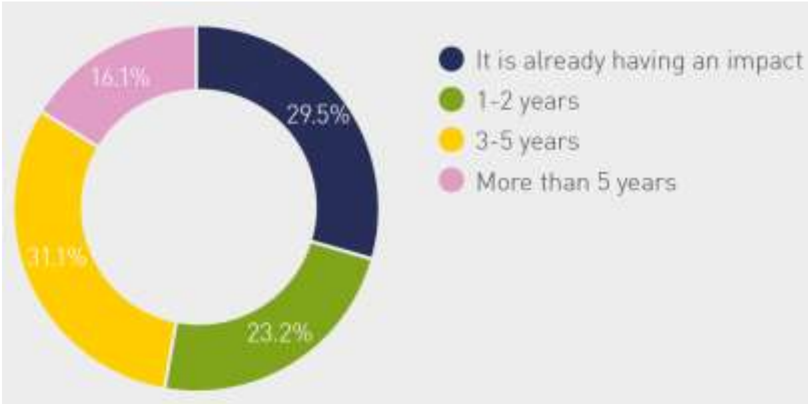


Figure 13.8: SF_QUAN_T1.4 Respondents - perception timescale for BIM impact on FM

13.2.2 CSF_QUAN_MT2: General perception/understanding of BIM by FM industry

This MT highlighted respondents' perception/understanding of key issues regarding BIM shown in Figure 13.9.

FROM YOUR AWARENESS AND UNDERSTANDING OF BIM, PLEASE INDICATE YOUR LEVEL OF AGREEMENT WITH THE FOLLOWING STATEMENTS:	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1. The FM industry is not clear about what BIM is	17.3%	54.7%	16.9%	10.6%	0.4%
2. BIM is about a collaborative working process not just the use of BIM software model(s)	52.0%	36.2%	11.4%	0%	0.4%
3. FMs have a good understanding of the RIBA 2013 Plan of Work and its work stages	1.6%	10.2%	50.4%	32.3%	5.5%
4. BIM is only for new build, not existing buildings/assets or refurbishment projects	2.8%	11.4%	13.8%	41.3%	30.7%
5. BIM has the potential to deliver significant added value to BIM	46.9%	37.0%	13.0%	2.8%	0.4%
6. The FM industry and FMs are well prepared to deal with BIM projects	0.8%	5.1%	26.4%	54.3%	13.4%
7. BIM should help improve data transfer into FM IT/CAFM systems	39.4%	44.9%	13.0%	1.6%	1.2%
8. BIM encourages early FM involvement in the design phase of projects to ensure the end users' needs are represented and give advice about life-cycle costing	39.8%	41.7%	14.6%	2.4%	1.6%
9. Companies adopting BIM may have a competitive advantage over those that do not	34.3%	45.7%	16.1%	2.4%	1.6%
10. FMs would benefit from more BIM familiarisation to help clearly define what they want in terms of outputs from the BIM process	49.2%	42.1%	7.9%	0%	0.8%

Figure 13.9: SF_QUAN_MT2 Respondents - perception general impact of BIM on FM

ST_QUAN_T2.1-FM industry understanding of BIM: 72.0% believed "*the FM industry is not clear what BIM is*"; indicating more **clarity** is required about 'what BIM is and is not' (17.3% *strongly agree*, 54.7% *agree*).

ST_QUAN_T2.2-BIM improving collaboration: 88.2% perceived BIM as "*an increased collaboration process and not just software models*"; indicating a strong potential of BIM to improve **collaboration** between stakeholders (52.0% *strongly agree*, 36.2% *agree*). Respondents noted: *"The BIM process should help **overcome traditional barriers**, improve the tender process and encourage more involvement and cooperation between the various stakeholders in the whole-life process".* Another added: *"it will improve **collaboration** and efficiency by everyone talking the same language*".

ST_QUAN_T2.3-FM familiarisation with the RIBA process: 50.4% were "*neutral"* when asked "*do FMs have a good understanding of the RIAB 2013 Plan of Work and its stages?*" 37.8% disagreed; indicating that more **familiarisation** could help engagement/involvement in BIM projects (5.5% *strongly disagree*, 32.3% *disagree*).

ST_QUAN_T2.4-BIM for existing buildings: 72.0% disagreed that "*BIM is only for new-builds*" indicating there was a majority perception BIM could be used for new-build and **existing buildings** (30.7% *strongly disagree*, 41.3% *disagree*).

ST_QUAN_T2.5-BIM adding value to FM: 83.9% agreed "*BIM has the potential to deliver significant added value to FM*"; indicating the majority perceived BIM as potentially **adding value to FM**; (46.9% *strongly agree*, 37.0% *agree*).

ST_QUAN_T2.6-FM industry readiness for BIM: 67.7% disagreed the "*FM industry is well prepared to deal with BIM projects*"; indicating more needs to be done to ensure **early FM and client engagement** (13.4% *strongly disagree*, 54.3% *disagree*). Respondents added; *"There is often a lack of a transparent understanding from clients/owners as to why they should invest in BIM and involve FM during early project stages. Education for all clients on how BIM can help them, is a must".*

ST_QUAN_T2.7-BIM improving data transfer: 84.3% agreed "*BIM should help improve data transfer into CAFM systems*"; indicating a majority perception BIM might help **improve data transfer** from construction to operation (39.4% *strongly agree*, 44.9% *agree*).

ST_QUAN_T2.8-Early involvement of FM: 81.5% agreed "*BIM encourages early FM involvement in the design phase of projects to ensure the end users' needs are represented and give advice about life-cycle costing*"; indicating BIM could help **early FM engagement** in the construction process (39.8% *strongly disagree*, 41.7% *disagree*). Respondents added; *"The integration of the operational and maintenance stakeholders early in the design phase will push maintainability and cost reduction in O&M".*

ST_QUAN_T2.9-BIM as a competitive advantage: 80.0% agreed BIM may "*offer companies that adopt and use it, an advantage over those that do not*"; indicating a perception companies using BIM could possibly gain a **competitive advantage** (34.3% *strongly agree*, 45.7% *agree*).

ST_QUAN_T2.10-Need for BIM familiarisation: 91.3% agreed "*FM professionals would benefit from more familiarisation with BIM to be able to define the outputs in the BIM process*"; indicating respondents felt more **training/familiarisation** might help improve engagement from FMs (49.2% *strongly agree*, 42.1% *agree*).

13.2.3 CSF_QUAN_MT3: FMs experience of preparing/using key BIM documentation

This MT explored respondents experience and confidence of preparing/using key BIM documents fundamental to successful BIM projects.

ST_QUAN_T3.1-Experience of a BIM project: 39.8% of respondents had *"some **experience of being involved in a BIM project**"*, whilst the majority (52%) had *"no experience",* and 8.3% did not answer. This indicated FM engagement is still in its infancy.

ST_QUAN_T3.2-General experience of key BIM documents: more than 60%, either "*knew of, but had not implemented/written*", or had "*no experience*" of **key BIM documents** (e.g. OIR, AIR, EIR etc.); indicating writing/implementing such documents might be a challenge for many respondents.

ST_QUAN_T3.3-Experience of writing BIM documents: experience levels of "*writing and implementing*" key BIM documents were generally low; **EIR** (20.1%), **AIR** (18.9%), **BIM** strategy (17.3%), **OIR** (15.0%), and **BEP** (12.6%) and **AMS** (12.2%). Their detailed responses are shown in Figure 13.10. The low percentage (12.2%) for the AMS was of concern (as the fundamental basis for the start of the BIM process). This might be due to BIM being relatively new to FM at the time, but also could indicate FMs require more **BIM training/familiarisation** to ensure they are equipped to write/implement key documents.

RESPONDENTS WERE ASKED IF THEY HAD ANY EXPERIENCE OF PREPARING OR USING A RANGE OF KEY DOCUMENTS USED IN THE BIM PROCESS	HAVE WRITTEN AND IMPLIMENTED	HAVE IMPLIMENTED BUT NOT YET WRITTEN	KNOW OF BUT NOT IMPLENTED/WRITTEN	NO EXPERIENCE
1. Asset Management Strategy (e.g. ISO 55000 or other	12.2%	8.3%	38.2%	33.1%
2. BIM Strategy	17.3%	9.4%	34.6%	30.3%
3. Organisational Information Requirements (OIR)	15.0%	9.4%	33.1%	34.3%
4. Asset Information Requirements (AIR)	18.9%	12.6%	31.5%	28.7%
5. Employers Information Requirements (EIR)	20.1%	10.2%	26.4%	35.0%
6. BIM Execution Plan (BEP)	12.6%	8.7%	30.7%	39.8%

Figure 13.10: SF_QUAN_T3.3 Respondents - experience of key BIM documents

ST_QUAN_T3.4-Confidence levels - reviewing/writing BIM documents; 40.9% felt "*very* or *fairly*" confident when asked "*based on your current knowledge/experience of BIM how confident would you feel about engaging in a BIM project and taking on roles such as reviewing/writing the OIR, AIR, EIR etc.?"* (*very* =16.9% and *fairly* = 24.0%). 27.6% answered *"neutral"* but 31.5% were "*not so confident*" or "*not at all confident*" (18.5% and 13.0%). This indicated more **familiarisation/training** might help respondent's **confidence** levels. Figure 13.11 shows their detailed responses.

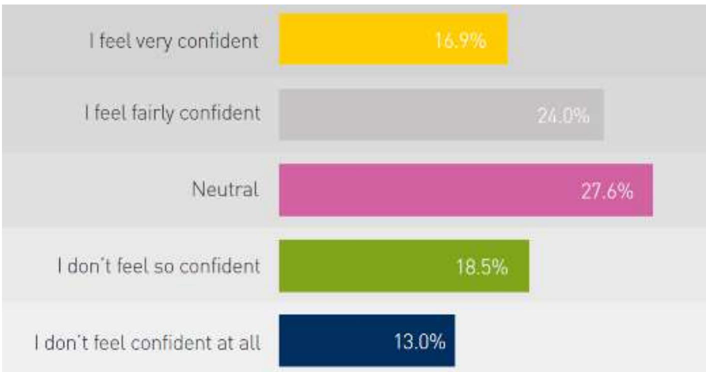


Figure 13.11: SF_QUAN_T3.4 Respondents – confidence levels with BIM documents

13.2.4 CSF_QUAN_MT4: AMS and BIM in respondents' organisations

This MT highlighted respondent's perception about BIM in the organisations to which they belong. Respondents gave feedback regarding key BIM documents including; AMS, BIM strategy, BIM processes, OIR, AIR, EIR, BEP.

ST_QUAN_T4.1-Lack of key BIM documents in respondent's organisation: BIM documents were often "*not in place*" (25.2%-29.5%). 17.7%-25.2% indicated they "*did not know*" and some indicated "*no requirement*" (15.4%-19.7%). The generally low figures might reflect respondents/organisations having none/limited involvement in BIM projects and/or a lack of clear awareness of the BIM process. This indicated a need for organisations to introduce BIM into their processes.

ST_QUAN_T4.2-Lack of organisation AMS: 25.2% indicated an AMS (e.g. '*ISO 55000'*) was "*not in place*", and 22.4% "*didn't know*". Where an AMS was in place; 11.0% noted it was "*implemented but not well used*". A further 12.2% indicated their organisations were "*considering implementing*" an AMS. This indicated a general lack of an AMS which was of concern as assets are often the second biggest expense after personnel. Respondents added; "*BIM will help companies validate, verify and comply with client's services and asset strategy*".

ST_QUAN_T4.3-BIM documents in place and being used: 8.7-16.1% indicated documents were "*in place and are well used*"; suggesting organisations might need to do more to ensure BIM documents are integrated into their processes. The ranking of the most implemented documents was:

- 1st AIR
- 2nd EIR
- 3rd BIM processes
- 4th AMS
- 5th BIM strategy
- 6th BEP
- 7th OIR

It was interesting that the AIR came top and OIR bottom; as the OIR should be the document that leads the AIR. Figure 13.12 shows their detailed responses. This indicated a possible disconnection between operation strategy and thinking about assets.

DOES YOUR ORGANISATION HAVE THE FOLLOWING IN PLACE?	IN PLACE AND IS WELL USED	IMPLEMENTED BUT NOT WELL USED	CONSIDERING IMPLEMENTING	NOT IN PLACE	NO REQUIREMENT	DO NOT KNOW
1. Asset Management Strategy (e.g. ISO 55000 or other)	12.2%	11.0%	12.2%	25.2%	19.7%	22.4%
2. BIM strategy	15.4%	7.1%	14.6%	29.1%	18.5%	18.9%
3. BIM processes	16.1%	7.5%	15.7%	29.5%	16.1%	17.7%
4. Organisational Information Requirements (OIR)	8.7%	10.2%	14.2%	28.7%	15.7%	24.4%
5. Asset Information Requirements (AIR)	13.4%	12.2%	13.0%	24.8%	15.4%	23.6%
6. Employer's Information Requirements	13.4%	10.6%	11.0%	25.6%	15.4%	25.2%
7. BIM Execution Plan (BEP)	14.2%	6.7%	11.8%	28.7%	16.1%	23.2%

Figure 13.12: SF_QUAN_T4.3 Use of BIM documents in respondents' organisations

13.2.5 CSF_QUAN_MT5: Benefits of BIM to FM

This MT highlighted respondent's perception of the benefits of BIM to FM.

ST_QUAN_T5.1-Key benefits of BIM to FM (high to low): Respondents indicated levels of agreement with nine **benefits** identified from the literature using a five-point Likert scale. Their responses are shown in Figure 13.13.

PLEASE INDICATE YOUR LEVEL OF AGREEMENT OF POSSIBLE BENEFITS OF BIM TO FM:	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1. Strategic decision making about asset maintenance and management	39.4%	48.4%	10.6%	0.4%	1.2%
2. Visualisation of buildings/assets for customers, H&S and maintenance issues	44.9%	42.1%	12.2%	0%	0.8%
3. Data transfer from construction into CAFM and other software tools for operation	41.7%	44.9%	11.4%	1.2%	0.8%
4. Cost management/transparency (whole-life, maintenance and replacement)	42.5%	43.3%	12.2%	0.8%	1.2%
5. Operational efficiency (in terms of cost/time)	36.6%	47.2%	14.2%	0.8%	1.2%
6. Space and move planning capability	29.5%	48.4%	19.7%	1.2%	1.2%
7. Simulation capability e.g. energy, fire evacuations etc.	33.1%	44.1%	21.3%	1.2%	0.4%
8. Sustainability in terms of reductions in energy use/carbon emissions	23.2%	43.3%	29.9%	2.8%	0.8%
9. Insurance costs for buildings due to availability and accuracy of information	20.1%	38.2%	37.8%	3.5%	0.4%

Figure 13.13: SF_QUAN_T5.1 Respondents' perception - benefits of BIM to FM

To be able to compare the quantitative and qualitative CSF the benefits were ranked using a weighted average approach (strongly agree = 5, agree = 4, neutral = 3, disagree = 2 and strongly disagree = 1). The **ranked benefits** are shown in Table 13.1.

Table 13.1: ST_QUAN_T5.1: Benefits of BIM to FM (ranked high to low)

ST_QUAN_T5.1-Key benefits of BIM to FM (ranked high to low)	Weighted score	Rank
SST_QUAN_T5.1.1-Visualisation of buildings/assets for customers, H&S and maintenance issues	4.303	1
SST_QUAN_T5.1.2-Data transfer from construction into CAFM and other software tools for operation	4.247	2
SST_QUAN_T5.1.3-Cost management/transparency (whole life, maintenance and asset replacement)	4.239	3
SST_QUAN_T5.1.4-Strategic decision making about asset maintenance and management	4.232	4
SST_QUAN_T5.1.5-Operational efficiency (in terms of cost/time)	4.160	5
SST_QUAN_T5.1.6-Simulation capability e.g. energy, fire evacuations etc.	4.082	6
SST_QUAN_T5.1.7-Space and move planning capability	4.026	7
SST_QUAN_T5.1.8-Sustainability in terms of reductions in energy use/carbon emissions	3.845	8
SST_QUAN_T5.1.9-Insurance costs for buildings due to availability and accuracy of information	3.737	9

The **top five** ranked SST quantitative benefits of BIM to FM were:

SST_QUAN_T5.1.1-Visualisation of buildings/assets for customers, H&S and maintenance issues ranked 1st (weighted-score 4.303). 44.9% "*strongly agree*" BIM can help "*visualisation of the virtual asset for customers with respect to maintenance, health and safety etc.*" Respondents noted; "*visualisation could help **health and safety tasks***".

SST_QUAN_T5.1.2-Data transfer from construction into CAFM and other software tools for operation ranked 2nd (weighted-score 4.247). Respondents noted; "*BIM will help ensure more complete **transfer of O&M information** into CAFM".*

SST_QUAN_T5.1.3-Cost management/transparency (whole-life, maintenance and asset replacement) ranked 3rd (weighted-score 4.239). Respondents noted; "*clients, FM professionals and investors should be able to make better-informed business and investment decisions before they invest in or build assets by using the data and information in a virtual context which **reduces risk***".

SST_QUAN_T5.1.4-Strategic decision making about asset maintenance and management ranked 4th, (weighted-score 4.232). Respondents noted; "*asset and risk-based maintenance will be improved due to the **level of confidence of data***". They added" *BIM can improve asset management strategy with respect to improved data for CAFM and other FM systems*".

SST_QUAN_T5.1.5-Operational efficiency (in terms of cost/time) ranked 5th, (weighted-score 4.160). Respondents noted; "*BIM will empower more **strategic decision making***".

For the remaining quantitative benefits interesting observations were:

SST_QUAN_T5.1.6-Simulation capability e.g. energy, fire evacuations etc.: respondents noted; "*BIM can help with **simulations** for fire evacuations, logistics etc.*"

SST_QUAN_T5.1.7-Space and move planning capability: respondents noted; *"BIM will help FMs **leasing, sub-tenant management** and **utilisation of space**".*

SST_QUAN_T5.1.8-Sustainability, energy use/carbon emissions: respondents noted; **"***BIM will enable improved **cradle-to-cradle strategies** and projects will be better able to forward plan the dismantling of buildings or building parts with less waste and more possibilities to re-use components".* They added *"**'Soft Landings'** needs to be integral to this process to ensure **life-cycle** of assets is optimised and to minimise energy usage reducing the **carbon footprint**".*

SST_QUAN_T5.1.9-Insurance costs for buildings due to availability/accuracy of information: respondents noted; *"insurance costs could drop due to good information about assets, but I am not sure".*

13.2.6 CSF_QUAN_MT6: Possible barriers/concerns to adoption and use of BIM

This MT highlighted respondent's perception regarding barriers/concerns to BIM adoption and use.

ST_QUAN_T6.1-Key concerns/barriers to adoption and use of BIM (high to low): Respondents indicated levels of agreement with 10 **barriers** identified from the literature using a five-point Likert scale. Their responses are shown in Figure 13.14.

PLEASE INDICATE YOUR AGREEMENT WITH POSSIBLE CONCERNS/BARRIERS RELATING TO BIM:	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1. I feel I need more knowledge about BIM before being involved in a BIM project	20.1%	40.9%	18.9%	12.6%	7.5%
2. I don't feel our organisation is adequately prepared to engage in BIM projects	14.2%	37.0%	22.8%	19.3%	6.7%
3. The cost of adopting/implementing BIM	13.4%	39.8%	32.3%	13.0%	1.6%
4. Ability of FM to write/specify the OI, AIR and EIR documents for a client	14.6%	46.9%	30.3%	6.3%	2.0%
5. Management/collection of data in the BIM process	13.4%	49.2%	26.8%	9.8%	0.8%
6. Using COBie for transfer of data into CAFM/other systems	12.2%	30.3%	46.1%	10.2%	1.2%
7. The impact of BIM from a legal perspective	10.6%	20.1%	51.2%	17.3%	0.8%
8. CAFM/software suppliers should work on tools that allow bi-directional transfer of data between the BIM and CAFM	33.1%	39.4%	22.8%	4.3%	0.4%
9. BIM training and how FMs will access data in 3D BIM models at handover	26.0%	45.7%	22.4%	4.7%	1.2%
10. Lack of/cost of training	23.6%	44.5%	24.4%	7.1%	0.4%

Figure 13.14: SF_QUAN_T6.1 Respondents' perception - barriers to BIM adoption/use

In order to compare these with findings from the qualitative CSF the 10 quantitative answers above were ranked using a weighted average approach (strongly agree = 5, agree = 4, neutral = 3, disagree = 2 and strongly disagree = 1). The **ranked barriers** are shown in Table 13.2.

Table 13.2: ST_QUAN_T6.1: Barriers to BIM use/adoption (ranked high to low)

ST_QUAN_T6.1-Key concerns/barriers to adoption and use of BIM (ranked high to low)	Weighted score	Rank
SST_QUAN_T6.1.1-CAFM/software suppliers should work on bi-directional transfer of data between BIM and CAFM	4.005	1
SST_QUAN_T6.1.2-BIM training and how FMs will access data in 3D BIM models at handover	3.906	2
SST_QUAN_T6.1.3-Lack of/cost of training	3.838	3
SST_QUAN_T6.1.4-Ability of FM to write/specify the OIR, AIR and EIR documents for a client	3.661	4
SST_QUAN_T6.1.5-Management/collection of data in the BIM process	3.646	5
SST_QUAN_T6.1.6-I feel I need more knowledge about BIM before being involved in a BIM project	3.535	6
SST_QUAN_T6.1.7-The cost of adopting/implementing BIM	3.507	7
SST_QUAN_T6.1.8-Using COBie for transfer of data into CAFM/other systems.	3.421	8
SST_QUAN_T6.1.9-Organisational readiness to engage in BIM projects	3.327	9
SST_QUAN_T6.1.10-The impact of BIM from a legal perspective	3.224	10

The **top five** ranked SST quantitative barriers to BIM use/adoption were:

SST_QUAN_T6.1.1-CAFM/software suppliers should work on bi-directional transfer of data between the BIM and CAFM: ranked 1st (weighted-score 4.005). Respondents noted; "*they should demonstrate how data can be **bi-directional between the systems***. They added "*If data-transfer is one-way (BIM-2-CAFM), rather than bi-directional, models will be left to go out of date*".

SST_QUAN_T6.1.2-BIM training and how FMs will access data in 3D models at handover: ranked 2nd, (weighted-score 3.906). Respondents noted; the importance of **keeping BIM models up-to-date "***unless properly managed the BIM models have limited use in operations, the data must be used and maintained*".

SST_QUAN_T6.1.3-Lack of/cost of training: ranked 3rd, (weighted-score 3.838). Respondents noted **adequate resources** were key; "*the biggest roadblock is lack of **appropriate tools and software** for FM*". Another observed; "*allocating FMs to BIM projects may require a considerable time away from daily operations. Not all organisations can dedicate that time concentrated for a year or a few mont*hs".

SST_QUAN_T6.1.4-Ability of FM to write/specify the OIR, AIR and EIR documents for a client: ranked 4th, (weighted-score 3.661). Respondents noted; **proper use of the BIM process** as important; "*FMs need to play a pivotal role and be on board with BIM."* Another noted *"there needs to be a **cultural change** to understand **what data is important** and provides value and then a culture of keeping it valid and current".*

SST_QUAN_T6.1.5-Management/collection of data in the BIM process: ranked 5th, (weighted-score 3.646). Respondents discussed improved **decision making;** "*clients, FM professionals and investors should be able to make better-informed business and investment decisions".*

Other comments from respondents highlighted:

SST_QUAN_T6.1.6-I feel I need more knowledge about BIM before being involved in a BIM project: **engagement** was essential; "*FMs need to play a pivotal role"* and *"be on board with BIM".*

SST_QUAN_T6.1.7-The cost of adopting/implementing BIM: ROI-of-BIM was essential; *"unless BIM management becomes a budget line in client's annual costs then BIM will not provide value in the operational phase*". Another noted "*organisations need to employ people to keep the information up to date".*

SST_QUAN_T6.1.8-Using COBie for transfer of data into CAFM/other systems: understanding IFC/COBie was important; **"***FMs will need know how to plan, manage and capture data in the BIM process including using COBie*". Others highlighted, "*CAFM developers need to work now to not only accept COBie style data but also integration with IFC*".

SST_QUAN_T6.1.9-Organisational readiness to engage in BIM projects: in additional comments respondents observed: *"Clients need to **invest in BIM** models for them to be of value. How many O&M's and record drawings are out of date within years of a building being occupied?"* Another noted: *"I am concerned that only the larger practices will be able to afford the staff to work in the BIM format".*

SST_QUAN_T6.1.10-The impact of BIM from a legal perspective: **legal implications of BIM** were noted: "*FMs need to be ready with BIM from a legal perspective*".

13.2.7 CSF_QUAN_MT7: Knowledge of UK BIM standards/guidance:

This MT highlighted respondent's knowledge of key UK BIM standards/guidance documents.

ST_QUAN_T7.1-Knowledge of key BIM standards/guidance (ranked): Respondents indicated their level their knowledge of 12 important **UK BIM standards** using a five-point Likert scale. Their responses are shown in Figure 13.15.

PLEASE INDICATE YOUR LEVEL OF KNOWLEDGE OF THE FOLLOWING KEY UK BIM RELATED STANDARDS AND GUIDANCE DOCUMENTS:	KNOW AND USE IN PRACTICE	KNOW WELL BUT DO NOT USE IN PRACTICE	HAVE BASIC OVERVIEW BUT DO NOT USE IN PRACTICE	HEARD OF BUT HAVE NOT READ	NOT AWARE OF
1. RIBA 2013 Plan of Work	16.9%	15.4%	16.1%	16.1%	35.5%
2. ISO 55000 (1/2/3) – Asset Management	12.2%	16.5%	22.8%	24.0%	24.5%
3. PAS 1192-2:2013 – Specification for information management for the capital/delivery phase of construction projects using BIM	11.0%	12.2%	15.7%	19.7%	41.4%
4. PAS 1192-3:2014 – Specification for information management for the operational phase of assets using BIM	10.6%	12.6%	16.5%	18.9%	41.4%
5. BS 8587:2012 – Guide to facility information managements	10.6%	10.2%	16.9%	22.8%	39.5%
6. ISO 15686-5 – Life Cycle Management	9.4%	16.5%	24.0%	22.0%	28.1%
7. BS1192:2007+A2:2016 – Collaborative production of architectural, engineering and construction information – Code of practice	9.1%	7.5%	18.9%	20.9%	43.6%
8. BS 1192-4:2014 – Fulfilling employer's information exchange requirements using COBie – Code of practice	7.5%	11.4%	16.5%	20.9%	43.7%
9. CIC suite of BIM documents; Professional Indemnity Insurance; Scope of Services for the Role of Information Management and BIM Protocol	6.3%	9.1%	14.6%	17.3%	52.7%
10. PAS 1192-5:2015 - Specification for security-minded BIM, digital built environments and smart asset management	5.5%	10.2%	18.5%	21.3%	44.5%
11. BS 8536-1:2015 - Briefing for design and construction. Code of practice for facilities management (buildings infrastructure)	5.1%	11.4%	22.0%	20.9%	44.5%
12. BS 8536-2:2016 – Briefing for design and construction. Code of practice for asset management (linear and geographical infrastructure)	4.3%	8.7%	20.1%	21.7%	45.2%

Figure 13.15: SF_QUAN_MT7 Respondents - knowledge of BIM standards

In order to compare these with findings from the qualitative CSF the quantitative answers above were ranked using a weighted average approach (Know and use in practice = 5, know well but don't / are not used in practice = 4, have a basic overview but don't use in practice = 3, Heard of but have not read = 2 and not aware of = 1).). The **Knowledge of UK BIM standards/guidance** are shown in Table 13.3.

Table 13.3: ST_QUAN_T7.1: Knowledge of UK BIM standards/guidance (ranked high to low)

No	ST_QUAN_T7.1-Knowledge of key BIM standards and guidance (ranked)	Rank	Weighted score
1	SST_QUAN_T7.1.1-ISO 55000 Asset management. Overview, principles and terminology	1	2.679
2	SST_QUAN_T7.1.2-RIBA Plan of Work	2	2.621
3	SST_QUAN_T7.1.3-ISO 15686 Buildings and constructed assets - Service life planning - Part 5: Life-cycle costing	3	2.571
4	SST_QUAN_T7.1.4-PAS 1192-3 BIM Specification for information management for the operational phase of assets using building information modelling	4	2.321
5	SST_QUAN_T7.1.5-PAS 1192-2 Specification for information management for the capital/delivery phase of construction projects using building information modelling	5	2.317
6	SST_QUAN_T7.1.6-BS 8587:2012 Guide to facility information management	6	2.296
7	SST_QUAN_T7.1.7-BS 8536-1:2015 Briefing for design and construction –Part 1: Code of practice for facilities management (buildings infrastructure)	7	2.195
8	SST_QUAN_T7.1.8-BS1192 part 4:2014 - Fulfilling employers information exchange requirements using COBie – Code of practice	8	2.181
9	SST_QUAN_T7.1.9-BS 1192:2007+A2:2016 - Collaborative production of architectural, engineering and construction information – code of practice	9	2.176
10	SST_QUAN_T7.1.10-PAS 1192-5: 2015 Specification for security-minded BIM, digital built environments and smart asset management	10	2.109
11	SST_QUAN_T7.1.11-BS 8536-2:2016 Briefing for design and construction. Code of practice for asset management (Linear and geographical infrastructure)	11	2.052
12	SST_QUAN_T7.1.12-CIC suite of BIM documents; Professional Indemnity Insurance, Scope of Services for the Role of Information Management and BIM Protocol	12	1.99

Other interesting observations were :

ST_QUAN_T7.2-Lack of familiarisation with UK standards: many respondents were "*not aware*" of the standards (ranging between 28.0% for '*ISO-15686'* and 52.7% for the '*CIC protocol*'). Some "*had heard of them but not read them*" (16.1% for RIBA PoW and 24%.7% for *'ISO 55000'*). The findings were lower than expected. However, the findings could be skewed if international respondents were not familiar with UK standards.

ST_QUAN_T7.3-AM, Planning and LCC standards (Non-BIM specific): the top three ranked standards were **general management standards:** 1st '*ISO-55000'* (2.679), 2nd RIBA PoW (2.621), and 3rd '*ISO-15686'* (2.571). This might be due to the range of stakeholders and the fact that BIM was relatively new to the FM industry at the time of the survey. Respondents added: "*the standardized BIM approach stakeholders to plan for **whole-life modelling and lifecycle replacement**. This can then be effectively integrated in to CAFM for future **risk planning***".

ST_QUAN_T7.4-BIM standards with respect to specific BIM standards/guidance: for **BIM specific standards** the top three ranked were: 1st '*PAS-1192-3'* (2.321), '*PAS-1192-2'* (2.317) and '*BS-8536-1'* (2.195). Both '*PAS1192-3/PAS1192-2*' had similar scores, indicating a balance of familiarisation from both the operation/construction perspectives. For **FM specific BIM standards**;

it was surprising '*BS-8536'* (Parts 1/2) did not score higher, as key documents guiding FM professionals in the BIM process. This indicated they need to be better promoted.

ST_QUAN_T7.5-BIFM (IWFM) BIM guidance documents: Respondents noted the BIFM BIM guides were "*a good starting point for FM professionals interested in knowing more about the BIM process"*.

ST_QUAN_T7.6-Other useful BIM guidance documents: people indicated as **useful to FMs** included:

- Government and BSRIA Soft Landings Policy
- GSA BIM requirements
- COBIM 2012
- Penn State BIM Execution Plan
- National BIM standard version 3 (National Institute of Building Science)
- NBS BIM Toolkit (digital Plan of Work and Uniclass 2015)
- CIBSE life cycles, PDTs
- RICS suite of information and their BICS service.

13.2.8 CSF_QUAN_MT8: BIM supporting the UK Government construction strategy

This MT highlighted respondents' perception of how BIM was supporting the Government's Construction Strategy and 2025 strategic targets:

ST_QUAN_T8.1-BIM helping meet government 2025 strategic targets; Respondents indicated levels of agreement using a four-point Likert scale as to whether *BIM would help the UK government meet **construction strategy targets***. Their responses are shown in Figure 13.16.

THE UK GOVERNMENT HAS SET OUT ITS STRATEGY FOR UK CONSTRUCTION IN 2025. THE STRATEGY INCLUDES FOUR TARGETS. PLEASE TELL US THE ROLE YOU THINK BIM WILL HAVE IN ACHIEVING THE FOLLOWING:	BIM WILL HELP	BIM WILL NOT MAKE A DIFFERENCE	BIM WILL HINDER	DO NOT KNOW
1. 33% reduction in the initial cost of construction and the whole-life cost of built assets	66.1%	5.5%	0.8%	27.6%
2. 50% reduction in the overall time, from inception to completion for new build and refurbished assets	54.3%	13.0%	2.0%	30.7%
3. 50% reduction in greenhouse gas emissions in the built environment	40.2%	24.8%	0.4%	34.6%
4. 50% reduction in the trade gap between total exports and total imports for construction products and materials	20.9%	33.1%	0.8%	45.3%

Figure 13.16: SF_QUAN_T8.1 Respondents – BIM supporting construction strategy targets

Respondents were generally positive about BIM supporting **government construction strategy targets.** A very small percentage indicated "*BIM will hinder"* them. However, more than a quarter answered they "*didn't know"*; indicating some people were unsure. The figures below indicated people were more confident about the first three targets but not so confident about the fourth:

- **First :** 66.1% believed "*BIM will help",* whilst 5.5% believed it "*won't make a difference"*.
- **Second:** 54.3% believed "*BIM will help",* whilst 13.0% believed it "*won't make a difference*".
- **Third:** 40.2% believed "*BIM will help*", whilst 24.8% believed it "*won't make a difference".*
- **Fourth:** 20.9% agreed "*BIM will help",* 33.1% believed it "*won't make a difference"* and almost half (45.3%) responded they "*don't know"*.

ST_QUAN_T8.2-Awareness of the UK BIM mandate: 53.5% of respondents were "*aware*" of the ***UK Government mandate to adopt and use BIM Level 2****.* This figure was lower than expected. This might be due to international respondents (less familiar with BIM in the UK).

ST_QUAN_T8.3-Awareness of maturity levels of BIM: 40.9% were "*not aware of the different levels of BIM*" and 12.6% "*don't know*" as shown in Figure 13.17; indicating a general lack of understanding about BIM maturity levels.

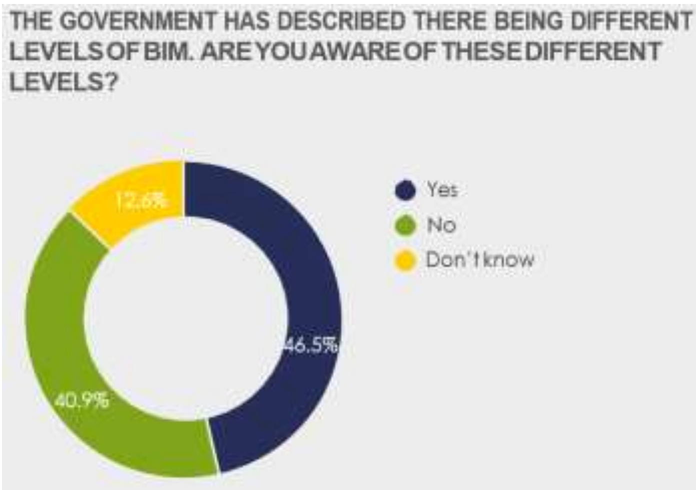


Figure 13.17: SF_QUAN_T8.3 Respondents – awareness of different maturity levels of BIM

Respondent's answers may have been due to confusion between 'BIM maturity levels' and **dimensions of BIM**; i.e. 4D=time/project information, 5D=cost data and 6D=FM.

ST_QUAN_T8.4-Awareness of BIM Level 3 strategy: 48% indicated they were "*not aware of"* of the Government's strategy. However, 13.8% indicated they "*know it well*", and 15% had "*heard of and briefly read it*". A further 23.2% had "*heard of but not yet read it*". Figure 13.18 shows the full range of responses.

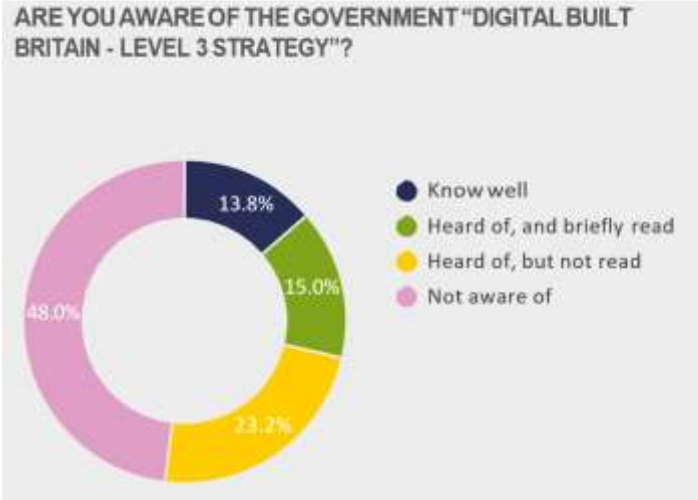


Figure 13.18: SF_QUAN_T8.4 Respondents – awareness of government BIM-level 3 strategy

ST_QUAN_T8.5-Awareness of government sponsored BIM websites; had a lower visibility rating than expected. All three had less than 48% visibility ratings as shown in Figure 13.19.

Respondents were also asked if they were aware of a series of government websites (linked to the UK BIM Task Group) with the purpose of supporting and helping disseminate information about BIM. ARE YOU AWARE OF THE FOLLOWING WEBSITES (LINKED TO GOVERNMENT BIM TASK GROUP)?	KNOW WELL AND HAVE ACCESSED REGULARLY	HEARD OF AND BRIEFLY ACCESSED	HEARD OF BUT NOT ACCESSED	NOT AWARE OF
1. BIM Task Group (www.bimtaskgroup.org)	18.1%	16.1%	13.8%	52.0%
2. Digital Built Britain (www.digital-built-britain.com)	10.2%	13.8%	16.5%	59.4%
3. BIM Level 2 (www.bim-level2.org)	12.6%	15.4%	14.6%	57.5%

Figure 13.19: SF_QUAN_T8.5 Respondents – awareness of government BIM websites

They were ranked in terms of 'access/having heard off them', using an average weighting approach:

- 1st - BIM Task Group (34.2% accessed)
- 2nd - BIM Level 2 (28% accessed)
- 3rd - Digital Built Brittan (24% accessed)

13.2.9 CSF_QUAN_MT9: BIM training within respondent's organisations

This MT highlighted respondents' perception regarding BIM training within their organisations.

ST_QUAN_T9.1-BIM training within respondent's organisations: Respondents indicate how their organisations are addressing **BIM training** using a five-point Likert scale. Their responses are shown in Figure 13.20.

PLEASE INDICATE YOU LEVEL OF AGREEMENT WITH THE FOLLOWING:	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
1. Our organisation has a clear understanding about BIM training and a plan in place for staff training	9.4%	12.6%	31.5%	29.5%	16.9%
2. Our organisation has adequate resources/funding available for BIM training	7.1%	15.7%	38.2%	26.0%	13.0%
3. Our organisation already has in-house BIM expertise which is being used to conduct in-house training	10.6%	16.1%	30.7%	24.4%	18.1%
4. Our organisation has a plan in place to actively evaluate its BIM training	6.3%	13.4%	37.0%	27.6%	15.7%
5. Our employees would benefit from BIM certification or further BIM training courses	17.3%	40.6%	28.3%	6.3%	7.5%

Figure 13.20: SF_QUAN_T9.1 – BIM training within respondent's organisations

ST_QUAN_T9.2-Organisation BIM training plans in place for staff: 46.4% disagreed their organisation had "*a clear understanding about BIM training and a plan in place for staff training*" (29.5% *disagree* and 16.9% *strongly disagree*), whilst 22.0% agreed (12.6% *agree* and 9.4% *strongly agree*). This indicated more BIM training is required. Respondents added "*it would be helpful to have specific BIM training courses delivered by professional associations*".

ST_QUAN_T9.3-Organisation resources/funding for BIM training: 39.0% disagreed their "*organisation has adequate resources/funding available for BIM training"* (26.0% *disagree* and 13.0% *strongly disagree*), whilst 22.8% agreed (15.7% *agree* and 7.1% *strongly agree*). This indicated organisations need to allocate resource/funding to prepare their staff for BIM projects. Some respondents added; "*allocating FMs to BIM projects may require a considerable **time away from daily operations**".*

ST_QUAN_T9.4-Organisation in-house BIM expertise used to conduct in-house training: 42.5.0% disagreed their "*organisation already has in-house BIM expertise which is being used to conduct in-house training"* (24.4% *disagree* and 18.1% *strongly disagree*), whilst 26.7% agreed (16.1% *agree* and 10.6% *strongly agree*). This indicated organisations could improve training by having in-house BIM champions. Respondents noted it was useful having "*internal company seminars and workshops addressing staff awareness of BIM*".

ST_QUAN_T9.5-Organisation plans in place to actively evaluate BIM training: 43.3% disagreed that their organisation had "*plans in place to actively evaluate its BIM training*" (27.6% *disagree* and 15.7% *strongly disagree*), whilst 19.70% agreed (13.4% *agree* and 6.3% *strongly agree*). This indicated organisations could do more to evaluate BIM training.

ST_QUAN_T9.6-Employee benefit from BIM certification or further BIM training: 57.9% agreed "*our employees would benefit from BIM certification or further BIM training courses*" (40.6% *agree* and 17.3% *strongly agree*), whilst 28.3% were *"neutral"* and 13.8% disagreed (*disagree* and *strongly agree*). This indicated there might be some benefit to providing certificate BIM training courses. Respondents noted; *"BIM will help the **overall education** of those responsible for FM for their clients".*

ST_QUAN_T9.7-Level of BIM training, education and support in organisations: only 31.1% of respondents had attended any BIM training, whilst 68.9% had none. Respondents rated the "*level of BIM training and support in their organisation*" using a 5-point Likert scale. 10.2% rated their organisations training as "*very good*", 12.6% "*good but could be improved*", 23.2% "*minimal*", 32.7% "*none*", 6.7% "*not necessary*", and 14.2% said they "*don't know*". The respondents added "*BIM can help to emphasise that **FM is a management discipline**".* This indicated further BIM training could be beneficial.

ST_QUAN_T9.8-Sources and types of training and education: Respondents noted sources for training included;

- "*Webinars from BIFM and other professional organisations*"
- "*Online courses*"
- "*BIM courses delivered as part of a further education programme (university etc.)*"

The types of course included:

- "*BIM familiarisation*"
- "*BIM manager courses*"
- "*University BIM courses*"
- "*BSI courses"*
- *"Accredited professional BIM training (e.g. BRE courses)"*
- "*CPD and distance learning*"
- "*BIM specific software training*"

13.2.10 CSF_QUAN_MT10: Digitalisation, technology and data/information transfer

This MT highlighted respondents' perception regarding digitalisation, technology and how data/information transfer might be improved in the BIM process. Respondent's comments are shown below:

ST_QUAN_T10.1-Impact of digitalisation and technology on FM: Respondents noted; **"*Automation and digitisation*** *will have a big impact on how FM is delivered".* Another added; "*FMs seldom need 3D BIM. It's important BIM does not complicate things and supports their daily work and accessing information using a relevant user interface*". A further commented: "*The BIM process (if planned properly) should help FMs ensure better handover of data and their CAFM tools are well* *populated with relevant and useful data*". The comments indicated there is a perception BIM can help FM operations, but also a danger it might complicate things.

ST_QUAN_T10.2-Using BIM to help visualise and market buildings and services: Respondents noted: "*BIM provides platform for **marketing buildings** and space to potential clients*". Another added: "*the information and model can help plan **way-finding systems** and how buildings could be **visualised and marketed**. BIM will link with **sensors** and other technologies*". This indicated the marketing of property (including retro-BIM models) had potential for development.

ST_QUAN_T10.3-Using BIM with VR,AR and MR: Respondents noted: *"Using BIM together with **virtual reality**, **augmented reality** and **mixed reality** (will help FM professionals plan and **run scenarios**. This could include training, maintenance and planning for emergencies".* Another added; *"VR/AR allow **remote maintenance**, cutting down on numbers of FM staff".* This indicated visualisation of BIM models using VR/AR and for remote working had potential for development.

ST_QUAN_T10.4-Maintaining BIM models: Some feedback highlighted "*concerns around the **cost and complexity** of ongoing **maintenance of BIM models** and their **associated data***". This indicated more thought is needed to consider how BIM models/data are kept updated.

ST_QUAN_T10.5-Software tools to help optimise the use of BIM for FM: Respondents noted; *"the biggest roadblock is lack of **appropriate tools (software)** for FM"*. Others added "*CAFM needs to be integrated in the*". Another added: "*BIM is a not the lead tool for the control for the built environment – CAFM and other tools are currently used there.* This indicated respondents felt there was significant scope for development and integration of BIM and FM software.

13.3 Inferential statistical analyses and hypotheses

This section presents the inferential statistical analysis findings and the results of testing the hypotheses from Chapter 12.2.1.

13.3.1 Test of normality and use of statistical tests

Saunders, Lewis and Thornhill (2016, p. 535) recommended using the Kolmogorov-Smirnov and Shapiro-Wilk tests for normal distribution. The results shown in Table 13.4 indicated in all but one case that the data is significantly divergent and therefore not normally distributed $P<0.05$. The exception was the measure for agreement with barriers of BIM $p=.07$.

Table 13.4: Tests for normality on questionnaire data

Tests of normality (for various questions)	Kolmogorov-Smirnov[a]	Shapiro-Wilk				
	Statistic	df	Sig.	Statistic	df	Sig.
Based on your current knowledge/experience of BIM, how confident would you feel about engaging in a BIM project and taking on such roles as reviewing and writing the OIR, AIR, EIR etc?	.162	254	.000	.909	254	.000
Do you believe BIM will help support the delivery of FM?	.501	254	.000	.452	254	.000
Do you believe BIM will have a significant impact on the FM industry?	.455	254	.000	.584	254	.000
Are you aware of the different levels of BIM (described by the Government)?	.295	254	.000	.787	254	.000
Are you aware of the Government mandate to adopt and use BIM level 2 on government procurement projects with effect from April 2016?	.359	254	.000	.635	254	.000
Are you aware of the Government 'Digital built Britain' – level 3 strategy?	.288	254	.000	.781	254	.000
Level of knowledge of key UK standards/guidance documents	.124	254	.000	.914	254	.000
Level of awareness of UK Government supported websites?	.276	254	.000	.785	254	.000
Level of awareness of UK Government strategy targets for UK Construction 2025?	.196	254	.000	.818	254	.000
Level of experience of using/preparing key BIM documents?	.153	254	.000	.896	254	.000
Levels of awareness and understanding of BIM?	.107	254	.000	.964	254	.000
Level of agreement with possible benefits of BIM?	.102	254	.000	.926	254	.000
Level of agreement with possible barriers to BIM?	.054	254	.066	.988	254	.039
Level of BIM planning in the respondent's organisation?	.108	254	.000	.955	254	.000
Level of training in respondent's organisation?	.112	254	.000	.976	254	.000

Q-Q plots were also used to visually check if the data was normally distributed in line with advice from Field (2009, p. 135). He noted where data is normally distributed "you'll get a lovely straight diagonal line" (p, 135). However, the plots indicated some variance from the straight line. As Field (2009, p. 540) noted where this is the case "we have to use special kinds of statistical procedures known as 'non-parametric' tests". The following tests were used:

Mann-Whitney U: recommended by Cronk (2018, p. 106) to ascertain "whether or not two independent samples are from the same distribution". It is generally seen as the equivalent of the 'independent *t'* test but is acknowledged as less accurate. However, Field (2009) recommended it as the best option, especially where the sample size is larger. This was deemed appropriate for the research where n=254. The test analyses rankings of the data and calculates differences between variables by ranking the range of answers provided in each variable, ignoring the group to which a person belonged. As such the data for the two samples must therefore be ordinal (Cronk, 2018, p. 106).

Pearson's Chi-squared: Saunders, Lewis and Thornhill (2016, p. 538) noted the test "enables you to find out how likely it is that two variables are independent". Field (2009, p. 688) recommended it "where you want to see whether there's a relationship between two categorical variables'.

ANOVA (one-way) Test: Field (2009, p. 348) noted is used to "analyse situations in which we want to compare more than two conditions". Saunders, Lewis and Thornhill (2016, p. 544) noted ANOVA "analyses the spread of data values, within and between groups of data by comparing means. The *F* ratio or F statistic represents these differences". They added "if the likelihood of any difference between groups occurring by chance alone is low, this will be represented by a large *F* ratio with a probability of less than 0.05. This is termed statistically significant" (ibid).

13.3.2 Impact of BIM training

Mann-Whitney U tests were used to investigate the hypothesis '*H0: People who have had some BIM training have higher levels of confidence and higher levels of belief that; 'BIM can support FM delivery' and have a 'significant impact on the FM industry'. They would also be more likely to agree with the 'benefits of BIM to FM' and disagree with 'the barriers to BIM adoption/use'*. The findings shown in Table 13.5 indicated for most variables this was the case, although there was no difference with respect to the 'barriers of BIM adoption and use'.

Table 13.5: Tests for difference between respondents who had some BIM training vs. none

No	Variables investigated	Test result
1	Was there a difference in respondents 'confidence levels to engage in a BIM project' where they had received some sort of BIM training?	A Mann Whitney U test indicated that respondents' confidence in engaging with BIM was significantly greater for those who had received some BIM training vs. those who had not (U= 18.86, P<0.05).
2	Was there a difference in respondents' perception that 'BIM would support FM delivery' where they had received some sort of BIM training?	A Mann Whitney U test indicated that respondents' belief that 'BIM would support FM delivery' was significantly higher for those who have received some BIM training vs. those who had not (U= 6149.50, P<0.05).
3	Was there a difference in respondents' perception that 'BIM would have a significant impact on the FM industry' where they had received some sort of BIM training?	A Mann Whitney U test indicated that respondents' belief that 'BIM will have a significant impact on the FM industry' was significantly higher for those who have received some BIM training vs. those who had not (U= 6149.50, P<0.05).
4	Was there a difference in respondents' level of agreement with possible 'benefits of BIM to FM' where they had received some sort of BIM training?	A Mann Whitney U test indicated that respondents' level of agreement of 'the benefits of BIM to FM' was significantly greater for those who have received some BIM training vs. those who had not (U= 14.80, P<0.05).
5	Was there a difference in respondents' level of agreement with possible 'barriers of adoption and use of BIM' where they had received some sort of BIM training?	A Mann Whitney U test indicated that there was no difference in the level of agreement of the 'barriers of BIM adoption and use' for those who have received some BIM training vs. those who had not (P>0.05).

13.3.3 Impact of BIM experience

Mann-Whitney U tests were used to investigate the hypothesis '*H1: People who have some BIM experience have higher 'levels of confidence to engage in a BIM project'; higher 'levels of knowledge of BIM standards/guidance' and higher levels of belief that 'BIM can support FM delivery' and have a 'significant impact on the FM industry'. They would also be more likely to agree with the 'benefits of BIM to FM' and disagree with 'the barriers to BIM adoption/use'*. The findings shown in Table 13.6 indicated for most variables this was the case although there was no difference with respect to the 'barriers of BIM adoption and use'.

Table 13.6: Tests for difference between respondents who had some BIM experience vs. none

No	Variables investigated	Test result
1	Was there a difference in respondents' 'confidence levels to engage in a BIM project' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' 'confidence level to engage in a BIM project' was significantly greater for those who had some experience of BIM vs. those who had no experience (U= 11,078.50, P<0.05).
2	Was there a difference in respondents' 'level knowledge of the standards/guidance' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' 'level of knowledge of the standards/guidance' was significantly greater for those who had some experience of a BIM project vs. those who had no experience (U= 52.04, P<0.05).
3	Was there a difference in respondents' 'level of belief that BIM would help support FM delivery' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' belief that 'BIM would help support FM delivery' was significantly higher for those who had some experience of a BIM project vs. those who had no experience (U= 5896.00, P<0.05).
4	Was there a difference in respondents' 'level of belief that will have a significant impact on the FM industry' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' belief that 'BIM will have a significant impact on the FM industry' was significantly higher for those who had experience of working on a BIM project vs. those who had no experience (U= 5383.00, P<0.05).
5	Was there a difference in respondents' 'level of agreement with possible benefits of BIM to FM' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' level of agreement regarding possible 'benefits of BIM to FM' was significantly greater for those who had some experience of working on a BIM project vs. those who had no experience (U= 14.82, P<0.05).
6	Was there a difference in respondents' 'level of agreement with possible barriers to adoption and use of BIM' where they had some practical experience of BIM?	A Mann Whitney U test indicated that respondents' agreement with possible 'barriers to the adoption and use of BIM' was significantly lower for those who had some experience of working on a BIM project vs. those who had no experience (U= 11,078.50, P<0.05).

13.3.4 General awareness of building information modelling in the UK and abroad

Mann-Whitney U tests were used to investigate the hypothesis '*H2: People based in the UK will be 'more familiar with UK 'BIM standards/guidance', 'the Government's targets with respect to BIM', 'the BIM Level 3 strategy' and 'BIM websites"*. The findings shown in Table 13.7 indicated for most variables this was the case although there was no difference in perception that 'BIM will support the Government's 2025 targets'.

Table 13.7: Tests for difference in general awareness of BIM: UK vs. non-UK respondents

No	Variables investigated	Test result
1	Was there a difference in the 'level of knowledge of BIM standards/guidance' between UK and non-UK respondents'?	A Mann Whitney U test indicated that the 'knowledge of BIM standards/guidance' for respondents' in the UK was significantly greater than those outside the UK ($U= 15.21$, $P<0.05$).
2	Was there a relationship between 'region' (inside/outside the UK) and 'awareness of the Government's mandate to adopt and use BIM level 2 on government procurement projects'?	A Pearson's Chi squared analysis identified a significant interaction was found that those in the UK were more likely to have heard of this mandate that those outside the UK (X^2 (1)= 13.13, $p<0.05$).
3	Was there a difference in perception of 'whether BIM will help support the UK Government strategic targets' between UK and non-UK respondents'?	A Mann Whitney U test indicated that there was no difference in perception that 'BIM will support the Government's 2025 targets' for UK and non-UK respondents ($U= .10$, $P=.75$).
4	Was there a difference in the 'level of awareness of government supported BIM websites' between UK and non-UK respondents'?	A Mann Whitney U test indicated that the 'awareness of government supported BIM websites' for those in the UK was significantly greater than those outside of the UK ($U= 6.60$, $P<0.05$).
5	Was there a difference in the 'level of awareness of the maturity levels of BIM' between UK and non-UK respondents'?	A Mann Whitney U test indicated that the awareness of the different maturity levels of BIM for those in the UK was significantly greater than those outside of the UK ($U= 10.99$, $P<0.05$).
6	Was there a difference in the 'level of awareness of the Government's 'Digital Built Britain' strategy between UK and non-UK respondents'?	A Mann Whitney U test indicated that the awareness of the 'Digital Built Britain' strategy for those in the UK was significantly greater than those outside of the UK ($U= 10,326$, $P<0.05$).

Note: A Chi squared test was used for number 2 as two categorical variables were involved (as opposed to the others where one categorical and one dependant variable were involved and hence the Mann Whitney U was appropriate).

13.3.5 Relationships between multiple variables

ANOVA tests were used to investigate the hypothesis: '*H3: Respondent's beliefs that 'BIM will help support FM delivery', 'BIM will have an impact on the FM industry'; and would have an impact on their 'level of agreement of possible benefits of BIM to FM'*. The findings shown in Table 13.8 indicated both beliefs have an impact on the respondent's agreement with levels of the possible benefits of BIM to FM.

Table 13.8: Tests for relationships between BIM beliefs and benefits of BIM to FM

No	Variables investigated	Test result
1	Was there a significant relationship between the 'belief that BIM will help support FM delivery' and the 'level of agreement of possible benefits of BIM to FM'?	An ANOVA test showed that the 'belief that BIM will help support FM delivery' has an impact on the 'level of agreement of possible benefits of BIM to FM'. ($F(2, 251)= 72.39$, $P<0.05$).
2	Was there a significant relationship between the 'belief that BIM will have a positive impact on the FM industry' and the 'level of agreement of the possible benefits of BIM to FM'?	An ANOVA test showed that the 'belief that BIM will have a positive impact on the FM industry' has an impact on the 'level of agreement of the possible benefits of BIM to FM, ($F(2, 251)= 37.77$, $P<0.05$).

A simple linear regression was used to investigate the hypothesis: 'H4: '*Where respondents have some 'experience of using/preparing BIM documents' this will have an impact on their 'confidence levels engaging in BIM projects'*. The findings shown in Table 13.9 indicated a significant relationship.

Table 13.9: Tests for relationships - experience of BIM documents/confidence levels

No	Variables investigated	Test result
1	Was there a significant relationship between 'confidence in engaging with BIM' and 'experience of using and preparing BIM documentation'?	A simple linear regression was calculated to predict the 'confidence of engaging with BIM based on experience of using and preparing BIM documentation'. A significant relationship was found, (F (1, 252)= 43.90, P<0.05), with an R^2 of .15.

A multiple regression was also calculated to predict the confidence of engaging in a BIM project based on several predicators. This investigated the hypothesis: '*H5: Respondents' 'confidence of engaging in a BIM project' is influenced by; 'experience of preparing and using BIM documents', 'barriers to BIM adoption/use', 'use of BIM in their organisations', 'knowledge of BIM standards/guidance' and 'knowledge of BIM websites'*. The multiple regression indicated a significant regression (F 5, 248= 40.74 p<0.05), with and r2 of 0.45 which explains 45% of the variance in confidence of BIM. Table 13.10 shows the resulting table of coefficients as an output from SPSS.

Table 13.10: Coefficients - dependant variable 'confidence levels with BIM'

Variables considered	b	SE b	Beta	p
Constant	.69	.38		P=.07
'Experience of using and preparing BIM document'	.02	.01	.13	P<0.05
'Barriers to BIM adoption/use'	-.03	.01	-.15	P<0.05
Use of BIM in respondent's organisation'	.03	.01	.24	P<0.05
'Knowledge of BIM standards/guidance)	.12	.01	.19	P<0.05
'Knowledge of BIM websites'	.11	.03	.27	P<0.05

This suggested that 'having experience of a BIM project' and where 'BIM is in place in the organisation' were important to the respondents' 'level of confidence in using BIM in a BIM project'. Additionally, the 'awareness of the BIM websites' and 'government BIM standards/guidance' impacted the confidence levels. A negative relationship was found between the 'level of agreement' regarding 'BIM to adoption/use of BIM', suggesting those who have less concern regarding barriers were more confident in engaging with BIM.

13.4 Observations regarding the hypotheses

The statistical testing indicated that respondents who had some form of BIM training and/or BIM experience were likely to be more confident in engaging in a BIM project and using/preparing key BIM documents. This supported the qualitative findings that people with more familiarisation of BIM tend to be more confident. The findings also indicated the training/experience led to higher levels of awareness of BIM standards/guidance; the belief that BIM had the potential to help support FM; make a significant impact on the FM industry and also deliver a range of benefits to FM. It was not a surprise that the results also confirmed respondents based in the UK were generally more aware of UB BIM standards/guidance, and government mandate.

13.5 Quantitative themes identified from the general FM industry questionnaire

Table 13.11 shows the final list of quantitative CSF. This comprised of 10 MT and 47 associated ST identified from the quantitative analysis of the questionnaire representing the 'general FM industry' awareness of BIM.

Table 13.11: Summary-list of identified quantitative CSF MT and ST

QUAN_CSF main-themes (MT) and sub-themes (ST)
CSF_QUAN_MT1 - General awareness of BIM and its impact on FM
ST_QUAN_T1.1-Awareness of existence of BIM
ST_QUAN_T1.2-Impact of BIM on FM industry
ST_QUAN_T1.3-BIM supporting FM
ST_QUAN_T1.4-Timescales for BIM to impact on FM
CSF_QUAN_MT2 - General perception/understanding of BIM by FM industry
ST_QUAN_T2.1-FM industry understanding of BIM
ST_QUAN_T2.2-BIM improving collaboration
ST_QUAN_T2.3-FM familiarisation with the RIBA process
ST_QUAN_T2.4-BIM for existing buildings
ST_QUAN_T2.5-BIM adding value to FM
ST_QUAN_T2.6-FM industry readiness for BIM
ST_QUAN_T2.7-BIM improving data transfer
ST_QUAN_T2.8-Early involvement of FM
ST_QUAN_T2.9-BIM as a competitive advantage
ST_QUAN_T2.10-Need for BIM familiarisation
CSF_QUAN_MT3 - FMs experience of preparing/using key BIM documentation
ST_QUAN_T3.1-Experience of a BIM project
ST_QUAN_T3.2-General experience of key BIM documents
ST_QUAN_T3.3-Experience of writing BIM documents
ST_QUAN_T3.4-Confidence levels - reviewing/writing BIM documents
CSF_QUAN_MT4 - Asset management strategy (AMS) and BIM in respondents' organisations
ST_QUAN_T4.1-Lack of key BIM documents in respondent's organisation
ST_QUAN_T4.2-Lack of organisation asset management strategy (AMS)
ST_QUAN_T4.3-BIM documents in place and being used
CSF_QUAN_MT5 - Benefits of BIM to FM
ST_QUAN_T5.1-Key benefits of BIM to FM
CSF_QUAN_MT6 - Possible barriers/concerns to adoption and use of BIM
ST_QUAN_T5.1-Key barriers/concerns to adoption and use of BIM
CSF_QUAN_MT7 - Knowledge of UK BIM standards and guidance
ST_QUAN_T7.1-Knowledge of key BIM standards and guidance (ranked)
ST_QUAN_T7.2-Lack of familiarisation with UK standards
ST_QUAN_T7.3-AM, Planning and LCC standards (Non-BIM specific)
ST_QUAN_T7.4-BIM standards with respect to specific BIM standards/guidance
ST_QUAN_T7.5-BIFM (IWFM) BIM guidance documents
ST_QUAN_T7.6-Other useful BIM guidance documents

QUAN_CSF main-themes (MT) and sub-themes (ST)
CSF_QUAN_MT8 - BIM supporting the UK Government construction strategy
ST_QUAN_T8.1-BIM helping meet the Government 2025 strategic targets
ST_QUAN_T8.2-Awareness of the UK BIM mandate
ST_QUAN_T8.3-Awareness of maturity levels of BIM
ST_QUAN_T8.4-Awareness of BIM Level 3 strategy
ST_QUAN_T8.5-Awareness of government sponsored BIM websites
CSF_QUAN_MT9 - BIM training within respondent's organisations
ST_QUAN_T9.1-BIM training within respondent's organisations
ST_QUAN_T9.2-Organisation BIM training plans in place for staff
ST_QUAN_T9.3-Organisation resources/funding for BIM training
ST_QUAN_T9.4-Organisation in-house BIM expertise used to conduct in-house training
ST_QUAN_T9.5-Organisation plans in place to actively evaluate BIM training
ST_QUAN_T9.6-Employee benefit from BIM certification or further BIM training
ST_QUAN_T9.7-Level of BIM training, education and support in organisations
ST_QUAN_T9.8-Sources and types of training and education
CSF_QUAN_MT10 - Digitalisation and technology impact on FM
ST_QUAN_T10.1-Impact of digitalisation and technology on FM
ST_QUAN_T10.2-Using BIM to help visualise and market buildings and services
ST_QUAN_T10.3-Using BIM with VR,AR and MR
ST_QUAN_T10.4-Maintaining BIM models
ST_QUAN_T10.5-Software tools to help optimise the use of BIM for FM

Chapter 14: Merging the qualitative and quantitative themes

This chapter presents an overview of how the primary findings compared with those from the literature. It also presents the 'process' and 'rules' which were adopted for merging the qualitative and quantitative CSF to achieve research objective (d) merge the CSF (from b and c) to establish a final summary list of CSF.

14.1 Comparison of the primary findings with the literature

This section presents a brief overview of how the primary CSF findings from the interviews and questionnaire compared with the CST from literature. To help the reader they are presented using the final list of CSF which were produced from the merging of qualitative and quantitative CSF and area as listed in Appendix S.

CSF MT1 - Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets: Generally, the primary findings were in alignment with those from literature. Interviewees expressed similar concerns regarding industries performance and contribution to sustainability; as per the many reports from Designing Buildings Wiki (2019a). However, they were also generally supportive of the UK Government's *'Construction Strategy 2011'* approach (Cabinet Office, 2011) to digitalisation and BIM. They also tended to agree government policy would support the development of smart buildings/cities as well as wider sustainability issues and the circular economy. However, they stressed a need for more emphasis on achieving long-term value and reducing OPEX costs, and less on value engineering, which was in line with literature findings e.g. Paulson (1976) and Mitchell, Swann and Poli (2009). Interviewees also believed most of the cost savings and benefits of BIM lie in the operational phase as reported by Eastman et al. (2011), Sacks et al. (2018) and others. Findings from the questionnaire highlighted many people felt the Government's BIM mandate would make a significant contribution and support the targets set out in their '*Construction 2025'* document (HM Government, 2013), especially with respect to reducing costs and time where agreement was 66.1% and 54.3% respectively. However, both the interviews and questionnaire indicated many people felt more time was needed before the full benefits of BIM can be realised, and that there is a desperate need for more examples of best practice to guide people.

CSF MT2 - Recognising the importance of digitalisation and technology to FM and the BIM process: In the literature (Noor et al., 2018), (Liu et al., 2015) and others agree with the primary findings which highlighted the revolutionary impact digitalisation, and especially BIM, are having on the construction industry. Interviewees noted there would be explosion in digitalisation in the next few years and that BIM and other technologies will underpin a wider ecosystem of digital trends that will totally change the industry, expressed in the overarching term 'PropTech'. This aligns with literature findings from Bowers et al. (2016) and IPA (2017). Findings from the interviews/questionnaire also showed BIM can save costs, time etc., in line with Gerbet et al. (2016), who indicated significant global cost savings of 13-21% for early construction phases and 10-17% for the operation's phase. Eadie et al. (2013) noted clients and FMs as the shareholders most likely to benefit from BIM, and the NBS (2020) that the biggest barrier (64%) was 'lack of client demand'. This view was also reflected by the interviewees/questionnaire, respondents noting the importance of better client engagement and a need to utilise online collaboration tools. GEFMA (2016), Kelly (2018) and others from literature highlighted the importance of BIM to underpin a wide range of FM processes. The primary findings reflect this and especially note the significance of BIM for efficiently transferring data into CAFM and other FM management systems. Research from RIBA (2020) also align with primary findings that anticipate developments will improve the interoperability between BIM and CAFM software. Suerth (2018) highlighted another key issue with BIM where people need to consider how BIM data and models are kept up to date. This was reflected in the primary findings with people expressing similar concerns regarding how this will work in practice after the handover from construction to operation. Some interviewees noted that they perceive the CDE as a mechanism to collect and coordinate BIM models and data during the construction phase but voiced apprehensions that little thought is given as to how the CDE and associated data will be kept up to date during the operational phase.

CSF MT3 - Addressing and overcoming perceived barriers and challenges to the adoption and use of BIM: The literature cites lots of challenges regarding the adoption and implementation of BIM including: Becerik-Gerber et al. (2012), Kelly et al. (2013), Brinda and Prasanna (2014) and others. The pilot research by Ashworth and Bryde (2015) ranked the top three challenges as; data management; cost of implementation; and the cost of BIM training. The primary findings differed slightly with interviewees reporting the top three as; lack of digital skills and experience; lack of FM industry willingness to engage; and cost of implementing and achieving an ROI from BIM. This also aligned with Kelly et al. (2013) who suggested the main challenge is proving the added value for clients in the O&M phase. The questionnaire also reported 67.7% disagreement that the FM industry is well prepared for BIM. The top three ranked challenges from the questionnaire were; the bidirectional exchange of data between BIM and CAFM software; BIM training; access to data after handover; and lack of/cost of training. Another area where the literature and primary findings align is that more transparency is required throughout the whole BIM process and specifically to be open about the challenges. Mordue, Swaddle and Philp (2016) also noted problems with 'BIM-wash' which were reflected in the primary findings. Where interviewees also agreed that posturing about BIM competency has a negative impact on trust and relationships. If the industry expects clients to react positively when being sold BIM as a solution it is important that people are open and honest about what can be achieved with BIM. The research and CSF list 25 challenges which need to be addressed.

CSF MT4 - Making the benefits of BIM to FM transparent, realistic and achievable: Many benefits are recorded in the literature including time and efficiency (CRC Construction Innovation, 2007), cost savings (Brinda and Prasanna, 2014), interoperability (Yalcinkaya and Singh, 2014) and many others. The pilot research by Ashworth and Bryde (2015) ranked the top three benefits as; data transfer to FM management systems; improved transition between construction and operation; and visualisation benefits. The primary findings had some overlap with the interviewees concluding access to accurate information in one place was paramount. This was followed by improved efficiency, maintainability, optimisation and ability, thereby reducing time to carry out tasks, which came joint second alongside improved strategic planning to ensure better usability of assets and availability of information. In third place was the need for improved visualisation for FM operations and communication with user groups. The questionnaire highlighted; visualisation of buildings/assets for customers, H&S and maintenance issues; transfer from construction into CAFM and other software tools for operation; and cost management/transparency. Other research by Ashworth, Druhmann and Streeter, (2019) with a specific perspective of FM was written up in in the 'Benefits of BIM to FM Catalogue'. The findings ranked; time savings, productivity and costs savings as the most frequently mentioned benefits. Savings were also an important topic investigated by Zeiss (2018) who suggested an average 5% ROI on operational expenditure. Furthermore Haines (2016) noted the benefits of BIM extend across all stakeholders in the whole life-cycle of BA. However, the primary research findings highlighted interviewees felt there is an urgent need to make benefits clear and transparent in order that they are believable and they should also be where possible evidence based, measurable and preferably presented as case studies which others can learn from. The research and CSF list 23 benefits that can be achieved from BIM projects.

CSF MT5 - Planning the strategic and operational information needs for FM in the BIM process: The *'ISO 19650'* standards (2018, 2020) are clear that clients, as the main 'appointing party', have the responsibility to clearly define their strategic needs in terms of information requirements. Beadle et al. (201) support this arguing early FM engagement within the design and construction process is vital in order that owners and designers receive value for money. This role was reflected in primary findings where interviewees noted the importance of the OIR, and AIR being defined by client/FM teams, and the need for direct communication with FM teams who will use the data in operation. They also noted that all information requirements should be clearly linked to the wider corporate and AM strategy, and take into account supporting risk management processes. The UK BIM Alliance (2019) suggested clients need to set up clear objectives and define clear project outcomes. Both *'ISO 19650'* (2018) and guidance from the UK BIM Framework (2020) promote the idea of only collecting the minimum amount of information needed. This was also reflected by interviewees who agreed a 'minimal useful' approach should be adopted to ensure that only relevant information, which people can then adequately manage, is produced rather than 'asking for everything'. Legal ownership of data produced during a BIM project needs to be established early on in the process, noted Rock (2018) and Fan et al. (2018). These concerns were also reflected by both interviewees and feedback from the questionnaire and align with the newly produced UK *'Information Protocol to support ISO 19650-2'* (2020).

CSF MT6 - Improving stakeholder collaboration and understanding of the BIM process: Yalcinkaya and Singh (2014), and Ashworth and Tucker (2017) noted the importance of the role of FM is now better understood in the BIM process. This was reflected by the primary findings where interviewees noted that FMs are those best placed to recognise clients' information needs as they understand their vision, mission and business objectives intimately. RICS (2015) and Alaloul et al. (2020) also argued BIM will improve collaboration. The interviewees also agreed, suggesting empowering FMs to collaborate with D&C teams to review potential designs and address potential problems early in the design. They also suggested a key role of FMs is to help the delivery teams understand existing information the FM teams need for their day to day business. An issue raised by Sacks et al. (2018) was that many owners have yet to realise all the benefits associated with a life-cycle approach to BIM. This was reflected in the primary findings, where it was suggested that FMs should support clients in understanding why they should invest in BIM, and how it will support their organisation's wider strategy needs. It was also interesting to see alignment concerning the use of BIM for existing buildings. Gausden (2015) and Yeoh (2018) supported its use, whereas Khaddaja and Srourb (2016) noted there are many challenges to overcome. The questionnaire found 72% disagreed BIM was only for new buildings. Interviewees noted the importance of being able to use BIM (or other data capture techniques) for existing buildings as these represent the majority of RE portfolios but that there is some way to go before creating such retrospective BIM models or digital twins becomes mainstream.

CSF MT7 - Clarifying the role of and tasks of FMs in the BIM process: Schley (2011, p. 4) argued that BIM promises information that is current, accurate, and relevant and was intrinsically critical to FMs being able to optimise and run buildings and associated assets. Hampl (2016) described such information as the 'life blood of FM'. The primary findings from the questionnaire noted similar views, suggesting good quality information from BIM could improve strategic decision making, H&S management, risk management, and the transfer of quality information at handover. Thomas (2017) noted the important role of FMs in representing the interests of the client and end-users to ensure that planned facilities can be operated, maintained and managed effectively. The primary findings supported these views; with interviewees noting that without a good AM strategy, based on solid OIR and AIR, BIM is likely to deliver a failure. This aligned with literature from the UK BIM Framework (2020) and *'ISO 19650'* (2018, 2020) which summarised that the key client/FM roles in a BIM project are to establish the projects information requirements (OIR, AIR and EIR); the information protocol; identifying existing information useful to the design teams; and ensuring a CDE is in place to support collaborative working. Primary findings from the interviews aligned with this; interviewees added the importance of FMs using their knowledge to contribute in 'pain-and-gain' workshops. They believed this to be an effective way to help project delivery teams understand the client's information requirements and the overall required project outcomes, in order to ensure only the most important data is planned for. The interviewees also noted a key role was to ensure FMs guide teams to plan the collection and transfer of information into the relevant FM systems. However, they also expressed concerns that most FMs have little experience of writing/implementing the key BIM documents and that further guidance and training is required in this area.

CSF MT8 - Acquiring essential knowledge of key BIM standards/guidance documents for practical use in a BIM project: Berstein (2019) noted the importance of standardisation and standards in driving transformation of the industry. The UK BIM Framework (2020) promotes their use to ensure different stakeholders have a common framework for communicating about BIM. The NBS (2020a) also suggested they be used together with a recognised classification system like the UK Uniclass system. All of this is also framed within the well-known *'RIBA PoW'* (2020). The findings from interviewees suggested a good starting point for FMs was the IWFM guidance documents about BIM, *'Soft Landings'*, several BIM books and *'BS 8536'* because they were specifically written with FMs in mind. The questionnaire highlighted the top three standards/guidance people were most familiar with were; *'ISO 55000'*, the *'RIBA PoW'* and '*ISO 15686'* regarding life-cycle costs of assets. The literature also noted the BIM *'ISO 19650'* standards can work in harmony with other key standards e.g. *'ISO 9001: Quality Management'* (ISO, 2015a), *'ISO 55000: Asset Management'* (ISO, 2018a) and *'ISO 21500: Project Management'* (ISO, 2012). Many interviewees also agreed *'ISO 55000'* was a fundamental starting point in the BIM process and that organisation's AM strategy should be foremost in people's minds when thinking about the approach to a BIM strategy. They also supported the need for more guidance to help FMs plan the move of data from BIM to CAFM systems. Something which came out of the primary findings (both interviews/questionnaire) was that many people felt it was not necessary or possible to be an expert on all the standards, but that a general awareness was important especially where FMs were actively involved. They also supported the collation of all the standards in one place e.g. as currently organised by the UK BIM Framework.

CSF MT9 - Ensuring people have adequate BIM training and competency skills to successfully engage in BIM projects: Dawood and Vukovic (2015) described 'people' as one of the key pillars to a successful BIM project along with 'processes, technology and policy'. Kivits and Furneaux (2013) also highlighted the need for investment in collaboration, training and new technology. Amuda-Yusuf (2018) also highlighted education and training one of the most important CSF for BIM implementation. The primary findings aligned with these views. Many interviewees highlighted the importance of the 'people' factor and that if we are to expect good results from BIM projects organisations needed to ensure people have adequate time, resources and access to training/guidance to ensure they can upskill and improve their competency levels. Many recommended the IWFM guidance and EIR as a good starting point. The questionnaire highlighted 46.4% of people felt their organisations did not have adequate plans in place, and 39.0% adequate resources for BIM training. This aligned with observations from the UK BIM Alliance (2019) who noted current BIM training provision was very variable across industry. The questionnaire also indicated 57.9% felt people would benefit from some form of BIM certification scheme, especially to bridge the digital skills gap between construction and operation teams. In terms of wider digitalisation, Ernst (2016) highlighted the need for increased ‘digital literacy’ as new roles appear, and we have seen such schemes now supported by buildingSMART, BRE, BSi, BSRIA, RICS and others. The primary findings also noted the increase in courses including digital aspects across universities and other training institutions. The interviewees/questionnaire also indicated a valuable resource was the wide range of networking groups which offer help and support. They also suggested videos and mobilisation checklists would be very helpful for FMs involved in a BIM handover.

CSF MT10 - Ensuring the 'successful transfer and ongoing management' of '3D models, alphanumeric data and documents' for CAFM/FM systems: Saxon, Robinson and Winfield (2018) noted a key benefit of BIM is the ability to efficiently transfer as-built O&M information into FM management systems. Findings from the questionnaire support this: 84.3% agreed BIM could help improve data transfer into CAFM systems. Kensek, (2015), and Ashworth et al. (2020) also added that such accurate information can then be used to improve the O&M of the asset over its whole-life. The primary data supported these views with interviewees noting that the phrase ‘starting with the end in mind’ could be applied to determining which systems will actually use data produced from BIM, and what management reports are required to support maintenance and planning over the whole-life of the assets. They also noted that well planned automatic transfers would save operations teams considerable expense and avoid loss of data. Naghshbandi (2016) and RIBA (2020) raised concerns that some CAFM systems are not fully compatible with BIM. This sentiment was also echoed in concerns raised in interviews/questionnaire. Yalcinkaya and Singh (2016) noted COBie is the UK Government’s nominated information exchange schema but some interviewees expressed concerns that COBie is not as user-friendly. Hence some people use a ‘COBie-Lite’ according to Hosseini et al. (2018). BuildingSMART (2020a) noted the importance of openBIM standards and IFC for the future success of BIM. These views were also strongly supported by findings from the interviews/questionnaire where people saw openBIM as critical to open exchange of data. The IWFM guidance ‘*BIM Data for FM Systems: The facilities management (FM) guide to transferring data from BIM into CAFM and other FM management systems’* by Ashworth et al., (2020) and ‘*ISO 19650’* (2018d) recommend a quality approval process for controlling the handover of data from construction to operation. The primary findings reflected this and some tools such as the LIBAL (2020) and other software were recommended by interviewees. Rock (2018) also suggested early discussions to clarify ownership of data from a legal perspective as well as confirming who will update models/data where needed. Response from the questionnaire supported this with people noting careful thought was essential to ensure plans were in place to allow the effective updating of models and data as required during the operational phase, and this would likely require the external services of relevant BIM software experts.

14.2 CSF merging process

Following the advice of Creswell and Clark (2018, p. 226) a 'side-by-side comparison' technique was adopted. They deemed it appropriate "when the researcher presents the integration of a convergent design in a narrative discussion" (ibid). The technique requires that "the researcher organises the quantitative results and the qualitative results side by side within a section of text and discusses them in terms of how the results are similar or dissimilar" (ibid). Figure 14.1 shows the steps and rules used.

Step 1: 'side-by-side comparison' of MT

The QUAL/QUAN CSF MT were compared using the 'side-by-side comparison' technique (Based on design from Creswell and Plano Clark, 2018).

Rule 1: All the QUAL/QUAN CSF MT were compared to see if any were '**similar**' Where one (or more) met this criterion, they were considered to **"converge".**
Note: These QUAL/QUAN CSF MT were then merged.

Rule 2: Where QUAL/QUAN CSF MT were deemed '**dissimilar**' to any others Then the MT was considered to **"diverge"**.
Note: Such MT and all associated ST/STT were then retained.

Step 2: 'side-by-side comparison' and merging to produce the 'CSF MT - Final List'

The '**CSF MT - Final List**' was produced using the technique. New 'MT Titles' were created by combining the old qualitative/quantitative CSF MT titles in order to make them easier for practitioners to relate to when using the '*FM-BIM Framework*'

Step 3: 'side-by-side comparison' of ST/SST

For each new CSF MT: the combined QUAL/QUAN ST or SST were then also compared using the 'side-by side comparison' technique. Similar rules were applied to check for any ST/STT tending to '**converge**' or '**diverge**'

Rule 3: The merged MT were then compared. Where one or more QUAL/QUAN CSF Any ST (or SST) deemed **'similar'** were considered to **"converge".**
Note: The ST/STT were then merged and renamed (if appropriate)

Rule 4: where a QUAL/QUAN CSF ST/STT was deemed to be **'dissimilar'** to any other it was considered to **"diverge".**
Note: Such ST/SST were then retained under the relevant parent MT.

Step 4: 'side-by-side comparison' with narrative discussion

The final set of **ten CSF MT** with associated ST/STT were produced.
'Narrative discussion' was then used to create the final MT and associated ST/SST for the *'FM-BIM Mobilisation Framework:*
Critical Success Factors to Help FM Deliver Successful BIM Projects'

Figure 14.1: CSF merging process steps

14.2.1 Step 1: 'side-by-side comparison' of the main themes

The 'side-by-side comparison' of the qualitative and quantitative CSF MT is shown in Table 14.1 shows. The comparison resulted in nine CSF MT that were considered to 'converge' and thus would be merged. One (CSF_QUAL_MT10) was considered to 'diverge' and thus retained.

Table 14.1: CSF merging process step 1 - 'side-by-side comparison'

The qualitative and quantitative MT were compared using the 'side-by-side' comparison technique. The first row shows an example where MT were considered to **'converge'** i.e. 'QUAL_MT1' with a focus on 'Government policy impact on the FM industry' was considered **'similar'** with 'QUAN_MT8' focused on 'BIM supporting the UK Government construction strategy'

Qualitative CSF MT	Converge or Diverge	Quantitative CSF MT
CSF_QUAL_MT1 - Government policy impact on FM industry	Converge	CSF_QUAN_MT8 - BIM supporting the UK government construction strategy
CSF_QUAL_MT2 - Barriers and challenges to the adoption and use of BIM	Converge	CSF_QUAN_MT6 - Possible barriers/concerns to adoption and use of BIM
CSF_QUAL_MT3 - Benefits of BIM to FM	Converge	CSF_QUAN_MT5 - Benefits of BIM to FM
CSF_QUAL_MT4 - Digitalisation and technology	Converge	CSF_QUAN_MT10 - Digitalisation and technology impact on FM
CSF_QUAL_MT5 - Strategic management and use of information	Converge	CSF_QUAN_MT4 - Asset management strategy (AMS) and BIM in respondent's organisations
CSF_QUAL_MT6 - People in the BIM process and improving collaboration	Converge	CSF_QUAN_MT1 - General awareness of the existence of BIM and its impact on FM CSF_QUAN_MT2 - General perception/understanding of BIM by the FM industry
CSF_QUAL_MT7 - Role of FM in the BIM process	Converge	CSF_QUAN_MT3 - FM's experience of preparing/using key BIM documentation
CSF_QUAL_MT8 - Key BIM standards and guidance for FM	Converge	CSF_QUAN_MT7 - Knowledge of UK BIM standards and guidance
CSF_QUAL_MT9 - Training and competency	Converge	CSF_QUAN_MT9 - BIM training within respondent's organisations
CSF_QUAL_MT10 - Data and information transfer in the BIM process	Diverge	

For the 'QUAL_MT10' this was considered to **'diverge'** as there was no **'similar'** qualitative

14.2.2 Step 2: producing the critical success theme final list

The 'side-by-side comparison' technique was then used to 'merge' the qualitative and quantitative CSF MT to create the **CSF MT 'Final List'** as shown in Table 14.2 During the alignment process the MT were 'renamed' to help clarify the titles for use by practitioners.

Note: Later in the validation process for the '*FM-BIM Framework',* the MT2 and MT4 swapped positions based on feedback from the 'FM/BIM experts'.

Table 14.2: CSF merging process step 2 - CSF MT Final List

New MT to help clarify the titles for use by practitioners in the '*FM-BIM Framework*'

Qualitative CSF MT	Converge or Diverge	Quantitative CSF MT	No	CSF MT 'Final List' - Renamed for use in *FM-BIM Framework*
CSF_QUAL_MT1 - Government policy impact on FM industry	Converge	CSF_QUAN_MT8 - BIM supporting the UK government construction strategy	MT1	Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets
CSF_QUAL_MT2 - Barriers and challenges to the adoption and use of BIM	Converge	CSF_QUAN_MT6 - Possible barriers/concerns to adoption and use of BIM	MT2	Addressing and overcoming perceived barriers and challenges to adoption and use of BIM
CSF_QUAL_MT3 - Benefits of BIM to FM	Converge	CSF_QUAN_MT5 - Benefits of BIM to FM	MT3	Making the benefits of BIM to the operational phase of assets transparent, realistic and achievable
CSF_QUAL_MT4 - Digitalisation and technology	Converge	CSF_QUAN_MT10 - Digitalisation and technology impact on FM	MT4	Recognising the importance of digitalisation and technology to FM and the BIM process
CSF_QUAL_MT5 - Strategic management and use of information	Converge	CSF_QUAN_MT4 - Asset management strategy (AMS) and BIM in respondent's organisations	MT5	Planning the strategic and operational information needs for FM in the BIM process
CSF_QUAL_MT6 - People in the BIM process and improving collaboration	Converge	CSF_QUAN_MT1 - General awareness of the existence of BIM and its impact on FM CSF_QUAN_MT2 - General perception/understanding of BIM by the FM industry	MT6	Improving stakeholder collaboration and understanding of the BIM process
CSF_QUAL_MT7 - Role of FM in the BIM process	Converge	CSF_QUAN_MT3 - FM's experience of preparing/using key BIM documentation	MT7	Clarifying the role and tasks of FMs in the BIM process
CSF_QUAL_MT8 - Key BIM standards and guidance for FM	Converge	CSF_QUAN_MT7 - Knowledge of UK BIM standards and guidance	MT8	Acquiring essential knowledge of key BIM standards/guidance documents for practical use in a BIM project
CSF_QUAL_MT9 - Training and competency	Converge	CSF_QUAN_MT9 - BIM training within respondent's organisations	MT9	Ensuring people have adequate BIM training and competency skills to successful engage in BIM projects
CSF_QUAL_MT10 - Data and information transfer in the BIM process	Diverge		MT10	Ensuring successful transfer/ongoing management of information/data for the operational phase of assets

14.2.3 Step 3: ‘side-by-side comparison’ of the sub-themes

Table 14.3 shows one example of the ‘side-by-side comparison’ technique extended to compare the ST/SST for each new MT (**Note**: MT1 is used as an example). The comparison resulted in one case considered to ‘converge’; ST_QUAL_T1.2 and ST_QUAN_T8.1, which were then be merged. The remaining six ST were considered to ‘diverge’ and thus retained.

Table 14.3: CSF merging process step 3 - ‘side-by-side comparison’ of ST

CSF_QUAL_MT1 - Government policy impact on the FM industry	Converge or Diverge	CSF_QUAN_MT8 - BIM supporting the UK government construction strategy
ST_QU		
ST_QUAL_T1.2 Impact of government policy on FM	Converge	ST_QUAN_T8.1-BIM helping meet government 2025 strategic targets
ST_QUAL_T1.3 FM Industry Readiness for BIM	Diverge	
	Diverge	ST_QUAN_T8.2-Awareness of the UK BIM mandate
	Diverge	ST_QUAN_T8.3-Awareness of maturity levels of BIM
	Diverge	ST_QUAN_T8.4-Awareness of BIM level 3 strategy
	Diverge	ST_QUAN_T8.5-Awareness of government sponsored BIM websites

The qualitative and quantitative ST were compared using the ‘side-by-side’ comparison technique. The second row shows an example where ST were considered to **‘converge’** i.e. ‘QUAL_T1.2’ with a focus on ‘Impact of government policy on FM’ was considered **‘similar’** with ‘QUAN_T8.1’ focused on ‘BIM helping meet government 2025 strategic targets’

More ST were considered to **‘diverge’** as often they were not **‘similar’** when comparing the qualitative and quantitative ST

14.2.4 Step 4: side-by-side comparison' technique with 'narrative discussion'

Table 14.4 shows an example of the 'side-by-side comparison' and 'narrative discussion' technique used in the development of the '*FM-BIM Mobilisation Framework'.* The example shown is a snapshot of **MT1: Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets**. The first three columns show the merging process for ST already described. The four columns to the right include the outcome of the 'narrative discussion'. The '**Aim**' row provides a 'strap-line summary' of the intended MT outcome. The '**Explanation**' column uses '**bold text**' to link topics identified from the findings chapters to narratively explain important aspects of each ST. The '**Examples**' column then provides useful information and sources (from literature, interviews and the questionnaire) which practitioners can refer to and use to help produce better project outcomes.

Table 14.4: CSF merging process step 4 – narrative discussion

Convergent design 'side-by-side' comparison of CSF			**CSF**	**MT1: Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets**		
Qualitative CSF		**Quantitative CSF**	**Aim**	Adopting a WLC approach to BIM will help deliver more sustainable built assets for people, organisations and society		
CSF_QUAL_MT1 - Government policy and its impact on FM	**Converge or Diverge**	**CSF_QUAN_MT8 - BIM supporting the UK government construction strategy**	**Ref**	**CSF ST**	**Explanation**	**Examples**
ST_QUAL_T1.1 Realising value over the WLC of built assets	Diverge		ST1.1	Using BIM to maximise the long-term value and ROI of built assets	Adopting a **WLC cradle-to-cradle approach** to BIM, rather than short-term capital expenditure (CAPEX) focus, will help maximise **best value** over the long-term and ROI for built assets. **Feedback loops** with design teams should review designs, energy systems and **quality/longevity** of products/systems to reduce frequency of asset replacement (thus waste) and ensure sustainable WLC options are chosen. **CAPEX and (operational expenditure) OPEX budgets** should be balanced to see where more spend upfront will save over the long term. **Value engineering** should not result in increased long term OPEX cost just to get the cheapest CAPEX cost. BIM can help **improve procurement** and also achieve sustainable outcomes. '***Soft Landings***' and '***BS 8536***' should be adopted. FMs should also consider setting up **performance targets** to measure the sucesss of a BIM project.	Adopting a WLC cradle-to-cradle approach will make the procurement of built assets more sustainable. The report '*Constructing a better future: achieving quality and best value in the built environment*' is a good reference to understanding how we should all work towards achieving best value. This requires considering CAPEX and OPEX costs, rather than focusing just on the intial CAPEX cost of buiding an asset (e.g. by considering equipment/material quality and life expectancy, and focusing on value engineering in favour of the operational phase). Research shows it is often worth paying more upfront for quality products that will reduce long-term operational costs. Project teams should also consider assessing life cycle costs of built assets. The '*Soft Landings*' approach should be adopted which takes into account CAPEX and OPEX costs. The '*BS 8536*' guidance standard should also be used to ensure FMs can give input at the appropriate time to achieve a sustainable outcome.
ST_QUAL_T1.2 Impact of government policy on FM	Converge	ST_QUAN_T8.1-BIM helping meet government 2025 strategic targets	ST1.2	Using BIM to reduce operational costs, improve sustainability and help meet government 2025 targets.	BIM enables FMs to contribute towards the **government's construction strategy targets** (research shows 66.1% of FMs believe BIM will help achieve the **first target** of a "33% reduction in the initial cost of construction and the WLC of built assets"). More **FM-BIM leadership** is needed to reduce operational costs through WLC decisions and help **clients drive change** in their organisations. The FM incentivisation is getting the correct information needed to run and mange assets. In a wider context the **digitalisation of Britain's assets** will help improve carbon sustainability and improve the circular economy as well as empowering the creation of smart cities. By supporting a more digitalised industry FM can also help attract **young people** into our industry.	The government's construction targets can be reviewed in the '*Construction 2025*' and '*Construction strategy*' documents. the IWFM guide '*The role of FM in BIM projects*' outlines how FMs should actively engage and work with design teams using their know-how to review the 'Digital Twin' (BIM model) and assess how the design will impact FM service delivery. Designs requiring expensive access equipment, or additional FM staff should be reviewed and a way found together with the design team to eliminate any unnecessary costs, e.g. by making access for maintenance easier, reducing the number of operational staff needed, etc.

Each row shows the 'side-by-side' comparison technique and if the ST **'diverge'** or **'converge'**

Bold topics e.g. **WLC** show key themes identified during analysis

Side-by-side' 'narrative text' was used in the 'Explanation' to highlight the importance the ST

Links/information are provided to help users (hyperlinks are linked to blue text)

14.3 Chapter summary

The 'CSF merging process' explained in Tables 14.1 to 14.4 was repeated for every MT/ST on the **CSF MT Final List** (Appendix S). This enabled the production of final CSF MT/ST tables for each CSF. The full set of tables were then included in the draft '*FM-BIM Framework'* which was then validated using the process explained in Chapter 15.

Chapter 15: Validation process

This chapter presents the two-stage qualitative process shown in Figure 15.1 used to validate the '*FM-BIM Mobilisation Framework'.*

15.1 Using a two-stage validation process

The first stage involved a focus group of 'FM/BIM experts' who reviewed the draft framework with a view to validating its usability and agreeing the format for use in practice. In stage two the same experts were asked to review the updated version and provide any final suggestions.

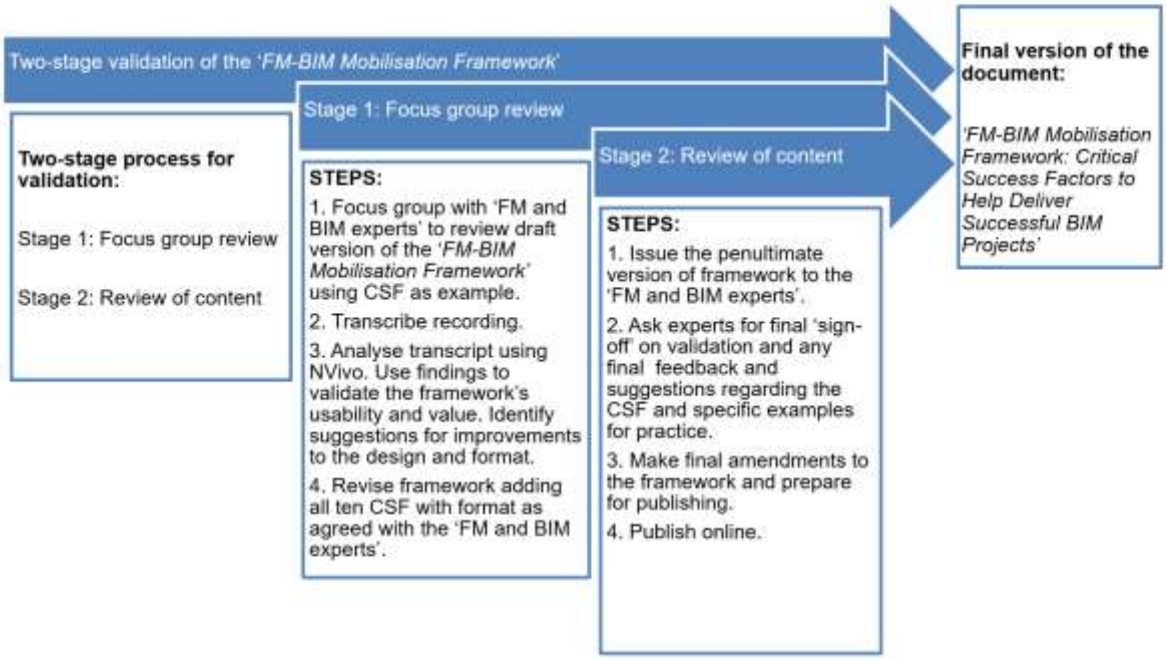


Figure 15.1: Two stage validation process for the '*FM-BIM Mobilisation Framework'*

The two-stage validation process required only one focus group. The findings were then used in Stage 2 to get one-to-one feedback from each expert about the final framework.

15.2 Validation Stage 1

15.2.1 Using a focus group approach in research design

Focus groups are a technique used to gather data through group interaction on a defined topic (Morgan, 1997). They can help validate findings from earlier stages of a research project (Creswell, 2014). The method is distinguished from 'one-to-one' interviews in that it involves the interaction of group participants with each other as well as a moderator (Morgan, 1998). The focus group approach was deemed appropriate because:

- As observed by Wilkinson (1998) they provide a suitable methodical approach when the aim is to discover peoples understanding and views. They are also not tied to a particular epistemology.
- Morgan (1997) recommended them as a good supplementary method for evaluating the outcome of an initial piece of research (the framework) carried out in a previous phase.
- Creswell and Plano (2018) note they are useful for corroborating findings about a topic, especially where the same people are included in the different phases of the research. As such it was decided to use some of the experts who had already been involved in the interviews.

Wilkinson (1998) notes they can be used to focus peoples' attention collectively upon a topic and in the case of validating the framework this could be achieve using questions to validate the framework design The discussions are "usually recorded, transcribed and then analysed using thematic analysis often using specialist analysis software packages" (ibid, p 182).

15.2.2 Process steps for managing the focus group

Knodel (1993) suggested a six-step process to manage focus groups as shown in Figure 15.2.

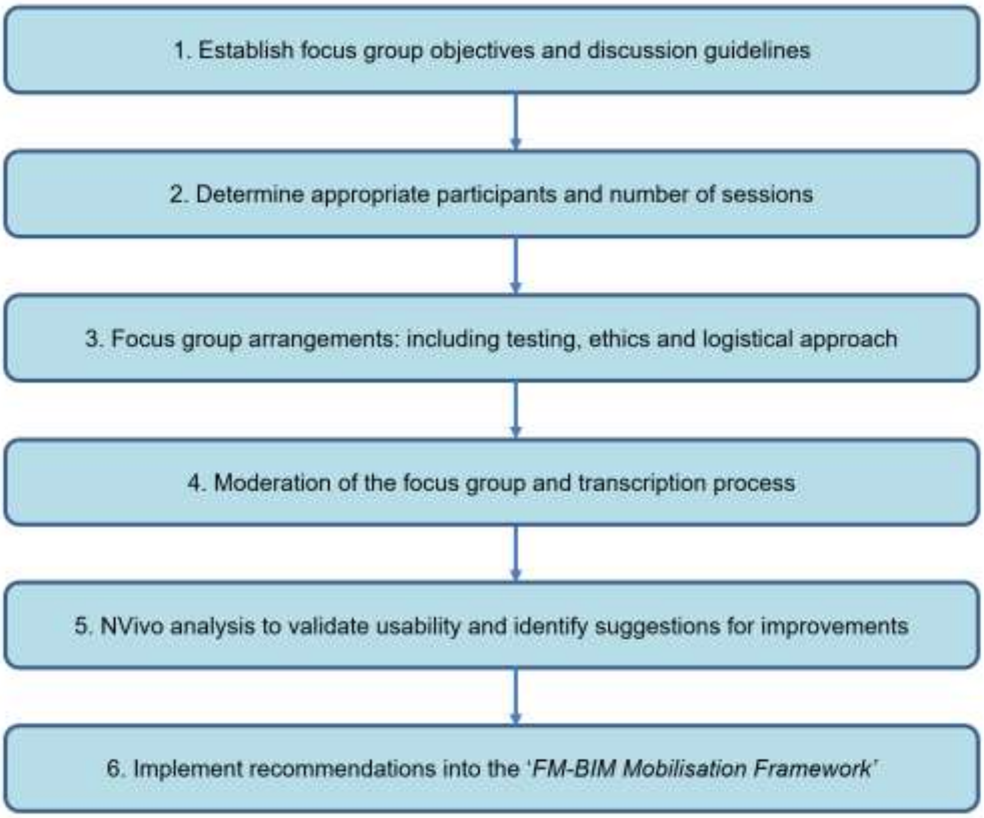


Figure 15.2: Focus group process - adopted from Knodel (1993)

15.2.3 Establish focus group objectives and discussion guidelines

The overall aim of the focus group was to help achieve research objective (f) validate the '*FM-BIM Mobilisation Framework'* with 'FM/BIM experts'. In order to achieve this the following objectives were set for validation from the focus group:

- To present an initial draft of the '*FM-BIM Mobilisation Framework'*
- To obtain feedback to validate the framework concept in terms of: its value, usability, format and feel; who the main beneficiaries/users are; and how to maximise its use for the FM industry and practitioners
- The seven specific questions asked are shown in Table 15.1

Table 15.1: Focus group questions

Questions set for the focus group
Q1: Sequencing of Main CSF: is the proposed sequence (as shown below) of the 10 main CSF logical, or would the group suggest any changes?
4. Tables: CSF Main-themes (MT) and Sub-themes (ST)
4.1. **CSF 1:** Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets
4.2. **CSF 2:** Addressing and overcoming perceived 'barriers and challenges' to adoption and use of BIM
4.3. **CSF 3:** Making the 'benefits of BIM to FM' transparent, realistic and achievable
4.4. **CSF 4:** Recognising the importance of digitalisation and technology to FM and the BIM process
4.5. **CSF 5:** Planning the strategic and operational 'information needs for FM' in the BIM process
4.6. **CSF6:** Planning the strategic and operational 'information needs for FM' in the BIM proces
4.7. **CSF7:** Clarifying the 'role of and tasks of FMs' in the BIM proces
4.8. **CSF8:** Acquiring essential 'knowledge of key BIM standards/guidance documents' for practical use in a BIM project
4.9. **CSF9:** Ensuring people have adequate 'BIM training and competency skills' to successful engage in BIM projects
4.10. **CSF 10:** Ensuring the 'successful transfer' of the: '3D models, data, information and documents' in the BIM process

Questions set for the focus group

Q2: Format and content: Is the suggested CSF table format clear and understandable? and does the group have any suggestions for possible improvements?

CSF	**MT1:** Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets					
	AIM: Adopting a WLC approach to BIM will help deliver more sustainable built assets for people, organisations and society			MOBILISATION STATUS CHECK LIST		
ST Ref	**CSF Sub-themes (ST)**	**Explanation**	**Examples**	**Completed**	**Initiated**	**Outstanding**
1.1	Using BIM to maximise long-term value of built assets	Adopting a WLC (OPEX) approach to BIM will maximise the long-term value of built assets. FMs should actively review the quality of products/systems with the aim of reducing the frequency of asset replacement (thus reducing waste) as well as reviewing systems where energy is used to ensure the most sustainable options are chosen over the life of the assets.	Focus should be given to achieving the best balance of cost vs. quality and longevity (by considering equipment/material quality and life expectancy). It may be worth paying more upfront for quality products that will reduce long-term operational costs			
1.2	Using BIM to reduce operational costs, improve sustainability and meet government 2025 targets	BIM offers FMs the chance to reduce operational costs through a mix of: WLC decisions, ways to achieve faster/easier retrieval of information and reducing the cost of getting accurate information into CAFM/other systems. This will help support UK government 2025 targets.	FMs should work with design teams to use the 'digital twin' (BIM) to assess FM tasks/services. Where expensive access equipment might be needed FMs can review with the design team ways to 'design out' unnecessary costs.			
1.3	FM industry readiness to engage in BIM projects	FM organisations such as the IWFM are providing specific guidance to help the FM industry to better engage in BIM projects and contribute towards better BIM project outcomes for FM.	FM specific guidance for FMs wishing to engage in BIM projects can be found at www.iwfm.org.uk			

Q3: RIBA Stages: Would it add any value to have a RIBA reference column indicating at what stage the CSF is most applicable in? What is the groups opinion as to which RIBA stage should be shown?

No	CSF main-themes (MT)	Relevant RIBA stages
MT1	Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets	WLC needs to be considered in the early BIM stages as 80% of long-term costs are fixed during first 20% of design.
MT2	Addressing and overcoming perceived 'barriers and challenges to adoption and use of BIM'	
MT3	Making the 'benefits of BIM to FM' transparent, realistic and achievable	
MT4	Recognising the importance of digitalisation and technology to FM and the BIM process	
MT5	Planning the strategic and operational 'information needs for FM' in the BIM process	
MT6	Improving 'stakeholder collaboration' and 'understanding of the BIM process'	
MT7	Clarifying the 'role of and tasks of FMs' in the BIM process	
MT8	Acquiring essential 'knowledge of key BIM standards/ guidance documents' for practical use in a BIM project	
MT9	Ensuring people have adequate 'BIM training and competency skills' to successful engage in BIM projects	For the FM staff involved during the BIM project this should ideally be done before Stage 0 as the project starts or as soon as possible. For operational teams training on accessing models and data should be considered as part of handover training.
MT10	Ensuring the 'successful transfer' of the: '3D models, data, information and documents' in the BIM process	The planning of what data is needed should be defined in the EIR at RIBA stage X. Checks should then be made using COBie drops during RIBA stages X-X. A final quality check should be carried out at handover before Stage 7.

Questions set for the focus group
Q4: Usability and benefit to FM: How does the group see the document being used in practice and how could it benefit FM?
Q5: Beneficiaries & stakeholders: Who does the group see as the 'main beneficiaries' and 'stakeholders' who might use the document?
Q6: Marketing of framework: How could the document be best marketed to the relevant target audience?
Q7: IWFM members: Would it be useful to have the document made available to IWFM members together with their other BIM guidance documents?

Krueger and Casey (2002, p. 5) suggested that in a focus group "the team must be clear about the purpose of the study". To achieve this a 'discussion guideline' was created (Appendix N) using PowerPoint to introduce the topic and ensure the experts understood the research subject, questions and objectives. They also suggest they are appropriate to "pilot testing ideas" to "get reactions to plans" (ibid, p6). The focus group approach was seen as a way of testing the '*FM-BIM Mobilisation Framework'* to see if it would be practical for FMs in practice. A separate pilot-test, using the slides, was conducted before the main event to evaluate the flow and understanding of the slides as a guideline.

15.2.4 Determine appropriate participants and number of sessions

Nyumba et al. (2018, p. 29) suggested "a clear rationale for the choice of focus group participants". Group sizes can vary depending on the objectives (Greenbaum, 1998). Small groups involving 2-6 people are very common (Morgan, 1997), however, Fern (2001) notes larger groups of 7-12 people can be used. As the focus group would be run as an online workshop, the researcher decided to keep the numbers low and targeted 6-8 people as advised by Krueger and Casey (2002). In terms of the sampling technique for the focus group it was decided to target a specific group of who were already involved in the early interview phase. This is referred to as a 'member-checking' approach and was in line with advice from Nyumba et al. (2018) who suggested the approach is appropriate "rather than from a statistically representative sample of a broader population" (p. 20). Wilkinson (1998) also suggested this approach as appropriate to validate and check findings in a two stage process. The six participants (P-1 to P-6) who were well known to the researcher were selected from the original 'BIM and FM experts' interviewees and then approached in person. The justification for selecting each participant is shown in Table 15.2.

Table 15.2: Selection of experts for the 2-stage validation process

No	Role and expertise	Justification
P-1.	Architect/BIM expert	Can give feedback on CSF, especially with respect to early interaction with clients, FM and construction teams during the RIBA project stages to make sure solutions are fit for purpose, incorporate a WLC approach and are planned to collect essential design information during the project for handover to FM.
P-2.	CAFM/BIM expert	Can give feedback on CSF, especially with respect to planning what data needs to be collected and how it should be structured for import into CAFM and other management systems.
P-3.	Construction/BIM/FM expert	Can give feedback on CSF, especially with respect to construction phases (BAP) ensuring interaction with FM and clients regarding the design, BIM models and collecting information and data from sub-contractors. Also, aspects of commissioning and handover.
P-4.	BIM/FM/WLC expert	Can give feedback on CSF, especially with respect to ensuring essential WLC aspects are considered for minimizing long-term life costs.
P-5.	Client/FM/BIM expert - 1	Can give feedback on CSF, especially with respect to FM planning (OIR, AIR, EIR etc.) and ensuring that all relevant information and data are made clear to the BIM project team and handed over for use in FM management systems (e.g. CAFM, SAP etc.)
P-6.	Client/FM/BIM expert - 2	(see 5 above)

15.2.5 Focus group arrangements: including testing, ethics and logistical approach

Advice from Morse (2003) was followed to minimise cost and participation time using the Zoom Room tool (2019) to run the online workshop. This meant no travelling, and participation from an environment that suited them. It allowed cloud-recording for later transcription with a helpful play-back feature highlighting the person speaking. The workshop was planned for 2-hours on 9th May 2019. Each participant was sent a formal invitation (Appendix O), an information sheet (Appendix P) and a consent form (Appendix Q) to sign and return before the event.

Participants were emailed to confirm: the attendees, the timing and practical arrangements, and that the workshop would be recorded. They were advised the final transcript would be anonymised in line with LJMU ethical guidelines. Separate pilot-tests were conducted with each participant before the workshop to explain the Zoom Room tool.

15.2.6 Moderation of the focus group and transcription process

Each participant was sent a link to join the Zoom Room meeting. Once everyone had joined, they were welcomed and given an explanation of how the workshop would be conducted. Ground rules were suggested as advised by Smithson (2008, p. 360) to help the discussion. One person was asked to speak at a time to improve clarity for transcription purposes. It was then verified that everyone was agreeable to recording the workshop. The guideline presentation slides were shared online to explain the research before addressing the questions planned for the focus group. The agenda and timeline were:

- 13:00 Introductions
- 13:10 Aims and objectives of the focus group
- 13:15 Overview of the PhD work
- 13:20 Initial CSF findings – qualitative and quantitative
- 13:30 Merging the CSF
- 13:35 Draft of the CSF *‘FM-BIM Mobilisation Framework’*

- 13:45 Group discussion and questions
- 15.00 Close of workshop

On completion of the workshop participants were thanked for their input. The recording was then transcribed resulting in a 10,145-word transcript (Appendix R).

15.2.7 NVivo analysis to validate usability and identify suggestions for improvements

Figure 15.3 shows the NVivo analysis of the focus group transcription. The findings were used to identify improvements for the *'FM-BIM Mobilisation Framework'* and validate its use.

Nodes

Name	Sources	References
Question 1 - Sequencing of the CSF MT	1	18
1.1 Validation and completeness of the MT list	1	2
1.2 Grouping and synergy of MT list	1	2
1.3 Priority and order of the MT list	1	11
1.4 Mind map and keywords to represent MT	1	3
Question 2 - Format and content of CSF MT tables	1	40
2.1 Validation feedback about the format	1	6
2.2 Observations about format of 'FM-BIM Framework'	1	7
2.3 Inclusion of important topics like the 'circular economy'	1	2
2.4 Suggested amendments to checklist status section	1	7
2.5 Terminology used in framework	1	2
2.6 Use of links to other resources	1	2
2.7 Having the 'FM-BIM Framework' in a downloadable template format which is editabl	1	8
2.8 Using the 'FM-BIM Framework' as a BIM knowledge checklist	1	3
2.9 Ongoing maintenance of the links and updating the framework	1	3
Question 3 - RIBA stages	1	16
3.1. Reservations about aligning the CSF with the RIBA stages	1	6
3.2 Overlapping of RIBA stages and their use as project gateways	1	5
3.2 Suggestion that the RIBA PoW should just be added as linked reference	1	2
3.4 Making the 'FM-BIM framework' easy to search for information as needed	1	3
Question 4 - Usibility and benefit to FM	1	15
4.1 Validation that the 'FM-BIM Framework' is a useful tool for FMs	1	3
4.2 Validation that the 'FM-BIM Framework' is also useful to other stakeholders	1	1
4.3 The useability to help FMs engage with project teams	1	4
4.4 The usefulness of providing helpful links to other information sources	1	1
4.5 Validation the 'FM-BIM Framework' checklist format works well	1	5
4.6 Ongoing versions of the 'FM-BIM Framework' as BIM evolves	1	1
Question 5 - Beneficiaries and stakeholders	1	12
5.1 FMs and client teams	1	7
5.2 Senior project team members - strategic perspective	1	2
5.3 FM operations teams	1	2
5.4 Design teams	1	1
Question 6 - Marketing of the framework	1	10
6.1 The 'FM-BIM Framework' should be targeted at multiple organisations	1	7
6.2 Marketting the 'FM-BIM Framework'	1	3
Question 7 - IWFM members	1	8
7.1 Validation of the 'FM-BIM Framework' relevance to IWFM members and non-membe	1	5
7.2 The 'FM-BIM Framework' should be free to all users	1	3

Figure 15.3: NVivo analysis of focus group transcript

15.2.8 Focus group findings

Tables 15.3-15.9 present the findings of the NVivo analysis of the focus group transcript and questions 1-7 using direct quotes from the participants (P1-6). Note: the 'red text' indicates important 'validation points' raised by the participants. The 'blue text' indicates 'suggestions' which were used to improve the next version of the '*FM-BIM Framework'*.

Table 15.3: Focus group validation/suggestions: 'sequencing of CSF MT'

Q1: Sequencing of the CSF MT: (19 passages of text)
Validation: (P-3) observed the '*FM-BIM Framework*' "*is a comprehensive list and covers everything from your research.*" (P-5) noted "*it has tried to follow some logic*" and (P-6) commented, it highlights "*what is useful to the user*".
Suggestions: (P-5) felt the *CSF for digitalisation should maybe come earlier in the order of MT* and should reflect "*the importance of digitalisation and technology of FM in the BIM process should be right at the start*". However, (P-2) suggested not "*to worry about the priority, the reader will decide what their priorities are*". (P-3) believed it was important to "*deal with barriers at the start because whoever is reading it will be aware of them*". (P-4) suggested approaching it as "*a mind map which doesn't involve a sequence*" and instead think of "*highlighting or focusing keywords to make it more transparent for readers*".

Table 15.4: Focus group validation/suggestions: 'format and content'

Q2: Format and content: (40 passages of text)
Validation: (P-5) confirmed "*it is easy to read and follow*", and (P-3) felt "*the document is straightforward and negotiable for someone coming to it for the first time*". (P-2) observed "*I like the format*" and that "*visually it looks nice with the coloured tick marks*". (P-1) felt "*the tick list on the right-hand side works well*". (P-6) noted "*the table seems quite logical. Comments that have been made are relevant*". (P-3) believed it has "*simple, understandable text and terminology for the explanation and the examples*". (P-2) also observed "*the way you have broken it down into main and sub-themes has a similar feel to how ISO 19650 is set up with key activities and sub-activities*". (P-3) felt it was important that "*behind the simple language and formatting you are giving people hyperlinks to more in-depth guidance on a per-item basis which will unlock the potential. People can take from that what they want and what is relevant*".
Suggestions: (P-4) suggested "*you could save some space by moving the first column in a bit, the explanation and example could go under it. Otherwise it looks good*". (P-2) questioned should the framework be a "*document or web-based resource?*". (P-3) suggested "*having other links to relevant topics, such as, 'circular economy' will draw attention*". (P-1) noted "*the word 'outstanding' for the red 'tick column' doesn't seem like the right term*" and (P-5) suggested a *replacement, "to do"*. (P-6) proposed in the CSF table "*you also need a 'not applicable' stage"* and that it would be helpful if it was available as a *"downloadable master table in Excel"*. (P-3) suggested if people "*are able to layer their project on top it would be really practical and make it a working document*". For links (P-2) noted *"you can include a short URL which when you hover over it will give you the full URL. You can have the displayed text and the alternate text"*. (P-1) felt for practical use it "*lends itself to being templated*" and (P-3) added "*everyone is crying out for a simple template*" which could "*allow people to replace the example with what they are planning"*. (P-1) also suggested "*you need to have a maintenance plan in place in order to update links"*.

Table 15.5 Focus group validation/suggestions: 'RIBA stages'

Q3: RIBA stages: (16 passages of text)
Validation: (P-4) observed "*it is very difficult to map the CSF to RIBA stages*" and (P-1) felt "*I don't see the necessity to do a direct correlation*". (P-2) noted "*trying to align them to the RIBA stages is not the right thing to do. I prefer the description with the pointers*". (P-3) also observed the CSF "*are required at the very earliest stage when strategic definition and concept design are happening, as that is when the greatest WLC cost benefits can be realised with FM at the table*". **NOTE: As a result, the CSF MT were not mapped to the RIBA stages.**
Suggestions: (P-2) suggested "*reference to the RIBA stages is important but a lot of the main themes should be considered right at the start of the project*". (P-2) also highlighted that "*it is important to educate FM that the stages do exist and that they drive the design and construction element*". (P-5) suggested people "*need guidance on how to approach and prioritise their approach in their own mind rather than suggesting they don't need to worry about something until later on*". (P-2) felt in the framework RIBA should be "*another reference document*"

Table 15.6 Focus group validation/suggestions: 'usability and benefit to FM"

Q4: Usability and benefit to FM: (15 passages of text)
Validation: (P-4) observed "*when I started there was nothing like this so having a reference broken down into bite size chunks whereby you can show progress with a tick list is of great use. Just having the list of CSF will be very helpful as a starting point*". (P-2) agreed "*It will definitely be useful for FM*". (P-1) felt "*I think providing the FM with a tool and a set of guidance lines is perfect*". (P-6) noted "*I like the idea of the check lists. It gives guidance for someone who is a FM and new to the process with BIM*". (P-2) agreed, "*using the check list will be a great help*". (P-4) mentioned the many links to other useful sources: "*as you become more familiar with the topics you can move on to the other documents.*"
Suggestions: (P1) suggested "*it could be used as an engagement tool, to not only help FM teams, but also the clients as to what they need*" and that the '*FM-BIM Framework*' could "*be a really good briefing document to be able to bring things such as the client's requirements and the project information requirements for the delivery team*". (P-6) suggested "*it will hopefully have future iterations that will increasingly become more useful. It is a good start*".

Table 15.7 Focus group validation/suggestions: 'beneficiaries and stakeholders"

Q5: Beneficiaries and stakeholders: (12 passages of text)
Validation: (P-1) felt "*the main beneficiaries are the FM and client teams*", (P-5) "*the focus is on senior FM and stakeholders*", and (P-3) "*probably the middle or senior manager who is responsible for delivering part of a project*". (P-6) felt the framework was "*more a senior project related document*" and (P-2) noted "*from an education point of view it will be useful for AEC as well, who often state that they don't understand what FM want*" and added "*it is almost a check list of engaging FM in your design project from the other side of the fence*".
Suggestions: (P-3) noted "*it is important to have something deliberately targeted at FM. They will gratefully receive something specifically given for them*". (P-2) also suggested it could be used as an "*an excellent tool for them to engage the operational teams*".

Table 15.8 Focus group validation/suggestions: 'marketing of framework"

Q6: Marketing of framework: (10 passages of text)
Validation: (P-2) "*I would like to see it across all the mainstream organisations, IWFM, IFMA, etc., where they are actually delivering FM*". **Suggestions:** (P-1) felt "*you should target the top level, buildingSMART, UK BIM Alliance; those who are producing the guidance documents for BIM delivery for the new standards. Maybe it could go the level of the NACF*". (P-3) "*Perhaps even organisations like SFT or the ESFA who procure projects through their framework and help academies, trusts, etc.*" or "*Procure 22 or the ESFA*". (P-2) observed it would be best to *avoid "branding against conflicting organisations"*. (P-1) also noted "*the UK BIM Alliance have relaunched their website and are publishing guidance information so I think it would be a perfect place to do it*". In terms of circulation (P-2) suggested "*the distribution can be done as widely as possible through the international organisations*" and (P-6) "*you could try to influence trade articles*".

Table 15.9 Focus group validation/suggestions: 'IWFM members"

Q7: IWFM members: (8 passages of text)
Validation: (P-6) spoke about targeting IWFM members, stating "*I think it's very reasonable*". However (P-3) felt "*a resource like this should be available to both IWFM members and non-members*". (P-2) agreed "*if it is restricted to IWFM members we have to accept most of them will probably never build a BIM project, so it needs to be an open resource*". **Suggestions:** (P-5) suggested with respect to possible promotion through the IWFM "*it should be made as readily available as possible. If there is value in it, they will want to promote it.*" (P-1) observed if it is made available on the BIFM website *it should be freely available* to "*non-members, who are just visiting the IWFM site as a reference location*". (P-1) also felt if it was exclusively for members "*it immediately puts a barrier in the way of anyone wanting access to really useful guidance and data*", but also acknowledged "*there is always a cost involved in producing these items and managing and maintaining it*".

15.2.9 Validating and improving the draft *'FM-BIM Framework'*

The qualitative analysis of the focus group transcript provided 120 passages of text. These helped validate and provide suggestions to improve the '*FM-BIM Framework'* document. The feedback provided clearly indicated that the document would be very useful to FMs, clients, project managers, AEC and design teams engaging in BIM projects. The format was validated as 'easy to read' and something that 'worked well'.

P5's suggestion was acted on to reposition the digitalisation MT to be presented earlier in the framework. It was clear an early idea to align CSF with the RIBA stages did not feel natural and was instead replaced with a link to the RIBA PoW and general advice about why each CSF was important. The final format (index) was thus established for the framework as shown in Figure 15.4.

FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

Index

Figure 15.4: Final index with format and CSF order for '*FM-Mobilisation Framework'*

Note: The full final list of CSF with the ST is shown in Appendix S.

Suggestions such as; highlighting key topics; providing hyperlinks to other important sources; adding a N/A column; making it available as an editable download; using text to suggest the framework be used as an engagement and briefing tool; were all used to make the document informative and interactive.

In terms of marketing and distribution the group validated it should be targeted across major professional institutions and distributed freely using as many channels as possible.

15.3 Validation Stage 2

15.3.1 Final improvements to the '*FM-BIM Framework'*

The experts from the focus group were contacted and sent the updated framework with the 10 completed CSF MT and a feedback form (Appendix T). They were given a 3-week period to review the framework and asked to complete and return the form which had four questions:

1. How do you feel the *'FM-BIM Mobilisation Framework'* guidance will be useful to the different stakeholders involved in in BIM projects?
2. Do you have any final comments about the look and feel and how the guide is structured?

3. How do you feel people will be able to potentially use (or adapt) it for use in their own BIM projects?
4. Do you think the framework will make a positive impact/contribution to industry, and in what way?

15.3.2 Expert final feedback and validation

The feedback from the experts was collated in a summary log (Appendix U). Each participant was coded using P1-6 for anonymity. The participants provided constructive comments which helped to provide final validation of the '*FM-BIM Framework'.* Some short exerts are shown below:

- *"The framework provides a comprehensive end-to-end framework for all stakeholders involved in project delivery using BIM"* (P5).
- *"Facility Managers can use it as a reference guide or even as a checklist to facilitate the use of BIM during the operations and maintenance processes"* (P3).
- *"The framework and CSF will allow FM professionals (and other stakeholders) from a range of backgrounds and experience to follow a pathway to receive useful information (BIM) to suit the requirements of their individual project and services"* (P1).
- *"The guide layout is very clear and organised in a manner which is easy to navigate"* (P2).
- *"I think the guide is a positive step towards educating FM as a sector about the benefits of BIM. I would like to see this available to colleagues in the AEC sector too as the difference in language between AEC and FM/Property and Asset management can differ significantly*" (P4).

Figure 15.4 shows a range of positive responses for each of the four questions asked, to enable visualisation the final validation of the 'FM-BIM Mobilisation Framework'.

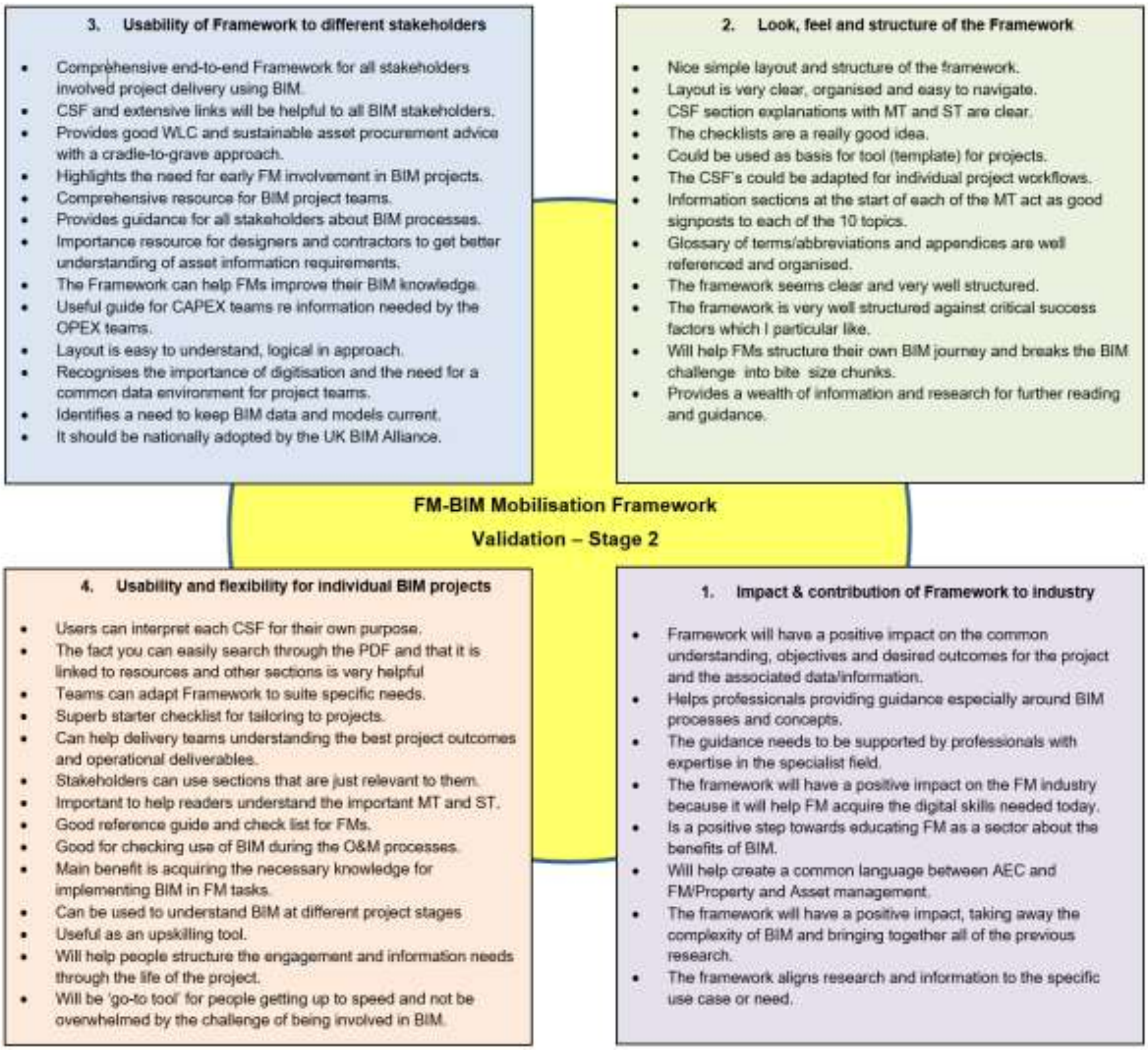


Figure 15.5: Validation Stage 2 - Final feedback from FM/BIM experts

15.4 Chapter summary

The two-stage validation process allowed research objectives (e) and (f) to be successfully achieved; to 'develop' and 'validate' the final '*FM-BIM Framework'*. This also allowed the answering of the primary and secondary research question(s). The final version of the framework has been produced as a professional document and is provided via a link (Appendix V) to academics and industry as an online resource. The FM/BIM experts found the design with hyperlinks very useful as a source of information and guidance. It was hoped the framework can be actively used by FMs and other stakeholders to improve the project outcomes of their projects on their own personal BIM journeys.

Chapter 16: Presentation of the final '*FM-BIM Mobilisation Framework'*

This chapter presents the final end product of the research; the '*FM-BIM Mobilisation Framework'* which addressed and incorporated the research objectives; (e) to incorporate the final list of CSF in an appropriate framework; and (f) to ensure it was validated by FM/BIM experts. The following sections explain the final document and its layout.

16.1 Overview of the final '*FM-BIM Mobilisation Framework'*

The framework provides FMs and other professionals with a practical interactive tool which could be used both as a reference source regarding CSF in BIM projects. It also provides a 'mobilisation check list' to help people check if they have reviewed the critical success factors to help achieve the best outcomes when working with the BIM process. In order to ensure a modern look and feel the services of a professional design service were engaged as shown by the cover presented in Figure 16.1.

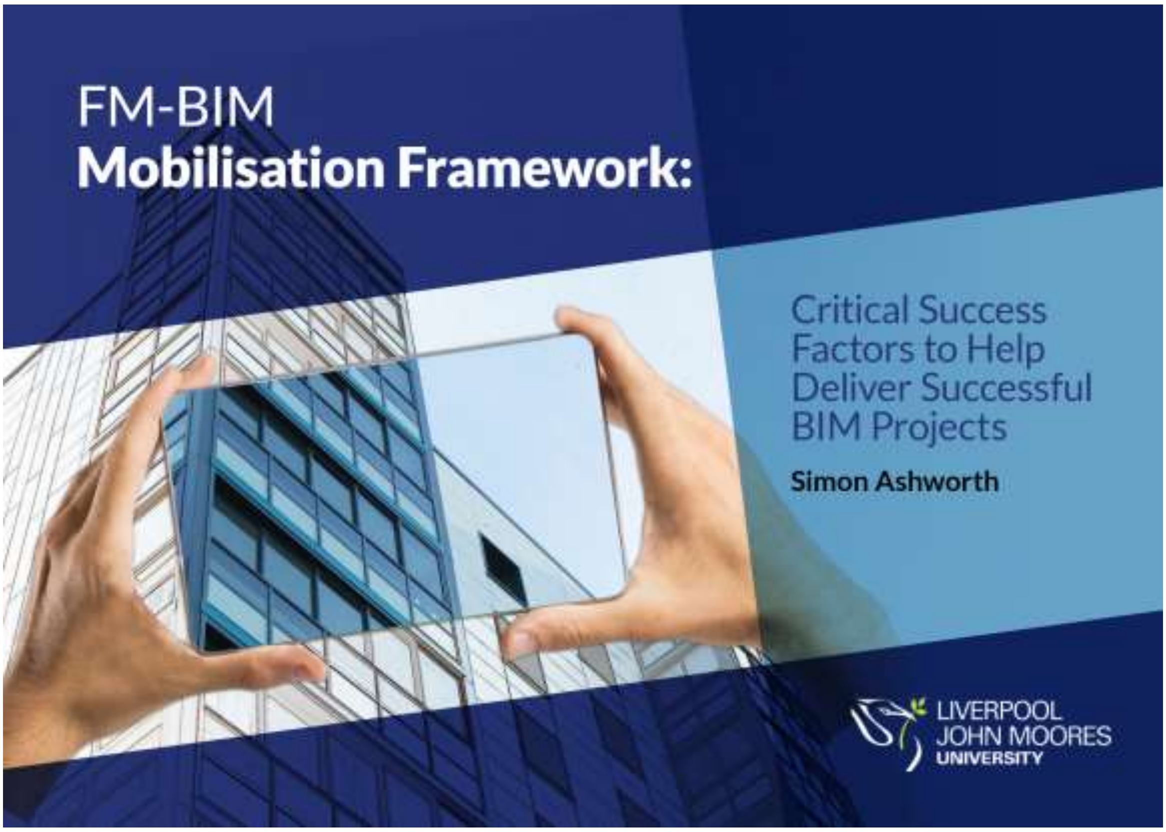


Figure 16.1: Front cover '*FM-BIM Mobilisation Framework'* (Ashworth and Tucker, 2020)

To ensure the framework would be as useful as possible it was developed in the form of an interactive and searchable PDF. This allows the reader to freely move around the document sections easily with navigation buttons and hyperlinks. The format also ensures people can quickly scan through the summary list to get an overview of each CSF, the topics addressed, and what is covered under each CSF. The framework is broken down into six sections with appendices as follows.

16.2 Section 1: Introduction

The Introduction, shown in Figure 16.2, presents the aim of the guide and how the 10 CSF (with the MT and ST) can be used to improve the engagement with, and outcomes of BIM projects. It explains the need for transparency in order to deliver the benefits of BIM across all the built asset's life-cycle phases . There is also a link to suggest updates and amendments to keep it up-to-date.

FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

1. Introduction

The aim of this guide is to provide a series of Critical Success Factors (CSF), which can be used by Facility Management (FM) professionals and other stakeholders to help them better engage in Building Information Modelling (BIM) projects. By doing so we will all help deliver better project outcomes and the full benefits of BIM, enabling us to optimise built assets in operation for users, organisations and wider society.

BIM has become the chosen route for procuring and delivering new built assets. In addition, the BIM process is increasingly being applied to existing built assets. Laser scanning and other data capture techniques are being used in the digitalisation of organisations' real estate portfolios.

The collection of information/data may also be used 'where appropriate' to set up retrospective BIM models. If well implemented, the BIM process has the potential to deliver significant benefits not only during the design and construction phases but also during the much longer operational phase. However, the benefits need to be clearly transparent, realistic and achievable. Working with the BIM process also presents its own challenges and concerns. If we are to deliver the full benefits of BIM across all the built asset's life cycle phases these barriers need to be addressed and overcome. This ***'FM-BIM Mobilisation Framework'*** presents ten CSF Main-Themes (MT) with associated Sub-Themes (ST). These can be seen as a **mobilisation checklist** of actions with supporting explanations, examples and useful links to resources for support. If acted upon, they will help people engage more successfully with BIM projects to achieve their desired outcomes. The CSF and associated guidance are not intended to be a complete guide to BIM as there are many other resources already available which fulfil this requirement.

The ***'FM-BIM Mobilisation Framework'*** is based on my PhD work and associated research papers. These can be accessed on my Researchgate account. I hope this guidance is useful to readers and would welcome any feedback or suggestions for additional examples, which might improve the document over time. Where links are not working please let me know and I will update the document.

Simon Ashworth (Lead Author)
ashw@zhaw.ch
Research Gate Profile

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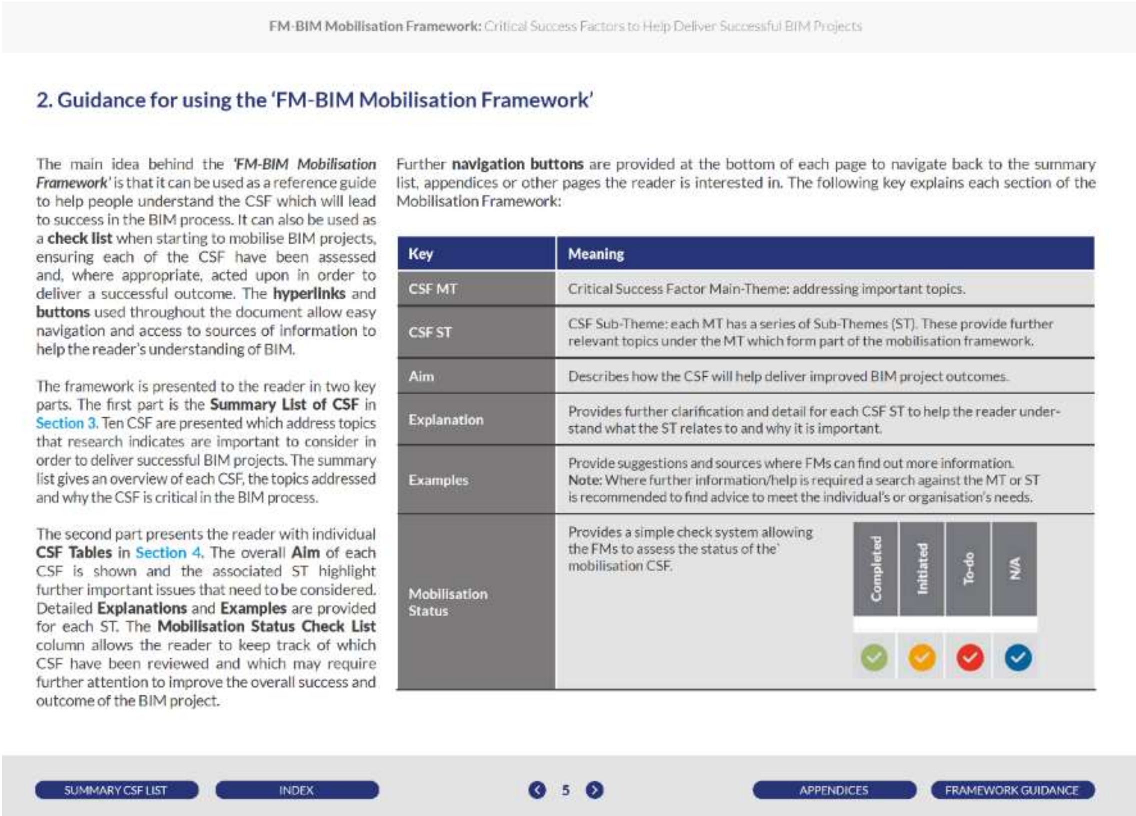
Figure 16.2: The '*FM-BIM Mobilisation Framework'*- Introduction

16.3 Section 2: Guide for using the ‘*FM-BIM Mobilisation Framework’*

Figure 16.3 provides readers with an overview and guidance on how to use the framework for both reference purposes and also as a ‘checklist’. It explains how the navigation buttons (shown in blue at the bottom) and the embedded hyperlinks (in bold) can be used to move between the different sections and to access resources linked to the work. It also introduces the following sections; the ‘Summary List of CSF’ (Section 3); and the individual ‘CSF Tables’ (Section 4).



FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

2. Guidance for using the ‘FM-BIM Mobilisation Framework’

The main idea behind the ‘***FM-BIM Mobilisation Framework***’ is that it can be used as a reference guide to help people understand the CSF which will lead to success in the BIM process. It can also be used as a **check list** when starting to mobilise BIM projects, ensuring each of the CSF have been assessed and, where appropriate, acted upon in order to deliver a successful outcome. The **hyperlinks** and **buttons** used throughout the document allow easy navigation and access to sources of information to help the reader's understanding of BIM.

The framework is presented to the reader in two key parts. The first part is the **Summary List of CSF** in Section 3. Ten CSF are presented which address topics that research indicates are important to consider in order to deliver successful BIM projects. The summary list gives an overview of each CSF, the topics addressed and why the CSF is critical in the BIM process.

The second part presents the reader with individual **CSF Tables** in Section 4. The overall **Aim** of each CSF is shown and the associated ST highlight further important issues that need to be considered. Detailed **Explanations** and **Examples** are provided for each ST. The **Mobilisation Status Check List** column allows the reader to keep track of which CSF have been reviewed and which may require further attention to improve the overall success and outcome of the BIM project.

Further **navigation buttons** are provided at the bottom of each page to navigate back to the summary list, appendices or other pages the reader is interested in. The following key explains each section of the Mobilisation Framework:

Key	Meaning
CSF MT	Critical Success Factor Main-Theme: addressing important topics.
CSF ST	CSF Sub-Theme: each MT has a series of Sub-Themes (ST). These provide further relevant topics under the MT which form part of the mobilisation framework.
Aim	Describes how the CSF will help deliver improved BIM project outcomes.
Explanation	Provides further clarification and detail for each CSF ST to help the reader understand what the ST relates to and why it is important.
Examples	Provide suggestions and sources where FMs can find out more information. **Note:** Where further information/help is required a search against the MT or ST is recommended to find advice to meet the individual's or organisation's needs.
Mobilisation Status	Provides a simple check system allowing the FMs to assess the status of the mobilisation CSF. Completed / Initiated / To-do / N/A

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Figure 16.3: ‘*FM-BIM Mobilisation Framework’*: Guidance on using the framework

16.4 Section 3: Summary list of the '*FM-BIM Mobilisation Framework'* critical success factors

The 10 Main Themes (MT1-10) are listed as the 'Summary List of CSF'. A short explanation as to the importance of each one is given in order to achieve success in a BIM project..

FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

3. Summary list of Critical Success Factors (CSF)

The table below shows the ten **CSF MT** and why they are important from an FM perspective. Each one should be reviewed and, where appropriate, actioned when mobilising BIM projects in order to deliver the required project outcomes. The **Why the CSF is important** column provides a single line summary of why each CSF is key to the success of the BIM process.

Note: The MT are not ranked in any order of importance. The reader should access them as appropriate to their needs. The hyperlinks can be used to navigate to the different MT themes.

No	CSF Main-Themes (MT)	Why CSF is important
MT1	Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets	BIM can help deliver improved WLC and sustainability, especially when considered over the typical long life of built assets.
MT2	Recognising the importance of digitalisation and technology to FM and the BIM process	To remain innovative and competitive organisations need to be aware of and prepared for the changes that digitalisation trends will bring to the FM and RE industries.
MT3	Addressing and overcoming perceived barriers and challenges to adoption and use of BIM	Overcoming barriers will avoid 'silo-mentality' working and ensure FMs can position themselves for early engagement in BIM projects.
MT4	Making the benefits of BIM to the operational phase of assets transparent, realistic and achievable	It is important to manage expectations about BIM and not over-sell its capabilities: therefore having realistic and achievable benefits will allow them to be achieved.
MT5	Planning the strategic and operational information needs for FM in the BIM process	Clearly defining the strategic information needs for the operational phase will ensure FM teams have the right information/data they need to run and optimise built assets.
MT6	Improving stakeholder collaboration and understanding of the BIM process	A project which makes the most out of the collaboration possibilities within the BIM process stands a much higher chance of delivering successful outcomes for all stakeholders.
MT7	Clarifying the role of, and tasks of FM in the BIM process	Having a clear understanding of the role of FM will ensure FMs contribute their knowledge, thus improving project outcomes and the successful delivery of BIM projects.
MT8	Acquiring essential knowledge of key BIM standards/guidance documents for practical use in a BIM project	Using BIM standards and a 'standardisation approach' with good guidance documents will ensure all stakeholders communicate in the same language and avoid confusion and costly mistakes.
MT9	Ensuring people have adequate BIM training and competency skills to successfully engage in BIM projects	FM teams must have the right digital skills to work in an increasingly digitalised environment and understand the implications and impact on how they deliver FM services.
MT10	Ensuring successful transfer/ongoing management of information/data for the operational phase of assets	Starting a BIM project by planning 'with the end in mind' will greatly improve the project outcomes and ensure the efficient, accurate and fast population of data into CAFM and FM management systems.

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Figure 16.4: Summary list of the '*FM-BIM Mobilisation Framework'* CSF

16.5 Section 4: Tables: Main-Themes and Sub-Themes in the '*FM-BIM Mobilisation Framework'*

This introduces how each of the framework's MT are presented together with associated ST. It also explains the layout and table format, as can be seen in Figure 16.5.

Figure 16.5: Tables (MT and ST) in the '*FM-BIM Mobilisation Framework'*

The individual CSF MT and ST are presented so that readers can get an overview of all the topics covered in the framework. The reader can also use the bolded MT titles (hyperlinked) to navigate between the 10 main CSF themes as shown in Figure 16.6.

FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

CSF MT and ST

MT1: Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets

ST 1.1 Using BIM to maximise the long-term value and ROI of built assets
ST 1.2 Using BIM to reduce operational costs, improve sustainability and help meet government 2025 targets
ST 1.3 FM readiness to engage in BIM projects
ST 1.4 Making the benefits of BIM to the operational phase of assets transparent, realistic and achievable
ST 1.5 Planning the strategic and operational information needs for FM in the BIM process
ST 1.6 Improving stakeholder collaboration and understanding of the BIM process
ST 1.7 Clarifying the role of, and tasks of FMs in the BIM process

MT2: Recognising the importance of digitalisation and technology to FM and the BIM process

ST 2.1 Awareness of digital trends and their potential impact on FM
ST 2.2 Using technology/software tools to help improve collaboration and sharing of data
ST 2.3 Linking BIM models to external databases
ST 2.4 Set up of the CDE and ensuring security of BIM data
ST 2.5 Ensuring data is correctly structured for efficient information exchange
ST 2.6 Using BIM viewing tools/mobile technology to help improve FM services and access to information
ST 2.7 Using social media for knowledge sharing and networking
ST 2.8 Maintaining BIM models to ensure they remain up to date

MT3: Addressing and overcoming perceived barriers and challenges to the adoption and use of BIM

ST 3.1 Upskilling FM teams to empower them for successful engagement in BIM projects
ST 3.2 Preparing people and organisations for full engagement in BIM projects
ST 3.3 Addressing concerns about costs associated with BIM and ROI
ST 3.4 Clearly articulating the value and benefit of BIM to FM and the operational phase of assets
ST 3.5 Setting realistic expectations of what BIM can deliver
ST 3.6 Addressing pessimism about BIM
ST 3.7 Understanding the need to focus on the quality of data rather than quantity
ST 3.8 Addressing concerns about the complexity of BIM
ST 3.9 Advising clients about BIM and how it might benefit them
ST 3.10 Deciding on the appropriate IT tools and whether to adopt an open or closed BIM approach
ST 3.11 Using case studies to document the benefits of BIM to FM
ST 3.12 Reviewing CAPEX/OPEX budgets to ensure a sustainable WLC approach
ST 3.13 Understanding legal implications for BIM projects
ST 3.14 Avoiding silo-working mentality and encouraging early FM engagement
ST 3.15 Assessing security and risks associated with BIM information
ST 3.16 Understanding and use of BIM acronyms
ST 3.17 Use of BIM/other standards with a KISS to ensure people can engage with BIM
ST 3.18 Using BIM for existing built assets and capturing 'as-built' records during construction
ST 3.19 Understanding the link between BIM, CAFM and FM management systems

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Figure 16.6: List of CSF with MT and ST in the '*FM-BIM Mobilisation Framework*'

Each of the 10 CSF are introduced with a background as to why they are important in the BIM process. An example (CSF 1) is shown in Figure 16.7. The bolded text highlights hyperlinks to sources which can be useful to the reader.

CSF 1:

Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets

Built assets are often procured with a **lowest price wins** approach. However, research and many industry *best practice reports* such as the CLC *'Procuring for Value'* (2018, p13) suggest that this is not the best approach to achieve long term value. The report recommends that in order to deliver sustainable built assets for society, the procurement should be carried by *"exploiting new technologies and encouraging a focus on delivering the greatest value throughout the life of the project"*. BIM offers an excellent opportunity to do this and at the same time consider the procurement process from an OPEX perspective. This will help reduce costs over the whole-life of the asset rather than just looking for the cheapest short-term CAPEX solution. The importance of early engagement to influence costs was highlighted by *Patrick MacLeamy* (2004) in his work with HOK and later buildingSMART. This work is based on earlier work, shown in Figure 1 by *Paulson (1976, p 588)* his findings illustrated how the early stages of a project are where **high influence** over changes and project costs can be achieved at **low expenditure.**

Such an approach to procuring our built assets will help reduce waste and contribute to a better *circular economy.* People wishing to find out more can look at the ARUP *Circular Economy in the Built Environment* web page.

The BIM approach also helps support key targets (Figure 2) outlined in the Government's *'Construction 2025'* industry strategy (HM Government, 2013, p5).

Achieving the targets will only be possible if all stakeholders in the BIM process take ownership and consider ways to improve how we currently deliver, maintain and run built assets over their whole-life. From an FM perspective this starts with early engagement in the BIM process by contributing FM knowledge and helping design teams choose quality products, systems and materials. This will help optimise the long-term running costs of the assets. FMs should also help review proposed designs from an operational perspective to avoid issues which might incur additional operational costs over the WLC (e.g. lights at height that require expensive access equipment to change bulbs). Through collaborative discussion such issues can be designed out or a better solution found by the team. The paper by Meslec et al (2018) *'Integrating Life Cycle Sustainability Analysis with BIM'* provides some useful insights as to how BIM can be used to help improve sustainability in the design process, and the paper by Ashworth and Druhmann (2016) also provides some insights on how *'Rating Systems in Conjunction with BIM Deliver Outstanding Possibilities for Sustainable Construction'.*

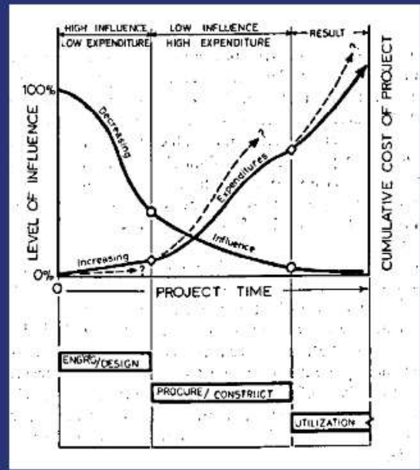

Figure 1

Figure 2

Figure 16.7: MT introduction example: CSF 1

Figure 16.8 illustrates how each CSF MT is presented in a table with an overall strapline 'Aim'. The associated ST are listed in numbered separate table line entries. The 'Explanation' column provides argumentation as to the importance of each ST, with key issues shown in **bold**. The 'Examples' column provides reference examples, and the '**blue bold text'** provides links to sources which readers may find useful if they want to explore the topic further. Lastly readers can use the 'Mobilisation Status Checklist' column to track when they have reviewed the individual CSF ST.

CSF	**MT1:** Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets						
	Aim: Adopting a WLC approach to BIM will help deliver more sustainable built assets for people, organisations and society			MOBILISATION STATUS CHECK LIST			
ST Ref	**CSF Sub-Themes (ST)**	**Explanation**	**Examples**	**Completed**	**Initiated**	**To-do**	**N/A**
1.1	Using BIM to maximise the long-term value and ROI of built assets	Adopting a **WLC cradle-to-cradle approach** to BIM, rather than short-term capital expenditure (CAPEX) focus, will help maximise **best value** over the long-term and ROI for built assets. **Feedback loops** with design teams should review designs, energy systems and **quality/longevity** of products/systems to reduce frequency of asset replacement (thus waste) and ensure sustainable WLC options are chosen. **CAPEX and (operational) OPEX budgets** should be balanced to see where more spend upfront will save over the long term. **Value engineering** should not result in increased long term OPEX cost just to get the cheapest CAPEX cost. BIM can help **improve procurement** and also achieve sustainable outcomes. *'Soft Landings'* and *'BS 8536'* should be adopted. FMs should also consider setting up **performance targets** to measure the success of a BIM project.	Adopting a WLC ***cradle-to-cradle*** approach will make the procurement of built assets more sustainable. The report ***'Constructing a better future: achieving quality and best value in the built environment'*** is a good reference to understanding how we should all work towards achieving ***best value***. This requires considering ***CAPEX and OPEX*** costs, rather than focusing just on the initial CAPEX cost of building an asset (e.g by considering equipment/material quality and life expectancy, and focusing on ***value engineering*** in favour of the operational phase). Research shows it is often worth paying more upfront for quality products that will reduce long-term operational costs. Project teams should also consider ***assessing life cycle costs*** of built assets. The ***'Soft Landings'*** approach should be adopted which takes into account ***CAPEX and OPEX costs***. The ***'BS 8536'*** guidance standard should also be used to ensure FMs can give input at the appropriate time to achieve a sustainable outcome.				

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Figure 16.8: Table example CSF - ST1.1 from the '*FM-BIM Mobilisation Framework'*

16.6 Section 5: Conclusion

This reminds readers of key issues in order to achieve successful outcomes. These include, the importance of making the benefits of BIM transparent; to 'start with the end in mind'; ensuring open communication and that people are supported to build their digital competencies; standardisation, and specifically the need for openBIM standards; the need for clearly defined information requirements; and ensuring teams use appropriate technology where possible to improve workflows and communication.

5. Conclusion

In the BIM process we are often reminded to **start with the end in mind.** This *'FM-BIM Mobilisation Framework'* together with the associated PhD research, allows contemplation of which success factors will help to achieve the intended objectives from the outset of a BIM project. The 10 CSF MT identified in the framework, together with their 102 associated ST, provide FM and all stakeholders involved with a way to help them on their BIM journey, whether they be right at the very start, or already well on the road. The MT and ST describe specific topics with associated resources, which can be tracked, and when acted upon, will help deliver better project outcomes and encourage everyone involved to work more collaboratively. BIM and digitalisation will provide new and exciting opportunities to add significant strategic value to the management of organisation's RE portfolios. Used appropriately BIM and digitalisation can help empower people to manage assets in more cost-efficient ways with a longer-term WLC perspective. However, in order for organisations and people to positively engage the **benefits** need to be made clear and transparent to everyone involved from the start of a project.

BIM and digitalisation are already having a significant impact on the AECO industries. Some of the change brought about is sometimes seen as challenging and adds complexity.

But, we need to remember project teams were managing building projects for many years before these topics became the new trends of today. BIM can help us address a key issue, which was often a problem in the past: namely the successful and timely transfer of valuable data, which was often lost between the construction and operation phases. What BIM and digitalisation do offer, are new opportunities to improve the way we work, deliver better built assets, and to be able to manage the wealth of information that results over the life of the assets. In order to adopt, use and benefit from such digital technologies a paradigm change in thinking and approach to collaborative working is required. We all need to think about how we can capture and work with the increasing amounts of information that will be generated. As *(Munir et al, 2019, p1)* argue in their paper *'BIM business value for asset owners through effective asset information management'*;

"for most asset managers, the problem is not the lack of information about their assets, but the abundance of it, and most especially the absence of established processes and protocols to effectively manage large sets of asset data. Therefore, it is crucial to develop a strategy to control and manage this information in order for asset managers to harness its potential and realise value from their organisation's information assets".

Figure 16.9: '*FM-BIM Mobilisation Framework'* conclusion

16.7 Section 6: Further literature

A list of further literature from the researcher (and colleagues) is presented, which may be of interest to readers.

FM-BIM Mobilisation Framework: Critical Success Factors to Help Deliver Successful BIM Projects

6. Further literature and papers by the Author

Readers who are involved in BIM projects maybe interested in the papers and sources from the author and fellow co-authors listed with links below.

Note: Hyperlinks to the sources to download the work can be found by hovering over the text.

Ashworth (2020), *'FM-BIM Mobilisation Framework - Critical Success Factors to Help FM Deliver Successful BIM Projects'*, PhD Thesis, Liverpool John Moores University.

Ashworth et al (2019), *'BIM Data for FM Systems'*

Ashworth et al (2019), *'The benefits of building information modelling (BIM) to facility management (FM) over built assets whole life cycle'*.

Ashworth et al (2019), *'The Benefits of BIM to FM Catalogue'*.

Ashworth et al (2018), *'Critical success factors for facility management employer's information requirements (EIR) for BIM'*.

Meslec et Al (2018), *'Integrating Life Cycle Sustainability Analysis with BIM'*.

Ashworth et al (2017), *'Building a bridge to BIM'*.

Druhmann and Ashworth (2017), *'Das FM und seine Daten' (German)*.

Ashworth et al (2017), *'Employer's Information Requirements (EIR): A BIM case study to meet client and facility manager needs'*.

El-Arousy et al (2017), *'Swiss-COBie: Development of a Design for Information Exchange Between Planners, Contractors and FM in Switzerland'*.

Ashworth and Tucker (2017), *'Introduction of Employer Information Requirements (EIR) Template and Guidance for Facility Management'*.

Ashworth (2017), *'BIFM Employer's Information Requirements (EIR) Template and Guidance'*.

Druhmann and Ashworth (2016), *'Rating Systems in Conjunction with BIM Deliver Outstanding Possibilities for Sustainable Construction'*.

Ashworth et al (2016), *'The Role of FM in Preparing a BIM Strategy and Employer's Information Requirements (EIR) to Align with Client Asset Management Strategy'*.

Ashworth et al (2016), *'Integration of FM expertise and end user needs in the BIM process using the Employer's Information Requirements (EIR)'*.

Ashworth and Druhmann (2016), *'BIM: Die Sicht der EU', (German)*.

Ashworth and Druhmann (2016), *'What Switzerland can learn from England (What Switzerland can learn from England)'*.

Druhmann and Ashworth (2015), *'FM Expertise und Digitale Gebäudemode modelle' (German)*.

Carbonari et al (2015), *'How Facility Management can use Building Information Modelling (BIM) to improve the decision making process'*.

Ashworth (2015), *'BIM and FM: Research and Practice Workshop'*.

Ashworth (2015), *'BIM und FM - Schweiz 2015', (German)*.

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Figure 16.10: '*FM-BIM Mobilisation Framework'* - further literature

16.8 Appendices

The framework's three appendices provide; 1) a detailed list of abbreviations, 2) a list of FM relevant guidance and standards, and 3) a list of sources for the various figures.

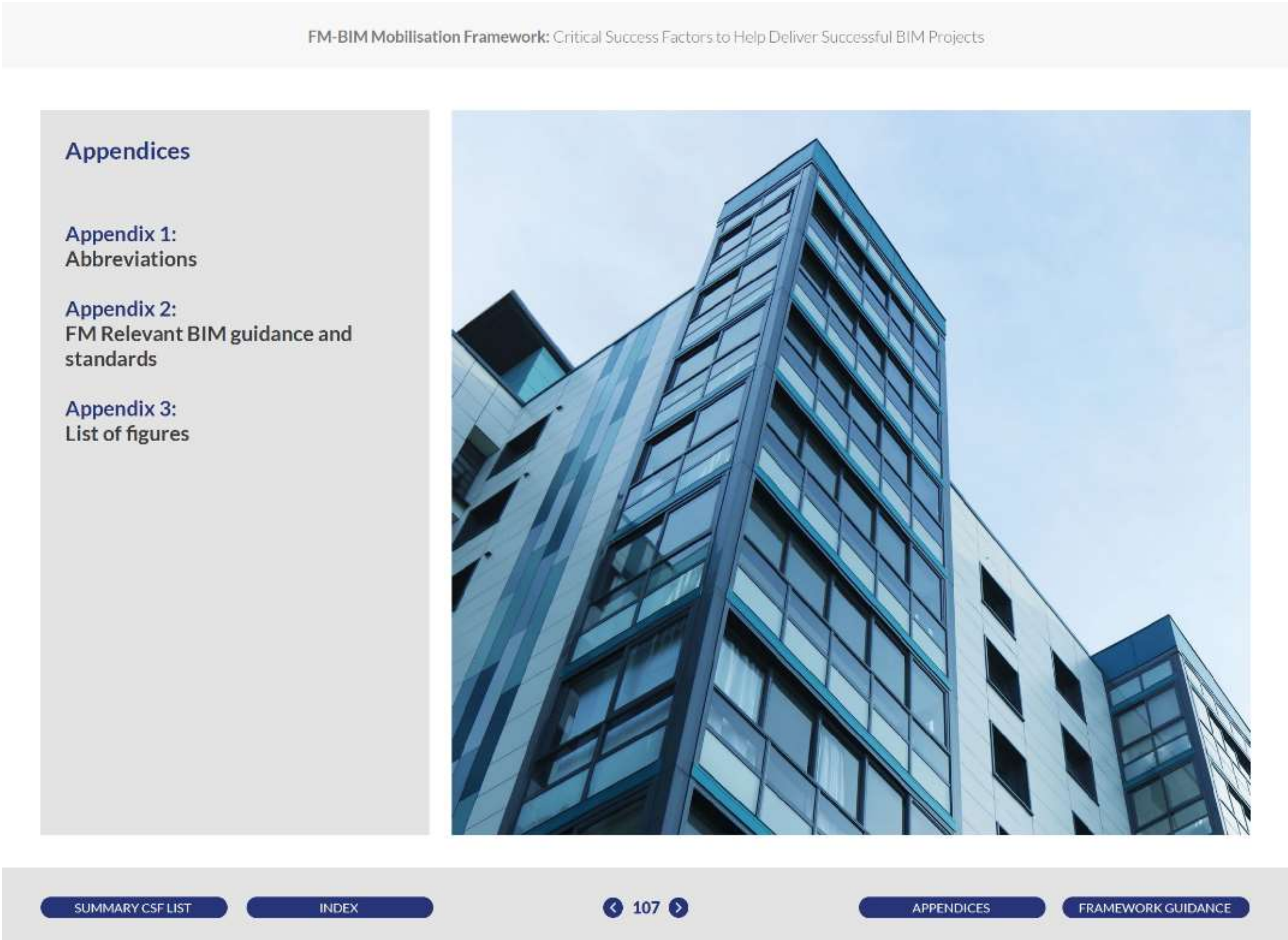

Figure 16.11: '*FM-BIM Mobilisation Framework'* - further literature

16.9 Chapter summary

The '*FM-BIM Mobilisation Framework'* presents the final end product of the research; a framework aimed at helping people deliver better outcomes from BIM projects. It addresses the significant research gaps identified in the research questions laid out in Chapter 1.4. The final merged list of 10 CSF are detailed in appendix S which were established during the analysis of the qualitative and quantitative CSF (Chapter 15). The framework provides all stakeholders in the BIM process with a practical tool to help organisations and individuals deliver successful BIM projects. It will also guide people as to how they can contribute towards realising the benefits of BIM to FM, and improve the transfer and use of information over the whole-life of the BA.

Chapter 17: Conclusion

This chapter reflects on the research work and the process of establishing the CSF and developing the *'FM/BIM Mobilisation Framework',* for use by FM and other AEC professionals in practice.

17.1 Reflection on the research and its achievements

The following sections provide a reflection on the research aim, approach, and success of answering the main research question, the six secondary questions, and the research objectives described in Chapter 1. Limitations impacting the research and contributions towards the body of knowledge are presented, followed by recommendations for further research studies and a final conclusion.

17.2 Reflection on the research aim, approach and objectives

The aim of the research was twofold, firstly, to identify the CSF that (if followed) would help FMs successfully engage in BIM projects. Secondly, to incorporate the identified CSF into a mobilisation framework for use by practitioners leading to more sustainable outcomes. The framework included clear explanations on the importance of each CSF and links to supporting information/sources. The final document provided a comprehensive 'BIM mobilisation checklist' linked to a wealth of resources easily accessible by practitioners to help them deliver their own BIM projects. Each research objective was reviewed and reflected upon as follows:

a): Review the state of the art and identify the CST with respect to the role of FMs in the BIM process in broad grouped themes related to: 'policy', 'processes', 'technology and digitalisation' and 'people'. The review will focus on the UK market but include other international sources where relevant.

The literature review successfully identified 13 CST MT, and 33 associated ST, deemed important to the role of FMs in BIM projects. The themes were grouped into key areas of: 'policy', 'processes', 'technology and digitalisation' and 'people'. The CST enabled a comparison between theory from the literature with findings from practice. This was achieved by incorporating the CST into questions in both the qualitative interviews and quantitative questionnaire. The research highlighted some key issues:

- **Policy:** The UK Government's 'construction strategy' and mandate to use BIM on government projects from 1st April 2016 was largely responsible for galvanising the industry into adopting and using BIM. They also took a leading role in driving a paradigm shift in the AEC industry to adopting a more sustainable whole-life approach. This has helped many in industry accept that maximum value is achieved over the long-term, rather than the mind-set of 'cheapest is best'.

- **Process:** the UK was an early adopter of BIM developing highly respected local BIM standards which clearly defined the BIM process. However, the local standards are gradually being withdrawn as the UK BIM Framework is fully aligned with the international BIM '*ISO-19650'* standards. We have also seen acceptance that FMs, as the people who will run the BA after completion, need to be included from the start of the process. This will allow their valuable knowhow to be included from the operational perspective. FMs need to take a more active role and help define the information requirements (OIR, AIR and EIR) to ensure they get the information they need to optimise BA in operation. Early engagement is also important to influence key decisions made during the early stages which will determine the long-term usability and avoid decisions that will increase operation costs of BA over their whole-life.
- **Technology and digitalisation**: the digital revolution is developing so fast that the challenge is keeping up with it. Technology, software and digital platforms have become essential to successfully delivering BIM projects as they provide the underlying tools that support the processes and people. There is no escaping that technology will play an increasingly important role in how BIM projects are managed and delivered. This will impact on the way information is captured and moved/shared with other systems, as well as supporting teams in communication, sharing and essential workflows.
- **People**: delivering the best project outcomes is only possible if the people making decisions are competent and have a good understanding of BIM standards and processes. They need to be positively engaged and empowered to work in a collaborative, with one common language to ensure the team can deliver the best possible outcomes. To achieve this, BIM training, knowledge and experience is essential to ensure competence and increase confidence levels. FMs are uniquely placed to help clients clearly define information requirements. They can give feedback on designs to ensure the right decisions are made and to avoid the "garbage in=garbage out scenario". This will ensure our BA can be run and efficiently managed over their whole-life.

b): To establish quantitative CSF based on a 'general FM industry' awareness of BIM, considering benefits and barriers to FM involvement in the BIM process. This will include inputs from the UK and other countries.

The quantitative CSF were successfully identified using the questionnaire with the 'general FM industry'. In total 254 completed responses provided a rich data set for statistical analysis (descriptive and inferential) using SPSS. The findings were composed of 10 CSF MT and 47 ST. The descriptive statistics allowed the CSF to be described using 'narrative text' (supported by additional comments from the questionnaire responses). The data also allowed several hypotheses to be tested showing statistically significant relationships between levels of knowledge, training, experience and confidence levels in engaging in BIM projects. The descriptive findings were formally published via the BIFM as the '*FM Awareness of BIM: 2017*' (Ashworth & Tucker, 2017) which is available via the IWFM website.

c) To establish qualitative CSF from 'FM and BIM experts' to understand their view of how BIM is impacting on FM and what would help FMs best engage in the BIM process. Input will be mainly based on the UK but may include international experts.

The qualitative CSF were successfully identified using the NVivo interview process with 19 'FM/BIM experts'. In total around 110,000 words of transcript provided a rich qualitative data source for the thematic coding using NVivo and thematic theme maps. The findings were composed of 10 CSF MT and 45 ST. This clearly identified CSF that would help FMs engage with the BIM process. The interviews also allowed further probing questions regarding benefits and challenges of BIM and how the experts perceived the use of BIM standards/guidance.

d): Merge the CSF (from b and c) to establish a final summary list of CSF.

The successful completion of objectives b) and c) enabled the researcher to proceed with the convergent design, recommended by Creswell and Clark (2018), using 'side-by-side' narrative text analysis to merge the qualitative and quantitative CSF. The analysis compared the CSF to see if they were 'similar' or 'totally different' in order to complete the merging process which produced a final list of 10 CSF MT. Some were subsequently renamed to make them more appropriate and comprehensive when used in the '*FM-BIM Mobilisation Framework'*. The same merging process was then applied to the ST/STT, producing a final accompanying list of 100 CSF ST.

Note: the large number of ST (100) reflected the decision to include a detailed list of benefits and challenges of BIM for FM in the final framework. This involved comparing the outputs from objectives b (23 benefits), and c (25 challenges) in the convergent merging process.

e): Identify a suitable format for the 'FM-BIM Mobilisation Framework' and incorporate the final list of CSF (from d) into a draft framework. The guidance and links will provide both UK specific and more generic advice for international users

The literature review in Chapter 7 helped establish there was no similar existing frameworks. The work was unique in bringing together CSF for BIM projects and integrating them into one framework. As discussed in Chapter 7.7 the literature helped establish a proposed structure for the proposed PhD framework which was inspired by three other reference frameworks; Aderiye (2015), Amuda-Yusuf (2018) and the SFT (2020). The successful completion of objective d) to identify the final CSF list was then used as the basis for successfully developing the '*FM-BIM Mobilisation Framework*'. An overview of framework is explained in Chapter 16.7.

f): Validate the '*FM-BIM Mobilisation Framework'* with 'FM/BIM experts'.

The framework was successfully validated using a two-stage validation process as suggested by Wilkinson (1998). This used 'member-checking' i.e. 'FM/BIM experts' who had previously engaged in the research to add credibility to the validation process. This focus group ensured a comprehensive review of the framework and allowed further changes to be made with respect to the look, feel, design, order of CSF and the usability/applicability, before the final framework was produced. The experts noted: it is *"very clear, organised and easy to navigate", the "checklists are a really good idea"* and it *"provides a wealth of information and research for further reading and guidance"*. The intention is that the framework is a live document which is updated as BIM develops. It is suggested the framework is adopted by organisations such as the IWFM and UK BIM Alliance to help people in practice. The full document is available from the link in Appendix V.

17.3 Success of answering the research questions

Achieving objectives, a) to f) allowed the research questions posed in Chapter 1.5 to be answered. These are reviewed and reflected upon in Table 16.1 which gives an overview of how successfully the research question(s) were answered.

Table 17.1 Reflection on the success of answering the research question(s)

Questions	Observation regarding the success of answering the primary and secondary research questions
Primary research question	**i) What are the CSF in terms of relevant knowledge, skills and competences, which will empower FMs to fully engage with the BIM process and ensure that built assets can be optimised in operation?** A final list of 10 CSF MT was identified from the convergent research design (combining qualitative and quantitative CSF using the side-by-side narrative merging approach). 100 ST were also successfully established incorporating aspects of BIM knowledge, skills and competences. The CSF highlighted specific actions (that when taken) will help FMs to engage fully in BIM projects and help deliver successful outcomes for BIM projects. The research also highlighted CSF essential to ensuring the planning and capture of information requirements to help optimise BA in operation.
Secondary question	**ii) What CST can be identified from literature which help improve the successful engagement of FMs in the BIM process?** 13 CST-MT with 33 associated CST-ST were successfully identified from the literature which might help improve FMs engagement in the BIM process. These were categorised into four main groups: policy, processes, people, and technology and digitalisation. The CST enabled a link to be established between theory and practice. This was done by using the CST as the basis for developing the themes for questions for both the qualitative interviews and the quantitative questionnaire.

Questions	Observation regarding the success of answering the primary and secondary research questions
Secondary question	**iii) Which quantitative and qualitative CSF are important for the successful delivery of BIM projects and can be identified respectively from best practice i.e. the 'general FM industry', and experts i.e. 'FM/BIM experts'?** The quantitative analysis using SPSS successfully identified 10 important quantitative CSF MT (with 47 ST) from the 'general FM industry' perspective. 10 important qualitative CSF MT (with 45 ST) were also established using NVivo to analyse the interviews and establish the 'FM/BIM experts' perspective.
Secondary question	**iv) What are the current levels of awareness of BIM in the 'general FM industry'?** The published report '*FM Awareness of BIM*' with the BIFM highlighted the levels of awareness of BIM from the 'general FM industry'. Amongst other findings this included 72% of the respondents feeling "*the FM industry is not clear what BIM is*" and 67.7% disagree or strongly disagree that "*the FM industry is well prepared to deal with BIM projects*" indicating more work needs to be done by the FM industry to ensure people are better informed about, and more prepared for BIM projects. The findings also highlighted 74% think "*BIM will have a significant impact on the FM industry*" and 83.8% indicated that "*BIM is already having an impact*" or will do so in the next five years. The findings highlighted some uncertainty about how to engage in BIM projects. This was not helped by the fact that the landscape of BIM standards/guidance has undergone significant change. This was driven by the gradual replacement of the UK '*PAS 1992*' standards with the '*ISO 19650*' standards. Associated guidance has therefore needed to be regularly updated to stay current. The review of several hypotheses highlighted that people who have had some 'BIM training' or 'BIM project experience' had higher levels of awareness of BIM and were also more confident to engage in a BIM project. These findings were borne out via qualitative feedback from the FM/BIM expert interviews.
Secondary question	**v) What are the main benefits of BIM to FM and how can these be made more transparent?** CSF 4 in the '*FM-BIM Mobilisation Framework*' successfully identified 23 ST which outline the main benefits of BIM to FM. They were addressed in the quantitative and qualitative approaches. The literature indicated FMs and clients stand to benefit most from BIM. However, to date there is little documented evidence to confirm this. This is largely because few comparisons have been made of buildings built with/without BIM, and not many which have been built with BIM are well into their operational phases. The research by PwC (2018) was a good exception which outlined two case studies indicating savings of 1.5%-3% in total (against the without BIM cost). Further research by Ashworth et al. (2019) has provided an online' *Benefits of BIM catalogue*' to make the benefits clear and transparent.
Secondary question	**vi) What possible barriers might prevent early FM involvement in the BIM process and how can they be overcome?** CSF 3 in the '*FM-BIM Mobilisation Framework*' successfully identified 25 ST which outline overcoming challenges of BIM. The challenges of adopting and using BIM were addressed in both the quantitative and qualitative research approaches. The research from literature and interviews highlighted that often the people who are not so well informed about BIM had the most doubts about it. In addition, the research established BIM training, familiarisation and experience all have a positive bearing on levels of confidence in overcoming barriers and engaging in BIM projects.

Questions	Observation regarding the success of answering the primary and secondary research questions
Secondary question	vii) **How could the qualitative and quantitative CSF be brought together in a framework to help organisations and individuals deliver successful BIM projects which realise the benefit of BIM and improve the transfer and use of information for the operational phase of BA?** The literature research highlighted a gap that no such framework existed which brought together CSF for FMs working on a BIM project. The findings also indicated 'FM/BIM experts' and others from industry felt there was a clear need for such a framework. The literature helped the author decide on an appropriate structure and design for the framework. The final list of CSF from objective d) was then used to achieve objective e) and f) to develop and validate the '*FM-BIM Mobilisation Framework*'. The validation was achieved using a two-stage process with a group of members checking 'FM/BIM experts'. Their feedback helped make final amendments to the order of CSF, the look and feel, as well as the usability and applicability of the framework in practice.

17.4 Research limitations

The following limitations were noted regarding the research:

a) There was very little in the way of well documented projects where BIM had been used across the whole-life process, i.e. from planning through to use in operations. As a result, it was difficult to find evidence from the literature to confirm some of the benefits of BIM to FMs in operation. As such some benefits can be considered subjective. Many academic papers made suggestions regarding the benefits, but for some there is a lack of empirical evidence to validate them.

b) At the start of the PhD there were very few studies found which focused on the role of FMs in BIM projects. As a result, several research projects were initiated with BIFM (IWFM) to explore their role in more detail.

c) Many of the specific UK BIM standards/guidance have changed (some several times) during the duration of the PhD. This meant at the point of write up some findings were already based on older documents. Care was taken to retrospectively update the literature sources both in the document and final '*FM-BIM Mobilisation Framework'* to reflect the current status quo. As such, some findings are based on a snapshot in time which is now a few years old and it would be impossible to repeat the research exactly. The researcher is of the view that this does not have a big impact on the final framework as this was updated, but it is an observation.

d) The CST established during the literature review were to a degree subjective, based on personal opinions and interpretations. It is possible that another researcher attempting to repeat the work would place more emphasis on other topics. However, the framework was validated using a two-step process which allowed other professional FM/BIM experts to confirm the work addressed the key issues (they raised no other issues).

e) Finding experts who had a good combination of FM and BIM experience was a challenge. People tended to have more of one than the other. There were few FM experts who had good experience of construction projects in the *'RIBA PoW'* stages, and less on BIM projects. This was probably due to FMs often being excluded from the process until the handover stage.

f) The qualitative interviews tended to provide a richer data set than that of the questionnaire. This was expected as during interviews there was a chance to ask follow-up probing questions to clarify and explore interesting observations made by the 'FM/BIM experts'. Whereas the questionnaire represented a single cross-sectional point in time with no chance to clarify issues raised. This tended to create a bias towards the results from the qualitative data analysis.

g) The BIFM had a general policy not to issue questionnaires to their whole membership, meaning the sample size was restricted to a 'representative' or 'cluster' using the BIFM IT/BIM Blog. As such the questionnaire cannot be said to be fully representative of the wider FM population, but provides a good approximation.

h) The validation of the framework was tested by the focus group of 'FM/BIM experts'. It would also be useful to test it in the wider FM population. This might also include feedback on its effectiveness and people's confidence in applying it in industry.

17.5 Contribution to the body of knowledge

The unique and significant contribution of the research is outlined below:

Contribution towards academic knowledge

a) The critical literature review, qualitative interviews and quantitative questionnaire uncovered new findings regarding the CSF of BIM specific to FMs in BIM projects. These were also brought together in one unique framework. The approach with the framework itself and the findings regarding the role of FMs in BIM projects brings new knowledge to academia.

b) The use of the 'convergent design' using the 'side-by-side narrative text' analysis of qualitative/quantitative CSF was unique as far as could be established, as there were no examples found in the literature. From this perspective the research approach applied to the specific topics was unique and makes a significant contribution to the knowledge.

c) Previous studies considering the 'benefits of BIM' have focused mainly on benefits in the context of construction. There are a few studies considering benefits in other RIBA phases. However, most of these do not specifically consider the benefits to FM. The work has contributed to the body of knowledge by specifically focusing on how the benefits impact on FMs and the FM industry. This work also resulted in the publication: '*Benefits of BIM to FM Catalogue*' (Ashworth, Druhmann and Streeter, 2019) which is available for other researchers to use.

d) Although some studies consider the stakeholders in a BIM project, the research is unique as it considers the specific role of FMs and how they can help deliver better BIM projects. This included exploring how their knowhow and input could help ensure BA can be optimised in the operational phase. It also considered their role in reviewing designs to ensure usability and avoid decisions that would increase long-term operational costs, as well as planning the right information for capture during construction for optimising BA in operation.

e) The research is unique in focusing on how FM's knowhow can help ensure that key BIM documents (OIR, AIR and EIR) are all clearly defined with the operational phase in mind. This extends to considering the role of FMs across all the *'RIBA PoW'* stages; from defining the early information requirements; giving inputs during design; and helping to ensure the information that is transferred is compatible with key FM management systems (e.g. CAFM).

Contribution to the FM industry:

a) Some elements of the research were explored in other studies. However, the work is unique in bringing together CSF and combining them into the '*FM-BIM Mobilisation Framework'*. As one of the 'FM/BIM experts' said it provides a *"comprehensive end-to-end framework for all stakeholders involved in project delivery using BIM"*. Another suggested *it "will be the 'go-to tool' for people getting up to speed and not be overwhelmed by the challenge of being involved in BIM".* At the time of publishing there was no other example of such a framework for practitioners.
b) The framework also helps reinforce current best practice by incorporating all the standards recommended by the UK BIM Framework (2020). This means it is in alignment with current best practice from the rest of industry and the '*ISO 19650'* standards.
c) Although the framework focused on UK standards, much of the content of the framework is generic in nature, and the focus on international standards means it can be of benefit to FMs and other BIM stakeholders from outside the UK.
d) The framework can be used in real life projects as an awareness and mobilisation check list. Practitioners can use it to keep track of specific CSF they have reviewed. It also uniquely provides the readers with a wealth of guidance and links to information sources, which can help readers who are interested in understanding the topics covered in more detail.
e) The research also led to several best practice guides with BIFM (IWFM) including the '*EIR Template and guidance*' by Ashworth and Tucker (2017a) and the '*BIM Data for FM systems'* by Ashworth et al. (2020) which have helped contribute to the knowledge and industry.

17.6 Recommendations for future studies

The following recommendations were identified for further research:

a) The framework was fully validated using a two-stage process with FM/BIM experts. Further investigation and assessment on its usability in the wider FM industry, and how it might contribute towards delivering better project outcomes on real-life projects, would help validate it in a wider context. The 'FM/BIM experts' suggested that it could be turned into an online-tool, and the mobilisation checklist made open so it could be configured for specific projects.
b) There is a need to understand how the framework and various other IWFM BIM guidance could form a knowledge basis for FMs in practice. As the PhD is being completed possibilities are being

discussed with bodies such as BSI and the UK BIM Alliance as to how the framework could support the wider industry and be measured in practice.

c) The research and associated work on the '*EIR Template and Guidance*' (Ashworth and Tucker, 2017) pointed towards the need to develop further guidance for the OIR/AIR. Although some people believe these documents cannot be standardised, the researcher (and many colleagues) are of the view there are many common elements in terms of reporting needs, types of assets to be maintained, etc. For many projects the same content is being rewritten and general guidance on writing OIR and AIR would be very useful to many FMs.
d) The researcher is convinced upskilling clients/FMs will help the start of the BIM process by ensuring they can competently order BIM projects. Research into what specific skills would enable clients/FMs establish clear client requirements would be of value.
e) The study identified many practitioners would like to see more case studies into issues that directly impact them, e.g., the process of defining the information requirements and then the quality management process of moving data into CAFM systems.
f) The question 'what data is actually needed in operation?' is often not easy for clients/FMs to answer. Research establishing a generic 'FM data catalogue' aligned with standard 'IFC P-Sets' would help ensure that the right attributes are captured by the supply chain and can be transferred into FM management systems
g) There is a need for a better level of understanding of 'what data needs to actually go into the BIM model(s)' vs 'what can be captured or stored in other platforms or databases'. Remembering you can only export from the BIM model what you have already put in it, in many cases, it may not make sense to load information/data into the BIM models to then transfer it to another system.
h) More research is required around how BIM models and associated data can be kept current as this is a problem many organisations will face over the coming years.

17.7 Final conclusions and chapter summary

The research successfully addressed all the research objectives and questions culminating in the final production of the '*FM-BIM Mobilisation Framework'.* The convergent design worked well, providing a practical way to bring together both quantitative and qualitative CSF inputs from the questionnaire with the 'general FM industry', and interviews with the 'FM/BIM experts' retrospectively.

The interviews were especially interesting as they provided a chance to explore the CST established from the literature review in depth. The interview environment allowed for a full exchange using probing questions to explore and follow up on points of interest. The wide range of expertise, which not only included FMs but architects, planners, BIM information experts and even legal experts, allowed for questions to be asked across all stages of the *'RIBA PoW'* stages from inception to handover to operation. The questionnaire gave a good snapshot in time of the 'general FM industry' awareness of BIM. It would be interesting to see, a few years on, if a similar study would return the same results.

The ‘side-by-side’ analysis approach allowed the quantitative data to be presented as narrative qualitative text enabling the merging process to take place. The final list of CSF was then integrated into the framework. The two-stage validation process also worked well using the same group of FM/BIM experts to validate the framework. The experts involved were all of the opinion the framework would benefit and be of use to FMs and other professionals involved in the BIM process.

Finally, it is hoped the ‘*FM-BIM Mobilisation Framework’* will give back to industry a useful tool to help FMs and other professionals achieve success on their own BIM journeys.

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Appendices

The following section lists the appendices, which support the research study.

Appendix A: Simon Ashworth - list of publications

Note: full list of publications is available at:

https://www.researchgate.net/profile/Simon_Ashworth2

1. Ashworth, S., Carey, D., Clarke, J., Lawrence, D., Owen, S., Packham, M., Tomkins, S. and Hamer, A. (2020) *BIM Data for FM Systems: The facilities management (FM) guide to transferring data from BIM into CAFM and other FM management systems*, Institute of Workplace and Facility Management
2. Ashworth, S. and Heijkoop, A. (2020) *Bestellerkompetenz: Kritische Erfolgsfaktoren für ein BIMProjekt*, FMPro, Zurich
3. Ashworth, S., Druhmann, C. and Streeter, T. (2019) The benefits of building information modelling (BIM) to facility management (FM) over built assets whole lifecycle, *18thEuroFM Research Symposium*, Dublin, Ireland
4. Ashworth, S., Tucker, M., and Druhmann, C. (2018) Critical success factors for facility management employer's information requirements (EIR) for BIM, *Facilities*, Vol. 37 No 1/2 pp 103-118
5. Meslec, M., Ashworth, S. and Druhmann, C. (2018) Integrating Life Cycle Sustainability Analysis with BIM, *17thEuroFM Research Symposium*, Sofia, Bulgaria
6. Ashworth, S., Tucker, M., and Druhmann, C. (2017) Employer's Information Requirements (EIR): A BIM case study to meet client and facility manager needs. *16thEuroFM Research Symposium*, Madrid, Spain
7. El-Arousy, M., Ashworth, S. and Druhmann, C. (2017) Swiss-COBie: Development of a design for information exchange between planners, constructors and FM in Switzerland. *16thEuroFM Research Symposium*, Madrid, Spain
8. Ashworth, S. and Tucker, M. (2017) *Employer's Information Requirements (EIR): Template and Guidance*, British Institute of Facility Management http://www.bifm.org.uk/bifm/knowledge/Operational_Readiness, ISBN: 978-1-909761-27-8.
9. Ashworth, S. and Tucker, M. (2017) *FM Awareness of building Information Modelling (BIM)*, PhD survey, British Institute of Facility Management
10. Druhmann, C. and Ashworth, S. (2017) *Das FM und seine Daten*, FMPro, Zurich
11. Druhmann, C. and Ashworth, S. (2016) Rating systems in conjunction with BIM deliver outstanding possibilities for sustainable construction. *Journal of Civil Engineering and Architecture Research*, Vol. 3, No. 10, 2016, pp. 1711-1717.
12. Ashworth, S., Tucker, M., and Druhmann, C. (2016) The role of FM in preparing a BIM strategy and Employer's Information Requirements (EIR) to align with client asset management strategy. *15thEuroFM Research Symposium*, Milan, Italy
13. Ashworth, S., Tucker, M., Druhmann, C., and Kassem, M. (2016) Integration of FM expertise and end user needs in the BIM process using the Employer`s Information Requirements (EIR). *CIB World Building Congress 2016*, Tampere, Finland

14. Ashworth, S. and Druhmann, C. (2016) *BIM: Die Sicht der EU* (Switzerland), BIM2FM, Zurich, Switzerland
15. Ashworth, S. (2016) *Was die Schweiz von England lernen kann (What Switzerland can learn from England)*. Digital Bauen, Zurich, Switzerland
16. Ashworth, S. and Druhmann, C. (2015) *FM Expertise und Digitale Gebäudemodemodelle*, FMPro. Zurich, Switzerland
17. Carbonari, G., Ashworth, S. and Stravoravdis, S. (2015) How facility management can use building information modelling (BIM) to improve the decision making process. *15thEuroFM Research Symposium*, Milan, Italy
18. Ashworth, S. (2015) *BIM und FM in der Schweiz*, IFMA spotlight research workshop, Zurich, Switzerland
19. Ashworth, S. and Druhmann, C. (2015) Integration of FM and asset management expertise in digital 3D building models. *7th International Facility Management Congress*, Vienna, Austria
20. Ashworth, S. (2015) *BIM and FM in Switzerland: A survey of the perception of BIM by FM professionals in Switzerland*, IFMA Schweiz. Zurich, Switzerland

Appendix B: List of primary activities in the BIM process (based on BS 8536-1:2015)

No	Primary FM activities in the BIM process
1	Identify the business-related activities and processes that are to take place in the new or refurbished asset/facility. This should include the FM strategy and Information management strategy (OIR, AIR and EIR) approach of the owner and how the information will be transferred from the PIM to the AIM (e.g. CAFM system) and how commissioning and training of FM staff will be carried out at handover.
2	Identify extent to which BIM is to be used and who will manage the process as well as how the relevant BIM data will be transferred to the owner's operational management systems. This should include how the CDE will work and consider how 3D walkthroughs can help design reviews.
3	Identify range of potential security issues that are applicable to the owner's business, assets/facilities and personnel. This will help identify key information needed to mitigate risks.
4	Carry out detailed stakeholder analysis to determine interests and needs in the asset/facility. Identify the owner/operator/end-users' and other key stakeholders' high-level needs. Define roles and responsibilities of all parties using a matrix approach and put in place communication plans.
5	Develop required project outcomes and targets for the operational performance and durability of the asset/facility from these identified high-level needs.
6	Determine how the design and construction team could assist in identifying these high-level needs and also how they will develop the design brief.
7	Identify the particular competences, skills and experience that the design and construction team need to bring to the project delivery process.
8	Determine the basis of the engagement of the design and construction team and its relationship with the operator, operations team or facility manager, as appropriate, end-users and other key stakeholders.
9	Identify the particular competences, skills and experience that the operator, operations team or facility manager, as appropriate, could contribute to design and construction.
10	Determine the targets for energy use, CO_2 emissions, water consumption, waste reduction, capital cost, operational cost, functionality and effectiveness and any other performance targets and also consider how seasonal testing will be carried out to prove designs.
11	Identify existing policies and standards that are relevant to the design, construction and operation of the asset/facility (e.g. internal design standards, construction standards and asset/facilities management standards).
12	Identify a design standardization policy, where appropriate, drawing on any owner-defined standard design elements, especially those driven by operational needs.

No	Primary FM activities in the BIM process
13	Assemble lessons learned from previous projects, including validated case studies and other reliable, documented sources.
14	Establish and set up a risk and opportunity register.
15	Establish space needs and plan how the asset can be made to accommodate changes in space needs (adaptability, re-use, quantity and function) over its lifetime.
16	Prepare a project management schedule to show the relationship between the phases in the project, the main activities, target dates and other key milestones.
17	Identify the performance benchmarks for this type of asset/facility for use in establishing targets and the processes for subsequently measuring performance. Also agree how reviews of design will be carried out to include operational input from FM teams.
18	Identify approach to POE and defined periods of aftercare (e.g. 6-8 weeks for initial aftercare, 3 years for extended aftercare) setting targets for measuring actual performance vs target performance of the asset/building.
19	Establish an initial view of operational expenditure, covering operations, maintenance, replacement costs, and costs relating to energy use, water consumption and waste disposal.
20	Identify any existing facilities management strategy and supporting policy or procedures and, where none exists, prepare such a strategy in outline.
21	Identify required security arrangements for the asset/facility in operation and during design, construction, testing and commissioning, handover and start-up.
22	Identify a holistic approach to address security around the aspects of people and process, as well as physical and technological security.
23	Establish expected CAPEX and OPEX costs as well as establishing the need for any simulation models (e.g. energy performance model).
24	Consider how the asset register will be developed with any unique numbering systems. Also consider the asset replacement strategy will operate over the life of the asset/building. Set up “Facility User” and “Facility Technical” guides and consider digital training guides.

Appendix C: Pilot questionnaire: BIM and FM – Switzerland

BIM and FM
Research and Practice Workshop

Appendix – BIM and FM Survey Findings

2015

BIM and FM – Switzerland

Ashworth Simon
(ashw@zhaw.ch)
PhD Supervisor:
Professor David Bryde - LJMU
5/31/2015

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BIM and FM
Research and Practice Workshop

Introduction

As part of the IFMA Switzerland "BIM and FM" Spotlight Event on the 30th March 2015 in Basel, the ZHAW initiated an online survey as part of a PhD research project undertaken by Simon Ashworth ashw@zhaw.ch asking IFMA members to help establish a benchmark regarding the current perception of BIM and FM in Switzerland. The results show how Facility Managers and other experts in Switzerland perceive BIM and how it will impact on the FM industry in the future.

Survey Participation and Findings

The response rate was good with a 52 fully completed questionnaires (33.7%). There was a wide variety of job functions represented (some with multiple roles) as shown in Fig 1. Others roles included: Data Managers, Surveyors and Government Administration roles. Most of the responses (34.6%) were from people working for companies with more than 1000 employees as shown in Figure 2 but there were responses from all sizes.

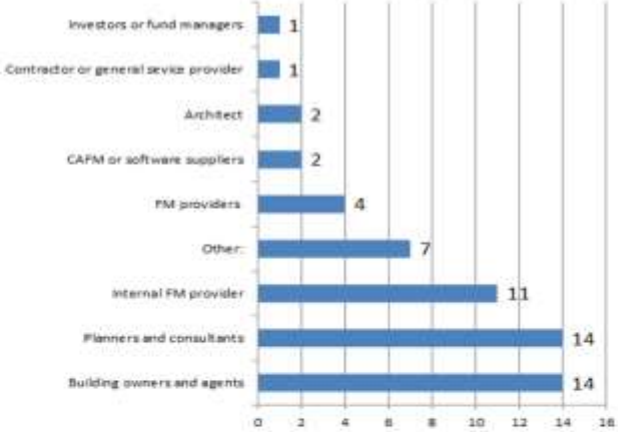

Figure 1: Job functions of participants

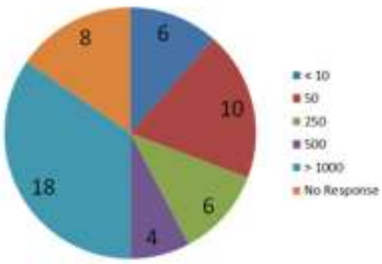

Figure 2: Company size

This indicates there is a wide interest in BIM and how it will impact on business in the future across the different stakeholders responsible for property portfolios and for large and small companies alike. The survey also asked respondents about their responsibility with respect to different types and size of their property portfolios. The most common type of portfolio was not surprisingly Office / Administrative space but there was a good representation across a range of different RE. Table 1 shows the range with the total and average m2 GF for each type.

Table 1: Real Estate Portfolio of Respondents

	Type of Space	Total [m2 GF	Average [m2 GF
A	Office / Administration [m2 GF]	6 516 093	310 290
B	Residential Flats [m2 GF]	1 500 000	251 056
C	Retail [m2 GF]	1 816 500	454 125
D	Hospital or care home [m2 GF]	1 330 000	166 250
E	Public Offices and Buildings [m2 GF]	1 735 025	347 005
F	Laboratories or Industry [m2 GF]	1 889 407	134 958
G	Other [m2 GF]	1 759 500	351 900

The survey also shows that BIM is already a topic of interest amongst stakeholders with 32% of respondents noting they already had some experience with BIM. Although BIM is a relatively new topic to FM 31.7% believe BIM will have an impact on FM in Switzerland in the next 1-2 years, whilst 44% felt BIM will impact on FM in the next 5 years. It was clear from responses that stakeholders are keen to see the establishment of BIM Standards and Guidelines. 34.8% of respondents were already aware of the Swiss Guideline SIA Merkblatt 2051 "Building Information Modelling" currently in development. 18.6% people were also familiar with the ISO 15686 Standard on Life Cycle Costing and some were familiar with the British PAS1192-2 and 1192-3 standards. (It was noted the PAS1192-2 standard will become an ISO Standard for Europe).

The survey also established that although the "FM industry is not yet sure what BIM actually is" respondents perceive BIM as a new way of working in collaboration and not just being about software. They also perceive that BIM can be used for both new and existing buildings.

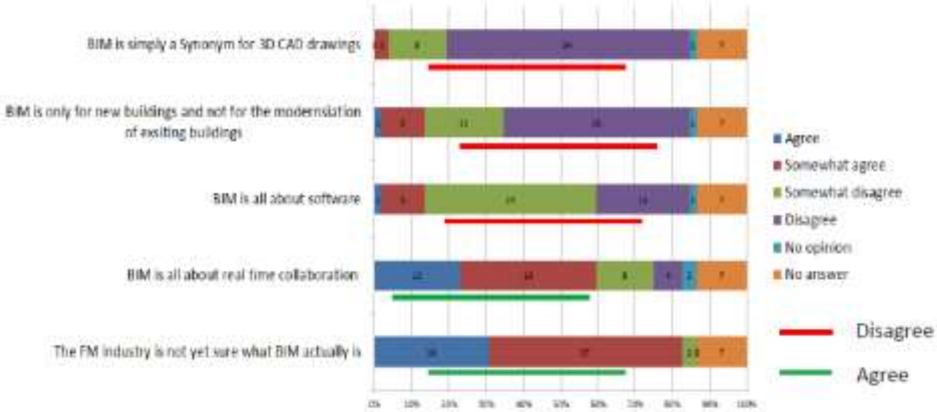

Figure 2: Perception of BIM

When asked how BIM might be used to benefit FM 28.3% of respondents felt that both Cost savings and Life cycle costing would be the key benefits. Feedback also indicates stakeholders are looking for case study evidence for ROI. 26.7% think BIM will help increase operational efficiency and 12.6% felt BIM may impact on reduction of carbon emissions and energy savings. Other potential benefits identified included: building databases, more exact planning, CAFM data input, QS for FM tenders, business continuity and service optimisation.

Several respondents note that there is a need to change "traditional ways of working and approached to contract structures and fee structures" before BIM can be easily implemented in Switzerland.

The key concerns raised by respondents regarding BIM were: data management and the cost of implementation as shown in Figure 3

Figure 3: Concerns regarding BIM

Other issues respondents were concerned focused on if BIM will result in the creation of "data cementries" and that there are many different interpretations of what BIM acually is. Discipline with respect to the flow of data, the need to consider standards, laws and legal liabilities, a possible lack of financial investment by customer due to clarity of benefits, buy in by all stakeholders (resistance by some) and the approriate and early involvment of FM were all raised showing that BIM has a way to go before these issues are addressed.

Respondents note that a paradigm change in way people work is required. Figure 4 shows the key barriers respondents raised with respect to possible use of BIM and FM in practice. The key barrier being the lack of internal expertise with respect to BIM showing the need for education and training with respect to BIM as a process and how it can be implemented. Cost was also a key barrier backing up the need to provide case study examples of ROI. This possibly connects with another barrier the current lack of demand from clients although this may change as BIM becomes more established as the norm.

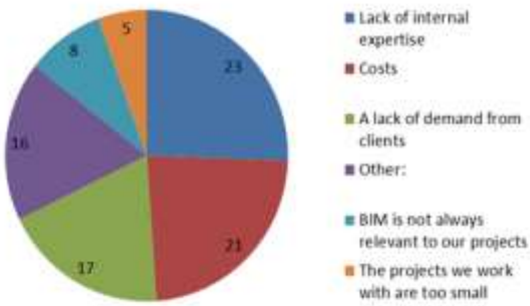

Figure 4: Barriers to BIM

The respondents however felt that there was a wide range of ways BIM may potentially benefit FM. These are shown in Figure 4. It is clear that respondents feel

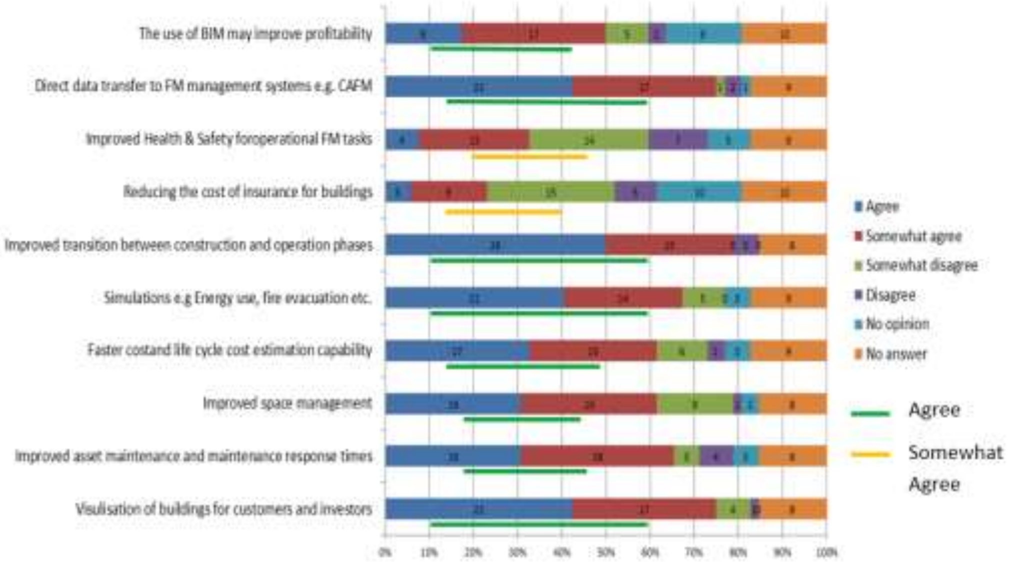

Figure 5: The Potential Benefits of BIM to FM

In summary the survey indicates that BIM has some way to go before it is fully established in Switzerland. There are concerns and barriers that need to be overcome if BIM is to become the norm. This is normal and requires a paradigm change in thinking to establish BIM as a new way of working together with the associated technology that is part of the BIM process. However the outlook shown by the results indicate that the perception is that BIM is likely to have a significant impact on FM in the next 1-5 years with clients and other stakeholders becoming more aware of the potential benefits of BIM to FM. The survey also indicates there is also a need for further education and training to allow FM and other stakeholders to fully acquaint themselves with the BIM process.

The survey results will form part of an ongoing PhD research project looking at "BIM and FM and the Role of Facility and Asset Management in the BIM Process in Improving Assets for Society". This project will compare BIM and FM in Switzerland with the more advanced market in the UK and other countries. The intention is to run further versions of the survey and to improve and refine the questions to obtain improved quality and quantity of data. If you are interested in BIM and FM, and would like to help contribute towards the knowledge or have a project which might be used as a possible case study for this PhD please contact Simon Ashworth ashw@zhaw.ch

Appendix D: Data fields (FM criteria) for planning, operating and maintenance

This work is based on project work at the IFM in Switzerland (Hubbuch, 2020).

Life Sciences und Facility Management

BIM2FM
Data fields for planning, operation and maintenance

Data Structure:

Structure of building elements:

Element:	a specific building component or technical element, including an ID-Nr.
Type of Elements:	building components, technical system (HVAC, S, E, BA), technical device (like a beamer, cooling device, washing machine, dishwasher etc.), (Appliance, Furnishing), according to eBKP-H
Element type:	typed building component, according to eBKP-H, with systematic of denotations in the specific building.

Structure of the data:

Machine-readable data:	Data, which can be read with a BIM and/or with a CAFM software program in a specific data format (e.g. IFC,xlm, xsd?)
Data for CAD:	Data, which can be read with CAD (or possibly with BIM or CAFM (Format like dwg, dxf)
Data readable for humans:	Data, which can be read by humans as pdf
Data for Excel:	Demand: Details, Components of systems
Images:	Photographs or other images in some kind of image format (jpg, gif, png)

Machine-readable data

Data of elements; machine-readable:

- Name/label/number
- Element type (Name/label/number according to eBKP-H)
- Location (tract, floor, room)
- geometric location + geometric dimensions, Form (in 3-D-BIM-Model)
- Size resp. dimensions (e.g. m^2, m, ...)
- Builder- or tenant fit-out (one or the other)
- Date of installation
- Date of inspection
- Date of the end of the warranty period (open defects)
- Date of the end of the warranty period (hidden defects)

Data per element, CAD: as before, from the geometry of the BIM-model generable (IFC → dwg, dxf?)

28.05.20/Datenfelder für FM_Hubb.docx Page 1 Prof. Markus Hubbuch

Data per element type, machine-readable:

Calculation LCC / planning of replacement

minimal and maximal expected lifespan (years)

specific building and installation cost per element (Fr. per element at size/dimensions)

Expected specific cost of operation per element and year (Fr. per element at size/dimensions)

Expected specific cost of maintenance per element and year (Fr. per element at size/dimensions)

Calculation LCA

Specific grey energy of production (in kWh primary energy per element of size/dimension)

Specific grey CO_2-emissions for production (in kg CO_2 eq. per element of size/dimension)

Specific environmental pollution of production (in UBP, Eco-points, per element of size/dimension

Planning, operation

Number of necessary visual controls per year (0 – n)

Number of necessary operation actions (e.g. refill, consumables or replacement wear parts) per year (0 – n)

Number of necessary inspections per year (0 – n)

Number of necessary services per year (0 – n)

Energy calculations

On elements of building structure:

- specific heat capacity c (J/kg K)
- specific density δ (kg/m^3)
- thermal conductivity λ (W/m K)
- **Vapour-Diffusion number** μ (-)
- if element = window/exterior door/gate:
  U-value (W/m^2 K), g-value (-), τ-value (-)

On technical elements, systems, technical device:

- efficiency η (-)
- possibly Coefficient of performance COP (-)
- possibly specific power per size (W/element of size)
- possibly power per element (W)
- possibly expected hours of operation per year (h)

Operation

Name, address producer

Name, address installer / contractor

Name, address planer

Information per element type, in pdf

Unlimited…., different requirement per producer and element type e.g.:

manufacturer specifications

Product description

Schemes etc.

Operations instructions and maintenance manual (divided by operating requirements, inspections, maintenance / services)

Safety requirements, notes

Safety verification etc.

Commissioning protocol

Inspection protocol

Warranty certificate

Etc.

For elements of a system (see above): possibly data for excel

Data as images	Photos of not any more visible installations (in particular of insertions, duct installation etc.), with information of date and exact location Photos of erection, inauguration etc. Alternative: Image/Photo documentation (e.g. of installation insertions) as pdf attached to element.
Data for excel	**If element = System:** Lists of parts, wear parts, replacement parts (as xls) List of facility components (with location operating requirements, maintenance and inspections per part) (as xls) List of cables (if system = electric installation) (as xls)

Appendix E: Pilot workshop: *BIM and FM Research & Practice Workshop*

BIM and FM
Research and Practice Workshop

Introduction

On the 1st June 2015, a group of twenty researchers, FM practitioners and construction professionals from the UK, Switzerland, Germany, Denmark, Norway, Netherlands and the US gathered at the prestigious Glasgow Riverside Museum for a "FM and BIM - Research and Practice Workshop" as part of ongoing efforts by the EuroFM Practice Network Group (PNG) to bring together academic researchers and FM practitioners to discuss important issues impacting on FM such as BIM.

Figure 1: Karin Schaad, Chair of the EuroFM PNG welcoming the group and opening the workshop

The workshop was jointly organised by Simon Ashworth from the Zurich University of Applied Sciences (ZHAW), Martin Bänninger (eneco) from Switzerland and Ivor McCauley from Glasgow Life who hosted the event at the Riverside Museum, one of a 168 buildings in their property portfolio. The event was well supported with representation from various international FM professional bodies including IFMA, the Danish FM Network (DFM), the Norwegian FM (NBEF) and STATSBYGG Associations and members of the BIFM Soft Landings group . Academics from the Zurich University of Applied Sciences and the Netherlands Hanze University Groningen joined with FM and construction experts including BAM UK and BAM Deutschland AG, Mace Macro, ISS, Halter AG, eneco, Robertson Facility Management, FES FM, Auwiesen Immobilien AG, UniversitätsSpital Zürich and Glasgow Life.

The Glasgow Life Experience of BIM and FM

Ivor McCauley presented "The Glasgow Life Experience of BIM and FM in practice so far" highlighting how the BIM process was used for the first time on the Kelvin Hall project in Glasgow. Key lessons learnt were:

Figure 2: Ivor McCauley presents the "Glasgow Life Experience of BIM and FM"

- All stakeholders involved found themselves on a steep learning curve as most knew little about BIM and how to implement BIM as a process on a project. The UK PASS 1192 Standards and BIM Task Group BIM Guidelines were used as tools for all to get up to speed.
- BIM should be seen as a process, not as a tool or piece of software. The BIM process required a different way of thinking and working together by all stakeholders involved.
- BIM helped collaboration between the FM and construction teams as FM were actively asked by the construction team for their input and involvement during design.
- Careful consideration should be given as to the Employers Information Requirements (EIR) and when the EIR is issued. For Kelvin Hall it was at RIBA Stage 3 (issued by the design team). The aim for future projects (e.g. the "Burrell Collection") is that FM take ownership and specifies the EIR in agreement with the design team earlier and ideally at RIBA Stage 0.

- For the Kelvin Hall project "the primary purpose of the BIM Model upon completion was to identify service runs and access routes and their interface with structural and architectural elements". Note: The workshop considered whether this statement was myopic in concentrating on the build and not the functionality of the facility. The discussion concluded that the FM team should take ownership of the EIR to ensure it meets their needs and so that FM get what they need at handover from construction to operation.

BIM and FM - Survey

Simon Ashworth presented the findings of a survey carried out by ZHAW and IFMA Switzerland in March/April 2015 as part of his PhD with Liverpool John Moores University focusing on "BIM and FM". The aim was to benchmark the current perception of BIM by FM practitioners and key stakeholders in the whole life process in Switzerland. The findings indicate that BIM is seen as important issue for FM with 32% of respondents saying they already had some experience of BIM and 31.7% believing BIM will have a significant impact on FM in Switzerland in the next 1-2 years and 44% in the next 5 years. The intention is to also carry out a similar survey on a larger scale in the UK.

Figure 3: Simon Ashworth presents the findings of the "BIM and FM" survey

Full details of the survey results can be found as an appendix to this report.

BIM and FM Workshop: Focus on EIR FM Outputs

Figure 4: The Burrell Collection

Three working groups discussed the role and needs of FM in the BIM process with a focus on trying to establish "FM Outputs" needed for an FM orientated EIR for the pre-tender process. The workshop was set in the context of planning the FM operation for the new "Burrell Collection" building. The groups were asked to consider the PhD research question:

"What information do facility and asset managers need from the Capex (capital expenses) phase of a project to deliver maximum added value in the Opex (operational expenses) phase?"

The three groups focused on one of the FM perspectives/service areas as follows:

1. **Operational:** Use "Space Management" as an example Service – what is needed?
2. **Financial:** What cost data should be included?
3. **Personnel:** What training and skills will FM need?

The groups then reconvened and presented their work to the whole group. A summary is as follows:

1. **Operational:** Space Management

There was a general discussion in the group about the many different needs and the information required to allow FM to efficiently manage "Space Management" as a delivered service. Specific outputs the FM Team would be looking for from the BIM process and models were:

Figure 5: Susanna Caravatti-Felchlin Chairwomen IFMA Switzerland presents the Space Management Outputs

- **Space reporting:** The BIM models should give FM the ability to quickly generate a wide range of management reports to identify all spaces in a building/asset, how they are used and where appropriate who owns the space or is responsible for it. The information should be delivered in a hierarchical manner with a unique and agreed "space naming system" defined by the customer (as opposed to just using construction numbering) to include as appropriate "locations", "zoning" (for fire evacuation and other purposes), defined "space types" (rented, internal etc.) and "functionality" (use – both planned and potential future use for flexibility). It is also important to understand the level of quality of the space and demands to be made on them.
- **Volumes, sizing and cost data:** The outputs should allow easy and flexible reporting for FM planning purposes with the ability to include data on volumes, sizes and costs information etc. associated with each space for calculation of operational costs per metre, the ability to then benchmark performance, use in tenders and for detailed costing for projects.
- **Inventory of assets related to space:** For each space the assets associated with that space should be easily identifiable and relevant cost and operational data attached to each asset to allow FM the ability to manage the space and assets together as a service. The availability of information early will help FM with detailed transition planning.
- **Logistics planning and concepts:** The FM Team should have a clear understanding of the logistics planning for the movement of people/equipment around the spaces to ensure access routes are available for changing pieces of plant and equipment at the point they need to be replaced.
- **Current and future use concepts**: for how buildings/assets are planned to be used at handover and how they could be used in the future should be provided for each space in the model with explanations of how easily spaces can be reconfigured to accommodate flexibility and change of use of the spaces in the future.

2. **Financial:** What cost data does FM need?

The group debated the different financial information that could/should be attached to the BIM models and how this information could benefit FM in both day to day operational management as well as forward financial planning for issues such as asset replacement, maintenance etc. Specific Outputs the FM Team would be looking for from the BIM process and models were:

Figure 6: Reid Cunningham from BAM UK presents the Financial Outputs

- **Commercial model data:** It was acknowledged that there could be sensitivities around the issue of commercial information but having full transparency of the Builders Procurement cost data will allow FM procurement to understand and build their FM operational and asset replacement programmes faster and more accurately for clients
- **Design efficiencies**: as part of the EIR the FM should be involved to ensure that site/building specific Issues such as transport, logistics etc. are thought through from an FM operational perspective to help the design team ensure better control over "change requests" and to provide "live feedback". This allows better and more accurate checks to be made on sensitivity analysis with checks made as appropriate at every stage/phase.
- **Lifecycle cost data:** Information should be included in the model about the individual assets in terms of cost and life expectancy to allow accurate life cycle calculations and to assist FM with asset replacement programmes.
- **Maintenance and Operational Costs:** The data should include information about maintenance frequencies and service and replacement parts costs for FM PPM schedules with appropriate frequencies and rates. The data should be configured to easily feed into the FM Management systems (CAFM etc.) and be compatible with a recognised system such as SFG20.
- **Schedules of elements:** The data should allow FM to run detailed reports with appropriate filters for various types of "equipment" or "systems" such that costs for maintenance of systems and individual items can be easily calculated, as a whole or per square metre. This should help FM to track planned vs actual costs in greater detail.
- **Asset Classification systems**: All assets should be classified using an appropriate and agreed system as defined by the client and their Asset Management System (OIR and AIR) such as Uniclass 2015, NRMJ etc.
- **Energy and Utility data**: Expected costs for energy/utility usage should be included so FM can compare actual vs planned usage. Design calculations and simulations should be included along with a strategy/plan for the metering of the building to clarify how the energy usage can be allocated around the building/asset. This is especially important in cases where the space will be rented out. **Note:** There was some discussion about if staged payments should be introduced based on energy use verification (apparently this is becoming more common in Norway).
- **Marketability (rental values) of space:** There should be a layer within the model that tracks the cost of the space (dependant on size, views, services etc.) which could be easily updated for companies who are planning to rent out sections of a building/asset and may wish to charge different rates for different spaces.

3. Personnel: What training and skills will FM need?

The group debated the issues around the training and skills that would need to be taken into account in the BIM process including the handover and transition process from build to operation as what skills would be needed in the design phase. The FM team need to acquire certain abilities but it is also about attitudes and new ways of approaching their tasks using the BIM models. Specific Outputs the FM Team would be looking for from the BIM process and models were:

Figure 7: Stephen Beadle from FES FM and the BIFM Soft Landing group presents the FM Training and Skills Outputs

- **Training roadmap:** It was suggested there should be a "FM Training Road Map" put in place in the BIM process to ensure that the FM staff receive the appropriate "pre-handover training" and are fully involved with the "transition commissioning" process at the right time. It is a common experience of FMs that this often gets omitted from planning or is squeezed as people try to meet project deadlines.
- **System Specific Training:** FM staff should have specific training with respect to the BIM models so they understand how to access all the data needed for FM to manage their standard CAFM / BEMS (BMS) etc. systems. It is essential for FM staff to be able to interrogate the BIM models otherwise there is no hope that the models will be kept up to date. It would be a shame if the potential benefits were not realised due to poor training and a lack of understanding as to how the models can be used to FM advantage. The training plans should encompass refresh and continuity training
- **Informing the client and design team:** The FM team should have adequate training and involvement during the design process whilst the models are being developed so that they can give feedback and make suggestions as well as become familiar with the models.
- **Post Occupancy Evaluations (POE)**: The FM staff should be included in the planning of POE from a soft landing perspective to ensure they understand how the BIM process and models will be used to help verify that the building is performing as per the design criteria and also so they can understand any variations that may occur due to occupant behaviour or other factors.

BIM and FM
Research and Practice Workshop

Conclusions and way forward

As a wrap up to the day the group discussed the feedback from the various groups and the plans for further research. The following observations were made:

- The workshop was seen as interesting and a useful day by all participants. It made them realize that as a community FM is on a sharp learning curve with respect to understanding how the BIM will impact on their FM operations.
- It was agreed that BIM is the way forward with respect to how buildings /assets will be delivered in the future. In order to ensure that FM does not fall behind we all need to get to grips with a better understanding of BIM and familiarise ourselves with how it can benefit FM
- FMs need to be actively involved early in the design process and following the logic of PAS 1192-2 we should "start with the end in mind" and think about:
    - What do FMs really need from the BIM process?
    - How should the EIR be structured in such a way that it delivers real benefit to the FM team at the point of handover?
    - Who should take ownership of the EIR? This point was debated and it was agreed as the client representatives FM should inform themselves so they can help pull together the EIR which after all is "the clients requirements"
- The workshop demonstrated how difficult it is to clarify the "FM Outputs" in such a way that they can be succinctly worded and that further work is required in this area. Simon Ashworth explained to the group that the intention of the PhD is to focus in this area. It is the intention to carry out a detailed survey of FMs to get a better understanding about their perception of BIM and what needs to be captured in terms of outputs and then to design models and templates to help FMs create "FM Friendly EIR documents".

BIM and FM
Research and Practice Workshop

Event Attendees:

The following is a complete list of the attendees participating in the workshop from the 1st June 2015 with their company and country of operation.

No	Last name	First name	Company	Country
1	Ashworth	Simon	ZHAW	CH
2	Bänninger	Martin	eneco	CH
3	Beadle	Stephen	FES FM/BIFM Soft Landings group	UK
4	Caravatti-Felchlin	Susanna	UniversityHospital Zurich /IFMA Switzerland	CH
5	Cunningham	Reid	BAM	UK
6	Bort	Bastian	BAM Deutschland AG	D
7	Henderson	Hugh	Mace Macro/BIFM Soft Landings group	UK
8	Jentzen	Gunar	Halter AG	CH
9	Malstrom	Ole Emil	Real FM (DFM)	DK
10	McCauley	Ivor	Glasgow Life	UK
11	McMillan	Gordon	Private Consultant	UK
12	Miller	Ross	Robertson Facilities Management	UK
13	Risse	Robert	Auwiesen Immobilien AG	CH
14	Schaad	Karin	ISS	CH
15	Haakon	Harv	STATSBYGG/NBEF	NO
16	Huesbye	Eystein	NBEF	NO
17	Reitsma	Albert	Hanze University Groningen	NL
18	Whittaker	James	IFMA International	US
19	Keane	Tony	IFMA International	US
20	Jeffrey	Johnson	IFMA International	US

Thanks:

The Author would like to thank Ivor McCauley and Glasgow Life for hosting the event as well as all the attendees for their time and inputting their experience to help the workshop deliver a useful outcome for the next steps in the PhD.

Figure 6: The Riverside Museum, Glasgow

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Appendix F: Interview participation e-mail text

Liverpool John Moores University

Interview Participation Text

Interview – PhD Study

Dear Sir/Madame

Participation in PhD Research Interview

I am currently doing a PhD with the School of the Built Environment at Liverpool John Moores University. The topic of the PhD is '*The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets*'. I would like to invite you to participate in an interview as part of this research, which aims to help the facility management industry by developing a '*FM-BIM Mobilisation Framework*' to help facility managers, and other stakeholders better engage with the BIM process. Your participation would be greatly appreciated.

The interview for the research project will last approximately 1 hour. (where further time is required this will be arranged separately). The interview will follow a structured set of questions and depending on answers may be followed up with further questions as relevant. The interview will be recorded so we can focus on the interview and the interview written up afterwards. As part of the process I will ask for your consent to the interviews being recorded. All information provided will remain anonymous and information will be kept confidential.

If you are happy to participate in the interviews, please print of the attached **Participation Information Sheet** and **Consent Form** and read these before agreeing to the interview. A signed copy of the Consent Form should be returned to me for our records.

Should you have any questions please feel free to contact me using the details below.

Kind regards and thank you for your cooperation.

Simon Ashworth
LJMU, School of the Built Environment
S.J.Ashworth@2014.ljmu.ac.uk
Tel: +41 79 138 68 52

Appendix G: Interview participation information sheet

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Name of Researcher and School/Faculty

You are being invited to take part in a research study being undertaken by Simon Ashworth from The School of the Built Environment at Liverpool John Moores University. Before you decide to participate, it is important that you understand why the research is being done and what it involves. Please take time to read the following information and ask if there is anything that is not clear or if you would like more information so that you can decide if you want to take part or not.

What is the purpose of the study?

The purpose of the study is to investigate how the use of operational know-how (in terms of critical success factors) from people who create, manage and operate buildings can be used to help improve the BIM process and in the early stages in the life of a project. This should ensure that buildings and assets are built in such a way that they meet the needs of the end users when the buildings are handed over to the Facility Managers. The study is being managed by and will support the PhD work being undertaken by Simon Ashworth in this area. I would like to agree a date and time that is convenient to yourself for conducting an interview.

Do I have to take part?

Your participation is voluntary, and it is up to you to decide whether to take part. If you do, you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason. If you wish to receive, a summary of the research findings on conclusion of the studies please let me know by email and this will be arranged in due course.

What will happen to me if I take part?

The interviews for the research project will last approximately 1 hour. The interview will follow a structured set of questions and depending on answers may be followed up with further questions as relevant. Your answers will be used to help inform the research and build an '*FM-BIM Mobilisation Framework*' with advice for other practitioners. It is intended that the interviews are recorded so we can focus on the interview and then the interviews will be written up afterwards. You will be asked to give your consent to the interviews being recorded. All information provided will remain anonymous and information will be kept confidential.

Are there any risks / benefits involved?

There should be no potential risks to participating in the research. However, the benefits should allow the researcher to help contribute towards the FM community and its engagement with the BIM process through the development of the '*FM-BIM Mobilisation Framework*'. This aims to supply guidance to FM professionals involved in BIM projects. The framework will be made freely available on completion of the work and might also be used by other stakeholders involved in the BIM process.

Will my taking part in the study be kept confidential?

All information given and used in the study will be kept confidential during and after the study. Transcriptions of each interview will use a separated coded letter/number system, which will ensure that all transcribed texts from interviews remain anonymous with respect to individuals and organisations. **Note:** This study has received ethical approval from LJMU's Research Ethics Committee No: 15/BUE/004

Contact Details of Researcher:

Please contact me using the details below if you have any questions or anything is not clear.

Simon Ashworth, PhD Student
The School of the Built Environment, Liverpool John Moores University
S.J.Ashworth@2014.ljmu.ac.uk (Tel: +41 79 138 68 52)

Contact Details of Supervisor

Dr Matthew Tucker:
The School of the Built Environment, Liverpool John Moores University
M.P.Tucker@ljmu.ac.uk (Tel – School +44 1512312861

The School of The Built Environment, Liverpool John Moores University, would like to thank you for agreeing to take part in this research.

If you any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix H: Interview consent form

Liverpool John Moores University

Interview Consent Form

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Researcher:

Simon Ashworth
LJMU, School of the Built Environment
S.J.Ashworth@2014.ljmu.ac.uk
Tel: +41 79 138 68 52

The Participant:

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐
2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐
3. I understand that any personal information or direct quotes collected during the study will be anonymised and remain confidential. ☐
4. I understand that the interview/focus group will be audio / video recorded and I am happy to proceed. ☐
5. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised. ☐
6. I agree to take part in the above study.

Name of Participant	Date	Signature
Name of Researcher	Date	Signature
Simon Ashworth		

Note: When completed 1 copy for participant and 1 copy for researcher

Appendix I: Interview protocol

Liverpool John Moores University

Simon Ashworth: PhD

Industry experts interview protocol

Research title:

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Introduction and scene setting (5 min)

- Confirm the interview format and briefly explain the research aim (see below)
- Explain the expected benefits to academia and FMs in practice
- Confirm permission to record the interview and the confidentiality of data

Research aim:

The research aims to establish a range of CSF, which will enable Facility Managers (FMs) to be better prepared for successful involvement in BIM projects. The interview questions are part of a concurrent methodology to gain feedback from FM/BIM industry experts building on other findings already established via my PhD:

- **Questionnaire:** issued to the wider '*general FM industry*' in March 2017 with the aim of benchmarking current '*facility manager awareness of BIM*'.

All the findings will be combined/triangulated and used to develop the basis of a '*FM-BIM mobilisation framework*' to help FMs better engage with BIM projects in such a way that they can optimise assets and buildings in operation. The specific aims of this interview are to discuss:

- CSF which will help enable FMs to successfully engage in BIM projects
- CSF to early FM involvement during the early stages of the BIM process
- CSF to overcome barriers to the use and adoption of BIM
- CSF to help realise the benefits of BIM in the operational phase of buildings
- CSF to enable better FM-BIM mobilisation/handover in BIM projects

Request permission to start recording the interview

Part A: Background information about the interviewee (5 min)

1. For the record please confirm your name, age and job title
2. What is your current function, how long have you been working in this position?
3. What sector(s) does your organisation work in and what is their core business?

4. What stakeholder role do you see yourself fulfilling in the WLC of buildings?
5. Which other stakeholders in the WLC process do you interact with most in your role?

Part B: Experience of FM, the Whole-life Cycle (WLC) process and BIM (15 min)

6. Please describe your personal experience of the WLC process, FM and BIM.
7. Is your organisation actively using, or planning to use BIM? If so in what context?
8. Have you/your organisation had experience of: a BIM strategy, OIR, AIR, EIR or BEP? If so please explain in what context.
9. How familiar are you with the RIBA PoW (2013) and its stages in relation to the WLC; and in your role, what stage(s) are you mainly involved in?
10. Have you been involved in the mobilisation of a project using BIM? If so, please describe your experience and possible lessons learnt?

Part C: CSF for FMs in the BIM process (20 min)

My review of literature/industry best practice identified 13 main themes, categorized into three areas; policy, process and people. The themes form the basis of identifying CSF for FMs involved in BIM projects. I am seeking your professional feedback on how the CSF contribute towards the success of FMs involved in BIM projects.

Policy:

14.1 **Government procurement strategy and policy:** is driving change in the construction industry including the adoption and use of BIM to meet its strategy targets (33% cost reduction and 50% sustainability, time and exports).

- 14.1.1 Do you see the government policy and the introduction of BIM significantly affecting the FM sector, and if so in what timescale?
- 14.1.2 Do you think the FM industry is generally well prepared for BIM?
- 14.1.3 What CSF might the FM industry consider to help enable FMs to support the Government in delivering on the strategic targets?

14.2 **Paradigm change towards a WLC approach:** driven by government policy the shift is towards trying to realise value by focusing on a WLC approach.

- 14.2.1 What do you see as the CSF with respect to realising value over the WLC?
- 14.2.2 How do you see the FM industry best supporting this approach and what are the CSF to FM using BIM to deliver long-term value to clients?

Process:

14.3 **Strategic planning using BIM to support Asset Management (AM):** will enable FMs to optimise assets in operation (better transparency, costs, etc.). However, to be successful they must be able to clearly articulate the organisations OIR, AIR etc.

14.3.1 What do you see as CSF for FMs with respect to linking strategic AM planning and BIM to help improve their ability to optimise AM in operation?

14.3.2 What do you see as the CSF in a producing a good OIR and AIR?

14.4 **Early FM engagement in the BIM process:** is vital to bring operational expertise into the process to help design, user/usability, sustainability, and service issues.

14.4.1 Do you agree with this and how important is early FM involvement?

14.4.2 What CSF will help bring FM expertise early in the design (BIM) process?

14.4.3 What do you see as key FM tasks in the early stages of a BIM project?

14.5 **Defining Employer's Information Requirements (EIR):** to avoid a 'garbage in = garbage out' scenario, FMs need to be involved in preparing the EIR. They should define what information is needed, and in what format, for the operation phase.

14.5.1 What information do you see as being key to FM (CAPEX-OPEX phase)?

14.5.2 Have you seen or worked with any EIR guidance documents? If so what were they like?

14.5.3 What do you see as CSF in specifying/producing a good EIR?

14.6 **Realising the potential benefits of BIM***:* The literature/PhD questionnaire identifies many potential WLC benefits: some more relevant to clients and FMs. However, the evidence with respect to realising benefits in operation is often not well documented.

14.6.1 Do you agree with this? And what CSF would make the benefits more credible and transparent?

14.6.2 What do you see as the key potential benefits of BIM to FM?

14.7 **Overcoming barriers to BIM adoption & use:** The literature/PhD questionnaire identified several potential barriers and some pessimism/doubts with respect to whether BIM will really deliver added value to FM in the operational phase.

14.7.1 How do you perceive and feel about such doubts?

14.7.2 What do you see as the key barriers that need to be overcome?

14.7.3 What CSF might help to overcome possible barriers?

14.8 **Knowledge management and data transfer to operational phase:** BIM has the potential to improve the WLC process of generating/transferring/using data and information from design/construction into the operation phase.

14.8.1 Do you agree with this and do you believe FMs are well prepared to plan the information needed in operation?

14.8.2 Do you see COBie as a useful tool for data drops/transfer into client CAFM and other enterprise management software systems?

14.8.3 What do you see as the CSF to ensure the right data and information are captured and transferred to benefit FM in the operational phase?

14.9 **Impact of digitisation and technology:** trends such as big data, sensors, smart buildings etc. will have an increasingly significant impact on the way FMs operate in the future and many maybe linked to BIM.

14.9.1 Do you see any links between these trends and BIM, which might be especially important for the FM industry?

14.9.2 What do you see as the IT and technological CSF to ensure FMs are prepared for BIM and the change these other trends may bring about?

People:

14.10 **Changing perception of FM:** the industry is increasingly perceived as strategically important to organisations in terms of supporting people and assets.

14.10.1 How important do you think the perception of other stakeholders is regarding FM involvement and capability in the BIM process?

14.10.2 What do you see as the CSF in FM strategically supporting organisations?

14.10.3 Do you believe BIM can help the strategic element of supporting people?

14.11 **Improved stakeholder engagement and cooperation (the people factor):** BIM has the potential to improve engagement and breakdown traditional stove piping between stakeholders. People are the most important element in realising success.

14.11.1 What do you see as the CSF in the BIM process to ensure FMs can engage with and contribute meaningfully to a team on a BIM project?

14.11.2 What do you see as the 'people' CSF in making BIM successful in projects?

14.12 **Competence and knowledge about BIM:** there is a potential growing knowledge gap between construction and FM professionals with respect to BIM, indicating the FM industry needs to do more in order to fully engage with BIM projects.

14.12.1 Do you agree with this?

14.12.2 Where do you think the focus of attention CSF should be with respect to FMs gaining competence and knowledge with respect to BIM?

14.13 **Specific FM (BIM) guidance and training:** there are now several guides produced by BIFM and others (Operational Readiness Guide, EIR Template and Guidance, FM Guide to BIM, Soft Landings etc.):

14.13.1 Are you aware of or have you used any such documents?

14.13.2 What CSF are important to ensure FMs can use/benefit from such guidance?

14.13.3 Do you see any key gaps in guidance to BIM?

15. Do you feel there are any other themes with CSF that are critical to FMs being successfully involved in BIM projects?

Part D: Current industry BIM standards/guidance (10 min)

There are a wide range of industry BIM standards/guidance recommended by the BIM Task Group and professional associations (see list below). I am seeking your professional feedback on the importance and usability of the documents to FMs and the BIM process.

16. In your opinion, to what level of detail should FMs be familiar with the documents?
17. Are there any documents CSF you feel are more important for FMs to focus on?
18. How do you see the documents being used in practice and in mobilisation of a BIM project?

Document list:

- BIFM: Operational Readiness Guide: A guide to ensuring long term effectiveness in the design and construction process (2016)
- BIFM: The role of FM in BIM projects (2017)
- BIFM: EIR, Template and Guidance (2017)
- BS 8536-1:2015 Briefing for design and construction –Part 1: Code of practice for facilities management (buildings infrastructure)
- BS 8536-2:2016 Briefing for design and construction. Code of practice for asset management (Linear and geographical infrastructure)
- BS 1192:2007+A2:2016 - Collaborative production of architectural, engineering and construction information – code of practice
- PAS 1192-2:2013 - Specification for information management for the capital/delivery phase of construction projects using BIM
- PAS 1192-3: 2014 - Specification for information management for the operational phase of assets using BIM
- BS1192-4:2014 - Fulfilling employers information exchange requirements using COBie – Code of practice
- PAS 1192-5: 2015 Specification for security-minded BIM, digital built environments and smart asset management
- CIC suite of BIM documents; Professional Indemnity Insurance, Scope of Services for the Role of Information Management and BIM Protocol
- Government Soft Landings
- ISO 55000 (1/2/3) - Asset Management
- ISO 15686-5 - Life Cycle Management
- RIBA Plan of Work (2013)
- BS 8587:2012 Guide to facility information management
- NBS - Digital Plan of Work and BIM Object Standard
- Uniclass (2015) classification system

19. In your opinion what are the CSF with respect to how FMs might best absorb the critical information from such documents?
20. Are you aware of other guidance documents (not listed) that you feel might be critical to FMs involved in the BIM process and explain why?

Part E: Mobilising for BIM projects (15 min)

I am interested in your <u>professional feedback</u> about the following aspects of mobilisation for a BIM project, and what you see as the CSF with respect to:

21. The key role of FMs in the mobilisation of BIM projects?
22. Identifying the key information needed in the AIM by FM at handover?
23. Ensuring the quality and reliability for information data drops and the final AIM?
24. The successful transfer of data into the clients CAFM system?
25. BIM training/familiarisation to enable FMs to access information and data at handover?

I am interested in your <u>professional feedback</u> about key FM activities for each of the RIBA stages. Two BIFM guides, see Attachments A and B, identified some key FM activities:

a) BIFM: Employer's Information Requirements (EIR) Template and Guidance
b) BIFM: The Role of FM in BIM projects

26. Please give your feedback with respect to the FM activities in Attachments A and B and highlight those that you see as CSF with respect to a mobilisation framework.
27. Are there other issues (CSF) you think are key to the '*FM-BIM mobilisation framework*'?

Part F: closing the interview (5 min)

28. Do you have any further comments or questions, which you feel, are important to address for my research?

Thank you for your time and the interesting insights you have given me during the interview. If anything comes to mind later that you would like to discuss, please feel free to contact me.

Appendix J: Interview sample transcript

Record of answers from interview:

LIVERPOOL JOHN MOORES UNIVERSITY

Part A: Background information about the interviewee

1. **For the record please confirm your name, age and job title.**
- XXX (Interviewees identification is anonymised)
- BIM Technologist

2. **What is your current function, how long have you been working in this position?**
- XXX Architects.
- 5 Years.

3. **What sector(s) does your organisation work in and what is their core business?**
- Architecture.
- We call it information management rather than BIM.
- The architecture is the core.

4. **What stakeholder role do you see yourself fulfilling in the WLC of buildings?**
- I have two roles, the first is the lead model author on projects; I will set up the architecture model and maintain it, do all the outputs and drawing schedules and coordinate with the other consultants.
- Secondly, I execute the information management side, writing the project information strategies, the BEPs, EIRs and join up the dots in terms of information from start to end.

5. **Which other stakeholders in the WLC process do you interact with most in your role?**
- I interact with them all.
- Clients to FM, constructors, to consultants and sub-contractors.
- That is because I am in a central management type role.
- I am also engaged in the design side.
- In terms of FM it is because of the information management side.

Part B: Experience of FM, the WLC process and BIM

6. **Please describe your personal experience of the WLC process, FM and BIM.**
- In terms of WLC, I am currently working on the world's first integrated insurance project. There is a full team from the start, one project bank account; one project insurance; it is a fully collaborative project.
- On the FM side, on this project I have been more engaged with the estate team, visiting their office to see what they do and listen to the everyday problems that we never get to know about. Hearing how they manage their assets and working with them to drive the information that they actually need, rather than what we think they need.
- BIM covers everything I do. I have been advocating it since 2009. I started learning Revit so became an 'expert'. I have Beta tested it and have a lot of knowledge on the subject, presenting at a BIM show live during digital construction week, and advocating open BIM principles.
- At the moment, I am working on a book with Bill East, the inventor of COBie. It is not clear in the industry what needs to go into COBie or how to produce it with current technology. I have been developing ways to produce COBie out of Revit and that is what the book is about. It is like a second job.
- I have issues with the Autodesk side of things; they are pushing us in one direction to use their tool. The book is about their tool, but I have developed another process using IFC and hopefully that will also be published as I see more value in it.

- At the end of the day, if you want COBie, the add-in will produce COBie, it is just not part of the IFC model. The target for the book is July this year.

7. Is your organisation actively using, or planning to use BIM? If so in what context?

- Yes, it is at the heart of everything we do. We are trying to align our business process to it.
- BIM is about communication, planning, validation and digitisation of information, which enables efficiency and value. It is all about developing efficient workflows, how information travels from A to B.
- In terms of 3D modelling, I build the strategy around openBIM, so it is fully collaborative and inter-operable with other software programs.
- Everything we do is data centric; we see things in terms of inputs, process and outputs. We are not normal architects in that sense.
- We do not see drawings as a pretty picture they are a way of communicating information. They can overprovide, inter-provide or not provide information in a way that a person on site can utilise it. It is a case of evaluating everything we have been doing in the past to make it more efficient.

8. Have you/your organisation had experience of: a BIM strategy, OIR, AIR, EIR or BEP? If so, please explain in what context.

- Following the Information Plan, I have been working on, I have developed the strategies for that, and they are now the template for the business. They have all been developed in-house.
- We have seen a few other EIRs, which was my motivation for writing EIRs from scratch. Previous ones I have seen have been large documents, but after reading them, I still had no idea what the client wanted.

9. How familiar are you with the RIBA PoW (2013) and its stages in relation to the WLC; and in your role, what stage(s) are you mainly involved in?

- Yes, very familiar.
- We are involved with all stages really. On this project at Dudley College Advance II, which is due for completion in the summer, we are dipping our toes into Stage 7 in terms of Soft Landings using BSRIA. With Integrated Project Insurance (IPI) there is the notion that you have to do Soft Landings, but it is integrated into the whole procurement method. There is a proving period where we have to make sure the building performs. It is fully tested and commissioned. Afterwards we want to educate the end users; with it being an educational facility, the things we have produced in terms of BIM are going to be used by the students teaching the next generation of construction professionals.

10. Have you been involved in the mobilisation of a project using BIM? If so, please describe your experience and possible lessons learnt?

- Yes. With regard to FM, I would have liked more input from the start. Not just FM but the construction industry in general are extremely reactive, they do not like planning things. They respond once a problem happens, rather than planning in advance so that the problem does not occur in the first place. It is a major issue.
- More involvement is required with EIR and AIR, so I know what to put into the model in terms of getting the correct outputs for them.
- At the start, we had a meeting with the estates team, the course leaders, electricians on site, joiners, etc. We should have had a few more meetings, I learn so much from talking to them and what they experience daily. They didn't continue, so now it is a case of what do you need?
- In terms of the BIM documentation, people did not engage with it. I wish there was more engagement with the documents; many of the problems occurred, and could have been prevented, because they were not read.

- Construction projects go on for such a long-time people lose steam halfway through. It is maintaining that motivation. One of the issues with BIM is it is all about sequence and order and maintaining cycles of information. Once you get out of sync problems occur and risk creeps in.
- The main problem with this being an archive project is behaviour. It highlights how peoples' behaviour affects a project. We have a long way to go to change that. For example, people in construction quickly resort to a traditional mind set rather than thinking outside the box. Especially when problems occur, they resort to type, going back into silos and blaming each other. We never learn, it becomes a continual cycle. The whole point of IPI is that it is a no blame culture. If a problem occurs, we work together to deal with and resolve it. You do not spend time backtracking and pointing the finger. It is so deep rooted it will take a few generations to remove that.
- IPI is the method of procurement for this project. It is very similar to IPD but there is one project bank account and insurance, which is meant to increase transparency and an open book approach.
- I did a BIM and IPI presentation at BIM show live during digital construction week about; I will send you the link.

Part C: Critical Success Factors (CSF) for FMs in the BIM process

My review of literature/industry best practice identified 13 main themes, categorized into three areas; policy, process and people. The themes form the basis of identifying Critical Success Factors (CSF) for FMs involved in BIM projects. I am seeking your professional feedback on how the CSF contribute towards the success of FMs involved in BIM projects.

Policy (technology):

11.1 Government procurement strategy and policy is driving change in the construction industry, including the adoption and use of BIM, to meet its strategy targets (33% cost reduction and 50% sustainability, time and exports).

11.1.1 Do you see the government policy and the introduction of BIM significantly affecting the FM sector, and if so in what timescale?

- We talk about technology, people and process; it is interesting that you refer to policy, people and process. The policy is required because it covers it all.
- In terms of people I have spoken to, no, they do not really know about it.
- Personally, I think it will, it has been a major catalyst for change in construction and the end goal of the BIM process is providing the correct information to manage the facility.
- The FM industry will be given all the data and information but need to be able to use it. I think that will be the catalyst to drive the FM industry.
- On the project I am working on, I have developed a process. The client's estates team do not have a CAFM team, they use spreadsheets. I have started with what they do at their level in terms of technology and have kept it simple. One of their requirements, which was brought up at the initial meeting, was that they spend hours looking for information, which I am sure is a familiar theme in FM. PDFs and paper documents are so inefficient.
- What we needed was a model so that if we clicked on a boiler, we could find out what the make and model were. That is linked to the Operations and Maintenance (O&M) information.
- What we are going to deliver to the estate team is traditional O&M information in PDF format and a federated 3D model.
- The model is not in Revit as not all consultants on a construction project use it. It will be used in Navisworks, which has a free viewer. It is relatively simple to use but we will provide training. With the model, they can click on an item to bring up the data and a hyperlink to a cloud-based storage system containing the O&M information. In addition, there will be the asset list, which

is based upon COBie. I went through all the relevant fields with them to produce a spreadsheet, which is generated with the data in the model so it will all be in sync. The hyperlinks will also be in the spreadsheet of the O&M information so they can access it through either the model or the spreadsheet.

- Clients always ask for COBie, which is not helpful. I have been through all the accoutrements they need the data for, so we have a list, and have then picked out what they want. Rather than delivering hundreds of lines of useless data, they will get quality data sets they require.

11.1.2 Do you think the FM industry is generally well prepared for BIM?

- No, it is similar to the way the construction industry was a few years ago. If you talk to FMs, most of them don't understand what BIM really is
- There are a few people talking about it, some of the major organisations say they are doing it, but there is still a lot of confusion and no one is really doing it. I need to do a lot more research into CAFM systems, but I do not think there are that many. If you take COBie, there is a lot of mapping required once you get the data in. It is still aspirational talk.
- About CAFM, I have not talked to anyone specifically.
- I am heavily involved on Twitter, there is the UK BIM community, #theUKBIMcrew, where we discuss and debate issues.
- I have looked at Ecodomus. Systems like Ecodomus which allow linking of different systems are pretty leading-edge approach to information integration

11.1.3 What CSF might the FM industry consider to help enable FMs to support the government in delivering on the strategic targets?

- Engaging more would be a start.
- It is down to education and training, making them aware of the bigger picture and why they are doing it.
- Successful BIM projects require FMs are able to clearly explain to others about assets i.e. building functionality, equipment, and how they will be used
- About the construction industry and BIM, you lose sense of why we are doing it. We are caught up in the BIM bling, but at the end of the day, it is to make the industry leaner and more efficient to cut out waste. It sometimes gets lost. If people have context as to why they are doing something they are more likely to pursue it.
- The government think of the long-term future in terms of smart cities. This is the start of that, and FM will have a massive role to play.

11.2 Paradigm change towards a WLC approach: driven by government policy the shift is towards trying to realise value by focusing on a WLC approach.

11.2.1 What do you see as the CSF with respect to realising value over the WLC?

- The IPI project is all about Life Cycle and designing sustainable equipment and items that can then be reused and reworked.
- One CSF is early engagement and defining requirements at the start.
- Being aware of what makes up the cost; it is not just capital; it is everything else. On the construction side, value engineering may seem to cut capital costs, but in the long term with all the changes it has massive impacts elsewhere that never get factored in. It may cost more. It is realising that you may save pennies elsewhere, but the pounds are piling up further down the line.

11.2.2 How do you see the FM industry best supporting this approach and what are the CSF to FM using BIM to deliver long-term value to clients?

- Passing on their knowledge and experience, they are the people doing it on a day-to-day basis.
- We must predict and guess what happens. The estates team give examples of things that happen daily, such as students taking the light fittings out in the lifts and stuffing cakes in them. If we know about those sorts of problems early, we can change the design of the light fitting.
- There was an issue with a lift that was procured because it was cheap, but it meant the client was trapped in an expensive maintenance schedule and ended up costing more in the long term.
- FMs have valuable knowledge about processes and WLC. However, in other aspects such as adopting BIM standards and grasping the process we have a lot of work to do" (I-7).
- Understanding the little things early makes a big difference later.

Process:

11.3 Strategic planning using BIM to support AM: will enable FMs to optimise assets in operation (better transparency, costs, etc.). However, to be successful they must be able to clearly articulate the organisations OIR, AIR etc.

11.3.1 What do you see as CSF for FMs with respect to linking strategic AM planning and BIM to help improve their ability to optimise AM in operation?

- Early engagement.
- Defining their requirements and needs.
- Planning what should happen in the standards. The asset information model is meant to build as the project progresses. They will receive required information so they can start to plan at an early stage, rather than be given everything at handover and then be expected to work out strategies as to how the building should be maintained that they do not even know how to use. It is the information exchanges throughout the project.

11.3.2 What do you see as the CSF in a producing a good OIR and AIR?

- When I was writing mine, there were no good OIRs or AIRs. What I found helpful was BS 8536-1 which had just come out. It made me join all the dots.
- I based my thinking around that.
- The main things in terms of OIRs and AIRs is understanding the client's business needs and what they want to get out of the facility. In terms of architects, we do not do that well. It is one thing we are focusing on when we are engaged at stage 0. Rather than just producing a beautiful building, it must perform for the client. What is the predicted return on investment? What are the day-to-day activities? Identifying and understanding their needs.
- The OIR I have done is a list of key purposes, understanding and defining them. The next part of the sequence can then be defined. I see it as different steps.
- In terms of the AIR, I want to do a lot more work on the data side and aligning it to COBie and aligning it to BIM principles.

11.4 Early FM engagement in the BIM process: is vital to bring operational expertise into the process to help design, user/usability, sustainability, and service issues.

11.4.1 Do you agree with this and how important is early FM involvement?

- Yes.
- It is critical. I see it in terms of inputs, processes and outputs, so how can you create something and define a process if you do not have the input.
- FM is the input.

11.4.2 What CSF will help bring FM expertise early in the design (BIM) process?

- About this project, it is the procurement method, which has been the catalyst.
- We designed the college's other buildings so getting feedback from the users about the buildings was useful.
- The client was also willing to cooperate and engage.
- The college has their own states departments, but I have worked on large commercial projects in London who contract the FM out to other companies, but do not do that until the end of the construction project. On those types of projects, it is procuring your FM team at the start so they can be fully engaged throughout the process.
- I have never seen a FM consultant replacing a FM team.
- One thing that's important, it's difficult to convince people to engage with and pay for BIM upfront without solid reference examples.

11.4.3 What do you see as key FM tasks in the early stages of a BIM project?

- Defining the needs and requirements in terms of both design and information.
- Talking about lessons learnt on previous projects.

11.5 Defining EIR: to avoid a 'garbage in = garbage out' scenario, FMs need to be involved in preparing the EIR. They should define what information is needed, and in what format, for the operation phase.

11.5.1 What information do you see as being key to FM (CAPEX-OPEX phase)?

- That was the main focus of the EIR I developed, which was missing from most of the EIRs I have read.
- There's still misunderstanding that what's important is quantity not quality of data, especially with respect to what gets put in models
- I listed every type of document required at handover, from traditional documentation, what drawings were required and what was wanted on those drawings to the O&M manual, the H&S file, logbooks, etc.
- Because it was with BSRIA Soft Landing, there was the requirement for an occupants' guide and a technical guide.
- The drawings helped me in producing the model as to what would be needed. I can then produce that drawing early on rather than being given a list of drawings I have to do at the end as an as built.
- The data set includes the data fields that would be required as well as what that kit would be needed for. It has all planned maintenance assets.
- I discussed the 3D model and the format that it would be in.
- They were my initial ideas about what would happen. As we have gone on, I have acquired information, which has refined the process.
- In my world, it would be a fully merged IFC file with local BIM data, but it will not work. I get frustrated, as people do not understand what I am talking about. In my head, it is very complex. People think it is simple, but there is so much work that has to be done initially in order to deliver. The technology process is very complicated.
- One reason I wrote the documentation was to help me. If I do not know what people want, I cannot deliver it.
- Eight years ago, the main theme was to create a list of the benefits of BIM for projects. We are past that now. There have been so many projects utilising the BIM process, there must be data out there that can be taken and analysed.
- It seems strange to hear you say BIM should be used on a project. To me it is the project. It is just managing and being more aware of the information and how wasteful we are with it.

- One of the things that's a massive barrier to WLC is the CAPEX/OPEX argument. Decisions usually are value-engineered in favour of CAPEX savings in the design and construction stage without any real thought for the larger whole-life costs.
- A lot of people see it as an add-on and do not think they need to be engaged with it; it is only for technophiles. Anyone who uses or produces information is just as much part of it as the person who builds the model. It is all centred around information and its efficiency, using technology with more defined processes.

11.5.2 Have you seen or worked with any EIR guidance documents? If so what were they like?

- Yes. When I started writing this EIR, I did not have many examples so used the BIM Task Group template. That like many of the documents had gaps in it. There are lots of issues in terms of semantics. Different people have different perceptions of the same thing. It is a major issue and there are a lot of contradictions and confusion in terms of standards.
- When I did my documentation, I linked everything together. There is consistent language throughout, and I had arguments with myself over what I would call the Revit model. Is it a BIM, an information model or a 3D model? I have tried to quantify and base things around logic, and theory around information.
- A lot of examples were just regurgitation of the standards. They had not applied it to the projects; it was a tick box exercise. The whole point of producing these documents is that they add value, help everyone on the project, and tell you what you need to produce.

11.5.3 What do you see as CSF in specifying/producing a good EIR?

- See previous question.
- The what, why, when, who, how. EIR is what and when, it is defining the initial PoW framework which is usually RIBA. Then defining the key project milestones in which you know what needs to be produced at each of those stages. That is the crux of EIR, what the client wants and when.
- FMs having an active role in the development of the EIR is really vital
- The basic premise of EIR is the client procuring their data.

11.6 Realising the potential benefits of BIM: The literature/PhD questionnaire identifies many potential WLC benefits: some more relevant to clients and FMs. However, the evidence with respect to realising benefits in operation is often not well documented.

11.6.1 Do you agree with this? What CSF would make the benefits more credible and transparent?

- Yes. It is not that well documented. Someone needs to seize the data, analyse it and produce some central documentation.
- In terms of the CSF, when you receive the data at handover, it is using that as a benchmark to then compare the actual data that is created by the building. You then have a comparison. That would be a good benchmark.
- The virtual side of the design and then what they have actually built in reality should be in sync. Sometimes they are not. We then give a product to the client that does not fully work. If it was something you had bought at a shop you would take it back. This is where disputes happen, and you get caught up in legal issues.
- You also have POE the human aspect of it which feeds into the data.

11.6.2 What do you see as the key potential benefits of BIM to FM?

- Efficiency.
- Providing value.
- Reducing costs, you can plan ahead more.

- BIM gives you the richest picture of your asset that you're likely to get. People need to remember the asset information should belong to the asset.
- Real time monitoring of data for your comparisons.
- Monitoring energy bills, if they are too high you can work out why you need to reduce them.
- Using the data to predict.
- If people in the field can visualise and access models on a tablet they can photograph and report faults to the CAFM in-situ rather than having to go back to the office.
- Getting the right information to the right person. If something breaks down and you have to call someone out. It is about getting the right information on that item to that person. If you could do it via a model, they could see exactly where it is and bring up the related information. They could access it via a smart phone. Maybe they then do not have to come back and can possibly order the parts before they get to the site. It is a case of being a trigger.
- It is also safer for the person doing the work - PAS 1192-6.
- Having a BIM object linked to data, which you can use to register faults is a huge benefit.
- Also, a really useful thing is hyperlinks within the model allow users to access information from external sources

11.7 Overcoming barriers to BIM adoption & use: The literature/PhD questionnaire identified several potential barriers and some pessimism/doubts with respect to whether BIM will really deliver added value to FM in the operational phase.

11.7.1 How do you perceive and feel about such doubts?

- I tend to find there are arguments as you go lower down the supply chain because the information has not really filtered down to them, they don't see it and understand what BIM is about. We need to dispose of the idea that BIM is just about software or 3D models. It's about the information and quality of data.
- When FMs can prove we get really good quality data from the BIM process to optimise operations the argument will be over.
- It is all about education and training, right down to the person putting up partitions on site; they might not want to know about it, but they need to know their role in it all and the context behind it.

  Education about BIM is top of the tree of barriers that need to be overcome and addressed if the FM industry is to move forward with BIM.
- I was talking to the college; they think the model is the future. It is about education and knowing what is out there. I am involved in it all the time, so it is normal, when you are out of the bubble it is not. It takes people like us to realise that, we get caught up in it and forget and then end up leaving others behind. We need to pass on and share the knowledge in a way everyone can understand by keeping it simple.

11.7.2 What do you see as the key barriers that need to be overcome?

- They will be the construction professionals of tomorrow. They will have it installed in them so when they come into the industry, they will be ready for it.
- People who are already in the industry, it is about behaviour, attitude, motivation. It is trying to change their way of thinking.
- The construction industry is renowned for not changing and not liking change.
- When I first started discussing BIM the older generation tended to think it was a fad.
- Also, if FMs don't know what's in it for them they won't be able to convince others. That could be an issue and we need to articulate the benefits of BIM and value proposition to help convince clients as to why they should invest in BIM

11.7.3 What CSF might help to overcome possible barriers?

- Education, education, education.
- Behaviour.
- It comes down to procurement with me. For example, on the IPI project, we need a major disrupter to the industry and that is change in BIM because that changes absolutely everything we know about structure.
- Potential barriers and pessimism exist, therefore need to take them seriously, especially if you want to convince people BIM is worth adopting.
- Definitely education and training. The good thing about Advance II will teach students about new ways of construction, digital, off-site, prefabrication, methods of construction, pre-technologies.

11.8 Knowledge management and data transfer to operational phase: BIM has the potential to improve the WLC process of generating/transferring/using data and information from design/construction into the operation phase.

11.8.1 Do you agree with this and do you believe FMs are well prepared to plan the information needed in operation?

- Yes
- No, I do not think so at the moment. On a lot of projects, what happens is the client asks for COBie and then they get a data dump at the end. It is not meaningful, is probably full of errors and contains thousands of lines of useless data. What do they do with that? If you gave them a really well-structured data set, of good quality, they probably still would not know what to do with it.
- It is understanding how the technology can use the data. Are there mapping processes involved?
- There needs to be a better link from construction into FM.
- There is still a line, which needs to blur more and become the next process in the Life Cycle. We produce data in a format they want, we pass it on to them; if they struggle, we engage with them. It is a two-way engagement in the process.

11.8.2 Do you see COBie as a useful tool for data drops/transfer into client CAFM and other enterprise management software systems?

- Yes, COBie is. FMs can carry out quality checks as to if they have received the data, specified in the EIR. COBie exports and a simple checking mechanism can do that in the software. However, people still need to check the actual quality of what's being handed over.
- I am very passionate about structured data in construction, which is why I am a big fan of IFC. When you do it at my level, you see what a mess it all is in terms of classification. There are so many variables in construction there and so many permutations of information. It is layered, multifaceted; it needs a common approach to make sense of it. COBie is that one structured data set that can be used on every project so you know exactly what to deliver, set up your processes once to deliver it, and then on both sides, construction and FM, you will get seamless transition.

(Additional question) In a perfect world, in the future, all the manufacturers make BIM objects which have all the information attached to them, they're in a library and then they can be dragged into Revit and bring all the information with them. Is it that simple?

- That was maybe the idea a few years ago in terms of BIM objects.
- There is still a similar idea, but the information may not live in the BIM object, it may live in an external linked database. There are a few groups coming together who are currently developing

product data sheets, which are a standardised format of content and product manufacturers. UK BIM Alliance is one stakeholder.

- It would be useful for you to look at Lexicon, which is a structured data set.
- We start off with European, then the UK and then to the specific product manufacturers data set, which should all link in with COBie which is going to form the basis of PAS 1192-7. I've not seen anything on it.

11.8.3 What do you see as the CSF to ensure the right data and information are captured and transferred to benefit FM in the operational phase?

- The useful stuff goes back to the AIR. The more you can define your information requirements early on, the more likely it will be valuable to you and deliver what you want.
- In working out the fields for our clients, we took an informal approach, just myself and a couple of people from the estate. I wanted to make it simple, so I showed them a typical COBie spreadsheet with all the fields. We went through each one to ascertain what they would use. We extracted what they wanted rather than delivering a full COBie, which has time, and a cost associated with it; by keeping it simple, we could provide what they wanted.

11.9 Impact of digitisation and technology: trends such as big data, sensors, smart buildings etc. will have an increasingly significant impact on the way FMs operate in the future and many maybe linked to BIM.

11.9.1 Do you see any links between these trends and BIM, which might be especially important for the FM industry?

- In the future we will look more at developing links between these will ensure external databases and BIM, as separate systems, can interface and exchange information.
- I went to Autodesk University and attended a few FM and technology classes. There was a really good talk I attended on IoE. During the talk I had a eureka moment when I realised that you have the BIM side for construction and IoE is almost the equivalent of the BIM side for the FM. We talk about it lots, but that is just a part of it. That is the technology side, the sensors, and they link back to the web. However, you also have the process, the people side, which is encapsulated with IoE. It is like a mirrored version of what we do in construction but in FM. I have been trying to think about the theory and how it all interlinks. That is how I see it happening in the future.
- BIM can be connected to plant and equipment to enable monitoring, visualising occupation of spaces etc., the list is endless.
- I think there are the same challenges in FM as in construction with procurement, in particular, behaviour and attitude. Could you change procurement on the FM side as well and make it more collaborative?

11.9.2 What do you see as the IT and technological CSF to ensure FMs are prepared for BIM and the change these other trends may bring about?

- It is back to education and training and trying to change peoples' mind set.
- Making people realise they need to be more information and data centric with their thinking and that they have to think differently. They have to go through the same type of pain as we have been through in construction.
- A great benefit is we can take models to site on a tablet. That helps find out where things are, i.e. you don't have to make a hole in the wall to work out where the pipes are etc

People:

11.10 Changing perception of FM: the industry is increasingly perceived as strategically important to organisations in terms of supporting people and assets.

11.10.1 How important do you think the perception of other stakeholders is regarding FM involvement and capability in the BIM process?

- I think it is really important and that the stakeholders need to show more recognition.
- They need to be more engaged with FM and their knowledge and experience. As architects, we do not know what happens after handover; we just pass the plans over and do a bit of snagging.
- We are not there on a day-to-day basis looking after a building. We do not understand the minor mechanisms.
- Stakeholders need to realise how important they are. As an industry we are very focused on the here and now rather than thinking about the next stage, or the end stage.
- People have issues with computing how important thinking with the end in mind is.
- FM are one of the main inputs to the whole project system. Without their input you won't get true value.

11.10.2 What do you see as the CSF in FM strategically supporting organisations?

- Their job role is the monitoring of the facility and making sure it performs.
- That information is then fed back to many of the organisational systems such as HR business, ERP and other ways of feeding back to the owner. The building is a business at the end of the day and needs to return a profit.

11.10.3 Do you believe BIM can help the strategic element of supporting people?

- When I think of FM I think of assets, but there is a people element to it.
- BIM is information, with support calling you could have apps on which people can record problems they see, take photographs and send them to the help desk. Engineers can then be sent out to resolve those issues. So, BIM is another information flow. It can be made more streamlined and efficient, so people are not waiting.

11.11 Improved stakeholder engagement and cooperation (the people factor): BIM has the potential to improve engagement and breakdown traditional stove piping between stakeholders. People are the most important element in realising success.

11.11.1 What do you see as the CSF in the BIM process to ensure FMs can engage with and contribute meaningfully to a team on a BIM project?

- Defining the scope of the service and the time when they are appointed.
- Having proper roles and responsibilities defined at each project stage.
- More engagement, bringing them into team meetings and ensuring that other members of the team are aware that they are there.
- To make use of their knowledge.
- Making sure that the team realise how important they are to projects.

11.11.2 What do you see as the 'people' CSF in making BIM successful in projects?

- Collaboration is a key CSF.
- With that comes communication; one thing we are not good at on construction projects.
- Email does not work and is used in the wrong way.

- People need to be proactive, motivated and willing to change. There are people who can and cannot model in 3D. It is not necessarily that they do not have the right tools but that they lack motivation.
- It is removing the adversarial behaviour within the industry, which underpins everything we do. It will take a long time.
- I am shy and do not like talking to people. I have been complimented and have changed over the last year. In my presentations, I find it difficult to stand up and speak so I have a written script on PowerPoint, which makes me feel more comfortable.
- In one of my presentations, I talk a lot about people in that IPI is meant to change peoples' attitudes because BIM won't. Only things like changing procurement will do that. You need a proper disrupter that affects everything about a project.
- A lot of companies get other consultants in to teach modelling. I learnt it myself with a book and a program.
- There is an online learning platform called Lynda.com which has tutorials covering a variety of software including Revit. It allows you to go at your own pace. Paul Orvin who does it is highly regarded. You do not have to use Revit, there are other programs like ArchiCAD. It's working out what you want from the software.
- I would do a project. Revit is the market leader, if you want to engage with more people it is a good choice. Whether it is a good tool is up for debate, ArchiCAD does a lot of stuff that Revit is not good at and is more open in terms of open BIM and culpability.
- I am trying to push Revit down that route to get the best out of it in terms of open BIM.

11.12 Competence and knowledge about BIM: there is a potential growing knowledge gap between construction and FM professionals with respect to BIM, indicating the FM industry needs to do more in order to fully engage with BIM projects.

11.12.1 Do you agree with this?

- There is a little gap, even on the construction front there is huge variation between the people leading the way and those who do not have a clue. I imagine it is similar in the FM world.
- Maybe overall construction is ahead by a couple of years but the levels of knowledge throughout the industry is vast.
- BIM should start with FM, but because it has not, the industry has learnt to use the tools as a process of BIM, but then backfilled to get the process bit sorted. It is Autodesk's fault in marketing Revit as BIM eight years ago. Everyone thought they were doing BIM but then had to backfill. Now it is a process heavily involving people, who are just tools to aid it.
- It needs digitising.

11.12.2 Where do you think the focus of attention (CSF) should be with respect to FMs gaining competence and knowledge with respect to BIM?

- I think they need to be more engaged with the construction side. Looking at what construction is doing, learning from mistakes and making themselves part of the construction process.
- There is a sharp line between FM and construction, the line needs to be blurred; it is just a continuation of the process.
- We are looking at BIM in terms of construction because it is a fixed short timeline compared to maintaining and operating a building. That is why construction have started. People need to realise that BIM extends all the way through until the building is demolished. It is bringing the use of the building into the BIM process, which is something I want to look at.
- In terms of training, the industry bodies of FM need to push it a bit more, but they are starting to do it with documentation.
- At the Women in Construction and Engineering Awards for the first time they had an award for 'Best Woman in FM'. It is starting to trickle through into construction. It was a good event; I

would like to win an award that is for men and women. There were a lot of men and an award for the 'Best Male Mentor'.

- I am also involved in the Core Team of Women in BIM.
- In the pipeline is some R&D with regards to FM.

11.13 Specific FM (BIM) guidance and training: there are now several guides produced by BIFM and others (Operational Readiness Guide, EIR Template and Guidance, FM Guide to BIM, Soft Landings etc.):

11.13.1 Are you aware of or have you used any such documents?

- No not really, I have not been writing any strategies.
- I will refer to them next time I write a strategy and looking at the MOD and MoJ ones.

11.13.2 What CSF are important to ensure FMs can use/benefit from such guidance?

- There is major issue with the documentation because no one reads it.
- I am finding, particularly with young people, that they expect information to be delivered to them. Exactly what they want to know at that moment in time. Giving someone a large document to look for the information does not work. If you want an answer to something you just Google it. That is also an issue I am looking at.
- One of the issues with documentation in the industry is a lot of copy and pasting from the standards. It is not bespoke and tailored to the organisation or client's needs. It has no value; it is just words with no meaning. The standards are a framework to build around.
- The client needs to engage with their FM team before inspection of the project team to create the EIR.

11.13.3 Do you see any key gaps in guidance to BIM?

- There is a lot of documentation out there, but it is all quite separate.
- It was a case of taking them and joining up the dots.
- Other problems are consistent language and semantics throughout which is very confused and something we debate a lot on Twitter, including the use of acronyms.
- In terms of documentation that is more-or-less covered now.
- I would like to do a presentation talking about the basics of data and data science and the thought behind it. That is essentially what we are trying to do. Very few people in the industry are in that mind set; until that is realised, we cannot move forward.

12. Do you feel there are any other themes with CSF that are critical to FMs being successfully involved in BIM projects?

- The main one is procurement.
- We are looking at different procurement methods for construction, integrated product reassurance being one of them, but how does procurement work in FM? If something breaks down do you have people on the books who will fix it? Do you get several quotes in? Does something need to be done to make procurement less adversarial?
- I see the FM as a copy of what happens in construction.
- Does that industry need looking at in terms of people, process and technology as well as the construction side?
- Getting to grips with technology, the technology itself allows for more effective collaboration.

Part D: Current industry BIM standards/guidance

There are a wide range of industry BIM standards/guidance recommended by the BIM Task Group and professional associations (see list below – section 15). I am seeking your professional feedback on the importance and usability of the documents to FMs and the BIM process.

13. In your opinion, to what level of detail should FMs be familiar with the documents?

- It depends which documents you are talking about.
- An overview of all of them as it gives you the context.
- A summary guide, rather than reading through every single one.
- There are key documents, which they should be familiar with, inside out.
- With respect to standards often people overuse them, they're not used in the spirit with which they were intended

14. Are there any documents (CSF) you feel are more important for FMs to focus on?

- BS 8536-1 is crucial, reading that you get quite a lot of context about the previous BS 1192 suite.
- Anything from BIFM is needed.
- PAS 1192-3 is required and goes hand in hand with BS 8536-1.
- There needs to be more understanding of digital security, which is currently a time bomb, I've seen it in the NHS. People are so lax in the construction industry with regards to digital security.
- Data centres need to be designed so they are really secure. I asked about their security strategy with regards to information and they didn't have one. PAS 1192-5 is crucial; it also talks about the organisation's security strategies so FM would need involvement.
- PAS 1192-6, H&S is required.
- ISO 55000 I have skirted around for asset management.
- Soft Landings is approaching BS 8536. Part 1 is for buildings; Part 2 is for infrastructure. They are both just standards. Government Soft Landings and BSRIA Soft Landings are frameworks, they are not standards. You still need one of those behind it to back it up and give you a road map of what you do when. It should be read in conjunction with BS 8536.
- The construction industry is not very happy about the overhaul of PAS 1192 Parts 2 and 3, which are due to be released. Some drafts have been released and there is still a lot of contradiction and issues and feedback has been provided. It was issued just before Xmas and they expected comments by January which didn't really help us. It's issued by BSI.

15. How do you see the documents being used in practice and in mobilisation of a BIM project?

- People writing the strategy documents use them. Unless they find another EIR that they change and say that it's theirs.
- They then are seeing their work coming back to them.
- I haven't yet seen my EIR regurgitated.
- They do say it's the highest form of flattery.
- A lot of it goes in the BEP, which is a summary of the documents.
- I don't think a lot of people actually go to the documents unless they are really interested.
- On projects you are trying to tailor the frameworks to you really need to start with the BEP because you may have modified something for the project
- For example, on BS 1192-1 you have the naming conventions, you may need to tailor some fields, I had to for the IPI project, there isn't a code for information manager, so I had to create one.

Document list:

- BIFM: Operational Readiness Guide: A guide to ensuring long term effectiveness in the design and construction process (2016)
- BIFM: The Role of FM in BIM projects (2017)
- BIFM: EIR, Template and Guidance (2017)
- BS 8536-1:2015 Briefing for design and construction – Part 1: Code of practice for facilities management (buildings infrastructure)
- BS 8536-2:2016 Briefing for design and construction. Code of practice for asset management (Linear and geographical infrastructure)
- BS 1192:2007+A2:2016 - Collaborative production of architectural, engineering and construction information – code of practice
- PAS 1192-2:2013 - Specification for information management for the capital/delivery phase of construction projects using BIM
- PAS 1192-3:2014 - Specification for information management for the operational phase of assets using BIM
- BS1192-4:2014 - Fulfilling employers information exchange requirements using COBie – code of practice
- PAS 1192-5:2015 Specification for security-minded BIM, digital built environments and smart asset management
- CIC suite of BIM documents; Professional Indemnity Insurance, Scope of Services for the Role of Information Management and BIM Protocol
- Government Soft Landings
- ISO 55000 (1/2/3) - Asset Management
- ISO 15686-5 - Life Cycle Management
- RIBA Plan of Work (2013)
- BS 8587:2012 Guide to facility information management
- NBS - Digital Plan of Work and BIM Object Standard
- Uniclass (2015) classification system

16. In your opinion what are the CSF with respect to how FMs might best absorb the critical information from such documents?

- With regard to the idea of having a road map, the problem on a project would be having the right person to lead that kind of information management. Would FM have a dedicated information manager working with the information manager on the construction side, so you have combined thinking? They need to absorb everything and then reiterate it to the team. There is a lot of language that a lot of people won't understand.
- All the acronyms I think are part of the job of the information manager. To absorb it and simplify it for different groups of people.
- The title of Information Manager is starting to be used a lot and is a defined role in the CIC Document. The CIC Protocol is separate. The role is more on the construction side, but there should be a requirement on the client's side.
- We talk about information exchanges and giving them information at each stage, but who will validate that for the client? They need a representative to do that on their behalf especially on big projects.

17. Are you aware of other guidance documents (not listed) that you feel might be critical to FMs involved in the BIM process and explain why?

- BS 1192-6, H&S.
- BSRIA Soft Landings.

- BS 1192-4 which is COBie, but it is not a document for an everyday person. It is about the content of COBie, not necessarily how you use COBie in the real world; it is about the technical set up of it. The only real standards in terms of that is the NBIMS US Version 3 by Bill East, which is free to download. That gives a bit more context, but is a huge document, so I think there is a gap for a document on COBie, its use and what it does.

Part E: Mobilising for BIM projects

I am interested in your professional feedback about the following aspects of mobilisation for a BIM project, and what you see as the CSF with respect to:

18. The key role of FMs in the mobilisation of BIM projects?

- It is all about the input side into the EIR, OIR, AIR and PLQs.
- As the project goes on the validation and verification side, you are comparing what is happening in the project to what was intended.
- Once the project is finished, you have the monitoring and feedback to the organisation.

19. Identifying the key information needed in the AIM by FM at handover?

- Having a robust process of proper information management.
- Working out what is needed and when.
- When I was doing the Advance II Project, I started to join up all the standards from the EIR to the BEP. You had a chain of actions you need to complete to get what you required at the end of it.
- Defining the PLQ.
- Creating a client information schedule, from that you can start to understand model level definition.
- You can then look at BIM uses, which drives what you need to put in the model.
- That links in with looking at LOD at an element level in terms of LOI and LOD. The LOI looks at the data side, your asset information requirements like COBie.
- FMs need to consider the required LOD and LOI at an element level
- I think the NBS BIM tool kit should cover all that, but it does not.
- My client information schedule is the client saying in their own language what they want.
- Information is over many levels.
- You have a deliverable level, which is your documents, drawings and schedules.
- Then your model level which is a database container.
- An element level, a piece of data relating to an object.
- A client will not work out which level a piece of information is on. I just wanted the client to give me some plans or particular bit of information. It is then my job to work out where it comes from.
- That is the starting point for the information management process. From that, you can decide does that come from the model. Is it a piece of data, graphical, or is it part of a document or drawing?
- In COBie part of the AIR is defining what fields you want when. You would not go into much detail until that product was actually specified.
- The first drop for COBie states this is the building and the site, the next one the rooms and levels, the next may list the types of equipment.
- You may have a table but not know the manufacturer because it is not filled in. Once you start getting those bits of information trickling through you fill it in more. There is never any wasted information.
- There is a lot of debate as to what goes into the Revit model; you do not have to include all the information such as the onsite data and installation date, warranty information. There are external databases being developed which hook into Revit.

- A lot of people get hung up on the BIM model which doesn't exist. An information model is a collection of 3D models, databases, drawings, schedules, etc. which are brought together.

20. Ensuring the quality and reliability for information data drops and the final AIM?

- The information manager will check it and check the fields for the data are there.
- They will check the required drawings are there.
- It is up to designers to verify the content.
- PLQ are there for the client to use for questions such as have I got all the drawings? The client can use the PLQ to verify the data that is important to them.
- Room areas is a typical question, they may want to make comparisons about numbers. It was easy to do as you can compare numbers as you have a piece of data to do it with.
- Generally, when I do my information issue, I reissue the updated area schedule, which easy to do in Revit.

(Additional question) Are you asked for that kind of information in relation to tendering, i.e. in cleaning for a list of rooms with the types of material on the different floors? It would be the sort of model the FMs could proactively use.

- I get asked for things from the client, although I may not know what for. One of the reasons I wanted to put together a client information schedule was to stop that from happening. It is disruptive; I have to stop what I am doing. I like to plan everything so I can model in the best way to get the best output. Looking at the information strategy helps me, as I am the person at the bottom picking it all up.

(Additional question) In preparation of tenders it would be useful to have at the beginning of the process a list of information that is in the model. I assume that would be possible.

- Yes definitely, that is exactly what the EIR is all about. A lot of them do not mention what information is needed. Because I know what is needed, I can plan the schedule and have the right data and parameters in the model.

21. The successful transfer of data into the clients CAFM system?

- One of the reasons I am pushing open BIM formats is, so it is fully interoperable.
- Once you go from one piece of software to another, they do not talk to each other.
- IFC is the openBIM transfer method used by the design and construction industry. As such FMs should know something about it
- Also, it's important to know keeping models current depends on their format. IFC and COBie help import models from native modelling software into CAFM and transfer data but they're only a snapshot in time. If you then need to make fundamental changes to the graphical elements or data, you need go back to the native software. A new IFC can then be produced and the process repeated.
- When you are structuring your data around an open BIM format, you are more likely to be able to use that data set from one software to another. A few of us in industry are trying to push it.

22. BIM training/familiarisation to enable FMs to access information and data at handover?

- Putting a plan together at the start of the project so you do not get to the end and find you have a lot of excess data you don't know what to do with.
- The EIR should take all that into account so you can work with the information manager to come up with a work plan in progress and using it after handover.

- You should know what systems are being used so you can structure the data for feeding in.
- I would expect the FM team to develop their own process.
- You are meant to know what systems you need to develop FM processes for.
- Soft Landings are blurred; you could have access to the construction team to help you.
- In the case of FMs not having the experience to access a particular software there needs to be a strategy as to what the client is going to do with the information at handover.
- How is the model going to be updated when something changes and who is going to be responsible for updating the data? It needs to be explored at the start of the project, maybe have a student to update the model. I have to future proof that so the process will work.
- FM have requested a model of BIM viewing tools so they can look at it to see what it contains and click on an item to get their asset data.
- Our client is not very technological but they have asked for a model so I am sure it will become a common occurrence.
- We will be providing them with a format in Navisworks, which can be opened with a free viewer. They do not have to have Revit as it is too complicated.
- In Navisworks you can hide elements, create saved views and walk around the model.

I am interested in your professional feedback about key FM activities for each of the RIBA stages. Two BIFM guides (as below) identified some key FM activities (listed in Appendix A):

a) BIFM: Employer's Information Requirements (EIR) Template and Guidance

b) BIFM: The Role of FM in BIM projects

23. Please give your feedback with respect to the FM activities in the attached appendix and highlight those that you see as CSF with respect to a mobilisation framework.

- Using the RIBA PoW stages to create your guidance is a good idea as it merges the two, rather than it being separate.
- I have glanced though it and you have picked up many of the items. It is well thought out.
- At Stage 0 you should discuss business case, the strategy around the business.
- The Strategic Brief used by the design team with the client needs to be developed. FM could help feed into that as its really high level.
- It might mean saving so much money a year on gas bills for example.

24. Are there other issues (CSF) you think are key to the FM-BIM mobilisation framework?

- One thing that would help FMs is when FMs attend construction and BIM conferences to meet BIM intellectuals as they will be able to offer lots of practical advice.
- A lot of BIM intellectuals will be present, if they know about it, as they are more likely to be the information managers on projects. It will be helpful to engage with them.
- You never know where clients are, so that could be difficult.
- Social media, LinkedIn and Twitter are useful tools.

Part F: closing the interview

25. Do you have any further comments or questions, which you feel, are important to address for my research?

- I do not think so.
- I would be happy to have a look through anything you do and check it over.
- When I start back on the strategy side, I will be able to help more.

- I like both sides, academic and practical, for my presentation I had to do a lot of research and theory and enjoy doing it.

Thank you for your time and the interesting insights you have given me during the interview. If anything comes to mind later that you would like to discuss, please feel free to contact me.

Appendix K: Questionnaire: support letter to BIFM research team

Liverpool John Moores University

To: BIFM Research Team (Operational Readiness Steering Group)

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Researcher:
Simon Ashworth
LJMU, School of the Built Environment
S.J.Ashworth@2014.ljmu.ac.uk
Tel: +41 79 138 68 52

Dear Mr XXXX

Joint Survey with BIFM: PhD Research Online Questionnaire:

I am contacting the BIFM to ask for support and assistance with research for my PhD. The work is being with The School of The Build Environment, Liverpool John Moores University. It focuses on the *'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'*

As part of this research methodology, I would like to ask if you would be willing to help distribute my PhD research questionnaire: ***'FM awareness of BIM'***.

I have attached an electronic copy of the questionnaire for reference.

If you are happy for your organisations members to participate, I would be grateful if you could confirm your consent by a return email for my records.

Kind regards

Simon Ashworth
LJMU, School of the Built Environment
S.J.Ashworth@2014.ljmu.ac.uk
Tel: +41 79 138 68 52

Appendix L: Online questionnaire: "*FM Awareness of BIM*"

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FM Awareness of BIM (Building information modelling)

This survey, which has been developed in partnership with Liverpool John Moore University (LJMU) and the Zurich University of Applied Sciences (ZHAW), to collaborate on primary research regarding FM sector awareness of BIM. LJMU/ZHAW and the BIFM Research and Information team are carrying out the research in two stages:

Stage 1: Establish a benchmark of FM sector level of BIM awareness, knowledge, experience and training addressed by this questionnaire.
Stage 2: Identify and assess the 'critical success factors' important to facilities management professionals involved in BIM projects. This will be a follow up questionnaire later in 2017.

A report based on the survey responses will be issued for public viewing shortly after the survey closes. If you have any enquiries please contact the BIFM Research and Information team, research@bifm.org.uk.

Your responses will remain confidential, responses will not be identified by individual or company. Any data included in the report will be at an aggregated level.

This survey should take approximately 5-10 minutes to complete.

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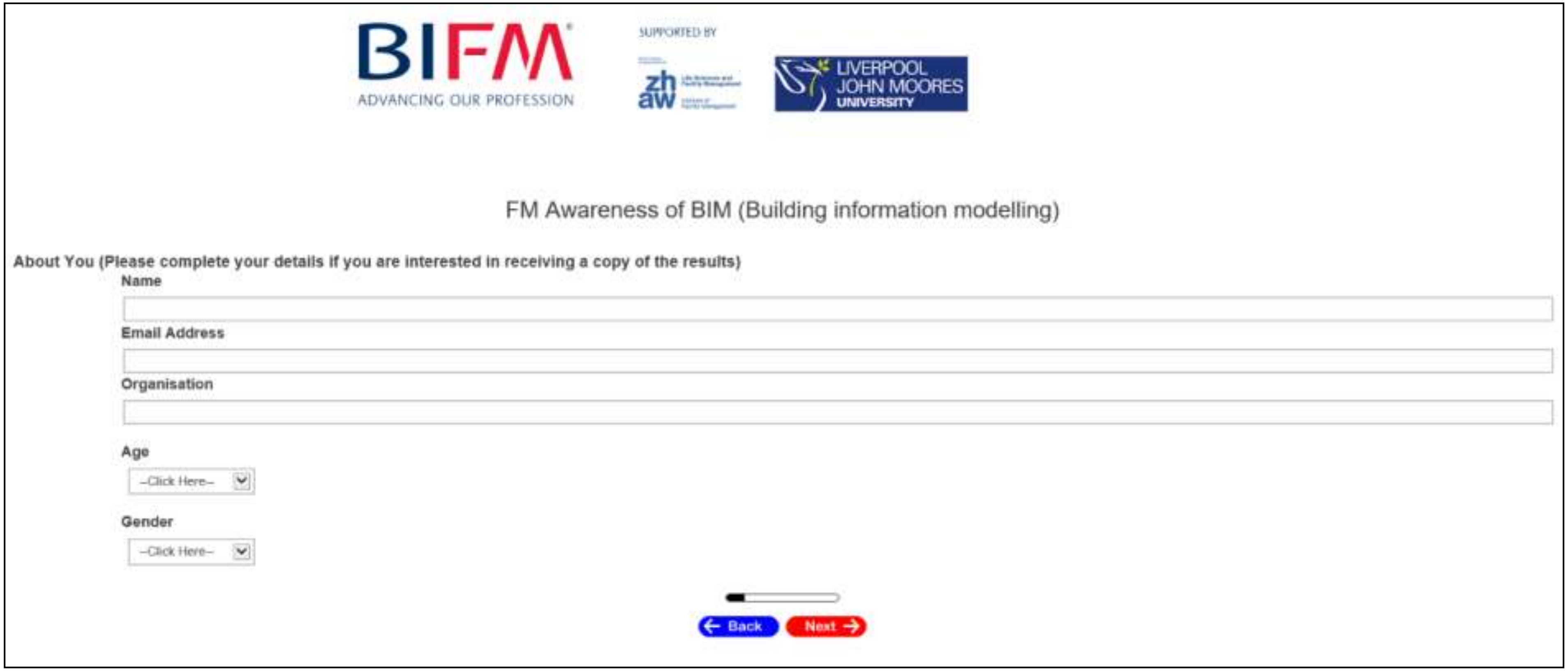

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FM Awareness of BIM (Building information modelling)

About You (Please complete your details if you are interested in receiving a copy of the results)

Name

Email Address

Organisation

Age

--Click Here--

Gender

--Click Here--

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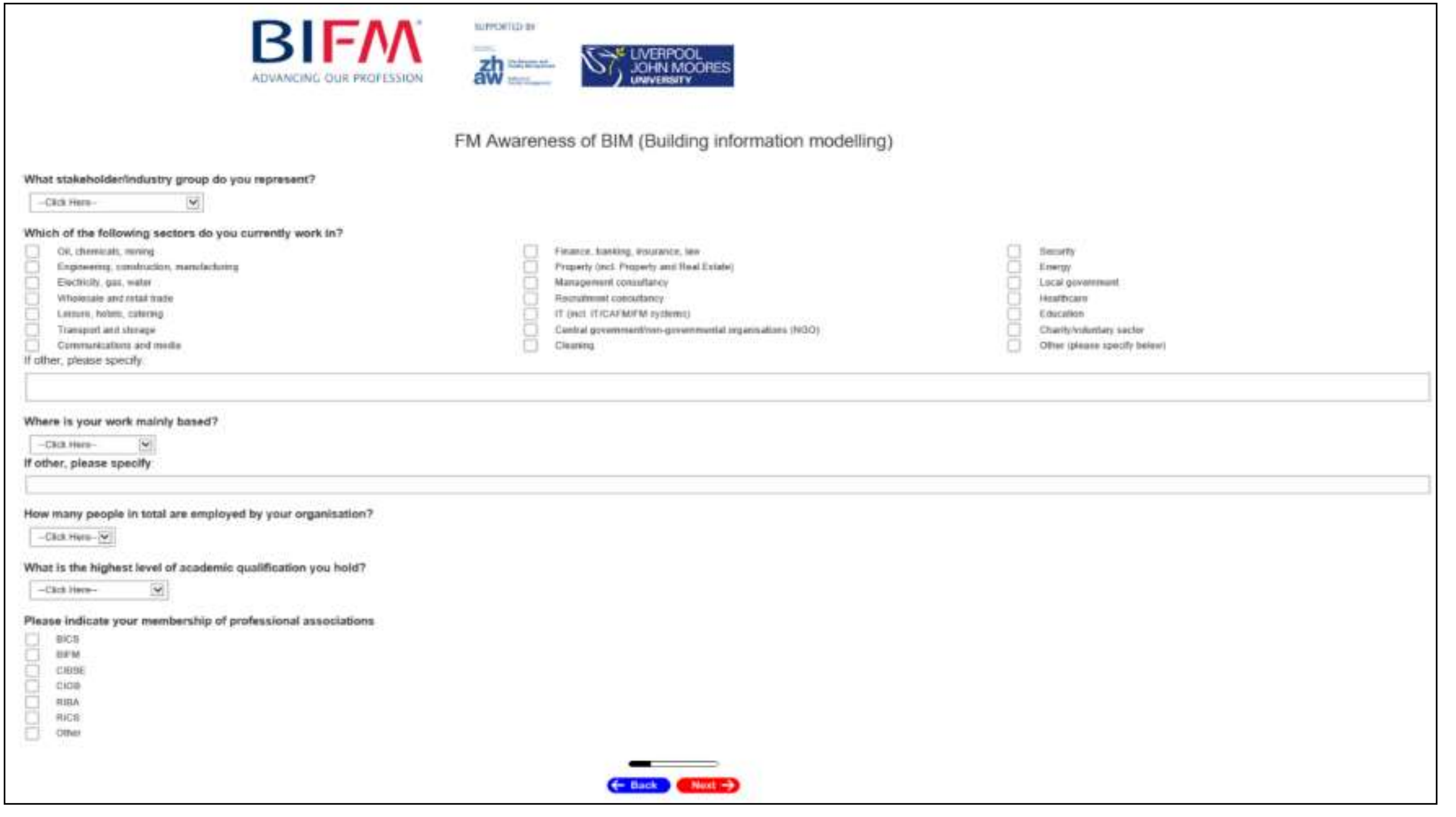

FM Awareness of BIM (Building information modelling)

What stakeholder/industry group do you represent?

--Click Here--

Which of the following sectors do you currently work in?

- Oil, chemicals, mining
- Engineering, construction, manufacturing
- Electricity, gas, water
- Wholesale and retail trade
- Leisure, hotels, catering
- Transport and storage
- Communications and media
- Finance, banking, insurance, law
- Property (incl. Property and Real Estate)
- Management consultancy
- Recruitment consultancy
- IT (incl. IT/CAFM/FM systems)
- Central government/non-governmental organisations (NGO)
- Cleaning
- Security
- Energy
- Local government
- Healthcare
- Education
- Charity/voluntary sector
- Other (please specify below)

If other, please specify

Where is your work mainly based?

--Click Here--

If other, please specify

How many people in total are employed by your organisation?

--Click Here--

What is the highest level of academic qualification you hold?

--Click Here--

Please indicate your membership of professional associations

- BICS
- BIFM
- CIBSE
- CIOB
- RIBA
- RICS
- Other

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FM Awareness of BIM (Building information modelling)

Part A: BIM Experience, Perception and Awareness

Before taking this survey had you ever heard of BIM (Building Information Modelling)?

- ○ Yes
- ○ No
- ○ Don't know

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FM Awareness of BIM (Building information modelling)

Do you have any experience of being involved in a BIM project?

- Yes
- No

If yes, please give brief detail of the project(s), your role and responsibilities

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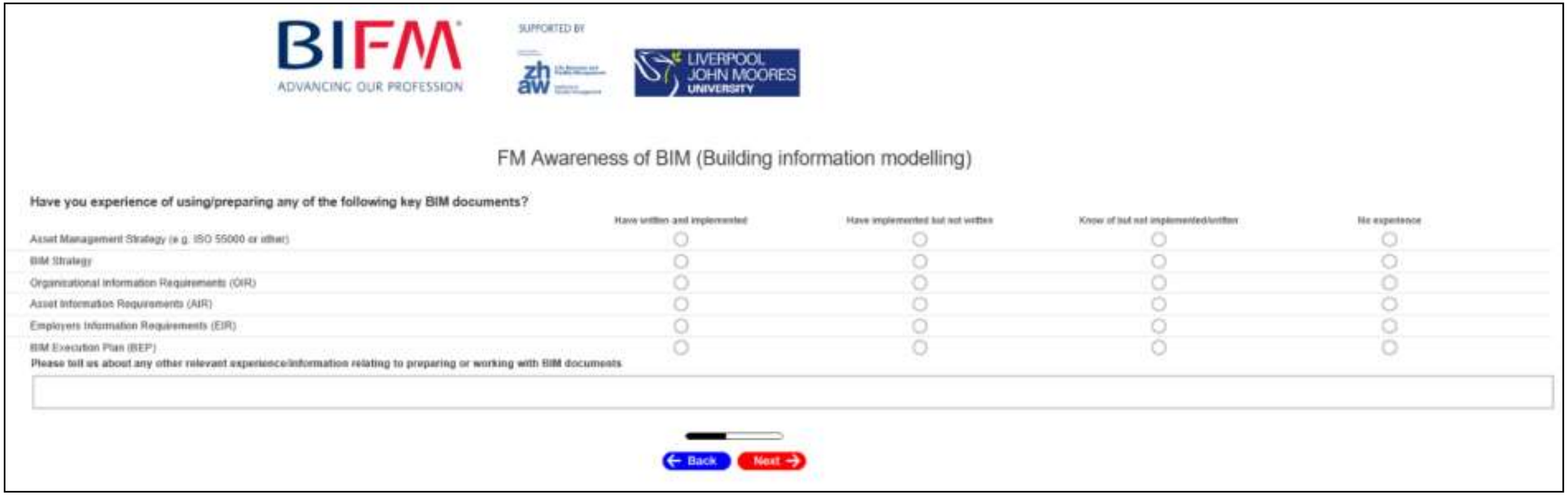
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FM Awareness of BIM (Building information modelling)

Have you experience of using/preparing any of the following key BIM documents?

	Have written and implemented	Have implemented but not written	Know of but not implemented/written	No experience
Asset Management Strategy (e.g. ISO 55000 or other)	○	○	○	○
BIM Strategy	○	○	○	○
Organizational information Requirements (OIR)	○	○	○	○
Asset information Requirements (AIR)	○	○	○	○
Employers Information Requirements (EIR)	○	○	○	○
BIM Execution Plan (BEP)	○	○	○	○

Please tell us about any other relevant experience/information relating to preparing or working with BIM documents

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FM Awareness of BIM (Building information modelling)

Based on your current knowledge/experience of BIM, how confident would you feel about engaging in a BIM project and taking on roles such as reviewing/writing the OIR, AIR, EIR etc?

- I feel very confident
- I feel fairly confident
- Neutral
- I don't feel so confident
- I don't feel confident at all

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FM Awareness of BIM (Building information modelling)

BIM Perception and Awareness

Do you believe that BIM will help support the delivery of facilities management?

- ○ Yes
- ○ No
- ○ Unsure

Do you believe BIM will have a significant impact on the FM industry?

- ○ Yes
- ○ No
- ○ Not sure

Please indicate the timescale you think is relevant for the impact?

- ○ It is already having an impact
- ○ 1-2 years
- ○ 3-5 years
- ○ More than 5 years

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FM Awareness of BIM (Building information modelling)

From your awareness and understanding of BIM, please indicate your level of agreement with the following statements

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
The FM industry is not clear about what BIM is	○	○	○	○	○
BIM is about a collaborative working process not just the use of BIM software model(s)	○	○	○	○	○
FMs have a good understanding of the RIBA 2013 Plan of Work and its work stages	○	○	○	○	○
BIM is only for new build, not existing buildings/assets or refurbishment projects	○	○	○	○	○
BIM has the potential to deliver significant added value to FM	○	○	○	○	○
The FM industry and FMs are well prepared to deal with BIM projects	○	○	○	○	○
BIM should help improve data transfer into FM IT/CAFM systems	○	○	○	○	○
BIM encourages early FM involvement in the design phase of projects to ensure the end users' needs are represented and give advice about life-cycle costing	○	○	○	○	○
Companies adopting BIM may have a competitive advantage over those that do not	○	○	○	○	○
FMs would benefit from more BIM familiarisation to help clearly define what they want in terms of outputs from the BIM process	○	○	○	○	○

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FM Awareness of BIM (Building information modelling)

Please indicate your level of agreement of possible benefits of BIM to FM

	Strongly agree	Agree	Neutral	Disagree	Strongly Disagree
Strategic decision making about asset maintenance and management	○	○	○	○	○
Operational efficiency(in terms of cost/time)	○	○	○	○	○
Cost management/transparency(whole life, maintenance and asset replacement)	○	○	○	○	○
Data transfer from construction into CAFM and other software tools for operation	○	○	○	○	○
Space and move planning capability	○	○	○	○	○
Sustainability in terms of reductions in energy use/carbon emissions	○	○	○	○	○
Visualisation of buildings/assets for customers, H&S and maintenance issues	○	○	○	○	○
Insurance costs for buildings due to availability and accuracy of information	○	○	○	○	○
Simulation capability e.g. energy, fire evacuations etc	○	○	○	○	○

Can you suggest any other benefits?

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FM Awareness of BIM (Building information modelling)

Please indicate your agreement with possible concerns/barriers relating to BIM

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
I feel I need more knowledge about BIM before being involved in a BIM project					
I don't feel our organisation is adequately prepared to engage in BIM projects					
The cost of adopting/implementing BIM					
Ability of FM to write/specify the OIR, AIR and EIR documents for a client					
Management/collection of data in the BIM process					
Using COBie for transfer of data into CAFM/other systems					
The impact of BIM from a legal perspective					
CAFM/software suppliers should work on tools that allow bi-directional transfer of data between the BIM and CAFM					
BIM training and how FMs will access data in 3D BIM models at handover					
Lack of/cost of training					

Do you have any other concerns?

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FM Awareness of BIM (Building information modelling)

Please indicate your level of knowledge of the following key UK BIM related standards and guidance documents

	Know and use in practice	Know well but don't use in practice	Have a basic overview but don't use in practice	Heard of but have not read	Not aware of
BS 8536-1:2015 Briefing for design and construction –Part 1: Code of practice for facilities management (buildings infrastructure)	○	○	○	○	○
BS 8536-2:2016 Briefing for design and construction. Code of practice for asset management (Linear and geographical infrastructure)	○	○	○	○	○
BS 1192:2007+A2:2016 - Collaborative production of architectural, engineering and construction information – code of practice	○	○	○	○	○
PAS 1192-2:2013 - Specification for information management for the capital/delivery phase of construction projects using BIM	○	○	○	○	○
PAS 1192-3: 2014 - Specification for information management for the operational phase of assets using BIM	○	○	○	○	○
BS1192 part 4:2014 - Fulfilling employers information exchange requirements using COBie – Code of practice	○	○	○	○	○
PAS 1192-5: 2015 Specification for security-minded BIM, digital built environments and smart asset management	○	○	○	○	○
ISO 55000 (1/2/3) - Asset Management	○	○	○	○	○
CIC suite of BIM documents; Professional Indemnity Insurance, Scope of Services for the Role of Information Management and BIM Protocol	○	○	○	○	○
RIBA 2013 Plan of Work	○	○	○	○	○
ISO 15686-5 - Life Cycle Management	○	○	○	○	○
BS 8587:2012 Guide to facility information management	○	○	○	○	○

Please give details of any other BIM guidance documents/tools which are not listed above which you use/think are useful reference for FMs

The government has described there being different levels of BIM. Are you aware of these different levels?

- ○ Yes
- ○ No
- ○ Don't know

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FM Awareness of BIM (Building information modelling)

Are you aware of the government's mandate to adopt and use BIM level 2 on government procurement projects with effect from April 2016?

- ○ Yes
- ○ No

Are you aware of the government "Digital built Britain - level 3 strategy"?

- ○ Know well
- ○ Heard of, and briefly read
- ○ Heard of, but not read
- ○ Not aware of

Are you aware of the following websites (linked to government BIM Task group)?

	Know well and have accessed regularly	Heard of, and briefly accessed	Heard of, but not accessed	Not aware of
BIM Task group (http://www.bimtaskgroup.org)	○	○	○	○
Digital Built Britain (http://digital-built-britain.com)	○	○	○	○
BIM Level 2 (http://bim-level2.org)	○	○	○	○

The UK Government has set out its strategy for UK construction in 2025. The strategy includes four targets. Please tell us the role you think BIM will have in our achieving the following:

	BIM will help	BIM won't make a difference	BIM will hinder	Don't know
33% reduction in the initial cost of construction and the whole life cost of built assets	○	○	○	○
50% reduction in the overall time, from inception to completion, for newbuild and refurbished assets	○	○	○	○
50% reduction in greenhouse gas emissions in the built environment	○	○	○	○
50% reduction in the trade gap between total exports and total imports for construction products and materials	○	○	○	○

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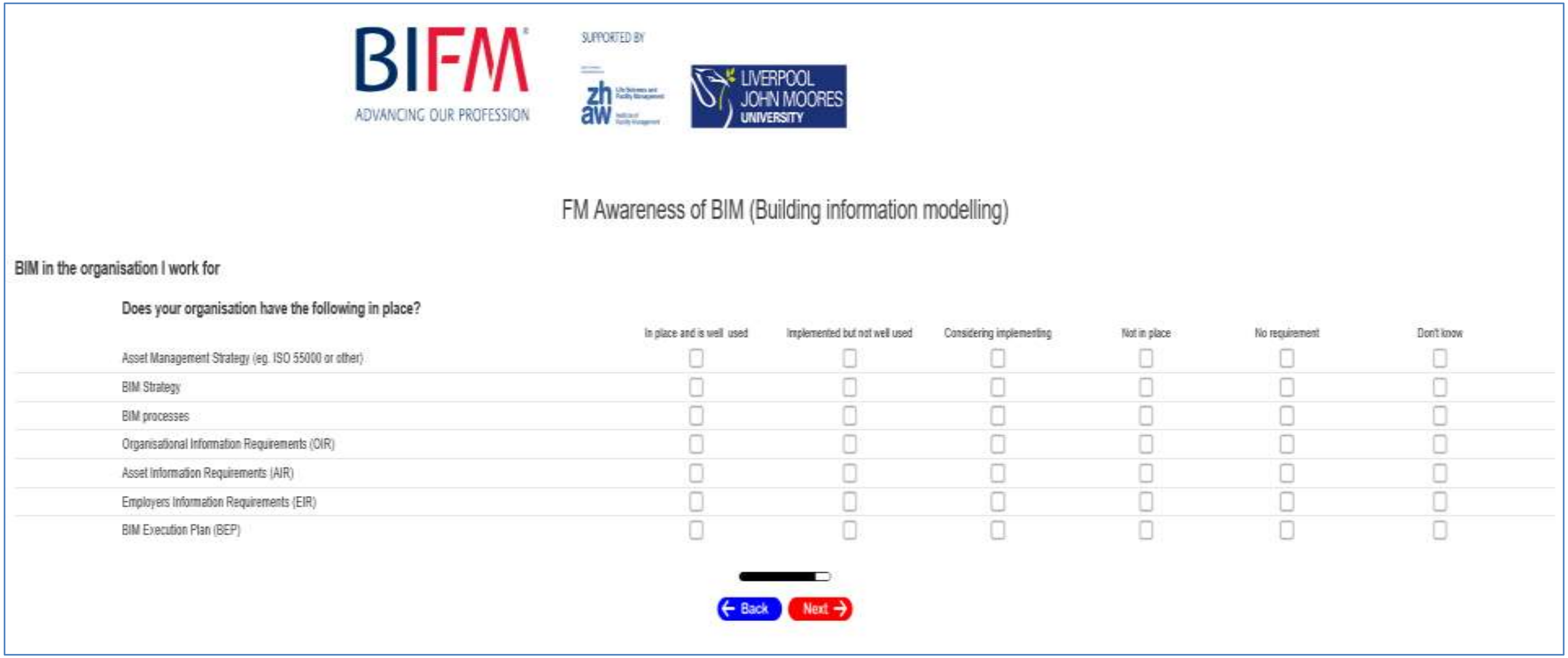

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FM Awareness of BIM (Building information modelling)

BIM in the organisation I work for

Does your organisation have the following in place?

	In place and is well used	Implemented but not well used	Considering implementing	Not in place	No requirement	Don't know
Asset Management Strategy (eg. ISO 55000 or other)						
BIM Strategy						
BIM processes						
Organisational Information Requirements (OIR)						
Asset Information Requirements (AIR)						
Employers Information Requirements (EIR)						
BIM Execution Plan (BEP)						

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FM Awareness of BIM (Building information modelling)

BIM training in the organisation I work for

Please indicate your level of agreement with the following

	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Our organisation has a clear understanding about BIM training and a plan in place for staff training	○	○	○	○	○
Our organisation has adequate resources/funding available for BIM training	○	○	○	○	○
Our organisation already has in-house BIM expertise which is being used to conduct in-house training	○	○	○	○	○
Our organisation has a plan in place to actively evaluate its BIM training	○	○	○	○	○
Our employees would benefit from BIM certification or further BIM training courses	○	○	○	○	○

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FM Awareness of BIM (Building information modelling)

Have you attended any BIM training courses?

- ◯ Yes
- ◯ No

If yes, please give details:

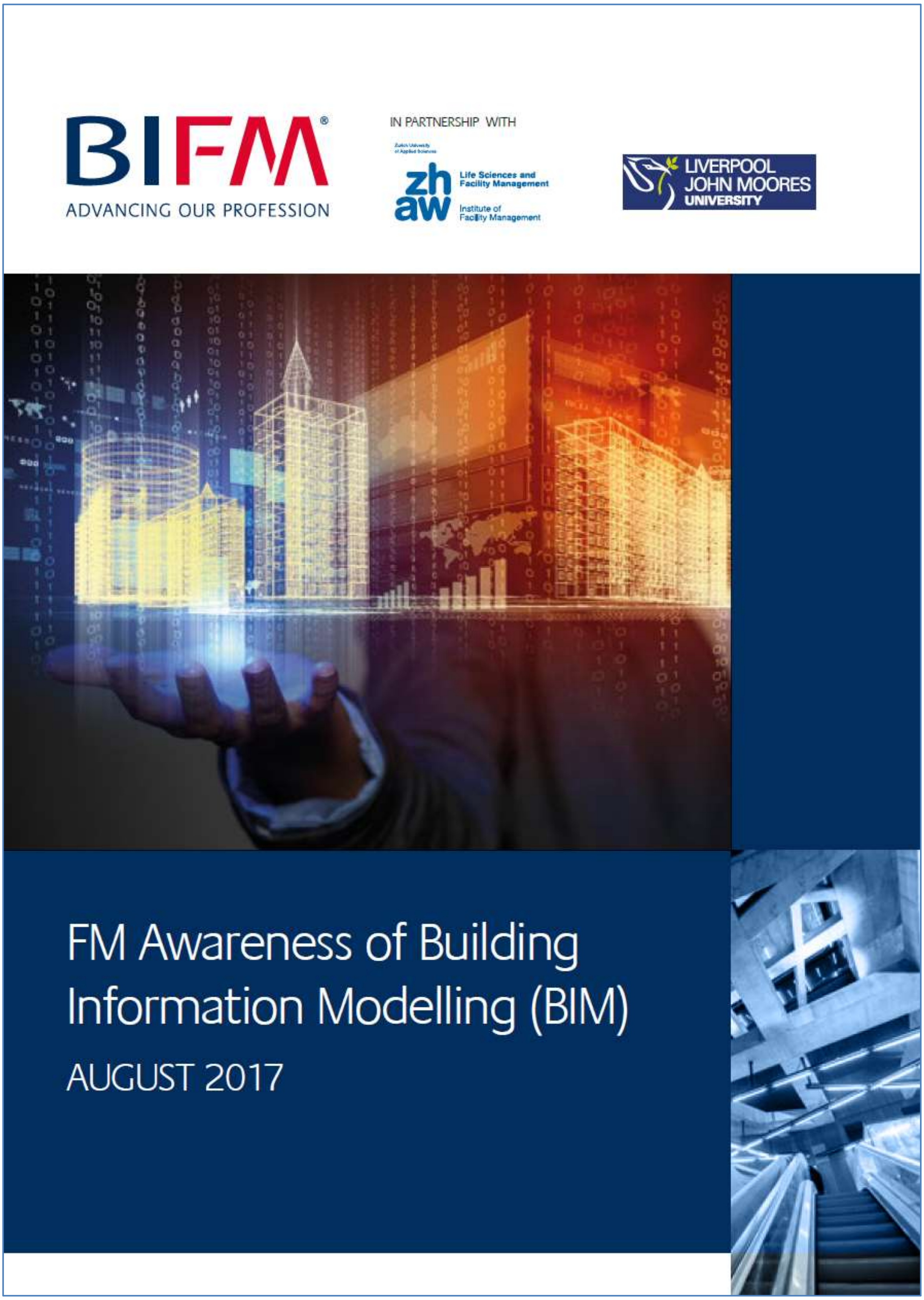
Please indicate the level of BIM training/support in your organisation

- ◯ Very good
- ◯ Good but could be improved
- ◯ Minimal
- ◯ None
- ◯ Not necessary
- ◯ Don't know

Thank you for completing the survey, once you click submit you will be re-directed to the BIFM website

Back Submit

Appendix M: '*FM Awareness of BIM: 2017*' published report with BIFM



Edition: First

Date: August 2017

Authors:
Simon Ashworth, Academic Researcher,
Zurich University of Applied Sciences (ZHAW) Switzerland
(PhD Student: Liverpool John Moores University)

Dr Matthew Tucker, Reader in Facilities Management, Department of the Built Environment Liverpool John Moores University

Contents

"

The Asset and Facilities Management (A&FM) sector play a critical part in the safe, reliable and productive delivery of services across the nation. Approaching a third more money is spent each year on operational budgets than capital, but the investment in innovation and development is less.

The nation has to deliver reliable social infrastructure to drive productivity, growth and fiscal well being. Assets have two governing variables, capacity (provided during construction) and availability (managed by the A&FM sector). The data created as part of the design and construct process is of vital importance to the safe and effective delivery of an operational strategy. The value of data derived from BIM is rich in detailed content, which in future will provide insights previously un-thought of as we start to integrate active sensor and condition monitoring strategies and the potential disruptive maintenance opportunities this will provide (such as the concept of Uber FM).

This survey has provided a valuable insight to the current operations market in the light of the Governments Level 2 BIM intervention. By its very nature the A&FM market lags the capital phase but in common with our construction colleagues we are starting to see improvements in operational performance when digital strategies are employed, but of course it does take time for these savings to manifest.

The opportunities for Level 3 savings discussed above are vast, both in terms of sector productivity and impact on the nation, but for organisations to achieve this Level 2 is a vital first step, I would encourage you to start your digital journey as soon as possible."

Dr Mark Bew MBE
Chairman,
Digital Built Britain

1. Foreword

BIFM Perspective

"BIFM has long recognised the vital role FM has to play within BIM projects and this is further highlighted within this report, this is why we formed our own Operational Readiness Steering Group in late 2015 to inform and develop a suite of guidance and knowledge materials to arm our members, and indeed the wider built environment industry, with the knowledge and skills they need to be operationally ready for BIM.

Our mission to equip FM practitioners with a thorough understanding of the purpose, value and benefits of BIM has been further underpinned by its recent incorporation into the FM Professional Standards, a change that reflects the growing impact it has on the working practices of our members as the industry adapts to the challenges and opportunities BIM will provide.

Therefore, whilst FM professionals begin to get to grips with BIM what it will mean for the profession the reality is that either now or in the near future they will be expected to operate in an area of innovation they may not necessarily know very much about, and ultimately that is why BIFM is acting now to bridge that knowledge gap and support our members.

This report introduces the work and partnership between BIFM, Liverpool John Moores University (LJMU) and Zurich University of Applied Sciences (ZHAW) and why BIFM see the work on BIM as important for the FM industry. The report presents the findings of the recent BIFM survey to benchmark the FM industry perception and awareness of BIM which the BIFM will use to help the development of further guidance material for our members."

Linda Hausmanis
CEO, BIFM

Industry Perspective

"The application of BIM-enabled facilities management has the potential to add significant value to assets and estates.

There are, however, many challenges and barriers that need to be considered to make the transition easier and the benefits clear to all. The point stands though that by embracing BIM, the FM process becomes more efficient, not least because the required information is available in a structured and integrated format. It is critical that clients engage in the BIM process to define what digital tools and processes they require in order to better manage their assets. This definition document is termed the Employers Information Requirements (EIR), BIM Academy supported BIFM in the creation of an example EIR that clients can use to become more informed in the BIM process."

Graham Kelly
Associate, BIM Academy

2. Introduction

Academic Perspective

The adoption and use of Building Information Modelling (BIM) in the whole life process of designing, creating and operating buildings, assets and infrastructure projects is a worldwide growing trend.

The research findings presented here aim to establish a benchmark of the current perception and awareness of BIM by facilities management professionals.

Simon Ashworth
Academic Researcher, Institute of Facility Management Zurich University of Applied Sciences and Liverpool John Moores University

Dr Matthew Tucker
Reader in Facilities Management, Department of the Built Environment Liverpool John Moores University

BIM and other digital trends such as big data and sensors have potential wide-reaching implications for many industries including facilities management (FM). In April 2016 BIM became mandatory for UK government procurement projects in line with the Government Construction Strategy (2011). Its adoption and use was seen as a critical step to help achieve the ambitious cost, sustainability and trade targets set out in the Construction 2025 strategy (2013);

- 33% reduction in the initial cost of construction and the whole life cost of built assets
- 50% reduction in the overall time, from inception to completion, for newbuild and refurbished assets
- 50% reduction in greenhouse gas emissions in the built environment
- 50% reduction in the trade gap between total exports and total imports for construction products and materials

The Architectural, Engineering and Construction (AEC) industries have already started to adopt BIM as the new norm for procuring, designing and creating assets. There have been regular surveys in these sectors by NBS and other professional organisations regarding the awareness and development of BIM. However, to date the level of awareness and perception of BIM from a FM professional's perspective has not received the same level of attention. This presents a critical gap in research as clients and FM professionals are key to the start of the BIM process in terms of defining the OIR, AIR and EIR. It is essential that academia works closely together with professional organisations such as BIFM to help FM professionals in practice and to better understand how BIM might affect and help the FM industry. This has never been more important as the role of FM in the BIM process is increasingly recognised as critical to realising the much talked about potential benefits of BIM.

Awareness of BIM is growing across the industry, but there are disparities in the level of sophistication, maturity and application of BIM in FM across specific organisations, sectors, industries, and countries. The growing importance of appropriate standards, professional guidance and academic research to bridge such gaps have never been more important. There is a growing body of international academic literature and industry reports pointing to the importance, and criticality of the involvement and integration of FM in the early design phase.

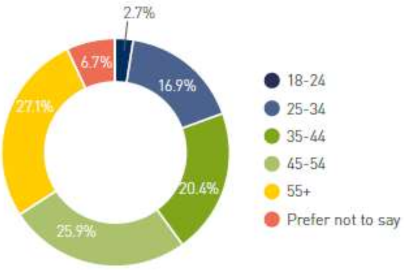
In order to ensure the FM industry is well prepared for engaging with other key stakeholders in BIM projects it is essential that the level of awareness of BIM and how facilities management professionals see BIM impacting on the FM industry are well understood. The results of the recent 'FM awareness of BIM' survey jointly undertaken between Liverpool John Moores University, the Zurich University of Applied Sciences and BIFM are published here to better inform industry. The aim is to help us understand how we can develop further BIM guidance material for BIFM members. Some guides have already been developed and published on the knowledge section of the BIFM website. These include the 'operational readiness' (BIFM 2016) of FM to implement BIM, the 'employer's information requirements (EIR): template and guidance' (BIFM 2017), and 'the role of FM in BIM projects' good practice guide (BIFM 2017).

3. Profile of respondents

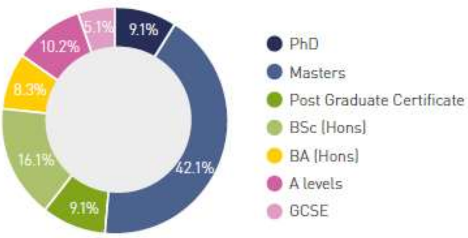
KEY POINTS:

- In total 254 people completed the online survey between 31 January and 15 March 2017.
- 22.4% of respondents were female, 72.4% were male, with 6.7% preferring not to answer.
- There was a balanced response across a wide range of ages and academic backgrounds.
- The majority of responses were from FM professionals but there was a great deal of input from other stakeholders involved in the whole life process.

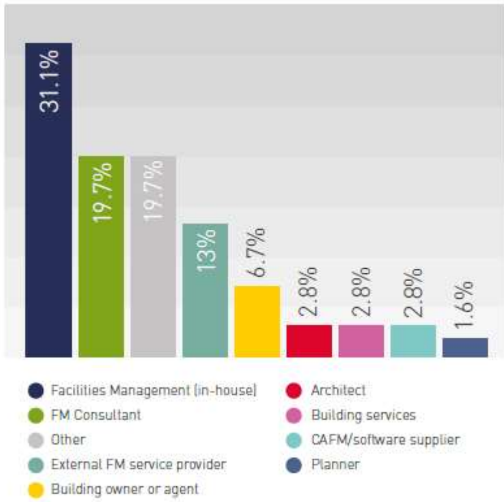
AGE



WHAT IS THE HIGHEST LEVEL OF ACADEMIC QUALIFICATION YOU HOLD?



WHAT STAKEHOLDER/INDUSTRY GROUP DO YOU REPRESENT?



Some stakeholders in the 'Other' category combined respondents from Academic/Researcher, BIM Consultants/Managers and FM Students/multi-disciplinary consultants (design & build).

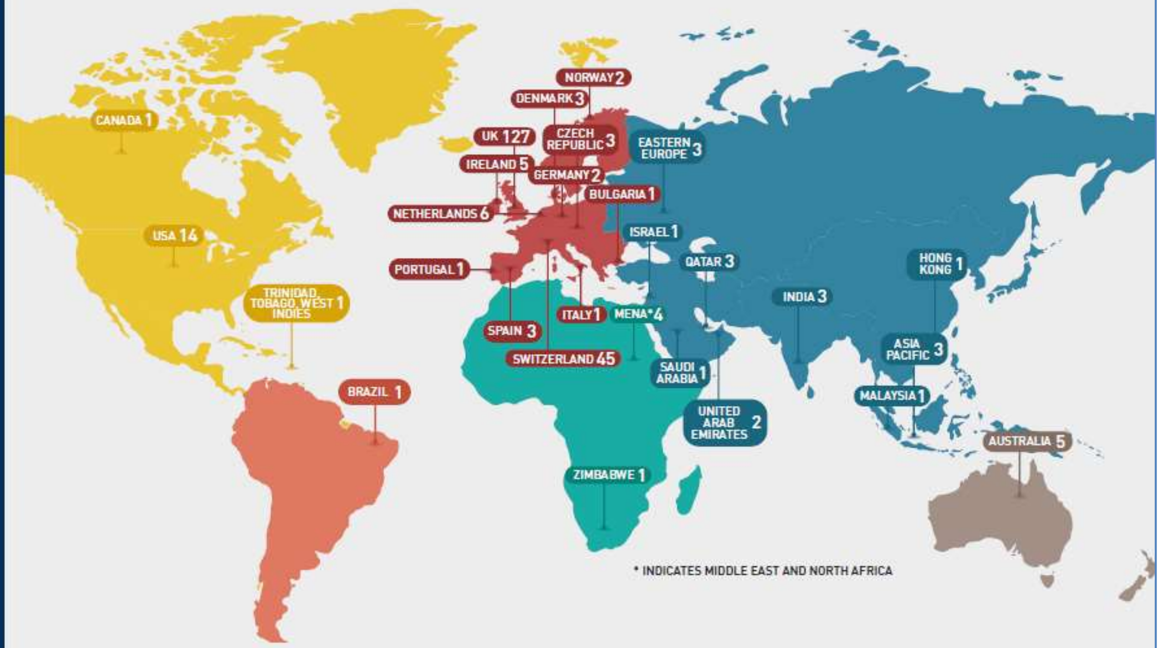
There was a good range of representation from organisations of all sizes with some of the higher numbers being from the 1-9 range (16.1%), and then the other end of the scale with 1,000-4,999 (23.2%) and 5,000+ (23.6%). The remaining representation was from 10-49 (8%), 50-99 (7%), 100-249 (9%), 250-499 (6%) and 500-999 (7%).

There was a wide range of responses from various industry sectors with the higher number of respondents coming from the property sector (inc. real estate) and the education sector, both at (27.2%) followed by engineering, construction and manufacturing (23.2%) with management consultancy next at 18.1%.

3. Profile of respondents

3.1 International Context

In terms of geographic representation there were many responses from the UK as well as across the globe. From the UK 16.1% indicated they were operating UK wide, 7.9% in London, 6.3% South East, 3.5% South West, 3% Scotland and 9.2% across the rest of the UK. The international input was a significant 53.9% from 28 different countries as indicated on the map below, with 10 respondents indicating a global reach.



Dr Carsten Druhmann
Lecturer and Researcher, Institute of Facility Management:
Zurich University of Applied Sciences Switzerland

"Today we are facing old and new global challenges within the discipline of Facilities Management.

A major "new" trend is the wider digitisation of the core businesses of the organisations and companies who form our customer base. BIM has been perceived as one of these new trends. However, it is now more than just a trend, resulting in a global paradigm shift towards a more whole life focused approach and process for the design and creation of buildings and infrastructure.

The AEC industries have already adopted and are actively using BIM. How the FM industry will be prepared to be involved is a challenging question that we all need to think about if the promised benefits of BIM are to be delivered to our customers and wider society. Academics and practitioners need to share knowledge and experience across international borders to help prepare the FM industry for digitisation and BIM. We need more discussion and research to identify ways to prepare industry. From a neutral position universities and inter-trade organisations are in an appropriate position to support industry and public organisations to better understand how to implement BIM in an efficient way. As part of this the ZHAW in Switzerland have joined forces with UMU and BIFM to help provide fundamental research to guide the creation of guidance for our global FM community."

4. The findings

4.1 Executive summary of the findings

AWARENESS OF BIM:

- A high number of respondents (91.7%) had heard of BIM with 83.5% believing BIM will help support the delivery of facilities management. 74% think BIM will have a significant impact on the FM industry with 83.8% indicating that BIM is already having an impact or will do so in the next five years.
- 81.1% (combined) strongly agree, or agree that BIM may offer companies, that adopt and use it, an advantage over those that do not. 83.9% (combined) strongly agree, or agree that "BIM has the potential to deliver significant added value to FM" and most people (84.3% combined) strongly agree, or agree, "BIM should help improve data transfer into CAFM systems".
- 72% say "the FM industry is not clear what BIM is" and 67.7% disagree or strongly disagree that the FM industry is well prepared to deal with BIM projects indicating more work needs to be done by the FM industry to ensure people are better informed about, and more prepared for BIM projects. This aligns with a high number of respondents (91.3%) who agree or strongly agree that facilities management professionals would benefit from more familiarisation with BIM to be able to define the outputs in the BIM process.
- 88.2% (combined) strongly agree, or agree BIM is about "an increased collaboration process and not just software models".
- 72% (combined) strongly disagree, or disagree that BIM is only for new-builds.
- Taking into account scores for strongly agree and agree (combined) the highest three ranking benefits of BIM to FM were perceived as
  1) strategic decision making about asset maintenance and management,
  2) visualisation of buildings/assets for customers, health and safety and for maintenance and
  3) data transfer from construction into CAFM and other software tools.
- Likewise the highest three ranking concerns were perceived as:
  1) CAFM software suppliers should work on tools that allow bi-directional transfer of data between BIM and CAFM,
  2) BIM training and how facilities managers will access data in 3D models at handover and
  3) lack of training and cost of training associated with BIM.
- 66.1% believe that BIM will help the UK government meet its target for a 33% reduction in the initial cost of construction and the whole life cost of built assets with 54.3% being generally confident about the targets for 50% reduction in the overall time to complete projects. However, they were slightly less confident about the sustainability and trade targets.

BIM EXPERIENCE:

- 39.8% had some experience of being involved in a BIM project but of concern was that only 20.5% (combined) have direct experience of writing or implementing an Asset Management Strategy in line with ISO55000 or other system. As assets are often the second biggest expense to organisations after personnel, perhaps more focus should be given to defining strategy with respect to asset management and BIM.
- The number of people who had both "written and implemented" key documents used in the BIM process was generally low. The percentages were as follows; OIR (15.0%), AIR (18.9%), EIR (20.1%), BIM strategy (17.3%) and BEP (12.6%) . This could be due to BIM being new to FM but might also indicate that more needs to be done to ensure the FM industry is equipped to write/implement key documents, which drive the start of the BIM process.
- 57.9% (combined) said that they agree or strongly agree "our employees would benefit from BIM certification or further BIM training courses". 28.3% were neutral and 13.8% (combined) disagree or strongly agree on this topic. This indicates a significant number of people who feel that further training is necessary.
- When respondents were asked to indicate the level of BIM training and support in their organisation only 10.2% rated it as very good, the more troubling statistics came from the minimal and none respondents with 23.2% recording minimal and a massive 32.7%, almost a third recording none!

"The use of BIM in FM operations by BAM FM provides a platform for improved maintenance planning, reactive responses and the quality of maintenance.

By combining 3D geometry with accurate data, instructions, and records for individual assets we can ensure that our employees have access to the information they need, where and when they need it. We also use BIM to participate in design and construction processes to make informed decisions on operational arrangements."

Reid Cunningham, Strategic Development Director, BAM FM Ltd

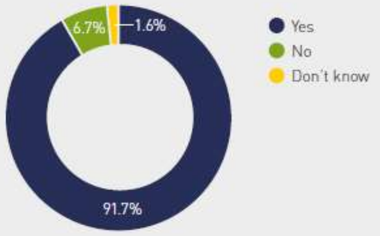
4.2 General experience and impact of BIM on FM

KEY FINDINGS:

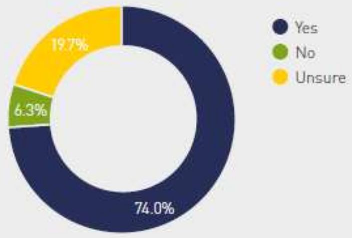
- Overall 91.7 % of survey respondents indicated they had heard of BIM before taking the survey, 6.7% had not heard of BIM and 1.6% were unsure. With respect to prior experience of BIM, 39.8% confirmed they had some experience of being involved in a BIM project whilst over half (52%) reported no experience (8.3% declined to answer).
- With respect to the question "Will BIM help support the delivery of facilities management?", the majority thought it would (83.5%), 12.6% were unsure and 3.9% believed not.
- When asked about the impact of BIM on the FM industry 74 % believe BIM will have a significant impact, 19.7% were not sure and only 6.3% believe it will not have a significant impact.
- 83.8% of respondents believe BIM is already having an impact on FM or will do so in the next five years, whilst 16.1% felt it would take more than 5 years.

THE IMPACT OF BIM ON FM:

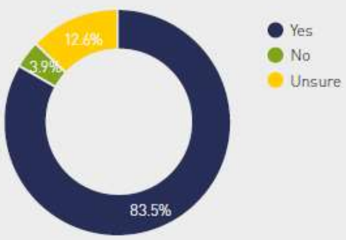
BEFORE TAKING THIS SURVEY HAD YOU EVER HEARD OF BIM (BUILDING INFORMATION MODELLING)?



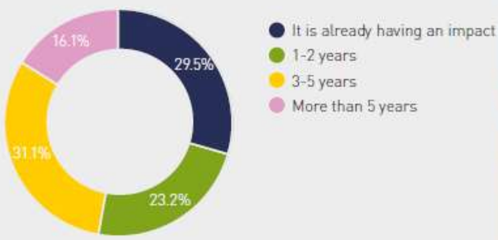
DO YOU BELIEVE BIM WILL HAVE A SIGNIFICANT IMPACT ON THE FM INDUSTRY?



DO YOU BELIEVE THAT BIM WILL HELP SUPPORT THE DELIVERY OF FACILITIES MANAGEMENT?



PLEASE INDICATE THE TIMESCALE YOU THINK IS RELEVANT FOR THE IMPACT?



4.3 FM experience of preparing or using BIM related documents

KEY FINDINGS:

- The results indicate not many people (12.2%) have experience of both "writing and implementing" an "Asset Management Strategy (e.g. ISO 55000 or other) and only a further 8.3% have implemented one written by someone else.
- In general the majority "knew of, but had not implemented/written" the key documents used in the BIM process, indicating that for many this would be a new challenge if they were to be involved in a BIM project. However only 13% indicated they would not be at all confident, and 18.5% indicated some concerns about confidence in preparing key BIM documents. This indicates the majority would be confident to engage in a BIM project and take on the roles of writing the documents.
- The percentage of respondents who have direct experience of writing and implementing the OIR (15%), AIR (18.9%), EIR (20.1%) and BEP (12.6%) for the BIM process is generally low. This could be due to BIM being new to FM but might also indicate that more needs to be done to ensure the FM industry is equipped to write/implement key documents which drive the start of the BIM process.
- As assets are often the second biggest expense to organisations after personnel, perhaps more attention should be given to ensure an asset management strategy is in place and people understand the organisations OIR and AIR before starting on the BIM journey.

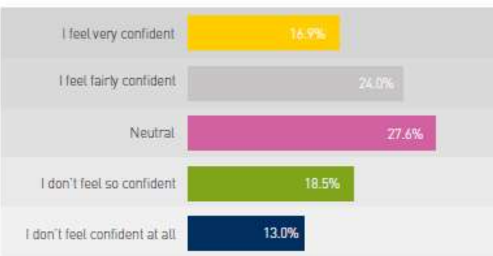
RESPONDENTS WERE ASKED IF THEY HAD ANY EXPERIENCE OF PREPARING OR USING A RANGE OF KEY DOCUMENTS USED IN THE BIM PROCESS. FEEDBACK WAS AS FOLLOWS:	HAVE WRITTEN AND IMPLEMENTED	HAVE IMPLEMENTED BUT NOT WRITTEN	KNOW OF BUT NOT IMPLEMENTED/ WRITTEN	NO EXPERIENCE
Asset Management Strategy (e.g. ISO 55000 or other)	12.2%	8.3%	38.2%	33.1%
BIM Strategy	17.3%	9.4%	34.6%	30.3%
Organisational Information Requirements (OIR)	15.0%	9.4%	33.1%	34.3%
Asset Information Requirements (AIR)	18.9%	12.6%	31.5%	28.7%
Employers Information Requirements (EIR)	20.1%	10.2%	26.4%	35.0%
BIM Execution Plan (BEP)	12.6%	8.7%	30.7%	39.8%

8.3% of respondents did not answer this question

Respondents were also asked to rate how confident they would feel about engaging in a BIM project and taking on the review of key BIM documents such as the Organisational Information Requirements (OIR), the Asset Information Requirements (AIR), the Employer's Information Requirements (EIR) etc.

BASED ON YOUR CURRENT KNOWLEDGE/EXPERIENCE OF BIM, HOW CONFIDENT WOULD YOU FEEL ABOUT ENGAGING IN A BIM PROJECT AND TAKING ON ROLES SUCH AS REVIEWING/ WRITING THE OIR, AIR, EIR ETC?

A positive finding was that a significant number of people (40.9%) feel "very" or "fairly confident" about engaging in a BIM project and writing the key documents. 27.6% were neutral but 31.5% felt "not so confident" or "not at all confident". For this 31.5% there is more work to be done to ensure they would feel positive about engagement in BIM projects.



4.4 General perception and awareness of BIM

KEY FINDINGS:

- 72% agree or strongly agree that "the FM industry is not clear what BIM is", and many, 67.7% disagree or strongly disagree that the FM industry is well prepared to deal with BIM projects. This indicates there is some more work to be done by the FM industry to ensure FMs are better informed about, and more prepared for BIM projects. This aligns with views that 91.3% agree or strongly agree that facilities managers would benefit from more familiarisation with BIM in order to define the outputs in the BIM process.
- Interestingly 80% (combined) of respondents strongly agree, or agree that BIM may offer companies that adopt and use it an advantage over those that do not.
- A high percentage (83.9% combined) of respondents strongly agree, or agree that "BIM has the potential to deliver significant added value to FM" and most people (84.3% combined) strongly agree, or agree "BIM should help improve data transfer into CAFM systems". This indicates a general positivity with respect to the potential benefits of BIM to FM.
- The findings indicate a significant number of responses (88.2% combined) strongly agree, or agree BIM is about "an increased collaboration process and not just software models". This is an important finding indicating that there is a general understanding about BIM as a process as opposed to software or models.
- Also of interest is that 72% (combined) of respondents strongly disagree, or disagree that BIM is only for new-builds. This indicates the majority also consider BIM can be used for existing buildings or refurbishments.

FROM YOUR AWARENESS AND UNDERSTANDING OF BIM, PLEASE INDICATE YOUR LEVEL OF AGREEMENT WITH THE FOLLOWING STATEMENTS.	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
The FM industry is not clear about what BIM is	17.3%	54.7%	16.9%	10.6%	0.4%
BIM is about a collaborative working process not just the use of BIM software model(s)	52.0%	36.2%	11.4%	0%	0.4%
FMs have a good understanding of the RIBA 2013 Plan of Work and its work stages	1.6%	10.2%	50.4%	32.3%	5.5%
BIM is only for new build, not existing buildings/assets or refurbishment projects	2.8%	11.4%	13.8%	41.3%	30.7%
BIM has the potential to deliver significant added value to FM	46.9%	37.0%	13.0%	2.8%	0.4%
The FM industry and FMs are well prepared to deal with BIM projects	0.8%	5.1%	26.4%	54.3%	13.4%
BIM should help improve data transfer into FM IT/CAFM systems	39.4%	44.9%	13.0%	1.6%	1.2%
BIM encourages early FM involvement in the design phase of projects to ensure the end users' needs are represented and give advice about life-cycle costing	39.8%	41.7%	14.6%	2.4%	1.6%
Companies adopting BIM may have a competitive advantage over those that do not	34.3%	45.7%	16.1%	2.4%	1.6%
FMs would benefit from more BIM familiarisation to help clearly define what they want in terms of outputs from the BIM process	49.2%	42.1%	7.9%	0%	0.8%

4.5 Possible benefits of BIM to FM

KEY FINDINGS:

- According to respondents the three highest ranking benefits of BIM to FM were perceived as:
  1) 87.8%: strategic decision making about asset maintenance and management.
  2) 87%: visualisation of buildings/assets for customers, health and safety and for maintenance.
  3) 86.6%: data transfer from construction into CAFM and other software tools.
- The findings indicate there is a perception that there may be a significant potential benefit of BIM to improve asset management strategy with improved data for CAFM and other FM systems. Many also felt there were significant benefits around visualisation of the virtual asset for a range of stakeholders and different reasons (maintenance, health and safety etc.).

Respondents were asked to indicate their agreement with a list of possible pre-identified benefits from a literature review. The results were as follows:

PLEASE INDICATE YOUR LEVEL OF AGREEMENT OF POSSIBLE BENEFITS OF BIM TO FM:

	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
Strategic decision making about asset maintenance and management	39.4%	48.4%	10.6%	0.4%	1.2%
Visualisation of buildings/assets for customers, H&S and maintenance issues	44.9%	42.1%	12.2%	0%	0.8%
Data transfer from construction into CAFM and other software tools for operation	41.7%	44.9%	11.4%	1.2%	0.8%
Cost management/transparency (whole life, maintenance and asset replacement)	42.5%	43.3%	12.2%	0.8%	1.2%
Operational efficiency (in terms of cost/time)	36.6%	47.2%	14.2%	0.8%	1.2%
Space and move planning capability	29.5%	48.4%	19.7%	1.2%	1.2%
Simulation capability e.g. energy, fire evacuations etc.	33.1%	44.1%	21.3%	1.2%	0.4%
Sustainability in terms of reductions in energy use/carbon emissions	23.2%	43.3%	29.9%	2.8%	0.8%
Insurance costs for buildings due to availability and accuracy of information	20.1%	38.2%	37.8%	3.5%	0.4%

"It is imperative that FM becomes involved in the BIM process from the start.

Our ability to support the strategic goals of organisations through effective delivery of lifecycle asset management provides much of the key data needed to formulate and describe the BIM requirements. BIM is no longer just a design led concept."

Steve Owen MBA CBIFM, Managing Director, FM180 Ltd

4.6 Other benefits

Respondents also identified a wide range of other possible benefits of BIM to FM. Some examples of other key themes identified were;

IMPROVED STRATEGIC ASSET PLANNING AND DECISION-MAKING:

- Asset and risk based maintenance will be improved due to the level of confidence of data about assets developed during the BIM process.
- Clients, FM professionals and investors should be able to make better-informed business and investment decisions before they invest in, or build assets by using the data and information in a virtual context created during the BIM process which reduces risk.
- The integration of the operational and maintenance stakeholders early in the design phase will push maintainability and cost reduction in O&M and ensure more complete transfer of O&M information.
- BIM will enable improved "cradle-to-cradle" strategies and projects will be better able to forward plan the dismantling of buildings or building parts with less waste and more possibilities to re-use components.
- The information from the BIM process will help FM in leasing, sub-tenant management, space utilisation and strategic decision making.

BETTER WORKING CULTURE FOR ORGANISATIONS AND PROJECTS:

- The BIM process should help overcome some traditional barriers, improve the tender process and encourage more involvement and cooperation between the various stakeholders in the whole life process. Respondents also mentioned collaboration and efficiency increased by everyone talking the same language.
- The BIM process (if planned properly) should help FM professionals ensure better handover of data at transition from construction to operation and their CAFM tools are well populated with relevant and useful data.
- If a standardised approach can be adopted by developers, installers and asset manufacturers then whole life modelling and lifecycle replacement can be effectively integrated in to CAFM for future risk planning.
- BIM will help FM companies validate, verify and comply with client's services and asset strategy.

NEW WAYS OF WORKING/TECHNOLOGY:

- Examples of other benefits of BIM include using the information and model to plan and help with way-finding systems and placement and use of sensor and other new technologies.
- BIM can provide a common, visually based communication platform for improving clarity and understanding among all project-related constituencies, including marketing to potential clients.
- Using BIM together with virtual/augmented reality will help FM professionals' plan and run scenarios. This could include maintenance and planning for emergencies etc.
- Allows for remote maintenance of a greater number of buildings, which cuts down on numbers of FM staff.

EDUCATION:

- BIM will help the overall education of those responsible for FM for their clients, as the general level of education and understanding of what FM is (and not) is quite low.
- BIM can help to emphasise that FM is a management discipline; overseeing and co-ordinating the efforts of others as opposed to the operational delivery of services.

However, some feedback indicated that respondents have "concerns around the cost and complexity of ongoing maintenance of BIM models and their associated data". Some people were "sure that BIM has potential benefits for FM", but stated, "We should really research the FM processes and their real data and information needs and their relationship to BIM". One respondent commented, "FM teams will require skills and support systems to maintain the model of the building in a suitable up-to-date format such that on-going revisions are incorporated and are valid". Another respondent observed "BIM is unlikely to be a 'silver bullet' but it has a high potential for improvement in the format of data".

4.7 Possible barriers and concerns to BIM adoption and use of BIM

KEY FINDINGS:

- In this section the highest three ranking barriers/concerns were perceived as:
  1) 72.5%: CAFM software suppliers should work on tools that allow bi-directional transfer of data between BIM and CAFM.
  2) 71.7%: BIM training and how facilities managers will access data in 3D models at handover.
  3) 68.1%: lack of training and cost of training associated with BIM.
- The findings highlight a need for CAFM software suppliers to help industry more. This might be addressing the issue of bi-directional data exchange between BIM-CAFM and how the plans to manage and capture data in the BIM process can be improved up to the point of handover. This was reflected in concerns about training and how facilities management professionals can access and keep data up to date between the BIM models and their CAFM systems.
- Also of interest was that many respondents noted their concerns as neutral with respect to the use of COBie for transfer into CAFM/other systems and the impact of BIM from a legal perspective. This might indicate that they see COBie as just part of the process. With respect to the legal concerns these did not feature very prominently. This might be because legal BIM clauses are not so common in standard types of contract and perhaps this is something that industry needs to consider.

PLEASE INDICATE YOUR AGREEMENT WITH POSSIBLE CONCERNS/ BARRIERS RELATING TO BIM	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
I feel I need more knowledge about BIM before being involved in a BIM project	20.1%	40.9%	18.9%	12.6%	7.5%
I don't feel our organisation is adequately prepared to engage in BIM projects	14.2%	37.0%	22.8%	19.3%	6.7%
The cost of adopting/implementing BIM	13.4%	39.8%	32.3%	13.0%	1.6%
Ability of FM to write/specify the OIR, AIR and EIR documents for a client	14.6%	46.9%	30.3%	6.3%	2.0%
Management/collection of data in the BIM process	13.4%	49.2%	26.8%	9.8%	0.8%
Using COBie for transfer of data into CAFM/other systems	12.2%	30.3%	46.1%	10.2%	1.2%
The impact of BIM from a legal perspective	10.6%	20.1%	51.2%	17.3%	0.8%
CAFM/software suppliers should work on tools that allow bi-directional transfer of data between the BIM and CAFM	33.1%	39.4%	22.8%	4.3%	0.4%
BIM training and how FMs will access data in 3D BIM models at handover	26.0%	45.7%	22.4%	4.7%	1.2%
Lack of/cost of training	23.6%	44.5%	24.4%	7.1%	0.4%

"Building Information Modelling (BIM) engages the facilities and building operational professionals from inception throughout the design and construction processes.

It allows them to consider and specify their holistic asset data and information requirements in line with their current and future asset management strategies, quality and data management systems."

Jason Clark, UBS Regional Head of Property Management

4.8 Other concerns

Respondents also identified a range of other concerns relating to BIM. Some examples of themed concerns identified were;

ENGAGEMENT, COOPERATION AND EFFORT REQUIRED

- FMs need to play a pivotal role and "be on board" with BIM. Automation and digitisation will have a big impact on how FM is delivered, but FM services will still be required even if the method of delivery changes and BIM needs to work with the way FM services are delivered.
- The lack of a transparent understanding from clients/owners as to why they should invest in BIM during early project stages often means they are reluctant to invest. To this end education for all clients on what BIM is and how it can help them, is a must.
- The pay back for the investment required is never mentioned and has not been qualified except with a 'utopian' view that does not reflect day-to-day operational reality.
- FM organisations have fast-pace day-to-day operations, therefore allocating FMs to BIM projects may require a considerable time away from daily operations during the first deployment in order to get their attention and feedback. Not all organisations can dedicate that time concentrated for a year or a few months.
- Traditional work cultures may hinder the implementation of BIM.

CAFM, BMS AND BIM:

- The ability to accept the level of detail required via COBie is ok in the short term however; CAFM developers need to work now to not only accept COBie style data but also integration with IFC.
- CAFM suppliers should demonstrate how data can be "bi-directional between the systems" – There needs to be an understanding/ clarification of what needs to be pushed back from CAFM into BIM.
- CAFM needs specific workflow to integrate CAD departments in change process, we need to ensure that there is a link with the BMS in the BIM planning process.
- I believe the biggest roadblock is lack of appropriate tools (software) for FM.

VALUE AND USABILITY OF MODELS:

- Clients need to invest in BIM models for them to be of value. How many O&M's and record drawings are out of date within years of a building being occupied? Unless BIM management becomes a budget line in client's annual costs then BIM will not provide value in the operational phase.
- Unless properly managed the BIM models have limited use in operations. We need to ensure a significant review of operational procedures to ensure that the data is used and maintained.
- Construction professionals need to ensure BIM models reflect reality. There needs to be a cultural change to understand what data is important and provides value and then a culture of keeping it valid and current.
- FMs seldom if ever need 3D BIM in their activities. We should not try to force them to learn things which are not beneficial for them, but analyse what they really need in their daily work and how that might be connected to the information in BIM but using a relevant user interface.
- We really need more case studies to show real positive value add and contribution to efficiency of FM operations.
- Soft landings needs to be integral to this process to ensure life cycle of assets is optimised and to minimise energy usage reducing the carbon footprint.
- I am concerned that only the larger practices will be able to afford the staff to work in the BIM format, especially for the first few years
- BIM is a tool but not the lead tool for the control for the built environment - the devil is in the detail and to ensure BIM is really useful it needs to take account that in operation there is a more systems orientated approach.
- Employing people to keep the information up to date.

"BIM is just as valuable to facilities and asset management professionals as it is to project clients.

The standards developed as part of BIM Level 2 spell out what FMs need to do to unlock this value. PAS 1192-3 provides a strategic framework explaining how information directly responds to the owner's/user's business needs, while BS 8536 provides recommendations for specific information deliverables needed by FM professionals at each stage of a project."

David Churcher, Director, Hitherwood Consulting Ltd

4.9 Knowledge of UK BIM standards and guidance documents

KEY FINDINGS:

- In general the findings indicate significant numbers of people were not aware of the UK BIM standards or maybe "had heard of them but not read them". However this result may be skewed by the high level of international respondents who understandably might not be so familiar with UK standards.
- With respect to the standards and guidance that scored higher it was interesting (and probably expected) that people were more familiar with those not just specific to BIM. Using combined scores, in terms of people indicating they "know them", and some "use in practice"; the top three ranked were The RIBA plan of Work*1 (32.3%), ISO 55000*2 Asset Management (28.7%) and ISO 15686-5*3 Life Cycle Management (25.9%).
- With respect to specific BIM standards and people indicating they "know them", and some "use in practice"; both PAS1192-2 and PAS 1192-3 scored highest registering 23.2%. This shows a balance of familiarisation from both a construction and operation perspective.
- Perhaps of concern was the relatively low familiarisation with BS-8536 (Parts 1 and 2) which scored low at 16.5% and 13% respectively. As two key documents guiding FM professionals in helping brief design teams and integrate the principles of soft landings perhaps more work needs to be done to promote these documents.

PLEASE INDICATE YOUR LEVEL OF KNOWLEDGE OF THE FOLLOWING KEY UK BIM RELATED STANDARDS AND GUIDANCE DOCUMENTS	KNOW AND USE IN PRACTICE	KNOW WELL BUT DON'T USE IN PRACTICE	HAVE A BASIC OVERVIEW BUT DON'T USE IN PRACTICE	HEARD OF BUT HAVE NOT READ	NOT AWARE OF
RIBA 2013 Plan of Work*1	16.9%	15.4%	16.1%	16.1%	35.4%
ISO 55000 (1/2/3) - Asset Management*2	12.2%	16.5%	22.8%	24.0%	24.4%
PAS 1192-2:2013 - Specification for information management for the capital/delivery phase of construction projects using BIM	11.0%	12.2%	15.7%	19.7%	41.3%
PAS 1192-3: 2014 - Specification for information management for the operational phase of assets using BIM	10.6%	12.6%	16.5%	18.9%	41.3%
BS 8587:2012 Guide to facility information management	10.6%	10.2%	16.9%	22.8%	39.4%
ISO 15686-5 - Life Cycle Management*3	9.4%	16.5%	24.0%	22.0%	28.0%
BS 1192:2007+A2:2016 - Collaborative production of architectural, engineering and construction information – code of practice	9.1%	7.5%	18.9%	20.9%	43.7%
BS1192 part 4:2014 - Fulfilling employers information exchange requirements using COBie – Code of practice	7.5%	11.4%	16.5%	20.9%	43.7%
CIC suite of BIM documents; Professional Indemnity Insurance, Scope of Services for the Role of Information Management and BIM Protocol	6.3%	9.1%	14.6%	17.3%	52.8%
PAS 1192-5: 2015 Specification for security-minded BIM, digital built environments and smart asset management	5.5%	10.2%	18.5%	21.3%	44.5%
BS 8536-1:2015 Briefing for design and construction –Part 1: Code of practice for facilities management (buildings infrastructure)	5.1%	11.4%	22.0%	20.9%	40.6%
BS 8536-2:2016 Briefing for design and construction. Code of practice for asset management (Linear and geographical infrastructure)	4.3%	8.7%	20.1%	21.7%	45.3%

4.10 Other BIM Standards, Guidance or Tools

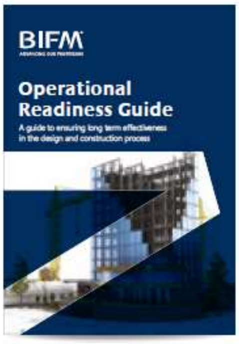
Respondents were also asked about any other BIM standards, guidance or tools which they considered useful references for facilities managers.

KEY FINDINGS:

- The research findings indicate that facilities management professionals and other stakeholders around the world are using a wide range of both UK and international BIM standards and guidance documents.
- The BIFM guidance documents for BIM were referred to in additional feedback from respondents as a good starting point for FM professionals interested in knowing more about the BIM process.
- Government Soft Landings(GSL) and adopting the principles contained within the BSRIA soft landings guidance was also mentioned by several respondents as very important to FM professionals and ensuring the BIM process starts as it should do.
- Guidance and tools developed by other professional associations such as NBS, CIBSE, RICS, NBIMS (US), GSA (USA), SIA (Switzerland), CoBIM (Finland), EU BIM Task Group were also seen as good reference for learning more about BIM.

PLEASE GIVE DETAILS OF ANY OTHER BIM GUIDANCE DOCUMENTS/TOOLS WHICH ARE NOT LISTED ABOVE WHICH YOU USE/THINK ARE USEFUL REFERENCE FOR FMs

- Government Soft Landings Policy
- BIFM Operational Readiness Guide
- BIFM Good Practice Guide "The Role of FM in BIM Projects"
- BIM Guide 08 - Facility Management – GSA
- GSA BIM requirements
- COBIM 2012
- BIM Handbook of EU BIM Task Group
- Penn State BIM Execution Plan
- National BIM standard version 3 (National Institute of Building Science)
- NBIMS standard, especially part 4.2 (COBie)
- NBS BIM Toolkit (digital Plan of Work and Uniclass 2015)
- CIBSE life cycles, PDTs
- RICS suite of information and their BICS service
- Switzerland SIA 2051: building information modelling (in development)

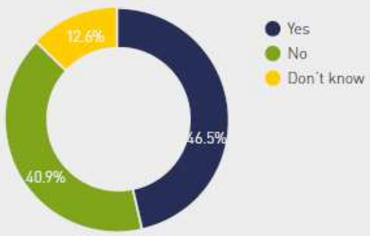


4.11 Awareness of the UK government's BIM strategy

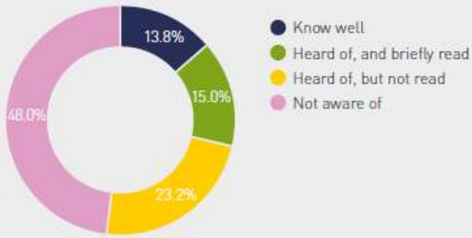
KEY FINDINGS:

- The findings show overall 53.5% of respondents are aware of the UK government mandate to adopt and use BIM level 2 on government procurement projects (effective from April 2016). If this figure had been based on UK responses only the expectation is that it would have been higher. However, considering the high international response the figure can still be considered quite high.
- Many (40.9%) globally are still not clear about the different levels of BIM. Feedback from comments indicate this might be partially due to confusion in connection with different "dimensions of BIM"; i.e. 4D (time/project information), 5D (cost data) and 6D (facilities management).
- Taking into account the large international response it was interesting that significant numbers were familiar with the UK governments "Digital Built Britain - level 3 strategy", 15% having heard of and briefly read it and a further 23.2% having heard of but not yet read it.
- 24% had also accessed the Digital Built Britain website, with 34.2% and 28% the BIM Task Group and BIM Level 2 websites respectively.

THE GOVERNMENT HAS DESCRIBED THERE BEING DIFFERENT LEVELS OF BIM. ARE YOU AWARE OF THESE DIFFERENT LEVELS?



ARE YOU AWARE OF THE GOVERNMENT "DIGITAL BUILT BRITAIN - LEVEL 3 STRATEGY"?



Respondents were also asked if they were aware of a series of government websites (linked to the UK BIM task Group) with the purpose of supporting and helping disseminate information about BIM.

ARE YOU AWARE OF THE FOLLOWING WEBSITES (LINKED TO GOVERNMENT BIM TASK GROUP)?

		KNOW WELL AND HAVE ACCESSED REGULARLY	HEARD OF, AND BRIEFLY ACCESSED	HEARD OF, BUT NOT ACCESSED	NOT AWARE OF
BIM Task group	www.bimtaskgroup.org	18.1%	16.1%	13.8%	52.0%
Digital Built Britain	www.digital-built-britain.com	10.2%	13.8%	16.5%	59.4%
BIM Level 2	www.bim-level2.org	12.6%	15.4%	14.6%	57.5%

4.11 Awareness of the UK government's BIM strategy

The respondents were asked for their views on whether they believed BIM would help the government meet their key strategy targets set for 2025.

KEY FINDINGS:

- Over half of respondents were generally confident (66.1%) that BIM will help the government meet its target for a 33% reduction in the initial cost of construction and the whole life cost of built assets.
- There was general confidence (54.3%) about the targets for 50% reduction in the overall time to complete projects.
- Results showed that there was a bit less confidence about the sustainability and trade targets.
- Further comments in the research indicate this might be due to a lack of well documented case study evidence. Some comments indicate the lower figure for the trade gap target might relate to people maybe not making a direct connection between BIM and reducing the trade gap.

"The FM and Asset Management Industry has played a significant role in the delivery of the Construction Strategy especially in the advancement of Soft Landings and BIM where the needs of the end-user has been considered and addressed throughout a digitised design process and data and information to support the operational and asset strategy defined through the integration and early involvement of FM players who have become the golden thread in the asset life-cycle."

David Philp, Global BIM Consultancy Director AECOM and Chair Scottish BIM Delivery Group

THE UK GOVERNMENT HAS SET OUT ITS STRATEGY FOR UK CONSTRUCTION IN 2025. THE STRATEGY INCLUDES FOUR TARGETS. PLEASE TELL US THE ROLE YOU THINK BIM WILL HAVE IN OUR ACHIEVING THE FOLLOWING:

	BIM WILL HELP	BIM WON'T MAKE A DIFFERENCE	BIM WILL HINDER	DON'T KNOW
33% reduction in the initial cost of construction and the whole life cost of built assets	66.1%	5.5%	0.8%	27.6%
50% reduction in the overall time, from inception to completion, for newbuild and refurbished assets	54.3%	13.0%	2.0%	30.7%
50% reduction in greenhouse gas emissions in the built environment	40.2%	24.8%	0.4%	34.6%
50% reduction in the trade gap between total exports and total imports for construction products and materials	20.9%	33.1%	0.8%	45.3%

4.12 Asset Management and BIM in your organisation

KEY FINDINGS:

- A worrying trend was that a significant number of people (25.2%) indicated their organisations do not have a formal asset management strategy (e.g. ISO 55000 or other) "in place". Another 22.4% of people indicated they "didn't know" if their organisation had an asset management strategy. A further 11.0% indicated that where an asset management strategy was in place "it was not well used". Interestingly a further 12.2% indicated they were "considering implementing" an asset management strategy. These overall figures show that many organisations do not have an asset management strategy in place or one which is well used and managed. This is an issue that maybe needs to be more widely addressed as any organisations intending to use the BIM process need to have their asset management strategy in place as a fundamental starting point for the BIM process.
- With respect to key BIM documents a relatively low range of percentages (8.7% - 16.1%) were indicated against the various documents being "in place and is well used". Interestingly roughly a quarter of people indicated they were "not in place", and a further quarter indicated they "did not know". These figures might reflect people not yet being aware of the BIM process and associated acronyms.
- The indication around there being "no requirement" for BIM strategy or documents was roughly between 15.4% - 19.7%. Further comments from the survey indicate this might be due to respondents (and their organisations) not yet having any involvement in a BIM project or the BIM process.

Respondents were asked about BIM in the organisation they work for and specifically if the following were in place; Asset management strategy, BIM strategy, BIM processes, OIR, AIR, EIR, BEP. The responses are shown below:

DOES YOUR ORGANISATION HAVE THE FOLLOWING IN PLACE?

	IN PLACE AND IS WELL USED	IMPLEMENTED BUT NOT WELL USED	CONSIDERING IMPLEMENTING	NOT IN PLACE	NO REQUIREMENT	DON'T KNOW
Asset Management Strategy (eg. ISO 55000 or other)	12.2%	11.0%	12.2%	25.2%	19.7%	22.4%
BIM Strategy	15.4%	7.1%	14.6%	29.1%	18.5%	18.9%
BIM processes	16.1%	7.5%	15.7%	29.5%	16.1%	17.7%
Organisational Information Requirements (OIR)	8.7%	10.2%	14.2%	28.7%	15.7%	24.4%
Asset Information Requirements (AIR)	13.4%	12.2%	13.0%	24.8%	15.4%	23.6%
Employers Information Requirements (EIR)	13.4%	10.6%	11.0%	25.6%	15.4%	25.2%
BIM Execution Plan (BEP)	14.2%	6.7%	11.8%	28.7%	16.1%	23.2%

4.13 BIM training

KEY FINDINGS:

- 57.9% (combined) of respondents agree or strongly agree "our employees would benefit from BIM certification or further BIM training courses". 28.3% were neutral and 13.8% (combined) disagree or strongly agree on this topic. This indicates a significant number feel they would benefit from further training.
- When respondents were asked to indicate the level of BIM training and support in their organisation only 10.2% rated it as very good, the more troubling statistics came from the minimal and none respondents with 23.2% recording minimal and a massive 32.7%, almost a third recording none.

PLEASE INDICATE YOUR LEVEL OF AGREEMENT WITH THE FOLLOWING	STRONGLY AGREE	AGREE	NEUTRAL	DISAGREE	STRONGLY DISAGREE
Our organisation has a clear understanding about BIM training and a plan in place for staff training	9.4%	12.6%	31.5%	29.5%	16.9%
Our organisation has adequate resources/funding available for BIM training	7.1%	15.7%	38.2%	26.0%	13.0%
Our organisation already has in-house BIM expertise which is being used to conduct in-house training	10.6%	16.1%	30.7%	24.4%	18.1%
Our organisation has a plan in place to actively evaluate its BIM training	6.3%	13.4%	37.0%	27.6%	15.7%
Our employees would benefit from BIM certification or further BIM training courses	17.3%	40.6%	28.3%	6.3%	7.5%

"Harnessing the potential of BIM in FM needs ongoing sector specific guidance and real-life examples to maximise knowledge transfer. What's equally important is having FM professionals leading the development of client EIR's as this provides the catalyst for understanding BIM and then improving its impact in operation."

Ivor McCauley, Facilities Manager, Glasgow Life

4.13 BIM training

Where respondents had received some form of BIM training they were asked to give general information about the type of training. The training was wide ranging including formal degrees from universities to specialist training delivered by a wide range of professional institutions and other organisations. Some of those mentioned included:

TRAINING DELIVERED BY:

- Webinars from BIFM and other professional organisations
- Internal company seminars and workshops addressing staff awareness of BIM
- Online courses
- Specific BIM training courses delivered by specialist organisations or professional associations (BIFM, BRE, BSi, BSRIA, RICS, etc.)
- BIM courses delivered as part of a further education programme (university etc.)

TYPE OF TRAINING INCLUDED:

- BIM familiarisation, essentials and awareness training
- BIM manager and project information manager courses (e.g. Mensch und Machine, Switzerland)
- BIM modules, research labs and electives (university)
- Training on specific standards associated with BIM (e.g. BSi courses)
- Accredited professional BIM training (e.g. BRE courses)
- CPD and distance learning
- BIM software training

“

Facilities management professionals as the long term custodians of an organisations buildings potentially can have a greater impact on the performance of the building than any other individual.

The engagement of the FM professional in the full design and build process helps to provide a building that can be maintained, and have in place the systems and processes to operate and maintain the building for optimal performance.”

Paul Thomas, Principal Consultant, Turner & Townsend

5. Conclusion, recommendations and BIFM's Action Points

The majority of FM professionals had heard of BIM and many respondents anticipate BIM will have a significant impact on the FM industry although the exact time scales are not clear.

It is clear from this survey's feedback that the majority of FM professionals both in the UK and internationally are aware of BIM. Many people indicated they feel it has significant potential to both; impact on the FM industry, and deliver significant benefits. Interestingly a high percentage of people indicated they felt BIM might offer organisations a competitive advantage. However, the level of awareness and familiarisation varies widely across the FM industry with approximately half of the respondents indicating "FM is not yet really sure what BIM is". BIFM recognises this as an important requirement to do more to help support people who are starting on their BIM journey and want to get up to speed.

Some of the key benefits of BIM to FM highlighted by the research were; helping strategic decision making about asset maintenance and management, visualisation in terms of customer perception of their buildings and assets and visualisation for maintenance staff for planning maintenance and health and safety issues. The transfer of data from construction into CAFM and other software tools was also seen as a significant benefit. However, people also indicated there is a strong need for CAFM software suppliers to develop tools that allow bi-directional transfer of data between BIM and CAFM.

There were indications that some people felt BIM has been perhaps oversold and that significant work still needs to be done by the FM industry (in partnership with the AEC industries) to help ensure the potential benefits of BIM can be both; planned for, and realised in the operational phase of assets. Although the wider benefits are generally acknowledged they perhaps need to be made more transparent and better promoted to facilities management professionals, clients and investors in order that they understand why they should buy into, and equally as important, drive the BIM process by defining their needs at the start of the process.

Respondents also indicated they had concerns regarding access to, and the cost of training associated with BIM. This is another important point which has been picked up by the BIFM; the need for more BIM training specific to clients and facilities management professionals with a focus on understanding how to plan what information is needed and how they will access data in 3D models at handover. The research has provided valuable information to help BIFM benchmark current levels of awareness and understanding of BIM across the FM profession.

"A soft landing means aligning asset construction and design with how we operate and maintain them. The FM professional on the project team from strategy stage and the use of BIM for the asset data are two areas in achieving buildings that truly deliver the outcome they are designed for."

Deborah Rowland, Director Public Sector Affairs, Sodexo

BIFM's Action Points

- Our Operational Readiness Group will continue its work to release further BIM guidance documents. Plans for future work include releasing guidance on the Organisational Information Requirements (OIR) and Asset Information Requirements (AIR) specifically for FM.
- We will also continue to develop our training portfolio around BIM as part of the BIFM Academy.
- We plan to continue our collaboration with our partners, Liverpool John Moores University and Zurich University of Applied Sciences and conduct a follow-up survey later this year. This will give us important feedback on the usefulness of the BIM guidance documents recently produced as well as any new guidance released and to understand how these are being used by FMs.

"I believe that most facilities management professionals now understand the 'why' and the 'what' of BIM. We get the transformational nature and we broadly understand the principles that we need to apply. There has always been a strong desire from FM professionals to engage especially in the early days of the design and build process and the handover stage. So the most pressing question now is 'how' do we do so. The industry as a whole and especially customers need to think about how to procure FM services and engage FM professionals as part of an extended design and build contract. This to me is the final piece of the jigsaw that will really accelerate the involvement of owners and FM professionals in the development of BIM."

Kath Fontana, Managing Director, ISS Technical Services

About BIFM
The British Institute of Facilities Management (BIFM) is the professional body for facilities management (FM). Founded in 1993, we promote excellence in facilities management for the benefit of practitioners, the economy and society. Supporting and representing over 17,000 members around the world, both individual FM professionals and organisations, and thousands more through qualifications and training.

We promote and embed professional standards in facilities management. Committed to advancing the facilities management profession we provide a suite of membership, qualifications, training and networking services designed to support facilities management practitioners in performing to the best of their ability.

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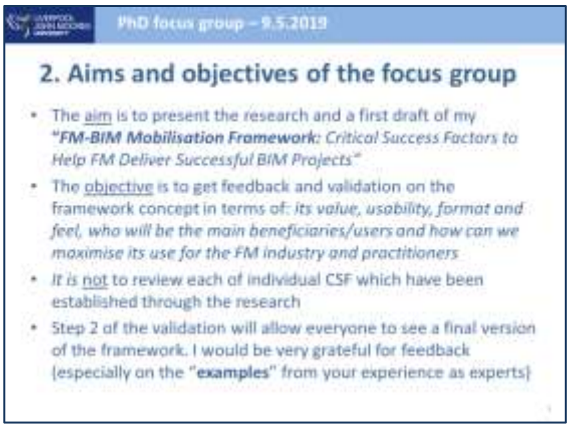
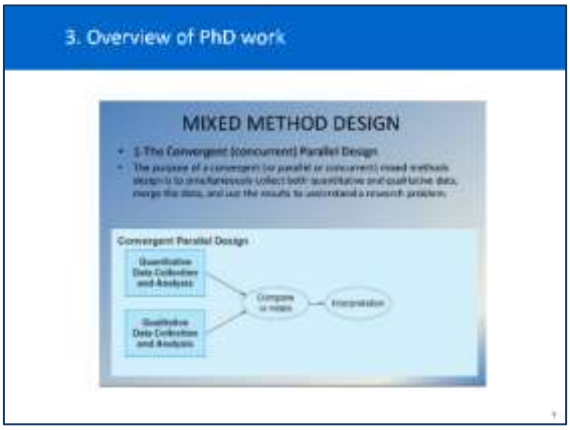
* While all due care is taken in writing and producing this Overview, BIFM does not accept any liability for the accuracy of the contents or any opinions expressed herein.

Appendix N: Validation process Stage 1 Focus group ‘discussion guideline’ slides






PhD focus group – 9.5.2019
Research approach overview


PhD focus group – 9.5.2019
overview ... continued


PhD focus group – 9.5.2019
overview ... continued


4. initial CSF findings – qualitative & quantitative
Search
Analysis
RESEARCH
Data
www.


PhD focus group – 9.5.2019
Qualitative approach: interviews
• 19 Semi-structured interviews
• Target: FM & BIM experts
• N-vivo used to analysis interviews and establish themes
• 10 CSF qualitative Main-themes
• 45 Sub-themes (e.g. Benefits of BIM to FM)

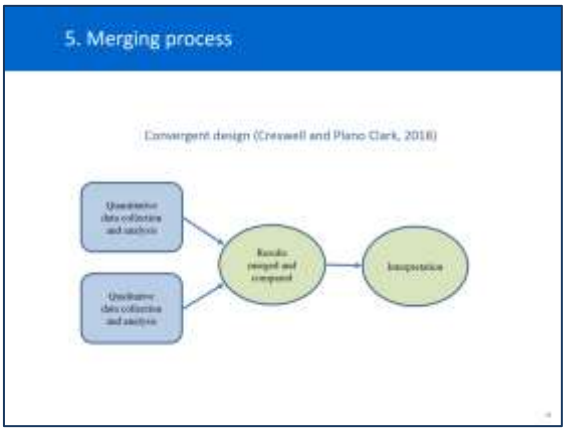

PhD focus group – 9.5.2019
CSF: Qualitative findings
CSF_QUAL_MT1 - Government policy and its impact on FM
CSF_QUAL_MT2 - Barriers, challenges and concerns to adoption and use of BIM
CSF_QUAL_MT3 - Benefits of BIM to FM
CSF_QUAL_MT4 - Digitalisation and technology
CSF_QUAL_MT5 - Strategic management and use of information
CSF_QUAL_MT6 - People in the BIM process and improving collaboration
CSF_QUAL_MT7 - Role of FM in the BIM process
CSF_QUAL_MT8 - Key BIM standards and guidance for FM
CSF_QUAL_MT9 - Training and competency
CSF_QUAL_MT10 - Data and information transfer in the BIM process


PhD focus group – 9.5.2019
Qualitative: Sub-themes


PhD focus group – 9.5.2019
Quantitative approach: questionnaire
1. FM Awareness of BIM Questionnaire
2. Target: general FM practitioners
3. Partnership with BIFM
4. n = 254
5. Statistical analysis
• Descriptive statistics
• Inferential statistics (SPSS)
• 10 CSF quantitative Main-themes
• 46 Sub-themes (e.g. barriers to BIM)
6. Descriptive findings published 2017
BIFM


PhD focus group – 9.5.2019
CSF: Quantitative findings
CSF_QUAN_MT1 - General awareness of existence of BIM and its impact on FM
CSF_QUAN_MT2 - General perception/understanding of BIM by FM industry
CSF_QUAN_MT3 - FMs experience of preparing/using key BIM documentation
CSF_QUAN_MT4 - AMS and BIM in respondents' organisations
CSF_QUAN_MT5 - Benefits of BIM to FM
CSF_QUAN_MT6 - Possible barriers/concerns to adoption and use of BIM
CSF_QUAN_MT7 - Knowledge of UK BIM standards and guidance
CSF_QUAN_MT8 - BIM supporting the UK government construction strategy
CSF_QUAN_MT9 - BIM training within respondent's organisations
CSF_QUAN_MT10 - Digitalisation and technology impact on FM


PhD focus group – 9.5.2019
Quantitative: Sub-themes


5. Merging process
Convergent design (Creswell and Plano Clark, 2018)
Quantitative data collection and analysis
Qualitative data collection and analysis
Results merged and compared
Interpretation


PhD focus group – 9.5.2019
CSF Merging process
The same merging process was applied to all the Sub-themes


PhD focus group – 9.5.2019
Final List of merged CSF
No
CSF main-themes (MT) - Final List
MT1
Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets
MT2
Addressing and overcoming perceived 'barriers and challenges to adoption and use of BIM'
MT3
Making the 'benefits of BIM to FM' transparent, realistic and achievable
MT4
Recognising the importance of digitalisation and technology' to FM and the BIM process
MT5
Planning the strategic and operational 'information needs for FM' in the BIM process
MT6
Improving 'stakeholder collaboration' and 'understanding of the BIM process'
MT7
Clarifying the 'role of and tasks of FMs' in the BIM process
MT8
Acquiring essential 'knowledge of key BIM standards/guidance documents' for practical use in a BIM project
MT9
Ensuring people have adequate 'BIM training and competency skills' to successful engage in BIM projects
MT10
Ensuring the 'successful transfer' of '3D models, aphanumeric data and documents' into FM systems


6. Concept for framework design
FM-BIM
Mobilisation Framework:
Critical Success Factors to Help FM Deliver Successful BIM Projects
Simon Ashworth
LIVERPOOL JOHN MOORES UNIVERSITY


PhD focus group – 9.5.2019


PhD focus group – 9.5.2019
Index


PhD focus group – 9.5.2019
1. Introduction


PhD focus group – 9.5.2019
2. Guidance for using the CSF Mobilisation Framework


PhD focus group – 9.5.2019
3. Summary list of Critical Success Factors (CSF)


PhD focus group – 9.5.2019
4. Tables:
CSF Main-themes (MT) and Sub-themes (ST)


PhD focus group – 9.5.2019
4.1 CSF 1:
Lower costs
33%
Faster delivery
50%
Lower emissions
50%
Improvement in exports
50%


PhD focus group – 9.5.2019


PhD focus group – 9.5.2019


PhD focus group – 9.5.2019

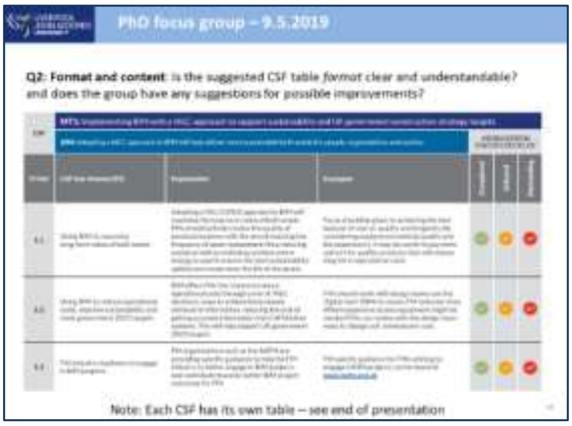

PhD focus group – 9.5.2019
5. Conclusion and further reading


PhD focus group – 9.5.2019
Appendix 1:
Abbreviations
Appendix 2:
Glossary of terms
Appendix 3:
Relevant BIM and FM standards


PhD focus group – 9.5.2019
CSF 10: each CSF MT/ST will be treated the same – with any improvements from the group


7. Group discussion and questions
Two-Stage Review:
1. Focus group
2. Follow-up peer review final validation
For Transcription:
Please state your name before speaking


PhD focus group – 9.5.2019
Q1: Sequencing of Main CSF: Is the proposed sequence (as shown below) of the 10 main CSF logical, or would the group suggest any changes?


PhD focus group – 9.5.2019
Q2: Format and content: Is the suggested CSF table format clear and understandable? and does the group have any suggestions for possible improvements?
Note: Each CSF has its own table – see end of presentation


PhD focus group – 9.5.2019
Q3: RIBA Stages: Would it add any value to have a RIBA reference column indicating at what stage the CSF is most applicable in? What is the groups opinion as to which RIBA stage should be shown?


PhD focus group – 9.5.2019
Q4. Usability and benefit to FM: How does the group see the document being used in practice and how could it benefit FM?
Q5: Beneficiaries & Stakeholders: Who does the group see as the 'main beneficiaries' and 'stakeholders' who might use the document?
Q6: Marketing of Framework: How could the document be best marketed to the relevant target audience?
Q7: IWFM members: Would it be useful to have the document made available to IWFM members together with their other BIM guidance documents?


End of workshop – Thank you very much for your time
Look! Is it a bird?
A plane?
No its a BIM empowered Facility Manager!

Appendix O: Invitation to participate in focus group workshop

Liverpool John Moores University

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Dear XXXX

Participation in PhD Research Focus Group 9.5.19:

Thank you for verbally confirming your willingness to help participate in my PhD focus group workshop. I am making final preparations for the focus group on 9.5.19. As part of the process I have to ask all the participants to sign a "consent" form and return it for the LJMU process. Please can you sign it and scan and send it back to me. There is also a general information participation sheet.

Thanks again for your help, it's much appreciated.

Simon Ashworth
LJMU, School of the Built Environment
S.J.Ashworth@2014.ljmu.ac.uk
Tel: +41 79 138 68 52

Appendix P: Focus group participation information sheet

Liverpool John Moores University

Focus group participation information sheet

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Name of Researcher and School/Faculty

You are being invited to take part in a focus group as part of a two-stage validation process study, being undertaken by Simon Ashworth, from The School of the Built Environment at Liverpool John Moores University. Before you decide to participate, it is important that you understand why the research is being done and what it involves. Please take time to read the following information and ask if there is anything that is not clear or if you would like more information so that you can decide whether you want to take part or not.

What is the purpose of the study?

The purpose of the study is to investigate how CSF (from industry best practice and '*FM and BIM experts*') can be used to help improve the BIM process in the early stages in the life of a project. This should ensure that buildings and assets are built in such a way that they meet the needs of the end users when the buildings are handed over to the FMs. The study is being managed by and will support the PhD work being undertaken by Simon Ashworth in this area.

The focus group will be held online using a Zoom Room facility between 13:00 and 15:00 UK time on 9th May 2019.

Do I have to take part?

Your participation is voluntary, and it is up to you to decide whether to take part. If you do, you will be given this information sheet and asked to sign a consent form. You are still free to withdraw at any time and without giving a reason.

If you wish to receive a summary of the research findings, on conclusion of the studies, please let me know by email and this will be arranged in due course.

What will happen to me if I take part?

The focus group for the research project will last approximately 2 hours. The workshop will commence with an introduction between all the participants and then a short presentation about the work to date. The focus group will be used to assess a draft version of the '*FM-BIM Mobilisation Framework*' and provide validation as to its value and usability, as well as feedback about the format and who the main beneficiaries and users will be. It is intended that the focus group is recorded so we can focus on the event. The recording of the focus group will be transcribed afterwards. You will be asked to give your consent to the focus group being recorded. All information provided will remain anonymous and information will be kept confidential.

Are there any risks/benefits involved?

There should be no potential risks to participating in the research. The findings will allow the researcher to help contribute towards the FM community and its engagement with the BIM process through the development of the '*FM-BIM Mobilisation Framework*'. This aims to supply guidance to FM professionals involved in BIM projects. The framework will be made freely available on completion of the work and might also be used by other stakeholders involved in the BIM process.

Will my taking part in the study be kept confidential?

All information given and used in the study will be kept confidential during and after the study. The transcription will use a separated coded letter/number system, which will ensure all transcribed text remain anonymous with respect to individuals and organisations.

Note: This study has received ethical approval from LJMU's Research Ethics Committee No: 15/BUE/004

Contact Details of Researcher:

Please contact me using the details below if you have any questions or anything is not clear.

Simon Ashworth, PhD Student
The School of the Built Environment, Liverpool John Moores University
S.J.Ashworth@2014.ljmu.ac.uk (Tel: +41 79 138 68 52)

Contact Details of Supervisor

Dr Matthew Tucker:
Liverpool Business School, Liverpool John Moores University
M.P.Tucker@ljmu.ac.uk (Tel – School +44 1512312861

The School of The Built Environment, Liverpool John Moores University, would like to thank you for agreeing to take part in this research.

If you any concerns regarding your involvement in this research, please discuss these with the researcher in the first instance. If you wish to make a complaint, please contact researchethics@ljmu.ac.uk and your communication will be re-directed to an independent person as appropriate.

Appendix Q: Focus group consent form

Liverpool John Moores University

Title of Project

'The Evolution of FM in the BIM Process: An Opportunity to Use Critical Success Factors (CSF) to Optimise Built Assets'

Researcher:

Simon Ashworth

LJMU, School of the Built Environment

S.J.Ashworth@2014.ljmu.ac.uk

Tel: +41 79 138 68 52

The Participant:

1. I confirm that I have read and understand the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily. ☐

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving a reason and that this will not affect my legal rights. ☐

3. I understand that any personal information or direct quotes collected during the study will be anonymised and remain confidential ☐

4. I understand that the interview/focus group will be audio / video recorded and I am happy to proceed ☐

5. I understand that parts of our conversation may be used verbatim in future publications or presentations but that such quotes will be anonymised. ☐

6. I agree to take part in the above study ☐

Name of Participant	Date	Signature
Name of Researcher	Date	Signature
Simon Ashworth		

Note: When completed 1 copy for participant and 1 copy for researcher

Appendix R: Focus group transcript

Transcript of PhD Focus Group Workshop
9th of May 2019

Transcript for Online PhD Focus Group Workshop – 9.5.2019

Note: Slides for the event are also shown in the appendices.

Welcome by Simon Ashworth

Title Slide: Thank you everyone for taking time to join me. The purpose of the workshop is to fulfil the validation section of my PhD research design. I will also present what I am calling the FM-BIM Mobilisation Framework: Critical Success Factors to Help FM Deliver Successful BIM Projects. I would also like to introduce virtually my supervisor is Dr Matthew Tucker at Liverpool John Moore, his picture is the one next to mine on my slide title page. The funny title cartoon is an elaboration on one from 2014 where FMs are shown as "super-people" as they need to know a little bit about everything in order to do their job, but being a "BIM Empowered Facility manager" will make the FM even more of a super person.

Slide 2: So, let's start the workshop. However before do I wanted to show this picture. In the world of BIM people always talk about "starting with the end in mind". For me the end in mind is to complete my PhD and I feel can finally see the light at the end of the tunnel, it has been a long journey getting here but I am extremely grateful for everybody involved here as you have given a lot of your time from previous interviews as well so it's very much appreciated.

Slide 3: The agenda for today will start with a brief round of introductions. I will then go through the aims and objectives of the focus group, I will then give an overview of my PhD work, discuss the findings and the CSF, which I think of as the key nuggets of information the research has identified which help FMs. There will be a brief overview of the methodology involves merging the quantitative and qualitative CSFs together and how I produced a final list of CSFs which was then used to produce the CSF Mobilisation Framework. Today I will be presenting a draft of that framework and we will then have a discussion where the main emphasis of the workshop will be in and finally, we will have a wrap up and address any open questions. I aim to close the workshop within two hours but if we need extra time, I have allowed an extra half hour.

1. Introductions

Slide 4: This picture shows a BIM model from our ZHAW building in Switzerland created by my colleague Mihaela Meslec who is on the call. It also shows the title of my PhD is '**The evolution of FM I the BIM process: an opportunity to use Critical Success Factors (CSF) for optimizing built assets**'. The word 'evolution' is important, as during my time researching FM and BIM, I feel the industry has gone through and still is an evolution with respect to BIM. When I first went to Liverpool and put EIR into the LJMU university search engine it came up with nothing at all. Now you are overwhelmed with BIM online information so I can say we clearly are in an evolutionary process.

Note: Slide 5: For the purpose of confidentiality the names of attendees at the workshop who then introduced themselves and gave a brief introduction of their job title and place of employment are not included in the transcript or the slides. Instead of names the people are represented as participants P1-P7 against passages of text which are highlighted in blue for easy recognition.

2. Aim and objectives of the focus group (Slide 6)

Slide 7: The aim is to present the research and my first draft of the "FM-BIM Mobilisation Framework: Critical Success Factors to Help FM Deliver Successful BIM Projects". I should note that during the research I focused on identifying the CSFs using a lot of complicated analysis with many coded variations. However as discussed with my supervisor the Framework as an end product should be as simple as possible as it is aimed at working FMs and people in the industry. It is a case of stripping away the complexity, equations and statistics to produce a useable product. This is what Matt and I have worked on to try and produce the FM-BIM Mobilisation Framework as a product useful to FMs in practice as a sort of 'mobilisation checklist'. So, the first key object of the meeting today is the first stage of validation in which I will show you the framework, how it will look and its format. I would like feedback on its usability, how does it look and feel, who the main beneficiaries and users may be and how we could maximise its use for the FM industry and practitioners.

Today is not about discussing the individual CSF established as that has already been done through the research. Today is to review the concept and validate if it will work in its current proposed format and be beneficial to FMs. The final end product will be produced as a glossy brochure in a PDF format, so we have created an overview and a detailed CSF example to present today for the groups feedback. Once we get that the remaining 9 will be replicated in the same way. For the second validation step I proposes to send each attendee a final version with all 10 CSFs for final checking and validation in quiet time. I would especially like people to give any specific examples that may help FMs in this second validation round. I aim to do this 2-3 week after the workshop when all the graphics work is completed.

3. Overview of PhD work (Slide 8)

As you will hear the approach, I have taken in my work is using a convergent parallel design using quantitative and qualitative analysis at the same time, rather than in separate phases of a consecutive deign. The findings are brought together and then compared for interpretation.

Slide 9: I don't want to go to much in depth but the following slides give an overview of the research which started with a detailed literature review of literature, BIM standards and industry best practice to identify critical success themes (CST) which are important to facility mangers successfully engaging in, and benefiting from the BIM process to optimise built assets in operation. This involved looking for critical success themes and these were broadly put them into the categories of policies, process, technology and digitalisation, people. As shown the main themes and sub-themes were broadly categorised into four areas many of us know well in FM: "policy", "processes", "technology and digitalisation" and "people.

The research problems we are all familiar with as shown here. You all know them well but they were identified as fundamental to identifying the research gap which was that there is a lack of research focused on identifying Critical Success Factors (CSF) which impact on facility managers ability to best engage with the BIM process and to help define the information requirements needed to ensure assets can be optimised from the BIM process in the operational phase. The research problems involve the focus traditionally being on CAPEX rather than OPEX thinking, with the construction industry having a history of inefficiency and waste, resistance to change in terms of traditional barriers and FMs not having much early involvement. The operation and information needs are not very well defined, or everything is required, it is unstructured and then becomes apparent at handover that the end result is disappointing. This perhaps has done more damage to BIM than anything else. Digital experience and skills is another big issue, this strongly became apparent during my research. People in FM are lagging behind what is happening in construction. The construction teams use BIM on a daily basis and so are getting very familiar but if the FM are not up to speed with how to use what is handed over and understanding its benefits my concern is that good data and information will end up in what has been dubbed a data cemetery. We therefore need to ensure people in the industry are aware and where necessary trained in BIM. This all resulted in the identified research gap. There isn't a lot of information on CSFs in this field so my focus is on how we can identify the CSF and use them to help FM.

Slide 10: This then led to me establishing 7 overall research questions as shown here. So for i) thus was mainly about as identifying the CSF, ii) supported this as I was interested in how the themes behind the CSF could be identified from literature as critical success themes and then in iii) and iv) I looked more at quantitative CSF via a questionnaire which many of you know well and the interviews which were focused on the qualitative CSF and were carried out with a wide range of people from BIM and FM, policy and legal experts to architects. Question v) I focused on another area of interest; how the benefits of BIM to FM could be made more transparent and then vi) what were the possible barriers to FM engagement and adoption and use of BIM. Finally, in vii) I was interested in how we could bring all this know-how together and create a framework of guidance in terms of CSF. These were then matched back to back by objectives to achieve and answer all the questions.

Slide 11: Shows the merging process and how the objectives or findings were combined or 'merged' as described by Creswell and Plano Clark in their suggested design approach and shown as objective (d) where the merging process takes place. In the past this was referred to as triangulation, it is now called convergent design. This took CSF from the general industry, the FM and BIM experts and merges them together to produce a final list of CSFs. The final CSFs have been amalgamated into the framework in objective (e). The final box represents objective (f) the validation process in two steps as already explained today is the first step and the follow up will be when I ask for final validation on the final product. So today is all about objective (f) and presenting the first draft of the BIM Mobilisation Framework.

4. Initial CSF findings – qualitative and quantitative (slide 12)

Slide 13: In terms of the findings themselves, from the qualitative side we had 19 semi-structured interviews with the target audience being FM and BIM experts. I used the N-Vivo software to analyse the interviews and established a series of themes and subthemes. There was approx. 111,000 words of text which when analysed resulted in 10 qualitative main themes and 45 sub-themes, an example of a theme here might focus on say 'the benefits of BIM' which was then broken down in the sub-themes to a lower level.

Slides 14 and 15: The identified list of qualitative themes is shown in the list 1-10. CSF stands for Critical Success Factor, QUAL stands for qualitative, followed by a series of numbers and text to produce the different categories. The full breakdown amounted to 3380 passages of text which have been apportioned to the various themes and sub-themes using N-Vivo.

Slides 16, 17 and 18: Again, the identified list of quantitative themes is presented in a similar way with the 10 shown in the list 1-10. The quantitative CSF were identified using the questionnaire, the target audience being the general FM practitioners along with some of the involved stakeholders. It was done at the same time as the interviews in partnership with BIFM and we ended up with 254 responses. Descriptive statistics were used as well inferential statistics with SPSS looking at relationships between variables. I should say it was a complete coincidence that we came out with very similar figures, 10 quantitative main themes and 46 sub-themes.

5. Merging process (slide 19)

Slide 20: The merging process could be considered in one of a few ways. When bringing qualitative and quantitative data together one could adapt the qualitative data and represent it in a quantitative way. However, I was more interested in seeing the data in a qualitative way as I believe the data is too complex to be just considered in a quantitative way. I wanted to be able to look at people's responses and understand things more from considering also what people have said. So, in my case the quantitative data was presented alongside the qualitative data in a narrative description style. The quantitative and qualitative CSF findings were then merged to provide an interpretation of the findings. This involved seeing how closely the quantitative CSG main themes could be mapped against the qualitative ones and where they tended to 'converge'. Some were very similar e.g. benefits of BIM to FM – in this case they converged and the findings were merged together. Some themes were grouped also together, i.e., theme 6 – People in the BIM process and improving collaboration. In other cases, the CSF could not be converged and therefore were considered to be 'diverged', whereby the themes remained in their originals state with all their associated sub-themes. The sub-themes were also analysed one to one, if they converge, they are combined, if they don't, they remain separate. This merging process was applied to all the sub-themes.

A final list is produced of all the merged CSF. In order to present it back to the practitioner's side, Matt and myself discussed stripping out all the quant, qual references thereby leaving the main 10 themes that need to be considered. They were also reworded to make them more comprehensible. Underneath each main theme are sub-themes which have been converged.

6. Concept for framework design (slide 22)

So, in this section I will present the draft concept of the framework design. I would grateful for people's opinions as we go through the detail so please feel free to interrupt at any point and comment s you see fit. I am interested also if people feel the title is clear or does it need to be clearer? I have used the words 'mobilisation framework' because in my previous days with Serco it was helpful to have tick lists when starting a project to keep on track. It has been approached from this perspective with FMs in mind who are starting a project as a preparatory way of preparing yourself through its duration.

P1: As part of the new international standard there is a new section on mobilisation strategy under Part 2. I don't know if there is any convergence between that and what you are providing? It is a new specific document that needs to be provided as part of the delivery strategy.

SA: That is helpful to know. I have read the document but don't remember that part. Thank you for highlighting it.

P1: It is specifically in phase 5 of 2 for CAPEX. It will be interesting to see how they deliver that when they do part 3 next year.

SA: I have been briefly involved in part 3 in giving feedback on it. I will go back and have a look at it.

Slide 23: With respect to the publishing date, I think Matt and I are being optimistic about getting it published in May, it is more likely to be June or July.

Slide 24: The idea of the document is outlined is that people are presented with a simple index where they can find the CSF and also the whole document will have hyperlinks shown as blue buttons at the bottom of the page which will take you back to the appropriate part of the framework document. Each CSF will have a link as well to more information in the relevant parts of the document.

Slide 25: There is a general introduction for the whole document. It is an explanation of what the document contains and the fact that is being produced as a mobilisation check list and asking for people to contact the author with feedback or to report broken links so it can be updated in due course.

Slide 26: Part 2 is a guidance section as to definitions of terms within the document, i.e., CSF MT, what is the aim, etc. The idea is to explain to people that it is provided in two sections. Initially we had lots of lists of CSF which for presentation purposes looked very dry. We therefore decided that each of the CSF MT topics will have a 'one-page introduction' to set the scene as to why that CSF is important.

Slide 27: One issue I want to explore is linkage with the RIBA stages. In previous BIM guidance documents, I have worked on with IWFM we included comments with regard to how relevant particular stages of RIBA are. I have considered this, for example, with regard to benefits, it could be argued that benefits are important to know about at the beginning of a project for your goals and aims, but ultimately, they will be realised at the time of handover. Here the benefits are more focused on FM rather than clash detection which we assume has already been done.

Slide 28: The next section focuses on the CSF tables in detail and how the table will look. There is a general introduction and then the idea is that for each CSF there is a 'on pager' that describes why that particular CSF is important.

Slide 29: so as an introduction for the first CSF it is important to think about the whole lifecycle approach because of sustainability and helping the government support its construction targets. This page over time will include some literature references, i.e., the *Procuring for Value* report that recommends that things should be done with a value approach rather than a simple CAPEX approach. I may bring in some statistics and bits from my research as well.

Page 30-32: The main table highlights the individual CSF. The dark blue being the title, the lighter blue the aim. It is a strapline to summarise the importance. The first column is the sub-theme reference, then a brief title for the sub-theme itself, then an explanation of what the sub-theme is about to give more of an understanding, the last column shows examples which may include hyperlinks or advice on what things should be considered. Some of the hyperlinks are quite long so I have just included the website address. It may be useful to have an appendix with detailed links, I would be grateful for any ideas. The last column is for recording whether CSF have been considered and acted upon.

Slide 33: I am also including references to some of the work done with IWFM, some of their key guides.

Slide 34: and finally, a series of appendix which have yet to be agreed, abbreviations, glossary of terms and development standards, and possibly graphics of the RIBA process. If anyone can suggest any other appendices which would be important that would be helpful.

Jump to Slide 35: This shows what the raw content looks like which is difficult to read on screen. For example, CSF 10 is about successful transfer of data, covering topics such as bidirectional moving of data classification systems. In step 2 of the validation I would greatly appreciate any ideas you could come up with for the example's column.

7. Group discussion and questions 42.00

SA: Is everything clear up to this point or do people have you any initial questions you want to ask?

P2: What format will it be in, will it be a document or web-based resource?

SA: At the moment it will be a document but I would like to produce it as a linked PDF whereby people can move around the document. The Scottish Futures Trust have a web portal, ideally this is what I would like to produce, but don't have the expertise and it costs a lot of money to produce.

P2: The reason I ask is the NBS? Platform and where you start specifying the project information, you could do the same sort of thing and hold it in a central repository.

P3: Would the web front end need to be hosted somewhere in a storage facility would that be more commercially based than academically.

P2: I think that is what the NBS have done. I can't remember the name of it.

SA: Do you mean the BIM toolkit, or the Scottish Futures Trust BOM portal

P2: Yes, this could one of those, we maybe your work could form the basis of an FM equivalent.

SA: David Philp at the Scottish Futures Trust said it cost about £15K to produce. If we were able to produce something similar at a reduced cost it would not need to be as advanced. Maybe the IWFM may be willing to support the idea. If we could find participants with the skills and time we could end up with a reasonable product.

P4: The BIM dictionary with interconnective terms and links on the BIMhub is an open source which can be developed by users. That uses crowd sourcing? Perhaps that could help your framework.

SA: That could be an idea.

P3: You were talking about organisational benefits, identifying the required benefits you want to achieve and the CSF required. I was wondering whether negatively or positively to pick up other terms from, for instance, PAS1192:3 where they discuss things such as the organisational information requirement with plain language questions. Are the plain language questions parallel to your identification of benefits? It is easy to become confused without introducing or having other terms which are possibly the same thing. However, I wouldn't assume they are the same things.

SA: I am not trying to reinvent the wheel. I will have to do a validation check when people read the document. I would only use the terminology that is in the new ISO standard. We are lucky that EIR is still EIR as an abbreviation but the E is now for 'exchange' rather than 'employers'. We do need to update the IWFM document. I also think that if you just include the table without an introduction people may think it is a bit heavy, so now before each section is a one-page overview. It is about finding a balance, if you have too much it becomes a monster. As this is a two-stage review, once this stage has been completed, I will send everyone a copy and would be grateful if you could take some time to read through it and mark up what format they think is easier.

So, let's go back now over each question in detail now so we clearly understand the document and context.

Q1: Sequencing of Main CSF

1. Have we got the CSF in the correct order?

For reference here my logic was to see if we should adopt a specific order. My thoughts were:

1. Highlight the bigger picture in terms of the WLC approach and how it will support the government.

2 and 3 I have debated as to whether to discuss the benefits first and then the barriers, or vice versa.

4. To set the topic of digitisation and technology.

5. Planning the strategic and operational needs of people.

6. Collaboration and understanding of the BIM process.

7. Clarifying the role of FM. I have some useful points, but am conscious of the fact that we have already done a guide about the role of FM in BIM projects. My aim is to bring the information together to enable people to pinpoint what their requirements are.

8. Acquiring essential knowledge. It is debateable as to how much time you spend reading all the standards. Maybe this should be nearer the front, but people may switch off too early. We have used the research to try and identify which of the standards are more important for FM.

9. Training is essential. It was the most debated topic.

10. Successful transfer of data. A colleague and I have been working with the BIFM on a guide of BIM2CAFM which will be referenced.

Q2: Format and content

Are they clear to read? We have tried to lighten the text, but there needs to be enough to make the document coherent. Does it matter if the text is justified on the side, does the mobilisation check list work. In an ideal world it would be helpful to click on the traffic light colours which would bring up an automatic list which you could then print off or save for later. Each CSF will have its own table.

Q3: RIBA stages

Is it helpful to indicate when these CSF may be more relevant and at what stage?

Q4: Usability and benefit to FM

Do you see the document working in practice and how could it benefit the FMs?

Q5: Beneficiaries and Stakeholders

Who are they?

Q6: Marketing of Framework

How might we do this?

Q7: IWFM Members

How may they benefit from this and would it benefit to include it?

The team then reviewed each question starting 56.50

Q1: Sequencing of Main CSF: is the proposed sequence (as shown below) of the 10 main CSF logical, or would the group suggest any changes?

P3: There is quite a lot in it, some of them could collectively come first. It is difficult to prioritise, it is as though you are trying to prioritise and order the list. I think it is a comprehensive list and covers everything from your research. I would need to think about whether everything is in the right order. I think you need to deal with the barrier at the start because whoever is reading it will be aware of the barrier at the start. As they proceed they will get the answers. In the change management process every time you do a change the first thing you face is a barrier. You have to accept it and work through it.

SA: Please also point out if there are any key words you would expect to see that aren't included.

P2: I am not so sure that you need to worry about the priority system. The fact that they are numbered allows you to identify them. The reader will decide what their priorities are. Rather than stating the order in which to do things, these are the considerations. Approach it as you need to.

SA: Maybe I haven't articulated that fact and need to.

P5: It has tried to follow some logic. I think recognising the importance of digitalisation and technology in FM in the BIM process is right at the start. But I don't think you need to show the process in order, it's just the list you need to consider.

SA: If we moved the importance of the digitalisation nearer the top of the list it wouldn't disturb the flow. I am conscious we maybe need to look at each main theme and its sub-themes. MT1 is about why BIM is important, you may even want to put digitisation before that. It would set the scene. I also need to put more into the sub-themes underneath.

RW: I agree with P2 and P5. The digitisation sticks out for me. This is paired together with MT1. There are themes were groups could be paired, implementation and digitisation sit together, as do the barriers and benefits. I think if you are going to order them, have those as paired categories. Like P2 said, they are individually labelled, anyone using this will want to address all the categories, so as long as you can categorise it and refer back, I don't think the order is massively important. A lot of it will in turn need to be dealt with.

P4: I don't believe the order is that important. Some people have different priorities, some are more advance in training, some are not. I would maybe not number it but present it in a mind map which doesn't involve a sequence. Secondly, maybe by highlighting or focusing just on keywords it would make it more transparent for readers

SA: The idea of a mind map and the highlighting sounds interesting, I will explore that.

P6: P4 I think has made an interesting point. I have looked at the numbering and have taken that as an automatic sequence that you would look to follow. That is maybe not the case, it is about picking out what is useful to the user. Maybe moving away from the sequence will help. I think that P1 said that there is a natural synergy with some of the topics. A mind map or nomenclature that identifies what each step is and where it may be applicable in a process may be more sophisticated.

SA: Summarisation is that there is a defined order, presenting it in another way would still allow people to hyperlink back to the individual sections so they can select what they think is the best way forward for them.

Q2: Format and content: Is the suggested CSF table format clear and understandable? and does the group have any suggestions for possible improvements?

SA: Is the format clear and concise, and does an explanation on the examples work? What do people think about the hyperlinks and where to put hyperlinks with a long address? What do you think about using the mobilisation checklist?

P2: I like the format. It would be nice to have a document that can be used as a checklist. It doesn't need to be part of this resource, maybe a hyperlink to a checklist that could be downloaded for use. Visually it looks nice with the coloured tick marks showing, but in order to use this process it would be helpful to have a functional document that can be used.

SA: The idea is that it will be a soft PDF that can be printed out or downloaded and used electronically. It will have hyperlinks but won't be that intelligent. That may be more of a web based function. In terms of the whole document, 10 tables, and introduction page for each table, some of which run over two or more pages the document will be about 40-50 pages long. We could do a version where we strip out the introduction and just provide the table. I would just like to explore what you meant P2.

P2: 30-40 pages is quite long but you could support that with one spreadsheet, for example which is the obvious choice for a tick list.

SA: I have all that in the background as my finding are in spreadsheet format, but it doesn't look as nice. I will consider the idea as an add on.

P5: I think it is easy to read and follow. I think it would be useful if you could download another format that could be used straight into a project.

P1: I would reiterate what has already been said. In the work I have done with some of the local government groups that what was majorly apparent was the need for templates. This lends itself to being a templated function. Within the report you have an explanation and the examples, maybe they could be removed to provide an area for the user to put in their project specific outputs. Or maybe another line, you could keep the explanation but take out the examples and have that as your project specific output. The tick list on the right-hand side works well although for me the word 'outstanding' for the red line doesn't seem like the right term.

SA: I would be grateful for your ideas on renaming.

P1: I was trying to come up with something. Not commenced?

SA: I was trying to keep it simple with one word.

P2: I would keep it simple, 'not started'.

SA: Any other suggestions:

P6 Incomplete?

SA: The green tick is to indicate completion, the red is to indicate the process hasn't been started.

P5: You could put it as planned, as in planned to do it.

P1: From a project specific point of view you may have some sub-themes which aren't relevant. You may need another category to say 'not applicable'.

SA: Good point, I can add something in.

P3: I similarly think everyone is crying out for a simple template, this satisfies that quite nicely with simple, understandable text and terminology for the explanation and the examples. RW's idea of having examples and when they've been implemented you could insert your own strategy to achieve the theme, for example, could be a useful way to use the table. It could either be blank or allow people to replace the example with what they are planning. Behind the simple language and simple formatting you are giving people hyperlinks to more in-depth guidance on a per-item basis which will unlock the potential. People can take from that what they want and what is relevant. I'm hearing a lot from the Netherlands on the first item, the long term value point, that there is more emphasis being given to circular economy. I keep telling everyone that it isn't about designers or builders, the circular economy is all about FM because we are the ones who will deliver it. It is good to hear that people are now considering designing buildings that are material stores and with reusable components. But the minute the project is finished, and they walk away all that will be forgotten, unless we can capture it in a way where in 10-15 years' time the FM who are responsible for that built asset can clearly see what was planned with what materials. Having some other links to other relevant topics, such as, circular economy will draw attention.

SA: I decided to do this in two steps as I think when you receive the final document you will edit it and come back with some great links and ideas. Those nuggets will be hugely helpful. What do you think about the issue of very long hyperlinks versus the title of the document and the website and people being intelligent enough to find them themselves? Do you think there should be an annex of useful hyperlinks or web addresses? The idea is that you should click on a link and be directed to where they need to be, but I don't want to fill the table up with long links.

P2: If you are going to produce this in PDF format, you can include a short URL which when you hover over it will give you the full URL. You can have the displayed text and the alternate text.

SA: I did wonder about that.

P1: How is the document going to be maintained?

SA: At the moment it will be myself. When I discussed it with my supervisor, you do your PhD and some work with Liverpool John Moore University which means that the intellectual copyright is shared between us, so I will maintain it. I would like to provide it for free. In order to gain as much exposure as possible I am not sure if I should ask somebody such as IWFM if they can use this document alongside the other EIRs and put it on their website. Ultimately someone will have to maintain it, in the short term it will me as I have the most invested in.

P1: It was a leading question as I have been doing a lot of work on our training material which contains hyperlinks. The problem is you have no control about where they end up. If the hyperlink breaks you need to have a maintenance plan in place in order to update them. You could say that at the time of publishing all information is correct, but within 6 months all those hyperlinks could be dead.

SA: It is a common topic. A maintenance element will definitely be required. The idea of giving the organisation links is that although they may move stuff around that they will keep their address. I anticipate that there would be a process that would need updating. At the beginning of the guide I would like to blatantly say if the hyperlinks don't work please let me know and I will update them. It is a balance, if I add the organisation link people may prefer to go direct to the document. There are cases, in the table for example, where an organisation may have several documents that deal with a topic. I have tried to point the lead as to where those documents are held, rather than each individual document.

P1: I have had similar issues with legacy training data and updating new standards and trying to decide how to deal with them.

P6: The table seems quite logical. The comments that have been made are relevant. Having a downloadable master table in Excel for going through each of the status would show progression. You also need a 'not applicable' stage.

SA: You could download the EIR and use it in your own way which is the direction I am taking.

P4: You could save some space by moving the first column in a bit if you like, the explanation and example could go under it. Otherwise it looks good.

Q3: RIBA stages: Would it add any value to have a RIBA reference column indicating at what stage the CSF is most applicable in? What is the groups opinion as to which RIBA stage should be shown?

SA: This is about do we include anything in the main list of CSF to do with the RIBA stages? In the work with IWFM we thought in great detail about what should be included in the different stages. My experience is that some people point out that certain things can't be done in particular stages. In terms of timelines, would it add value to have information about when things appear in the RIBA process?

P1: I have reservations about applying any plan of work to this. You are pigeonholing the RIBA plan of works as an example but there are maybe others that should be applied. They may not be as linear as the RIBA. It is not a bad idea, but you may find that some of the main topics apply to all of it.

SA: Some of them, i.e., the benefits, you almost need to know what it is that you are aiming to achieve at the beginning to achieve an end result. In others the role of FM during the BIM process, a lot of it goes across the whole of the life of the project, or should. It may have peaks and troughs. Does it add value to refer to the RIBA stages? The sub-themes are difficult, trying to ascertain what RIBA stage they fall within. It may have benefits.

P1: I think you need to look at the sub-themes as they may have an influencing factor. I think your explanation as to what the themes are, they are the key benefit as oppose to the application against a plan of works directly. You may disagree, I don't see the necessity to do a direct correlation.

P3: Some of them overlap with different stages. A lot of them are required at the very earliest stage when strategic definition and concept design are happening as that is when the greatest WLC cost benefits can be realised with FM at the table. It is easy to consider RIBA stage 7 where a lot of our work involves PAS1192:3 Kitemark. On your MT10 the idea of a successful asset of data transfer and the creation of a central environment for storing geometry documents and assets is a milestone for FM in BIM. However, the PAS in stage 7 asks how you are going to maintain it once you have it. For MT10 you almost have two sub-divisions, a, and b. B is definitely stage 7, it is about managing the data and the governance you put around the control of that data for the future. Otherwise, MT1 to MT10a have different relevance. When you look at the detail behind them that may inform where they should be placed.

SA: I have another specific CSF where I have mentioned the fact that once upon a time you would have 2D drawings which would have been kept up to date because they were part of the building. People wonder why BIM needs to approached in the same way. We are trying to say that you need to think about how at the point of handover they are going to carry that out. Will they need to go to a specialist because the FM may not be able to do any of the Revit model changes needed?

P5: I would love to be able to do this, but I am struggling to align these two specific RIBA stages. They are very broad and the sub-themes go across many of the camps. On this occasion I would go against it. If this is used during the project, they will struggle. It is more a case of I am planning to do a BIM project, I need guidance on how to approach it and therefore prioritise my approach in my own mind rather than suggesting that I don't need to worry about something until later on.

SA: It is an interesting idea that the maximum benefit is by having read all the CSF before starting your journey rather than finding out later that something may be a problem.

SA: When I presented the tables I had some general comments from you relating to WLC costs and the fact that 80% of the fixed costs during the first 20% of the design. Rather than talking about specific RIBA stages would more general comments be more helpful?

P5: As in the why would you do it, the benefit? It's more the benefit than the programmatic approach.

SA: If you look at MT9, the observation I am trying to make is that if you are the FM involved in the project from start to finish you will need some in-depth training, whereas if you are the team receiving the end data your focus may be that you need to up to speed a few months before you get it in order to understand the model. I was trying to give a flavour depending on where you are coming from. I am not sure if that is more useful than trying to indicate what to do at what particular stage. My other concern is as to how well FM know the different RIBA stages. I myself don't understand the difference between some of them.

P5: Even the people in the know get confused. We use the RIBA gateway stages as freeze points where we engage for our soft landings programs. We don't refer to them as RIBA we call them gateways and use them as a reference point to engage and make sure we are taking them through the change management process. In relation to this subject I am not sure it would have much benefit.

P6: I can see the benefit and I was a supporter of gateways on the trial we carried out. The reason being that this a guide for FM. With them being involved in the project if you have a design team with a traditional latitude I don't always think they consider the end client and how the building will actually work and operate. That's the reality which still exists with a lot of professionals. The stages were more a trigger point for the FM. If you are in a design meeting or on a project where the pressure is on to deliver the goods and timescales are an issue questions such as whether the BIM model is being applied properly aren't being addressed as well as they should be. It gives the FM an opportunity to question as to whether they have dealt with things in terms of the information needed for BIM or the output from the client's perspective. You get strong design teams who focus on delivering a design or building at a certain time within a specified budget. The end user is always the person who has to give way in terms of awareness as to how the building should operate. The FM at the end, or even after the project is handed over, trying to ascertain how the building works. If the information is the right stage early on in the process you wouldn't have that problem. It is difficult to apply it to these indicators and I can see the existing dichotomy. I am a firm believer in gateways that can help FM challenge the design process to ensure that the whole life of the building isn't being ignored as part of the process.

SA: The general feeling I get from the group is that some form of comment might be helpful. Maybe as P5 states don't call it RIBA stages but something else with another header column.

P5: We just call them gateways.

P4: I am in general agreement. It is very difficult to map the CSF to RIBA stages and to which stage they would add the biggest impact. If some are considered at the end and not at the beginning of the project, you can't really refer to them as CSF as they will not be a success.

SA: I did think about having an appendix at the end of the document with the RIBA stages for anyone who is not familiar with them. Would that add value or should I just add a hyperlink?

P5: Isn't it another reference document just like all the others that they need to have awareness of? It will be important but similarly some of the IWFM documents use that alignment to the RIBA stages so they will become familiar with it.

P2: I agree with the comments. Trying to align them to the RIBA stages is not the right thing to do. I prefer the description with the pointers. It is important that the RIBA stages, particularly the initial stages are where FM need to make their point. We need to accept from a contractual perspective that if FM aren't written into the contractual documentation trying to get the information if it is not in there is very difficult. Reference to the RIBA stages is important but a lot of the main themes should be considered right at the start of the project.

SA: That is interesting to hear. I am feeling that going through this as a pick list as early as possible in the project may stimulate consideration of what to do at what stage.

P2: FM don't generally know what the RIBA stages are. As P5 said, it is not part of their normal vocabulary. It is important to educate FM that the stages do exist and that they drive the design and construction element.

Q4: Usability and benefit to FM: How does the group see the document being used in practice and how could it benefit FM?

How does the group see the document being used in practice? We have briefly discussed this in terms of a downloadable checklist. Is it useful for FMs and will something such as the tick list help?

P6: I think it is useful and a good starting tool. I like the idea of the check lists. It gives guidance for someone who is a FM and new to the process with BIM. It has an evolution within it as BIM gets a grip within the sector and evolves with BIM further it will hopefully have future iterations that will increasingly become more useful. It is a good start.

SA: I am of the view that if it should be kept up to date and live. I would love to have it web based, that is the next stage of the dream.

P7: It will be useful as a starting point. As you become more familiar with the topics you can move on to the other documents that align to gateways and when you should and shouldn't do things. When I started there was nothing like this so having a reference broken down into bite size chunks whereby you can show progress with a tick list is of great use.

P2: It will definitely be useful for FM. From an education point of view it will be useful for AEC as well who often state that they don't understand what FM want. They don't know what the questions are that they need to ask of FM, and FM don't know what questions they should be asking of AEC. It is almost a check list of engaging FM in your design project from the other side of the fence. It's more than just a benefit for FM.

SA: When I was thinking about the overall title for the document I wondered whether I should call it CSF to help stakeholders which would make it more general, rather than FM-BIM mobilisation, factors to help FM as FM is already included in the first part of the title. Is it better targeted specifically at FMs?

P2: The difficulty a lot of FMs will face is not necessarily knowing what to do, using the check list will be a great help, but how do they get involved in project teams, where does that come from, who is driving it and who do they need to talk to. Part of the education needs to be getting project teams to engage FM as well as FM understanding what they need to do. I don't know if that is a different subject altogether? It is certainly something that would need to be considered.

P3: The document is straightforward and negotiable for someone coming to it for the first time. If they are then able to access relevant supporting material and further detailed guidance all the better. If they are then able to layer their project on top it would be really practical for them and make it a working document. It is important to have something deliberately targeted at FM. Everyone else has had numerous chances to receive and digest lots of BIM related material, training and conferences, etc, FM has always been the poor relation for all the reasons we have discussed. It is just the nature of two slightly different industries. I think FM will gratefully receive something specifically given for them. Architects, engineers, etc, should probably know that they should be conversing with FM but it is often overlooked. If we can engage with the FM industry or professionals and they come along to meetings they can stand their ground and engage with other professionals on their requirements. I think the FMs need something, if it's diluted they may feel it's not for them and what is for them.

P1: I would agree but I think providing the FM with a tool and a set of guidance lines is perfect. It could be used as an engagement tool to not only help FM teams but also the clients as to what they need. From the delivery team's point of view it often comes back to what does the client want? The response from the client being that they don't know what the FM team want. You have the multi-tiered approach, from your RIBA stages the link between stage 7 and stage 0 in the engagement and feedback loop of bringing the FM team in as part of the briefing stage. That could be a really good briefing document to be able to bring things such as the client's requirements and the project information requirements for the delivery team.

SA: I could insert some wording into the first pages explaining that the document can be used to help do x, y and z.

P1: More often than not, on the projects I have worked on, the FM aren't considered to be engaged until a long way down the line. That is not necessarily a problem on the construction or design side, but is a problem from the client's point of view. You need to start with the end in mind, we're not doing that.

Q5: Beneficiaries and Stakeholders: Who does the group see as the 'main beneficiaries' and 'stakeholders' who might use the document?

SA: We have touched on stakeholders and beneficiaries and discussed that it should mainly be targeted at FM. Who do we think are the main beneficiaries within FM? Do we need to distinguish between the FM teams who go all the way through a project versus the people at the end of the process who take over? For example the FM who should be talking to the design team versus the FM who will be taking over the information in the BIM model who needs to know how to work their way around things?

P3: For credibility, and my experience sitting in front of a design team, you need to be eloquent in your explanation of your purpose and understanding the business objectives and needs and how tangible pieces of data will inform those things. You also need to stand up to the design team if you are not ready to move on to the next stage, or need something done to evaluate whole life costs.

Individuals in FM whether it is a customer client, client in-house FM, client organisation or a contractor you need someone who is well informed and probably senior in front of the design team. At the delivery end you need people who appreciate that the data they are getting is highly reliable and verified and has a value to it. When they are using the data they need to exercise caution that they don't delete, radically change it, copy and paste it or cut and paste it. My point on stage 7 is with regard to people appreciating that there needs to be more care with the asset data they've got, what they do with it and what they do to maintain and sustain it rather than leaving it on a shelf and become out of date. As soon as that happens the whole thing becomes worthless. They also need to take care that they don't corrupt it in some way, it's very valuable. In the past we have ben carefree with data, assuming it's probably out of date anyway, we didn't have much faith in it. In terms of who might use the document, probably the middle or senior manager who is responsible for delivering part of a project. They may take the document and use it as their method statement for how they're going to get through the different stages of the project and how they will eventually inform their team of stakeholders about the asset they've been given and how to care for it.

SA: That is the type of person I had in mind. It is the group of operational people who are not involved in the project but who get the result. They are the primary group of beneficiaries, the in-depth project management FM. It is whether we need to do anything else for the other people who are involved, the operational teams who end up receiving the data. For example, how do actually use the models? A BIM viewer is a simple answer but if you can't work your way around it, it can be a frustrating experience.

P1: I think the main beneficiaries are the FM and client teams. It will be useful for the entire stakeholder's team to have it and a basic understanding as to how it is to be applied. The way you have broken it down into main and sub-themes has a similar feel to how ISO 19650 is set up with key activities and sub-activities. I can see parallels there, if there is a key understanding of a similar process that can be applied at any stage then it's useful for the entire team.

P2: I agree with everybody. I think it is for senior/strategic in FM terms, but is an excellent tool for them to engage the operational teams. It allows detailed management of that process. I'm not saying it wouldn't be useful to the operational teams but I think some of it is material that they wouldn't engage with directly.

P5: I think the focus is on senior FM and stakeholders.

P6: I think it is more a senior project related document in parts.

P4: FM will benefit from it, just having the list of CSF will be very helpful as a starting point

Q6: Marketing of Framework: How could the document be best marketed to the relevant target audience?

SA: Marketing of the frameworks, this has links with question 7. What would be the best way to market the framework? I will try and market it through the IWFM, but do you have any other ideas on how to promote it?

P6: I think the IWFM or through the AEC to become more visible. You could try to influence trade articles.

SA: RICS are becoming more FM orientated. Is it worth approaching them? I think some organisations are fighting each other rather than collaborating.

P2: I don't have an issue with that. Rather than branding against conflicting organisations, Ariva and NVS may be interested, finding FM engaged in BIM is a struggle.

SA: I don't want to be controlled in just one place – to me it should be shared for the benefit of all and I would prefer it to be marketed for free if possible.

P1: Maybe you should target the top level, Building Smart, UK BIM Alliance, those who are producing the guidance documents for BIM delivery for the new standards.

P3: The BIM Task Group and UK BIM Alliance would probably actively promote something to support FM.

P1: There are a couple of representatives from IWFM as part of a steering committee. We are indirectly linked as one of the sponsors of the UK BIM Alliance. They are having a chairing meeting in June or July, they have relaunched their website and are publishing of guidance information so I think it would be a perfect place to do it.

P3: Maybe even people like SFT or the ESFA who procure projects and through their framework help academies, trusts, etc. They could possibly suggest a tool like this for Procure 22 or the ESFA Academy framework or the CCS. Potentially they could promote it.

P1: Maybe it could go the level of the NACF (National Association for Chartered Frameworks – needs checking), that may be a way of getting it in as a whole.

SA: I may come back and ask if you have contacts for these organisations.

P2: Marketing is one aspect; the distribution can be done as widely as possible through the international organisations.

P4: I think Building Smart is the perfect organisation.

Q7: IWFM Members: Would it be useful to have the document made available to IWFM members together with their other BIM guidance documents?

SA: Will it make sense to make it available to the IWFM? I presume the answer will be yes.

P6: I think it's very reasonable.

P1: You note in your question 'made available to IWFM members', what about non-members, i.e., people who are just visiting the IWFM site as a reference location?

SA: It's a very good point. I am very much of the opinion that it should be provided free of charge. If it becomes chargeable people will look elsewhere.

P1: I feel it is something that is limiting the new ISO standard. From a UK perspective the PAS guidance was completely free and available for anyone to access, now the international standard has been launched you have to pay for it. It immediately puts a barrier in the way of anyone wanting access to really useful guidance and data. There is always a cost involved in producing these items and managing and maintaining it.

P2: I would like to see it across all the mainstream organisations, IWFM, IFMA, etc, where they are actually delivering FM.

SA: Some groups are sensitive as to how they implement things.

P3: A resource like this should be available to both IWFM members and non-members.

SA: When I get to the final product I have no problem with the group using it on their own platforms as long as we keep the intellectual rights. I want it to be available across the board.

P2: If it is restricted to IWFM members we have to accept most of them will probably never build a BIM project, so it needs to be an open resource.

P5: You expect the answer to Q6 to be IWFM, this question should reinforce why they should market it, but I agree with the others, it should be made as readily available as possible. If there is value in it they will want to promote it.

End of Workshop

SA: Thank you for your time. Once I have worked the document to the next level, if you are happy, I will send it to each of you and ask for your feedback.

Appendix S: Final list of CSF with ST for '*FM-BIM Mobilisation Framework*'

CSF MT1	**Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets**
ST 1.1	Using BIM to maximise the long-term value and ROI of built assets
ST 1.2	Using BIM to reduce operational costs, improve sustainability and help meet government 2025 targets
ST 1.3	FM readiness to engage in BIM projects
ST 1.4	Making the benefits of BIM to the operational phase of assets transparent, realistic and achievable
ST 1.5	Planning the strategic and operational information needs for FM in the BIM process
ST 1.6	Improving stakeholder collaboration and understanding of the BIM process
ST 1.7	Clarifying the role of, and tasks of FMs in the BIM process
CSF MT2	**Recognising the importance of digitalisation and technology to FM and the BIM process**
ST 2.1	Awareness of digital trends and their potential impact on FM
ST 2.2	Using technology/software tools to help improve collaboration and sharing of data
ST 2.3	Linking BIM models to external databases
ST 2.4	Set up of the CDE and ensuring security of BIM data
ST 2.5	Ensuring data is correctly structured for efficient information exchange
ST 2.6	Using BIM viewing tools/mobile technology to help improve FM services and access to information
ST 2.7	Using social media for knowledge sharing and networking
ST 2.8	Maintaining BIM models to ensure they remain up to date
CSF MT3	**Addressing and overcoming perceived barriers and challenges to the adoption and use of BIM**
ST 3.1	Upskilling FM teams to empower them for successful engagement in BIM projects
ST 3.2	Preparing people and organisations for full engagement in BIM projects
ST 3.3	Addressing concerns about costs associated with BIM and ROI
ST 3.4	Clearly articulating the value and benefit of BIM to FM and the operational phase of assets
ST 3.5	Setting realistic expectations of what BIM can deliver
ST 3.6	Addressing pessimism about BIM
ST 3.7	Understanding the need to focus on the quality of data rather than quantity
ST 3.8	Addressing concerns about the complexity of BIM
ST 3.9	Advising clients about BIM and how it might benefit them
ST 3.10	Deciding on the appropriate IT tools and whether to adopt an open or closed BIM approach
ST 3.11	Using case studies to document the benefits of BIM to FM
ST 3.12	Reviewing CAPEX/OPEX budgets to ensure a sustainable WLC approach
ST 3.13	Understanding legal implications for BIM projects
ST 3.14	Avoiding silo-working mentality and encouraging early FM engagement
ST 3.15	Assessing security and risks associated with BIM information
ST 3.16	Understanding and use of BIM acronyms
ST 3.17	Use of BIM/other standards with a KISS to ensure people can engage with BIM
ST 3.18	Using BIM for existing built assets and capturing 'as-built' records during construction
ST 3.19	Understanding the link between BIM, CAFM and FM management systems
ST 3.20	Ensuring standard classification systems are used to improve access and transfer of data /information
ST 3.21	Ensuring FM is fully and positively engaged with other stakeholders
ST 3.22	Understanding the possible impact of short-term FM contracts and data ownership in a BIM project
ST 3.23	Understanding the limitations of bi-directional transfer of data between BIM and FM systems
ST 3.24	Working with BIM processes and preparing good quality OIR, AIR and EIR documents
ST 3.25	Understanding the use of IFC/COBie for transfer of data into CAFM/other FM management systems

CSF MT4	**Making the benefits of BIM to FM transparent, realistic and achievable**
ST 4.1	Using case studies as reference material to help provide evidence of the benefits of BIM to FM
ST 4.2	Making the benefits of BIM clear and transparent
ST 4.3	Ensuring a WLC perspective is taken to realise the full potential of BIM to FM
ST 4.4	Measuring the benefits of BIM
ST 4.5	Planning realistic timelines for the realisation of benefits
ST 4.6	Ensuring access of good quality data from one place
ST 4.7	Increasing operational efficiency
ST 4.8	Improving strategic management of assets
ST 4.9	Using the visualisation power of BIM models to help improve FM planning and safety
ST 4.10	Improving the prediction of maintenance costs and ROI
ST 4.11	Improving sustainability and the transparency of WLC
ST 4.12	Helping collaboration with the design and construction teams
ST 4.13	Improving health, safety and risk management
ST 4.14	Supporting innovation, commercial models and use of visualisation technologies (AR, VR and MR) and AI
ST 4.15	Using BIM to improve procurement, tendering and for insurance
ST 4.16	Improving the handover from construction to operation
ST 4.17	Reducing the cost of transferring data from construction into FM management systems
ST 4.18	Avoiding abortive, disruptive or wasteful work
ST 4.19	Using BIM for benchmarking RE
ST 4.20	Providing added value by integrating BIM with other technology
ST 4.21	Using Retro-BIM techniques to provide additional information about existing assets
ST 4.22	Improving the handover process of quality information from construction to operation
ST 4.23	Using BIM to improve the advertising and management of space
CSF MT5	**Planning the strategic and operational information needs for FM in the BIM process**
ST 5.1	Using BIM to support an organisation's AM strategy
ST 5.2	Defining what FM information is needed from the CAPEX phase for the OPEX phase
ST 5.3	Ensuring a good EIR is in place which addresses client and FM needs
ST 5.4	Ensuring BIM models and quality information are updated and maintained after handover
CSF MT6	**Improving stakeholder collaboration and understanding of the BIM process**
ST 6.1	Improving the perception of FM in BIM projects
ST 6.2	Using BIM to improve collaboration between stakeholder groups
ST 6.3	Ensuring FM readiness for early engagement in the BIM process
ST 6.4	Using BIM to meet government targets for improving assets and adding value to wider society
ST 6.5	Motivating and supporting people in the BIM process
ST 6.6	Preparing for the impact of BIM on the FM and AEC industries
ST 6.7	Using BIM to gain a competitive advantage
ST 6.8	Using BIM and other technologies to support FM delivery for existing buildings
ST 6.9	Using BIM to help improve data transfer
CSF MT7	**Clarifying the role of and tasks of FMs in the BIM process**
ST 7.1	Supporting and advising clients in BIM projects
ST 7.2	Defining the EIR, OIR, AIR and FM information requirements to support the AM strategy
ST 7.3	Defining the data structure for BIM projects
ST 7.4	Considering the long-term OPEX budget in BIM projects
ST 7.5	Writing key BIM documents and providing guidance for clients
ST 7.6	Helping design teams understand the information needs of FM
ST 7.7	Giving feedback to D&C teams to improve operational and WLC decisions
ST 7.8	Using BIM to improve the handover process from construction to operation
ST 7.9	Identifying client needs and using FM know-how to help improve BIM project outcomes
ST 7.10	Validating data in BIM projects and keeping the BIM models up to date

CSF MT8	**Acquiring essential knowledge of key BIM standards/guidance documents for practical use in a BIM project**
ST 8.1	Using BIM standards and guidance in projects to achieve better outcomes for all stakeholders
ST 8.2	Other useful BIM guidance documents
CSF MT9	**Ensuring people have adequate BIM training and competency skills to successfully engage in BIM projects**
ST 9.1	Acquiring essential knowledge about BIM standards and guidance documents
ST 9.2	Using key BIM standards/guidance in practice
ST 9.3	Sources for EIR guidance, BIM books and BIM training courses
ST 9.4	Ensuring FM have the right guidance for engaging in BIM projects
ST 9.5	Bridging the digital knowledge gap between construction and operation
ST 9.6	BIM training for FM staff to ensure they have the necessary BIM and digital skills competencies
ST 9.7	Using the IWFM BIM guides to help improve FM engagement in BIM projects
ST 9.8	Essential tips for developing BIM guidance
CSF MT10	**Ensuring the 'successful transfer and ongoing management' of '3D models, alphanumeric data and documents' for CAFM/FM systems**
ST 10.1	Planning the data transfer and quality checking process for BIM projects
ST 10.2	Planning what data to collect and how to transfer it into FM management systems
ST 10.3	Using standards and a specific classification system to ensure data is well-structured to enable easy transfer from BIM models using COBie/IFC
ST 10.4	Bi-directional data transfer and improving data handover processes and future possibilities

Appendix T: Validation process stage 2 – invitation FM/BIM experts for feedback

Liverpool John Moores University

'FM and BIM expert' - stage 2 validation of the '*FM-BIM Mobilisation Framework*'

Dear focus group member

Feedback on improved *'FM-BIM Mobilisation Framework'*

Please find attached the penultimate draft of the ***'FM-BIM Mobilisation Framework'*** which was initially discussed in our focus group held on 9th May 2019. The first stage of validation was to incorporate the initial feedback, suggestions and amendments from the focus group and then complete the remaining 10 CSF. The feedback is now reflected in the attached booklet with all the completed CSF.

For the final stage in the validation process I would be grateful for your final feedback. Please can I ask you to take some time to review the attached document and answer four specific questions on the attached form if possible, by Saturday 14th March 2020. Once completed please can you return the form for my records.

If you wish to make any other final 'suggestions' or 'good reference examples', please feel free to mark these up directly in the attached PDF and send it back to me. These can then be incorporated into the final validated version of the '*FM-BIM Mobilisation Framework*' which will be produced after an internal final review before publication. All information provided will remain anonymous and kept confidential. Please can I also ask that you keep the document confidential until the final version is produced. I will send you a personal copy at this time.

Should you have any questions please feel free to contact me using the details below.

Kind regards and thank you for your cooperation.

Simon Ashworth
LJMU, School of the Built Environment
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Tel: +41 79 138 68 52

'FM-BIM Mobilisation Framework' **- Final Validation Feedback questions:**

Name: ________________________ **Date:** __________ **Signature:** ___________________

1. How do you feel the "FM-BIM Mobilisation Framework" guidance will be useful to the different stakeholders involved in in BIM projects?
2. Do you have any final comments about the look and feel and how the guide is structured?
3. How do you feel people will be able to potentially use (or adapt) it for use in their own BIM projects?
4. Do you think the framework will make a positive impact/contribution to industry, and in what way?

Appendix U: Validation process stage 2 – summary log of expert feedback on framework

Validation Stage 2 – Summary of Feedback from FM/BIM Experts

1. How do you feel the "FM-BIM Mobilisation Framework" guidance will be useful to the different stakeholders involved in in BIM projects?

(P1): "The framework and critical success factors will allow FM professionals (and other stakeholders) from a range of backgrounds and experience to follow a pathway to receive useful information (BIM) to suit the requirements of their individual project and services".

(P2): "The construction industry requires guidance during times of change and adaption to new processes and technologies so guides such as this can be incredibly useful. Guidance such as this needs to have a level of national recognition and position itself within the larger guidance and standards packages to be accepted, understood and adopted by the wider industry. With strong backing already from IWFM it may be useful to have this considered for inclusion by the UK BIM Alliance and within the UK BIM Framework set of documentation. Potentially this could be an important resource for designers and contractors to also get a better understanding of the required asset type deliverable information that needs to be produced during the capital phase of designing and constructing projects".

(P3): "It depends on the stakeholders, for example the facility managers could use the framework to become more knowledgeable and use BIM during the operational phase. However, the stakeholders involved in the design and construction phase are already far ahead in using BIM and for this reason a mobilisation framework is not needed".

(P4): "The framework is a comprehensive resource to information needed throughout the process. The layout is easy to understand, logical in approach with links to useful documents and other evidence".

(P5): "The framework provides a comprehensive end to end framework for all stakeholders involved project delivery using BIM. In particular highlighting the need to involve FM from concept to completion".

(P5): "Providing invaluable FM data and lifecycle/e costing into the project. Specifically:

- WLC and sustainable asset procurement with the cradle to grave focus.
- Expanding the sources of FM data and linking FM databases.
- Recognising the importance of digitisation and the common data environment.
- The challenge of keeping the model current".

2. Do you have any final comments about the look and feel and how the guide is structured?

(P1): "I like the simple layout and structure of the framework".

(P2): "The guide layout is very clear and organised in a manner which is easy to navigate. The CSF section explanations with Main themes and Sub themes are clear however there are a lot of sub themes applied to some main themes which make some sections quite wordy containing lots of detail that may be lost on some industry professionals who are not used to terminology or processes listed within".

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(P2): "The checklists are a really good idea and tool that could be applied to a simplified output for projects to be tested or checked against however it may be useful to provide a blank template as a starting point for any professionals to utilise and apply the CSF's to their own project workflows".

(P2): "The information sections at the start of each of the main topics is nice and clear which act as good signposts to each of the 10 topics. Referencing is great as long as the links to various web resources remain live. Glossary of terms/abbreviations and appendices are well referenced and organised".

(P3): "The framework seems clear and very well structured".

(P4): "I like the structure, look and feel and also the detail however; the size of the guide may be intimidating for the casual FM observer".

(P5): "The framework is very well structured against critical success factors which I particular like. This will assist FM in structuring their own BIM journey and breaks the BIM challenge into bite size chunks. Alongside these is a wealth of information and research for further reading and guidance".

3. "How do you feel people will be able to potentially use (or adapt) it for use in their own BIM projects?"

(P1): "I think users will be able to interpret each CSF and its aim / explanation for their own purpose and will be able to adapt the framework to suite their specific needs".

(P2): This is a superb starter and a modified version of the checklist tailored to a project could be utilised to improve the understanding and QA for Operational deliverables. Essentially its use will come down to the scope of the organisation either setting up requirements for FM deliverables, delivering information around the FM deliverables or utilising the delivered outputs for operations and maintenance processes. It may be the case that only a few of the CSF's main or sub themes will be applicable to the project in which the project specific scope requires. That being noted it will be important for the individuals using the guide to have a good understanding of the application of each of the main and sub themes and how to apply them so education around the content which goes hand in hand with CSF 9 within the report."

(P3): "Facility Managers can use it as a reference guide or even as a check list to facilitate the use of BIM during the operations and maintenance processes. The main benefit would be acquiring the necessary knowledge for implementing BIM in FM tasks".

(P4): "By giving people the scenarios at different stages of the process and providing them with relevant reading materials, I feel the user should be able to quickly gather the key information they need".

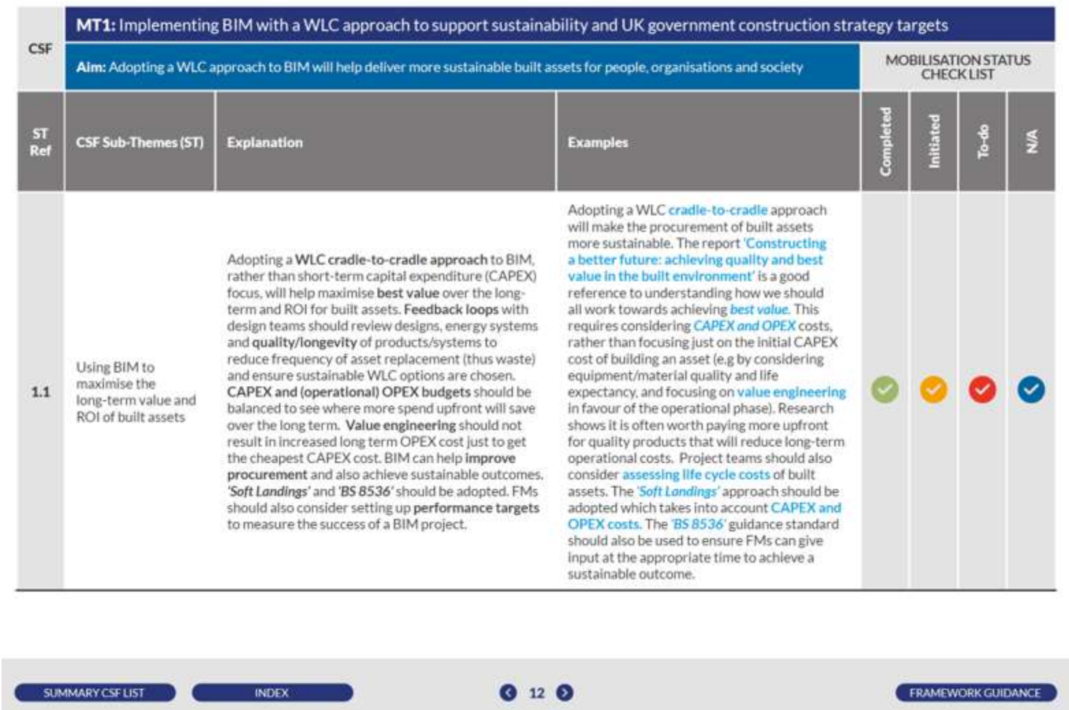
(P4): "It is also useful to keep returning to the guide at different stages to upskill or refresh knowledge".

(P5): "The framework will be used by FMs/project going forward to structure the engagement and information needs through the life of the project. For anyone starting in BIM it will be the go-to tool to allow them to get up to speed and not be overwhelmed by the challenge of being involved in BIM".
4. Do you think the framework will make a positive impact/contribution to industry, and in what way?
(P1): "Where BIM is being consistently implements by project stakeholders then the framework could make a positive impact on the common understanding, objectives and desired outcomes for the project and the associated data/information". (P2): "If formally adopted by the wider construction community and recognised by the relevant organisations and action groups, it could definitely make a positive impact and contribution to the industry. Professionals are always in need of guidance especially around new processes and concepts; however, these need to be supported by professionals with expertise in the specialist field. Documents, standards and guidance have their place, however practical application of that guidance and modification of its content will be the true test of how this can be applied within real life project environments and also ensuring that the information and processes being used and produced effectively. I feel that support and careful adoption is key to launching any new guidance or standard and addressing the need for adaptation as circumstances change will result in something that the industry can use". (P3): "The framework will have a positive impact on the FM industry because it will help FM acquire the digital skills needed today. The mobilisation framework will speed up the process of upgrading CAFM systems to become in the near future BIM compatible". (P4): "I think the guide is a positive step towards educating FM as a sector about the benefits of BIM. I would like to see this available to colleagues in the AEC sector too as the difference in language between AEC and FM/Property and Asset management can differ significantly. We need to bring everyone together to develop a shared language, this guide helps with that process". (P5): "I believe the framework will have a positive impact, taking away the complexity of BIM and bringing together all of the previous research, which is readily available to the industry, but previously lacking the structure of a framework like this. Aligning the research and information to the specific use case or need".

Appendix V: Link to published *'BIM-FM CSF Mobilisation Framework'*

The final version of the ***'FM-BIM Mobilisation Framework'*** is a 114-page guide and is available online at the following link: https://www.researchgate.net/project/FM-BIM-Mobilisation-Framework-Critical-Success-Factors-to-Help-FM-Deliver-Successful-BIM-Projects

Note: the intention is that it will be regularly updated and reviewed in order to stay up to date. The graphics below show the front cover and an example page from the CSF tables.



CSF	**MT1:** Implementing BIM with a WLC approach to support sustainability and UK government construction strategy targets						
	Aim: Adopting a WLC approach to BIM will help deliver more sustainable built assets for people, organisations and society			MOBILISATION STATUS CHECK LIST			
ST Ref	**CSF Sub-Themes (ST)**	**Explanation**	**Examples**	**Completed**	**Initiated**	**To-do**	**N/A**
1.1	Using BIM to maximise the long-term value and ROI of built assets	Adopting a **WLC cradle-to-cradle approach** to BIM, rather than short-term capital expenditure (CAPEX) focus, will help maximise **best value** over the long-term and ROI for built assets. **Feedback loops** with design teams should review designs, energy systems and **quality/longevity** of products/systems to reduce frequency of asset replacement (thus waste) and ensure sustainable WLC options are chosen. **CAPEX and (operational) OPEX budgets** should be balanced to see where more spend upfront will save over the long term. **Value engineering** should not result in increased long term OPEX cost just to get the cheapest CAPEX cost. BIM can help **improve procurement** and also achieve sustainable outcomes. *'Soft Landings'* and *'BS 8536'* should be adopted. FMs should also consider setting up **performance targets** to measure the success of a BIM project.	Adopting a WLC cradle-to-cradle approach will make the procurement of built assets more sustainable. The report 'Constructing a better future: achieving quality and best value in the built environment' is a good reference to understanding how we should all work towards achieving *best value*. This requires considering *CAPEX and OPEX* costs, rather than focusing just on the initial CAPEX cost of building an asset (e.g by considering equipment/material quality and life expectancy, and focusing on value engineering in favour of the operational phase). Research shows it is often worth paying more upfront for quality products that will reduce long-term operational costs. Project teams should also consider assessing life cycle costs of built assets. The *'Soft Landings'* approach should be adopted which takes into account CAPEX and OPEX costs. The *'BS 8536'* guidance standard should also be used to ensure FMs can give input at the appropriate time to achieve a sustainable outcome.	✓	✓	✓	✓

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