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Identification of Key Performance Tasks to Demonstrate the Benefit of Introducing the Facilities Manager at an Early Stage in the Building Information Modelling process on Public Sector Projects in Ireland.

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Identification of Key Performance Tasks to demonstrate the benefit of introducing the Facilities Manager at an early stage in the Building Information Modelling process on public sector projects in Ireland

by

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THESIS

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DECLARATION

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Barry McAuley

May 2016

ABSTRACT

The involvement of the Facility Manager within both the traditional and Building Information Modelling (BIM) governed process was investigated in this thesis. Governments are now seeking a more rewarding methodology in the management and procurement of public sector building assets. This has seen an integrated focus by International Governments on BIM as a partial solution in both managing and procuring public sector building assets. Despite BIM bringing the Facility Manager closer to project conceptualisation, there was still a reluctance and a lack of perceived benefits of having them involved earlier in the design phase. There remains a lack of clear evidence on what improved contribution the Facilities Manager can provide.

This thesis provides a review of current initiatives in place in the Irish public sector and advocates BIM and early Facility Manager involvement as a solution in establishing a more intelligent public sector estate. There was a strong understanding that early Facility Management involvement is a crucial requirement in the design process to ensure the model is challenged for operability and maintainability issues. Their involvement though has been hindered by a clear lack of understanding to what areas they can contribute to within the early BIM design process.

In depth observational studies identify inefficiencies that currently exist in the Irish public sector. In particular, demonstrations have been provided to show how the Facility Manager can be included in the design team to assist in addressing a number of these inefficienes.

Surveys carried out by the author suggest that there was a high level of awareness and early usage of BIM in Ireland. Despite the lack of involvement of the Facility Manager in the traditional process there was an understanding that he/she can utilise current BIM technologies in addressing key areas of concern which are usually left unaddressed until the operational phase.

The thesis presents a number of Key Performance Tasks (KPTs) that can be used to demonstrate the benefit of including the Facility Manager earlier in the BIM process for public sector projects. The KPTs have been piloted, refined and validated on a number of pilot and public sector projects. The output from this research has demonstrated that the inclusion of the Facility Manager can ensure a more robust Facilities Management (FM) design process for public sector projects, thereby realising improved project outcomes.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ACROYNOMS

3D	3rd Dimension
4D	4th Dimension
5D	5th Dimension
6D	6th Dimension
AEC	Architecture Engineering Consultant
AEC/FM	Architecture Engineering Consultant/ Facility Management
AECO	Architecture Engineering Consultant Operational
AHU	Air Handling Unit
AIM	Asset Information Model
AIR	Asset Information Requirements
AR	Augmented Reality
BAS	Building Automation Systems
BCA	Building and Construction Authority
BEP	BIM Execution Plan
BEM	Business Excellence Mode
BIM	Building Information Modelling
BIM for FM	Building Information Modelling for Facility Management
BMS	Building Management System
BSI	British Standards Institution
BSC	Balanced Scorecard
CAPEX	Capital Expenditure
CAD	Computer Aided Facilities Management
CAFM	Computer Aided Facilities Management
CIC	Construction Industry Council
CIF	Construction Industry Foundation
CIFM	Computer Integrated FM
CitA	Construction IT Alliance
CMM	Capability Maturity Model
CMMS	Computer Maintenance Management System

List of Acronyms

CNC	Computer Numerical Control
COBie	Construct Operate Build Information Exchange
CWMF	Capital Works Management Framework
DAC	Disabled Access Certificate
DIT	Dublin Institute of Technology
DoES	Department of Education and Skills
DSTV	Deutsche Stahlbau Verband
EI	Enterprise Ireland
EIR	Employer Information Requirement
EU-CPD	EU Construction Products Directive
FM	Facility Management
FMS	Facility Management Systems
GCCC	Government Construction Contracts Committee
GPS	Global Positioning System
GSA	General Services Administration (GSA)
GSL	Government Soft Landings
H&S	Health and Safety
HKHA	The Hong Kong Housing Authority
HVAC	Heating, Ventilation, and Air Conditioning
HSE	Health Service Executive
ICT	Information Communication Technology
IFMA	International Facilities Management Association
IFC	Industry Foundation Class
IIBH	Institute of International Harmonization of Building and Housing
IPD	Integrated Project Delivery
IPFMA	Irish Property and Facilities Management Association
K-BIM.	Knowledge based BIM
KPI	Key Performance Indicators
LEED	Leadership in Energy and Environment Design
M&E	Mechanical and Electrical

MTM	Measured Term Maintenance
MVD	Model View Definitions
NBI	National BIM Initiative
NBIMS	National BIM Standard
NBS	National Building Standard
NDFA	National Development Financial Agency
NEEAP	The Irish Government's National Energy Efficiency Action Plan
NFMA	National Facilities Management Association
O&M	Operation and Maintenance
OIR	Organisational Information Requirements
OPEX	Operational Expenditure
OPW	Office of Public Works
PAMD	Property Asset Management Delivery Plan
PAS	Publically Accessible Specification
PII	Professional Indemnity Insurance
POE	Post Occupancy Evaluation
PMS	Project Management Services
PRSP	Public Service Reform Plan
PWC	Public Works Contract
UAV	Unmanned Aerial Vehicle
QS	Quantity Surveyor
UK	United Kingdom
USACE	U.S. Army Corps of Engineers
R&D	Research and Development
RFI	Request for Information
RIAI	Royal Institute of Architects in Ireland
RFID	Radio frequency identification Technologies,
SCSI	Society of Chartered Surveyors Ireland
TOTEX	Total Expenditure
WC	Water Closet

1 INTRODUCTION

In 2005 the Department of Public Expenditure and Reform implemented a national policy on public procurement, particularly in relation to construction procurement. The reform was one of a number of key value for money measures announced by the Minister in 2005 and was put in place to help address concerns about the extent of cost overruns on public works and construction consultancy contracts. This background led to the introduction of the Capital Works Management Framework (CWMF) in 2007. Within the CWMF the Irish Government published a new suite of public sector contracts. In a recent review of these contracts in 2014 a number of professional bodies, such as the Construction Industry Foundation (CIF), Royal Institute of Architects in Ireland's (RIAI) and Society of Chartered Surveyors Ireland (SCSI) expressed their concern that these new forms of contracts have given rise to a more adversarial industry (Office of Government Procurement, 2014).

A more rewarding construction methodology, as suggested by the author throughout the research, based on the recommendations of existing international case studies, was that the Irish Government moves towards the mandatory imposition of BIM on public works projects by following a similar methodology to that adopted in the UK. This view has been reinforced through existing industry reports, such as Forfas (2013) and Construction 2020 which both suggest BIM as a more rewarding construction methodology. The Irish public sector needs to put efficient management processes in place to ensure that it has a more energy efficient and enhanced physical environment in which to operate. This can be achieved through the application of BIM, in partnership with early Facility Manager involvement, in offering an alternative methodology towards achieving a more innovative approach in realising the client's needs. This process will result in substantial monies being saved by the client throughout the structure's life cycle (McAuley et al., 2012a, b, c and d).

BIM technologies, along with earlier Facility Manager involvement, could help reshape future public assets (West et al., 2013). The Facility Manager must play a much more important role within the design and construction process, as he/she will be responsible for the operational phase, which incurs approximately five times the initial capital cost (McAuley et al., 2013a and Hore et al., 2013). Though BIM will not answer all of the Irish estates' concerns, it will offer the chance for the Irish construction and Facility Management (FM) sector to take a step in the right direction towards a more sustainable future. This was important, as there has been little move towards cutting edge technologies from the Irish FM sector, in order to streamline maintenance and further enhance lifecycle management. (McAuley et al., 2013b and c).

Despite enhanced FM being the goal of this collaborative BIM approach, there was still a reluctance and a lack of perceived benefits of having the Facility Manager involved earlier in the design phase (Kelly et al., 2013 and Wang et al., 2013). In order to justify their inclusion this research has developed a number of Key Performance Tasks (KPT) to demonstrate their specific contribution at an early stage in the BIM process on public sector projects. This is a new term proposed by the author, as the application of Key Performance Indicators (KPI) was not suitable to this research, as nothing was required to be measured. The research findings further support the business case for the adoption of a more robust FM process for the public sector, facilitated by the use of a suite of KPTs (McAuley et al., 2015a&b).

1.1 AIM OF THESIS

The overreaching aim of this research was to establish a set of BIM focused KPTs that can be used to guide early Facility Manager involvement in the BIM process for public sector projects.

1.2 OBJECTIVES

In order to achieve this aim, the following objectives were established:

1. Identify the current awareness and usage of BIM within Ireland.
2. Review the appropriateness of implementing BIM as a solution in procuring and managing both International and Irish public sector assets.
3. Identify the inefficiencies that currently exist in the management of both International and Irish public sector assets.
4. Examine the current role of the Facility Manager within the International and Irish public sector and his/her perceived role within the construction process.
5. Establish where the Facility Manager can have the greatest impact in the design process.
6. Demonstrate, by use of a pilot project, how the shifting of project focus from design to FM can be enhanced through inclusion of the Facility Manager in the BIM process.
7. Establish and validate a set of KPT’s that can support the business case for the early inclusion of the Facility Manager in the BIM design process for public sector buildings.

1.3 METHODOLOGY

A detailed methodology is included in chapter three of the thesis. The research methodology included five distinct phases of research; a literature review, an explanatory sequence design, a transformative design, thematic analysis and field validation of the KPTs through expert analysis.

Initially an extensive literature review was undertaken to identify relevant literature on the key role of FM within public works projects. This review discussed why BIM was important for both Irish and international governments. This progressed into investigating the emerging importance of BIM and its' impact on the FM process, before examining the current role of the Facility Manager in the design process. This established the current techniques in place for recording the benefits of BIM. The chapter established current research gaps and the proposed contribution to knowledge.

The methodology proposed an explanatory sequential design for phase one of the research. The first stage of phase one involves a qualitative based case study, where the author observed a number of professionals working on a simulated pilot case study. The study sought to examine how BIM could offer a more rewarding approach with regards to procuring and managing the facilities of newly built public sector assets. The second phase of the sequential design involved two cross-sectional surveys. The first survey was structured around the results from the observation case study and aimed to establish the level of support for the introduction of BIM, to assist in achieving the vision of the CWMF. Ultimately, it aimed to explore the current adoption of BIM in both the private and public domain. The results from the first survey informed a follow-on survey which focused on BIM and early FM involvement in public works. The survey provided a snapshot of the current Irish FM sector and the technologies that were now commonly in place within the private and public sector. It also established the current role of Facility Managers within the design process and their particular contributions.

The next stage of the methodology involved a transformative design approach. This involved a pilot design that aimed to shift project focus from design and construction to FM and operations through earlier involvement of the Facility Manager in the BIM process. In order to establish the KPTs a three stage process was adopted, as it enabled the triangulation of both the core competencies and early design target areas associated with the role of the

Facility Manager, with existing BIM KPIs. The triangulating of these three performance areas resulted in the establishment of common criteria which served as the basis of the KPTs.

The penultimate stage of the methodology involved conducting further analytical rigor on the research collected through the first two phases of the research. Before this was performed it was important that any validation of the KPTs in the field represented a solution which was directly relevant to the public sector. To achieve this the author worked in the Office of Public Works (OPW) for a period of time on a BIM public works project. The data collected during the action research was integrated with previous data collected during the first two phases of research within a thematic analysis. This ensured that all collated data received a high level of cross reference and analytical rigor ensuring any previous data not analysed was incorporated into the refined KPTS. The purpose of applying a thematic analysis approach was to refine the KPTs before final validation in the field.

The final phase involved the validation of the KPTs on two public works BIM models. Neither model had any early FM input. Two expert Facility Managers were used to validate the KPTs. One Facility Manager had no knowledge of BIM, while the other had an extensive knowledge of using BIM for FM software. The KPTs were further refined following expert analysis from the FM practitioners.

1.4 OUTLINE OF CHAPTERS

The thesis commences with a literature review in chapter 2. This chapter sets the scene for the research problem by discussing problems faced by international governments and how BIM was currently viewed as part of a solution to increase value for public sector assets. This was then explored and related to the Irish public sector. The chapter further discusses the benefits and limitations of how BIM can be used to manage public sector assets. Further focus was placed on the role of Facility Managers within this context and the perceived barriers and drivers regarding their early involvement in the BIM governed design. Finally, a review of current tools in place to record their contribution was undertaken. The research demonstrated that there was a limited understanding to the benefit of their inclusion in the early BIM process.

Chapter three concentrates on the selected methodology and rationale for its selection. A mixed methods approach was selected based on the pragmatic worldview adopted by the author. The methodology was broken down into four distinct phases that involved an explanatory sequence design, a transformative design, thematic analysis and field validation of the KPTs.

Chapter four, five and six contains the results of phase one of the primary research. The results from the 2011 pilot demonstrated a positive outcome in regards to how BIM could offer the CWMF a more rewarding methodology. However, there remained significant gaps with regards to Irish literature in the context of both BIM and FM. The first survey aimed to address this and found that the Architecture Engineering Consultant/ Facility Management (AEC/FM) sector was still uncertain, as to the exact meaning of BIM, and further education was needed to address this. Despite this, a high awareness level of BIM was evident. The survey provided a good overview of BIM in Ireland. The second survey focused on the area of BIM for FM on public works projects in Ireland, as well as the strategic role of the Facility Manager in the construction process. The results showed that there was little involvement of the Facility Manager during the early stages of construction, despite the benefits that were presented in the literature.

Chapter seven concentrated on phase two of the primary research. A three stages process was adopted to create the KPTs. The results helped establish a set of KPTs to better understand the areas where the Facility Manager can have the greatest impact in the early design. It was established that the Facility Manager can play a significant role in ensuring the most functional and practical design can be realised through his/her involvement.

Chapter eight represented phase three of the research and concentrated on refining the KPTs through a thematic analysis approach. This involved an initial three-month action research study where the author spent a period of time working on a public works project collecting data to ensure the KPTs represented a solution that would be directly relevant to the Irish public sector. It was found that BIM was in its infancy in the public sector and there was no interaction between the Property Maintenance Department and the design team. The thematic analysis enabled the testing of all the collected qualitative data to ensure the proposed KPTs for early Facility Manager involvement addressed the key concerns now faced by the Irish public sector estate.

Chapter nine focused on the final phase of research by validating the KPTs on the two public sector BIM models that had not benefited from any FM input. Two expert Facility Managers were used to validate the KPTs. This led to further refinement of the KPTs.

The thesis concludes with a brief description of the research undertaken, principle conclusions and an evaluation of whether or not the research objectives had been met. A section on limitations and further research was also provided.

Figure 1.1 details a road map of the research journey undertaken through the course of the thesis.

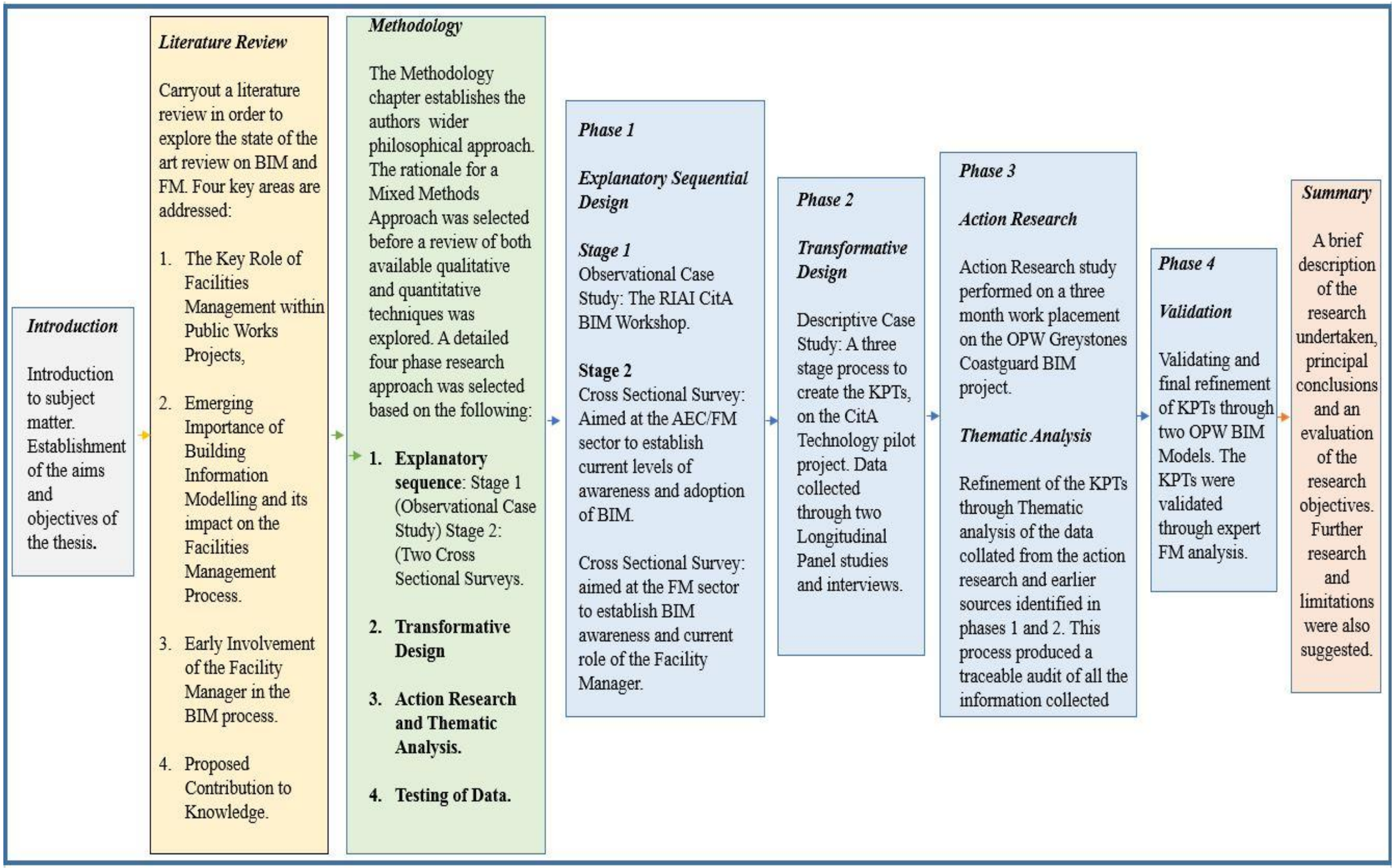


Figure 1.1 Thesis road map

2. LITERATURE REVIEW

2.1. INTRODUCTION

Parker and Hu (2013) state that the difference between the private and public sector was that the public sector functions within a bureaucracy while the private sector was driven by market imperatives. One significant difference was that the private sector serves customers which were easily identified and the public service sector serves citizens who feel it was their right to receive a service provision. Boyne (2002) explains that the main conventional distinction between public and private organisations was their ownership. Private sector firms are owned by entrepreneurs or shareholders while public agencies are funded largely by taxation rather than fees paid directly by customers. Boyne further clarifies, that the primary constraints faced by the public system were political based compared to the private sector which were economic based. While the private sector has opportunities to seek additional investors, Governments are under pressure to improve public sector performance and at the same time contain expenditure growth, with citizens demanding that governments be made more accountable for what they achieve with taxpayers' money (Curristine et al., 2007). Public sector bodies are responsible for diverse, expensive but capital intensive assets, which require the adaption to all changes taking place in their environment, as well as anticipation of future challenges (Rymarzak and Trojanowski, 2012). One of the biggest threats faced by international governments in delivering greater efficiency on public works was the need for the public sector to have an enhanced physical environment to operate from. A poorly designed public estate can now significantly impact on an international government's monetary budget.

The largest building cost component over a building's life-cycle was maintenance which was largely ignored in the design phase (Liu and Issa, 2013). With 85% of the life cycle cost occurring after construction this would suggest that the information needs of the Facility Manager far outweigh those of the design and construction professionals (Aguilar and Ashcraft, 2013). Eastman et al., (2011) reiterated this challenge by focusing on the current facility delivery process, which remains fragmented and depends on paper-based communication, which was littered with errors and omissions in content causing delays, financial burden and friction between all parties involved.

The Construction Intelligence Centre (CIC) forecast that the global construction industry by 2020 will accelerate to an annual average of 3.4%, up from 2.4%, with the industry reaching a value of US$10.0 trillion. This has resulted in the need for the construction sector to drive out inefficient and outdated traditional work practices and seek out new more innovative ways of working that will deliver faster, cost effective and more sustainably built facilities. One of the major developments that is taken place through construction industries across the world at present is BIM. Public sector bodies and Governments around the world have recommended or mandated the use of BIM as a strategy for addressing declining productivity (Kassem et al., 2015).

For Facility Managers, BIM software can be a powerful new tool to enhance a building's performance and manage Operation and Maintenance (O&M) activities more effectively throughout a building's life. The model can help to automate the creation of inventory lists for equipment, populate current FM systems and reduce redundancy in the maintenance of facility data for FM activities (Brindal and Prasanna, 2014).

BIM promises to offer a new level of functionality for the management of buildings and the physical assets within them, providing a unified digital repository of all building components and as a full 3D model capable of displaying views with a clarity that typically eludes users not schooled in interpreting standard 2D building drawings (Sabol, 2008 pp 4).

BIM in FM can facilitate the future involvement of Facility Managers at a much earlier design stage, in order to convey their input and influence on the design and construction of a building (Kassem et al., 2015). BIM will only add value to the FM process once modellers or designers are able to share Facility Managers' values right from the very early stages of the project's life (Olatunji and Akanmu, 2015).

Despite the claims made by a number of authors, with regards to early Facility Manager involvement in the BIM process, it was still not a common or established procedure. Wang et al., (2013) has outlined that little research was evident in investigating the benefit of integrating FM in the early design stage. Kelly et al., (2013) further highlights a number of procedural and cultural mind-set issues, as to why BIM for FM was not readily adopted, which includes the need for Facility Managers to be involved much earlier in the project.

The literature review establishes the current position of the Facilities Manager within the BIM governed design process with regards to the delivery of public works. An argument will be presented throughout the literature that the Facility Manager should play an active role within the design process. Further to this a contribution to knowledge has been put to advance this stance and in effect reengineer the Facility Manager's perceived role. This has been achieved by creating a set of KPTs to help demonstrate their contribution through earlier involvement in the BIM governed design process within public works contracts. Figure 2.1 provides a process map of the literature that has been reviewed within this chapter.

2.2 THE KEY ROLE OF FACILITIES MANAGEMENT WITHIN PUBLIC WORKS PROJECTS

In order to convey the critical role that FM plays within the public sector, an understanding of FM and BIM was required. A critical understanding of these two concepts has enabled the researcher to understand the contribution that these ingredients can play in the management of the Irish public sector estate.

2.2.1 Understanding Facilities Management

A brief explanation of FM is detailed below from three leading global FM organisations.

- *"FM is the integration of processes within an organisation to maintain and develop the agreed services which support and improve the effectiveness of its primary activities"* (British Institute of FM, 2015).
- *"FM is a profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology"* (International Facilities Management Association (IFMA), 2015).
- *"FM professionals and organisations are responsible for the effective operational management of the buildings and precincts which form the majority of Australia's built environment"* (Facilities Management Association of Australia, 2015).

All of these explanations retain a central theme that the FM service was ultimately about ensuring that through a combination of people, skills and technology, it serves a key primary function in ensuring that the built environment runs at optimum efficiency. This is not to be confused with asset management, which is a process of making decisions and their implementation related to real estate acquisition, use and disposal. Asset management covers numerous operations and activities performed in a variety of areas, including, e.g. inventory, valuation, portfolio analysis and auditing and reporting (Rymarzak and Trojanowski, 2012).

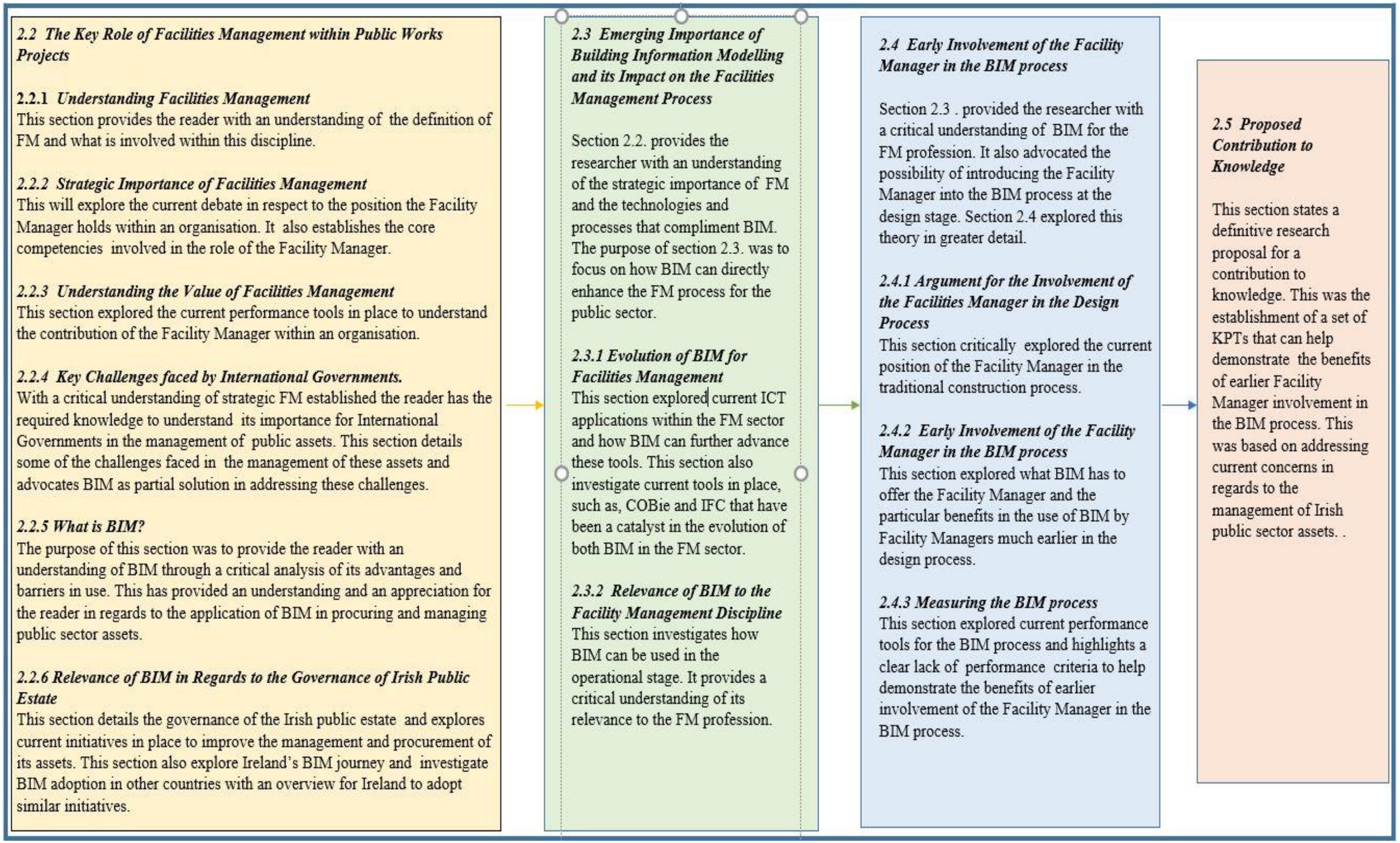


Figure 2.1: Literature Review Process Map

The differences between both definitions suggest that while the asset manager concentrates on fixed assets, with regards to improving maintenance effectiveness and efficiency, the Facility Manager was responsible for coordinating the physical workplace with the people and the work of an organisation.

Despite the vision of FM definitions, many authorities were unclear as to the exact contribution of FM. In some circles there was a claim that FM was essentially about ensuring that a business's facilities support its corporate goal and makes a positive contribution to its financial performance and sustainability (Leifer, 2003, Alexander, 2003 and Saleh et al., 2011). This opinion was shared by Scupola (2012, pp 198) who defines FM as *"the integration and alignment of the non-core services, including those relating to premises, required to operate and maintain a business to fully support the core objectives of the organisation".*

This view was not universally shared with others arguing that the battle to define FM and its strategic importance continues, and has become somewhat counterproductive (Price, 2001 and Grimshaw, 2007). These definitions instead of clarifying what FM is, have contributed to the unclear characterisation of the FM profession as a whole (Mobley and Khuncumchoo, 2006). Despite the ongoing battle to define FM, it was still seen by many businesses as an end point function following the design and construction phases. Steenhuizen et al. (2014) was of the view that the FM, both as a profession as well as an educational field, has not reached equilibrium on a worldwide or European basis.

2.2.2 Facilities Management Sector

Brochner (2010) states that the beginning of FM can be traced back as far as Roman times. Brochner details how the Roman Republic was a period of innovation for construction technology, which was important for FM i.e. pozzolane concrete, glass blowing and opus reticulatum walls. The author further elaborates that only through a series of innovations in the 1870s, most notably the distribution of electricity and its use in buildings for lighting, vertical transport, heating, ventilation, cooling and a number of other purposes, did a distinction between Roman and more modern FM began to form.

Drion et al., (2012) claim that an accurately reliable history of the development of FM has yet to be written. In essence, FM has a 30-40-year global pedigree. Price (2003) traces the origins of the word FM to the banking sector were it was understood to be the complete takeover of a client's data processing by a service frim. Price outlines two significant, simultaneous events in the 1970s which helped the evolutionary course of FM. These events included the use of increasingly sophisticated furniture instead of freestanding office screens and the introduction of computer terminals into the workstation, which challenged Facilities Managers to solve computing wiring, lighting, acoustic and territory problems.

The first real step for FM towards formation was through the Herman Miller Research Corporation who hosted a conference on "Facility Influence on Productivity," This was the meeting place for the three founders of the International Facilities Management Association (IFMA). Price adds that in 1980 a meeting was hosted to establish a formal organisational base for a FM association in which the National Facilities Management Association (NFMA) was formed with a constitution, bylaws, and temporary offices.

From a European perspective, FM emerged about 25 years ago, primarily as a means of linking real estate and construction industry concerns, with the productive use of workplace building assets (Drion et al, 2012). Pathirage et al (2008) explains that within the UK that a reason for the development of FM in the past ten years, was due to the UK imposing a severe commercial and competitive pressures on businesses in both the private and public sectors. These pressures made organisations realise that they must seek some form of competitive advantage, which resulted in them introducing a core business philosophy and in the process the recognition of the strategic role that FM can play. This has seen the job of the Facilities Manager grow from humble beginnings, to encompasses a wide range of complex and challenging roles, often across entire estates (Booty, 2009). FM has grown since the late 1980s, and in that time has gradually gained a foothold as a discipline and profession within the property and Construction Industry (Jay et al., 2001).

A number of International FM associations now exist such as the IFMA, which is world's largest and most widely recognised international association for FM professionals, supporting 24,000 members in 105 countries. Other FM associations include the Facility Management Association (FMA) in Australia, EuroFM which is represented throughout Europe, the British Institute of FM (BIFM) and the Irish Property and Facility Management Association (IPFMA) in Ireland who now operate under the jurisdiction of the SCSI, to name a few. Importantly |FM education, teaching and research has taken root in the higher education sectors of some countries, providing the beginnings of a system of credential-based entry to managerial-level employment (Drion et al, 2012).

The history and definition of FM though somewhat uncertain has still yielded a key managerial position that must be addressed in order for an organisation to adequately function. The question now faced by practitioners and academics is where the Facility Manager and his team reside within the core business strategy of an organisation.

2.2.3 Strategic Importance of Facilities Management

Pathirage et al., (2008) suggests that the FM discipline has now progressed to be seen as an integrated management role that has the ability to be a significant determinant of corporate goal achievement. Madritsch and Ebinger (2011) outlines that a professional Facility Manager plays a crucial role of ensuring added value to the company and in adopting a strategic approach. FM was now becoming the norm for an organisation, as these facilities shall be a critical part in financial performance and sustainability (Madritsch and Ebinger, 2011 and Saleh et al., 2011).

FM organisations can contribute value to its organisation more than just reducing cost of operation and provision. In order to deliver the value added by FM services to the core business, the FM organisation must align FM services and solutions with core business needs and requirements (Katchamart, 2013 pp 227).

A global job task analysis in 2009 conducted a comprehensive and global survey analysis of Facility Managers in 62 countries within the IFMA set up. They identified 11 defined core competencies of Facility Managers. These include:

- **Communication -** Communication plans and processes for both internal and external stakeholders.
- **Emergency Preparedness and Business Continuity** - Emergency and risk management plans and procedures.
- **Environmental Stewardship and Sustainability -** Sustainable management of built and natural environments.
- **Finance and Business -** Strategic plans, budgets, financial analyses, procurement.
- **Human Factors** – Healthful and safe environment, security, FM employee development.
- **Leadership and Strategy -** Strategic planning, organise staff and lead organisation.
- **Operations and Maintenance** – Building operations and maintenance, occupant services.

- **Project Management -** Oversight and management of all projects and related contracts.
- **Quality -** Best practices, process improvements, audits and measurements.
- **Real Estate and Property Management** – Real estate planning, acquisition and disposition.
- **Technology** - Facility management technology, workplace management systems.

Codinhoto et al. (2013) conveys that the three FM objectives are strategic, tactical and operational and should be in close synchronisation with the mission and vision of the organisation. The authors, referencing BSI 2007, illustrate in table 2.1 a myriad of actions for the FM team that must have authority and be prepared to accept full accountability for all actions. This table assigns these actions into three different levels that represent the organisation's strategic objectives in the long term, its tactical objectives in the medium term and finally at an operational level, which were the day-to-day operational tasks. Figure 2.2 illustrates a further breakdown of these services and provides an understanding of where the Facility Manager can contribute.

Strategic level: to achieve the objectives of the organisation in the long term through:	**Tactical level** - to implement the strategic objectives in the organisation in the medium term through:	**Operational level** - to create the required environment to the end users on a day-to-day basis through:
• Defining the Facility Management strategy in compliance with the organisation's strategy. • Policymaking, elaborating guidelines for space, assets, processes and services. • Active input and response. • Initiating risk analysis and providing the direction to adapt changes in the organisation. • Initiating service level agreements (SLAs) and monitoring key performance indicators (KPIs). • Managing the impact of facilities on the primary activities, external environment and community. • Maintaining relations with authorities, lessees and tenants, strategic partners, associations etc. • Supervision of the Facility Management organisation.	• Implementing and monitoring guidelines for strategies. • Developing business plans and budgets. • Translating facility management objectives into operational level requirements. • Defining SLAS and interpreting KPIS (performance, quality, risk and value). • Monitoring compliance to laws and regulations. • Managing projects, processes and agreements. • Managing the facility management team. • Optimising the use of resources. • Adapting to and reporting on changes. • Communicating with internal or external service providers on a tactical level.	• Delivering services in accordance with the SLA. • Monitoring and checking the service delivery processes. • Monitoring the service providers. • Receiving requests for service e.g. via a help desk or service line. • Collecting data for performance evaluations, feedback and demands from end-users. • Reporting to tactical level. • Communicating with internal or external service providers on an operational level.

Table 2.1: FM objectives at strategic, tactical and operational levels - *Source: Codinhoto et al. (2013, pp 22 (adapted from BSI, 2007)*

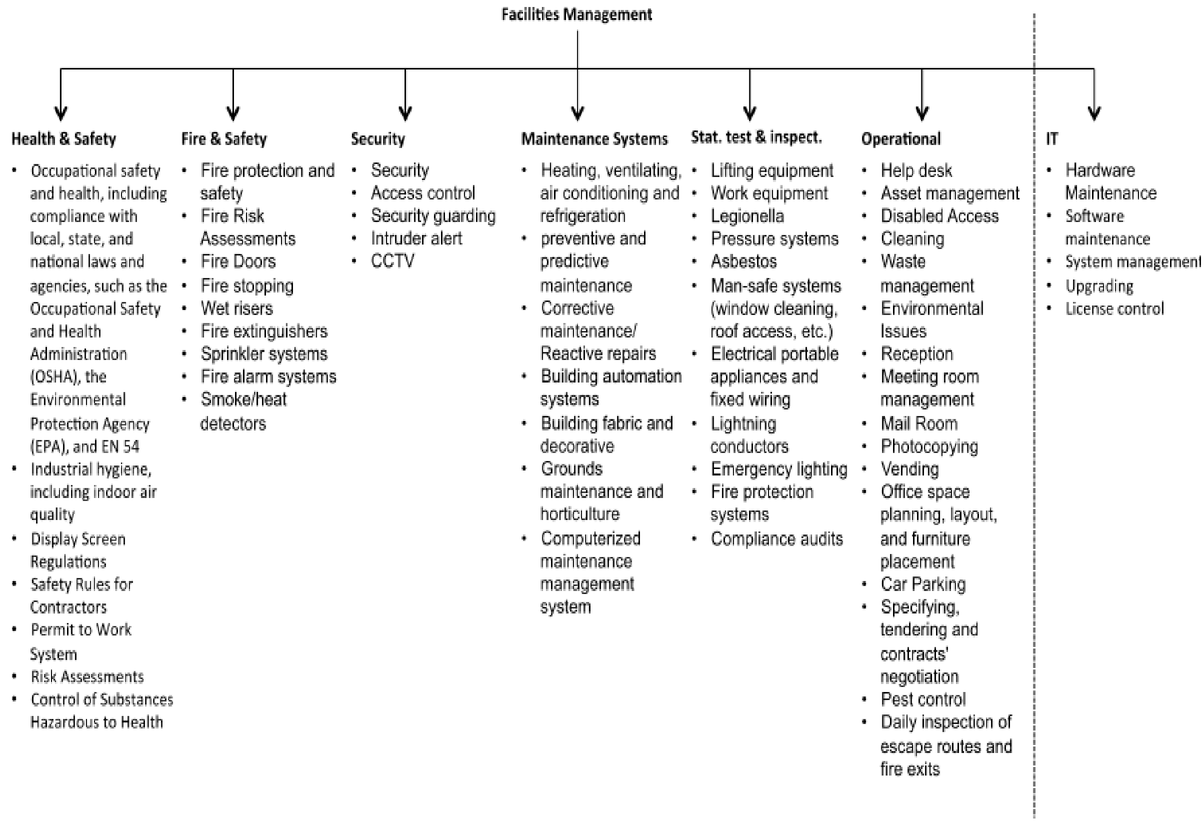


Figure 2.2: Facilities management services – *Source: Codinhoto et al. (2013, pp 37)*

The opinion that FM was a strategic tool that contributes added value was contested by a number of leading academics who believe that FM remains rooted in an operational and cost focussed stance, unable to communicate its contribution to the core business and has become a commodity rather than a professional skill in many organisations, to be procured at lowest cost (Price, 2003 and Ware and Carder, 2012).

Grimshaw (2007) also has concerns that FM has been too associated with cost cutting and has largely failed in its attempts to establish any credible model for added value or any direct link between physical facilities and productivity. He added that it was more associated with the "facilities" side than the "management" side of its title.

FM has a long history of declaring, without much evidence, that it adds value as well as cutting cost. (Price, 2012 pp 11).

Codinhoto et al. (2013) argues that the overall concept of FM and its importance was misunderstood, which has seen the FM function being widely associated with keeping the cost factor to a minimum when it comes to non-added value activities, such as maintenance, and janitorial services. Codinhoto et al., contends that this narrow view has unwittingly relegated the relevance of FM to the background, away from influencing an organisation's decision making and strategic thinking. Coenan et al., (2013) argues that FM needs to break away from current thought patterns and adopt a new way of thinking. This involves an open system of relationships. The authors believe that work to identify the added value of FM from a managerial perspective was in its infancy and that FM and its key stakeholders were no longer seen as separate, but rather as an integrated economic system to co-create value.

The research for adding value to the FM process continues and has seen a number of value maps proposed in recent years. These include Jensen (2011) whose value maps has helped to support the dialogue between the supply side and the demand side of FM, and Coenan et al., (2013) FM Value Network, which offers a conceptual foundation to reflect on the idea of FM as an open system of relationships. This search for added value within the FM profession seemed for the moment to be an ongoing debate.

Comprehensive assessment tools to visualise and benchmark the added value of FM performance are emerging, but are still fragmented and limited, there is ongoing work on models and definitions to fill this gap (Madritsch and Ebinger, 2011 pp 4).

Some suggest that in order for FM to add value and make the greatest impact that it should be integrated much earlier into the construction process, as this can help maximise sustainable construction potential, as well as providing a new cost focus for buildings (Shah, 2007).

2.2.4 Understanding the Value of Facilities Management

The aim of this thesis was to create a set of KPTs that can demonstrate the benefit of introducing the Facilities Manager at an early stage in the BIM process for public sector projects. To achieve this an understanding of existing tools currently in place within the FM profession for understanding the added value, which the Facility Manager brings to an organisation was reviewed. This was best realised through reviewing existing performance measurement tools.

Performance measurement, by consensus in the business management community, can be defined as quantifying the efficiency and effectiveness of an action (McDougal et al., 2002). *Measurement is an important part of performance management. Adages such as "you can't manage what you can't measure" and "what gets measured gets done" are common elements of management texts (Amaratunga and Baldry, 2001 pp 97).* Pitt and Tucker (2008) acknowledge that FM can add to the performance of an organisation through many different aspects, such as strategy and culture, and, so for that reason it was important that there were procedures in place to measure the effectiveness of FM functions on an organisation's core business, together with systems to measure Facility Managers own performance. Pitt and Tucker advocate the use of benchmarking techniques which can significantly help FM organisations drive innovation in their performance measurement systems.

Madritsch and Ebinger (2011) in their pursuit for a less fragmented industry neutral process framework outlined a number of existing assessment tools to benchmark the added value of FM performance. These include:

- **International FM Organisation:** A knowledge based framework orgainsed in eleven core competencies**.**
- **European FM standard**: A set of definitions focusing on service delivery, quality management and process development.
- **Institute of Asset Management:** The organisation of relevant knowledge in its competency framework.
- **The Association of Physical Plant Administrators**: They offer a body of knowledge with four core competencies and manage a database of comparative performance metrics.
- **National Research Council:** They propose a multidimensional framework for FM.
- **Chotipanich and Nutt (2004):** They developed an inventory of FM functions and assessed how to best position these functions within an organisational context to generate strategic value.
- **Then (1999, 2004):** A set of integration models and process sequences to facilitate the alignment of facilities demand and supply.
- **Dettbarn et al., (2005):** The authors introduced the concept of Key Process Areas and process maturity, borrowed from Capability Maturity Models, to define a model that integrates the strategic, operational, and tactical aspects of managing.

Meng and Minogue (2011) explain that though performance measurement was new to FM, there was still a lack of a systematic investigation of performance measurement in the context of FM, making it difficult to justify whether these models were effective or not. Meng and Minogue reviewed four different methods of measuring FM, which included a Balanced Scorecard (BSC), a Business Excellence Model (BEM), Key Performance Indicators (KPIs) and a Capability Maturity Model (CMM). It was ultimately found that KPIs were more popular with FM practitioners and organisations, as they can be used for a selection of FM service providers to communicate a clear description of desired outcomes and how they will be monitored and controlled. The area of performance measurement, especially KPIs, as a reliable and valid measurement method, was an ongoing research gap within the FM field (Jensen, 2012).

All of the detailed performance measurement tools identified focused on the built environment and did not offer any guidance when it came to the design stage. It was the overreaching aim of the research to establish a number of KPT's that can provide an initial basis for validating the Facility Manager's contribution in the design process.

2.2.5 Key Challenges Faced by International Governments.

Governments throughout the developed world are now under pressure to efficiently manage their public estates. This has become more difficult given the ongoing burden on their operating costs and the more sophisticated demands emanating from international climate change standards and similar regulatory changes that impact on public sector facilities.

The last 25 years have seen rapid changes in all aspects of working practices and the public sector has not been immune to these. The pervasive impact of technology, the rise of the service culture and search for greater efficiency in the use of all resources have challenged professionals to deliver new and more responsive property solutions to meet the needs of the occupiers, customers and a wide range of services (Gibson, 2008 pp 8).

One of the biggest threats faced by international governments in delivering greater efficiency on public works was the need for the public sector to have an enhanced physical environment to operate from. The physical environment can either enhance or impede worker productivity therefore, contributing to its bottom line profits and success of the organisation (Teicholz, 2001). The built environment is one of the largest expenses to an organisation with O&M costs reported to reach as high as five times the capital costs, with the business operating costs reaching up to two hundred times the capital costs over the lifecycle (Wu et al., 2006). The National Institute of Building Sciences (2007) reported that a total of 3.8 % of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility.

A poorly designed public building can now significantly impact an international government's monetary budgets. Liu and Issa (2014), noted that that the largest building cost component over its life-cycle was maintenance, which was usually ignored in the design phase. Kassem et al., (2015) outline that of the $15.8 billion loss caused by interoperability inefficiencies, $10.6 billion were attributed to the owner and operator during the operations and maintenance phase of a building. Other concerning issues include ongoing carbon legislation and sustainability matters, with the buildings estimated to account for 30.8% of global energy consumption and greenhouse gas emissions from the building industry predicted to be responsible for 25 % of all across the world by 2030 (Li et al., 2012).

Deloitte (2012) warn that governments are now recognising the need to takes steps to better manage their property and ensure property takes its rightful place at the heart of work to modernise government. Such recommendations put forward included he need to prioritise real estate management and empowering Facility Managers accordingly and the better collection and use of data. However, as discussed by Eastman et al (2011) the facility delivery process remains fragmented and it depends on paper based communication, with errors and omissions in these documents causing delays, financial burdens and friction between all parties involved.

In some instances, this has seen a number of governments turn towards ICT and soft landing frameworks, in order to explore new ways of getting full value from public sector construction. The primary objective for this approach was to seek a representation of all the required information to detail the building throughout the complete lifecycle (Howard and Bjork, 2008). The purpose of such an approach was to ensure better information management, as the integration of information using ICTs has the potential to allow more collaborative working, thus benefiting everyone in construction teams and should therefore continue to play an increasingly crucial role within the AEC industry (Dawood and Sikka, 2009).

One such ICT related approach which was beginning to break down these barriers was the move from 2D drawings to the application of 3D technologies. Williams (2007) outlines how 2D drawings have several limitations that have promoted the use of 3D CAD in construction. These limitations include:

- 2D plans can be difficult to visualise.
- The 2D plans may require extensive interpretation by the user.

These limitations are being addressed by BIM as it can facilitate better visualisation. This relatively new technology has allowed a new paradigm within the AEC sector, as it has the ability to promote and encourage each stakeholder, within the project, to play a more prominent role (Godager, 2011). Hijazi and Aziz (2013) state that BIM allows for progressive collection of building data and could play a key role in streamlining the data collection process.

This has seen a number of stakeholders, as observed by Samso et al., (2012), especially owners and operators now focusing on implementing BIM to support the FM and operations phases, with an emphasis an improving energy efficiency of their facilities.

Governments around the world have recognised the inefficiencies affecting the construction industry in general, and have either recommended or mandated the use of BIM as a strategy to addressing a declining productivity (Kassem et al. 2015, pp 55).

Further to this BIM can assist in driving value for a governments asset portfolio, as it enables effective management of information throughout the lifecycle of a facility or physical asset. If project or asset information was systematically managed then it is widely accepted that more accurate and informed decisions were possible during project conception, feasibility assessment, design, construction, operation and ultimately decommissioning or refurbishment (McKenna et al., 2015)

2.2.6 What is BIM?

Construction is a complex process of creating a unique product undertaken mainly at the delivery point by cooperation of a multi-disciplinary team, based around temporary relationships within a fragmented industry (Masterman, 2012 and Aapaoja et al., 2013). Such traditional practice creates conflicts and disputes, poor collaboration, a lack of focus on customers' requirements, and failure to satisfy clients' needs (Akintan and Morledge, 2013). Ibrahim et al., (2010) warn that traditional ways of performing and managing construction processes face unprecedented challenges, as a result of growing competition that have forced construction companies to rethink construction practices with regard to improving productivity, quality and efficiency. This has resulted in a paradigm shift to rectify a number of problematic areas that include productivity, efficiency, infrastructure value, quality, sustainability, high lifecycle costs, lead times and duplications via effective collaboration and communication of stakeholders in construction projects (Arayici et al., 2011). Ku and Taiebat (2011) reaffirmed that the operating environment of the AECO industry is undergoing rapid changes, reinforced by globalisation, information technology advancements and the imperative of environmental sustainability.

This has resulted in recent years for the call for a more collaborative and integrated construction methodology. Collaboration and integration among the project team members and stakeholders is needed in order to enhance value and should not be confined to certain parties (Aapaoja et al., 2013 pp 698).

The authors add that the construction industry was well aware of the need to improve the integration, planning, and control of its design and delivery processes. This has seen the evolution of Integrated Project Delivery (IPD) to help yield better results and enhance project value creation. IPD is a project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses all participants to reduce waste and optimise efficiency through all phases of design, fabrication and construction (Kriphal & Grilo, 2012). Another methodology that has emerged was BIM, which was seen as not just a technology but as a catalyst for a deeper process (Hannele, 2012). There have been suggestions that IPD with the utilisation of BIM could improve the construction process, as BIM was essential to efficiently achieve the collaboration required for IPD, as the combination of BIM and integrated teams allows the project to be defined and coordinated to a much higher level prior to construction start, enabling more efficient construction and a shorter construction period (Haron et al, 2009 and Kriphal & Grilo, 2012).

The emergence of BIM has changed the way one builds, the way the buildings look, the way they function and the way buildings were maintained and managed, and can be further used as a platform to engage with multi-disciplinary stakeholders through its 3D visualization capabilities (Godager, 2011, Hijazi and Aziz, 2013). BIM is a modelling technology with an associated set of processes to communicate and analyse building models that has information and data within it that can help support the design, procurement, fabrication, construction activities and operations and maintenance processes (Azhar, 2011 and Eastman, 2011). BIM technology can facilitate improvements in the information flow between actors in a building project which can be enhanced and made more effective. The information flow can be attained with better coordination and reuse of information, which BIM technology can facilitate (Jensen and Johannesson, 2013). BIM supports a comprehensive digital database which is an ideal method of communicating the design team's intent to the owner and project participants. Traditionally BIM has been used for the design and construction phase with owners now realising it has potential for further use after a project's completion (Golabchi et al., 2016).

Khemlani (2011) points out that in regards to FM, the BIM model can be used for O&M, as it captures much of the building information, meaning that this information does not need to be recreated after handover. BIM was not just a technology, but was being championed as a process that can revolutionise the construction industry because of its promise to radically improve collaboration among construction professionals and increase efficiency (Kent and Gerber, 2011 and Hannele, 2012). Race (2012) believes a better term for BIM would be 'Building Information Management' as BIM was both an incomplete and infinite concept.

2.2.6.1 Barriers to BIM

BIM has encountered a number of obstacles in the form of both legal, cultural and technical categories. Some of the barriers, as stated by McAdam (2010), Eastman (2011) and Wang and Chong (2015) can range from:

- Process – There is a change in the workflow as BIM encourages the sharing of construction knowledge earlier in the design process. This will take time and education before professionals become accustomed to this.
- Interoperability – Will all participants be working from the same software and, if not, how faithful will their model be to other software been used?
- Status of the model- The extent to which a BIM model could stand as a legal document. The possibility of ambiguity if the contract documents were 2D and the project was constructed in accordance with virtual, collaborative BIM design.
- Cost of BIM – The designer was at the most risk of incurring the cost and not reaping the rewards unless there was a change of practice.
- Design Liability – The extent to which participation may give rise to legal liability, even where no contractual relationship may exist.
- Design Delegation – The delegation of design elements will have to be carefully explored i.e. in certain areas of noncompliance who will be responsible.
- Ownership and Protection of Data – In the case of copyright where the legal line will be drawn?

- There will be challenges with communication, as different disciplines will be working from varying forms i.e. the architectural model may not have sufficient detail for the contractor to work from.
- Implementation issues may arise, as replacing a 2D or 3D CAD environment, with a building model system involves far more than acquiring software, training and upgrading hardware. BIM requires that changes be made at almost every single level of a firm's organisation.
- Legal implications due to the practice of BIM still evolving. At the outset of the project, a different tendering process should be designed to cater for the collaboration of all parties at an early stage and newly defined roles need to be incorporated into the management plan along with risk allocation. Further to this, warranties and indemnities issues need to be addressed accordingly when drafting the contract document.

Holzer (2011) explains the seven deadly sins of BIM, which represent some of the most common barriers the author has experienced and witnessed whilst working with BIM. These include:

1. Technocentricity i.e. focus on software instead of design culture: BIM is not a new version of CAD and is about an entire process change that impacts nearly all activities related to the planning, delivery and operation of buildings on a social, business and even political level.
2. Ambiguity: Differing views on the value that BIM adds to projects, results in clients becoming more reluctant to compensate their consultants for BIM related services. A clear understanding of the design deliverables, the most appropriate software and the interoperability issues allows BIM to become a hub for information exchange during the planning phase of a project and beyond.
3. Elision i.e. omission of information: Recent graphs such as figure 2.3, the Patrick MacLeamy graph, represents the difficulty involved in implementing design change as the project progresses. The MacLeamy Curve diagram highlights that the further one was through the design process, the higher the cost of design change. For this reason, the BIM process draws the project stakeholders together earlier so that the individual parties can coordinate their design input, encouraging a more integrated approach to project design and delivery (NBS, 2014).

4. This needs to be reviewed as new information is continuously updating the BIM process, with an open dialogue required where those stakeholders resolve what kind of information the BIM should contain and who was responsible for adding it.

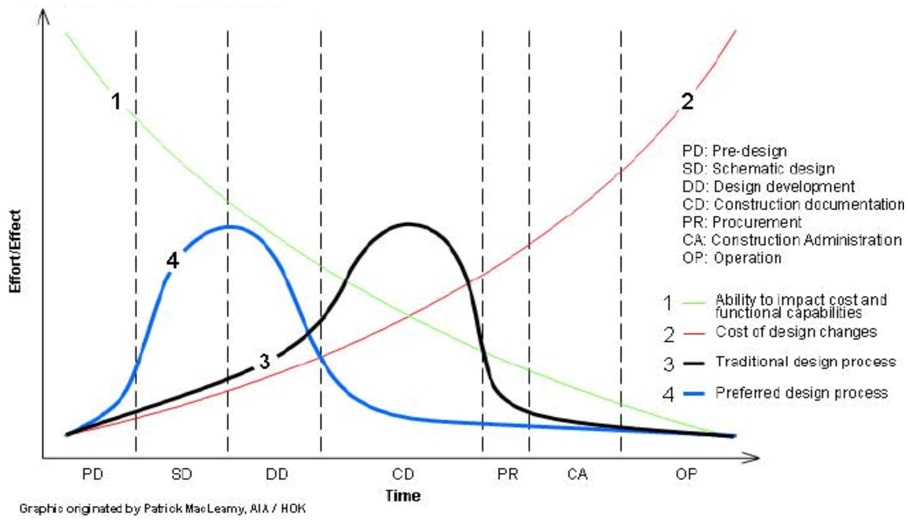


Figure 2.3 Patrick MacLeamy Graph – *Source: Holzer (2011, pp 470)*

5. Hypocrisy i.e. the IPD excuse: The mention of IPD has either become an excuse to cover for the shortcomings of BIM or it was used as a buzz-word by teams who claim to 'do' IPD simply because they share their model information. IPD requires the upfront resolution of cultural, political, legal and business related aspects of architectural design and delivery, in order to pave the way for its implementation.
6. Delusion i.e. asking for 2D while requiring 3D work: Despite the continuous development and industry uptake of BIM over the past 8-10 years, the ultimate deliverables for designers still remain the submission of 2D documentation.
7. Diffidence i.e. denying the need for process change: The process change for BIM implementation is substantial, and it requires a venturous mind-set plus the willingness to take risks by a practice's leadership in order to succeed. A step by step approach with small increments will in many ways not suffice to enable true change.
8. Monodisciplinarity i.e. design exploration in professional silos: Current BIM tools still barely support early design collaboration across various disciplines.

Marasini and Patlakas (2012) suggest that the adoption of BIM comes with significant overhead costs that can be prohibiting for SMEs. The authors observe that SMEs have to operate with small numbers of staff, limited margins and the upfront costs might prove prohibiting. The authors also add that although the breakeven of BIM costs may take a few years, when the training and learning experience phase of BIM was over, there was evidence of considerable savings through productivity increase and efficient use of information.

2.2.7 Relevance of BIM in Regards to the Governance of Irish Public Estate

The Irish Public Service exists to support the three branches of the State, which are the Executive, the Legislature and the Judiciary to fulfil their mandate, which is to serve the people of Ireland (Public Service Reform Plan for 2014 – 2016). This mandate is extensive and far-reaching and performs a diverse range of functions i.e. Civil Service, Health Sector, Education and Training Sector. A wide range of public servants work, within this sector including teachers, nurses, hospital clinicians, fire officers, and defence forces, and there were currently in the region of 290,000 people employed in the Public Service, which has been reduced from a peak of 320,000 in 2008.

To meet the needs of the public sector, the sector was broken into a number of departments with the responsibility for the Irish estate lying with the Department of Public Expenditure and Reform. The Department is responsible for overseeing the reform of the Public Sector and consists of the following:

- Minister for Public Expenditure and Reform:
- Minister of State for the Office of Public Works (OPW), Public Procurement and International Banking.

The Office's main business activities are Estate Portfolio Management, Procurement, Heritage and Flood Risk Management. The Heritage Services Department consists of the National Monuments Service and National Historic Properties Service, with the Flood Risk Management Department responsible for the coordination and implementation of Government policy on the management of flood risk in Ireland. The Estate Portfolio Management Section provides the following services:

- **Managing Property Portfolio**: Property Management Services is a key business unit in the OPW. The efficient procurement and management of accommodation for government departments and agencies is critical to the success of Government strategy.
- **Maintaining Property Portfolio:** Property Maintenance Services provides a service to their clients and building users and to other OPW business units. It is responsible

for maintaining the value and condition of the State's property portfolio, including cultural institutions and heritage properties.

- **Construction Projects:** Project Management Services, in conjunction with OPW's Architectural and Engineering Services delivers new construction, refurbishment, conservation and major maintenance projects on behalf of the State and OPW's customers.
- **Architectural Services:** The Architectural Services division of the OPW is responsible for designing, developing, constructing and supervising work associated with property occupied by government departments, cultural institutions and other public bodies.

The OPW carries out a dual role of property management and property maintenance. This includes architectural, engineering, valuation, quantity surveying, project management and FM services for central government departments and agencies. In recent years the OPW through Government guidance has implemented a number of initiatives in delivering greater value through more efficient management of the Government estate.

2.2.7.1 Irish Governments Focus on Greater Efficiency

In 2005 the Department of Public Expenditure and Reform implemented a national policy on public procurement, particularly in relation to construction procurement. The reform was one of a number of key value for money measures announced by the Minister on 20 October 2005 and was put in place to help address concerns about the extent of cost overruns on public works and construction consultancy contracts. The aim was to eliminate such cost overruns, through better planning and greater use of the works contracts and conditions of engagement, by means of optimal risk transfer to contractors and consultants who were best placed to manage and control such risks. This background leads to the introduction of the CWMF in 2007. The CWMF was a series of documents which collectively describe the operating environment, procedures and processes to be followed for the delivery of capital works projects in Ireland. It incorporates contractual provisions, guidance material and technical procedures covering the public works project lifecycle from inception to final project delivery and review. The aim of the CWMF was to ensure that there was an integrated methodology and a consistent approach to the planning, management and delivery of public capital works projects, with the objectives of greater cost certainty, better value for money and more efficient project delivery. Within the CWMF the Irish Government published a new suite of public sector contracts. The new forms sought to reflect the latest thinking in project and risk management and to recognise the development of new procurement methods, such as design and build. These new forms also aimed to support the certainty of outcome in terms of cost, quality and programme.

These new GCCC forms of contract were met with huge opposition from nearly all areas of the Irish AES sector. Cunningham (2011) concluded that they lacked balance in their risk allocation approach and were overly bureaucratic, while doing little to help the industry in a time of unprecedented difficulties. However, he did note that it significantly improves cost and time certainty and therefore, promotes effective project delivery.

These contracts far from placing risk on the party which is best placed to manage it, have moved as much risk, as possible, away from the Employer and onto other parties resulting in the PWC suite of contracts doing nothing to assist the recovery of the construction sector of the Irish economy and possibly contributing to the continuing recession in the industry (Frasier, (2013 pp 8).

In a recent review of these contracts in 2014 the Construction Industry Foundation (CIF) expressed their concern that these new forms of contracts have given rise to a more adversarial industry where contractors were spending more and more time in consultation with the legal profession. It was also noted that the adversarial nature of these contracts was not conducive to the collaborative working practices, which have shown great improvements in efficiency and value for money in other jurisdictions. The OPW noted that the existing contracts require a major change to address issues that have arisen throughout their use. They add that the Irish State was in a much better position to take on risks than the contractor and there needs to be a rebalancing of risk.

The Royal Institute of Architects in Ireland’s (RIAI) main concern was for the client, because as they may only occasionally engage in the construction procurement process, there needs to be a more comprehensive guidance for clients / employers who were obliged to use the GCCC system. The Society of Chartered Surveyors Ireland (SCSI) warned that these contracts facilitate an adversarial approach, as well as an unfair transfer of risk to contractors.

The Irish Government Chief Procurement Officer for Public Service (2015) also commented in a recent article in the Irish Building Magazine that the biggest reform facing the construction sector was the change to these public works contracts, as it was debatable if these fixed price contracts provided better value for money considering the collapse of the industry. He adds that new changes are now being made in 2015, which include the awarding of contracts, not on a lowest price basis, but on a selection of quality criteria. This will ensure an unsustainable tender does not win the contract.

In a report on the review of the performance of the PWC published in December 2014, by the GCCC, it was found that risk was not being priced in many tenders for a variety of reasons and where risk arose, it was leading to claims. The report also included a medium term strategy in respect to BIM. This strategy details that the GCCC has recognised that BIM was a powerful risk management tool that also offers opportunities to move the construction of buildings from the building site to off-site fabrication. It also states that BIM can provide more efficient and safer ways of working that generates less waste. BIM also offers significant potential for savings on the operational costs of buildings. A more collaborative and fairer approach can be achieved through the re-drafting of the public works contracts to include the use of BIM technologies (Frasier, 2014).

The Forfás Report (2013) echoed this sentiment and proposed to work with industry organisations to promote the use of BIM and develop the appropriate technical skills amongst Irish construction firms, so that they could successfully compete in markets where BIM was widely adopted or a requirement. The report further acknowledges that within the Irish construction sector, there was a continued low take-up of ICT and an emerging competitive disadvantage in project delivery, due to slow adoption of process improvement and productivity enhancing BIM systems.

This has become even more important owing to the fact that the EU Procurement Directive has embraced BIM and has become ratified by the European Parliament in October 2013. In the UK and Ireland, the EU Construction Products Directive (CPD) became mandatory from 1st July 2013 with the adoption of the Construction Products Regulations 2011 (Frasier, 2013). Hore (2014) stresses that if our closest neighbours, the UK, were going to mandate BIM, it was an inevitability that Ireland will have to follow.

In Construction 2020 which was a strategy for a renewed construction sector by the Irish Government, it outlines how it intends to increase the capacity of the sector to create and maintain jobs, and to deliver a sustainable sector, operating at an appropriate level. Within this strategy it was suggested that BIM was seen as a *"powerful tool in driving efficiencies and increased productivity in construction and is rapidly becoming a standard requirement* *internationally, Construction 2020, pp 57*”. This has seen initiatives put in place by Enterprise Ireland (EI), such as the BIM Enable and BIM Implement strategies. EI’s overall aim was to support companies that wish to implement BIM strategically and support the training costs of those companies that wish to implement same rapidly. In addition, organisations such as the Construction IT Alliance (CitA) in Ireland in recent years have worked with the industry to promote BIM through their networking events and training programmes.

BIM could provide the opportunity to complement a number of other initiatives now put in place by the Irish Government. These include:

- **The Irish Government’s National Energy Efficiency Action Plan (NEEAP) for the period 2007 – 2020**: The NEEAP outlines how the Government has committed to achieving by 2020 a 20% reduction in energy demand across the whole of the economy through energy efficiency measures. BIM would seem to be a process positioned to rapidly communicate C02 emissions for various building sizes, due to the tools that exist within BIM to help in reducing significant carbon emissions (Mah et al., 2010 and McGraw – Hill Green BIM Report, 2010)**.**
- **Cloud Computing Strategy:** This was a strategic approach for the public service to engage with Cloud Computing and to undertake a comprehensive programme of Data Centre Consolidation. The strategy details the criteria to be considered by individual public bodies when considering public Cloud offerings, and highlights how a Public Service Community Cloud will be progressively phased in. Wong et al., (2014) explain that Cloud BIM technology can provide the real time monitoring of construction progress, clash detection and data sharing amongst the construction team. The proposed cloud strategy, if linked to BIM, could potentially offer significant benefits for the Irish public sector.
- **Department of the Environment:** This involves the awarding of State contracts worth up to €16 billion a year for environmentally-friendly policies in 2010. Using BIM to create more sustainable designs results in the ability to optimise the building design efficiently in the very early stages of the whole process and produce a better solution (Wong and Fan, 2013).

- **Department of the Education:** A €2.2 billion five-year capital investment programme launched in 2012 to provide new schools with 70 school projects scheduled for construction in 2015.
- **Public Service Reform Plan (PRSP) 2014 -2016:** There were four key themes running through this reform plan:
  1. Delivery of Improved Outcomes: This will focus on reducing the cost of delivering public services and will be centred on using alternative models of service delivery, including commissioning for specific outcomes; more digital delivery of services; and service delivery improvements at sectorial and organisational level.
  2. Reform Dividend: This was about freeing up resources by making existing processes more cost effective and efficient, and using the savings to invest in new or improved services. This will underpin and help sustain the reform agenda beyond the current fiscal crisis.
  3. Digitalisation / Open Data: This will address the use of new and emerging technologies, ensuring that the Government was designed around real needs and taking steps to improve the take-up of Digital government.
  4. Openness and Accountability: This programme will focus on delivering greater openness, transparency and accountability to strengthen trust in Government and public services, and enhance public governance.
- **ICT Skills Action Plan:** This Action Plan builds on current strengths and was intended to meet the Government’s ambition, set out in the Action Plan for Jobs, that Ireland will become the most attractive location in the world for ICT Skills availability. Construction 2020, which was a strategy for a renewed construction sector by the Irish Government, suggested that BIM can increase the attractiveness of the sector for younger professionals.

As a result of the PRSP the Property Asset Management Delivery Plan (PAMD) was developed. The plan aims to improve the planning and management of the public service property portfolio in Ireland by improving co-ordination of strategies and activities, processes for strategic planning, projects and property management, standards for accommodation fit-out and data capture, accountability for decision making and deployment of resources. The premise was that efficiencies can be achieved by adopting a more strategic and standardised approach to property asset management. Similar strategies were now in place, within the

UK, to enhance the management of their public sector portfolio. This strategy which is detailed later in the chapter has enabled the UK public sector to become a better client that was more informed, and to replace adversarial cultures with collaborative ones. It recognises the importance of a more robust asset management plan and has mandated BIM in tandem to achieve this. The BIM model in regards to asset management could potentially serve as an electronic version of the owner's manual, with critical information about a building, could be easily retrievable (Dave et al., 2013).

2.2.7.2 Global BIM

BIM permits governments to explore new ways of getting full value from public sector construction. Furneaux and Kivvits (2008) reported on the Australian Government's use of BIM to reduce the start-up time of a project and for the Australian Government this translated into reduced costs both financial and in-kind. Furneaux and Kivvits reported that such savings would enhance the ability of government to build sustainable assets and set a great example for industry. The authors outline the benefits of implementing BIM on Australian government projects in table 2.2.

The key advantage of BIM is its accurate geometrical representation of all the parts of a built asset capturing all necessary and relevant data of every part in an integrated environment. The benefits of this integration are:	
Benefit:	**Result:**
- *Increased utility and speed* (In all phases)	Information is more easily shared, can be value-added and reused
- *Enhanced collaborations* (Mainly in the design and construction phase)	Across discipline and organisation, built asset proposals can be rigorously analysed, simulations can be performed quickly and performance benchmarked, enabling improved and innovative solutions
- *Better data quality* (In all phases)	Documentation output is flexible and exploits automation. Requirements, design, construction and operational information can be used in FM resulting in better management of assets
- *Visualisation of data* (Mainly in the design and construction phase)	The added value of 3D visualization leaves little room for misinterpretation by all parties involved and it helps to realign their expectations
- *Enhanced fault finding* (In all phases)	BIM greatly reduces conflict issues by integrating all the key systems into the model. Design BIM systems can detect internal conflicts and model viewing systems can detect and highlight conflicts between the models and other information imported into the viewer

Table 2.2: Benefits of implementing BIM on government projects – *Source: Furneaux and Kivvits (2008, pp 18)*

Governments around the world have recognised the inefficiencies affecting the construction industry in general, and have recommended and mandated the use of BIM as a strategy to addressing a declining productivity (Kelly et al., 2013 pp 191).

This has seen large public owners, including the General Services Administration (GSA) and the U.S. Army Corps of Engineers (USACE), requiring BIM deliverables on all major projects in the US (GSA, 2006). Scandinavian countries, such as Finland have required the use of IFC BIM models on all of its projects, with Norway using the Directorate for Public Property and Construction Management for Industry Foundation Class (IFC) BIM to facilitate the flow of information through the whole life cycle. Denmark has also mandated use of 3D/BIM for design and for tenders, and an electronic handover of information to the client (Government Construction Client Group, 2011).

In Asia the Building and Construction Authority (BCA) in Singapore has a roadmap for BIM that pushes its construction industry to be using BIM widely by 2015. To incentivise early BIM adopters, it has introduced a $6-million BIM fund in June 2010 to cover costs of training, consultancy, software and hardware with Singapore universities encouraged to offer courses of BIM and organise BIM workshops and seminars regularly (Khemlani, 2012).

In Hong Kong, the Government attaches great importance to sustainability and BIM has been applied during various stages of building development. The Hong Kong Housing Authority (HKHA) was one of the BIM pioneers in Hong Kong, with the goal to fully implement BIM for all projects by 2014 (Wong and Fan, 2013). The McGraw Hill Smart Market Report for the business value of BIM in China (2015) predicts a 108% growth for contractors who will be doing over 30% of their work in BIM. This report also forecasts on a 200% increase of Architects at a higher BIM implementation level in the next two years. The Institute of International Harmonization of Building and Housing (IIBH) in Japan conducted a BIM adoption survey in 2016. Only 57% felt that using BIM was successful, and 45% felt that it was too expensive to purchase the necessary tools to start using BIM. This survey made clear that there was still a long way to go for BIM to become popular in Japan.

McGraw Hill (2010) reported that in western European countries, such as France, UK and Germany nearly 60% of total respondents were currently frequent users and 74% of Western European BIM users report a positive perceived return on their overall investment in BIM. In a subsequent report in 2014 it was noted that contractors in France, Germany and the UK were currently at relatively low BIM engagement levels but were planning investments to increase usage. There have been recent advancements in France with the establishment of the “Le Plan Transition Numérique dans le Bâtiment” task group. This new group will create an outline BIM plan which includes the ambition of developing 500,000 houses using BIM by

2017. In Germany their DIN standard system was embracing BIM, but current legally protected professional titles and fee scales were proving more of a barrier to BIM's collaborative mindset (Chartered Institute of Building, 2015). Bosch et al., (2015) in relation to Dutch public sector assets believe that BIM enables information management, which results in an improvement in the quality and consistency of information.

The wide scope of international public sector bodies now turning towards BIM highlights the benefit it possesses for the public sector. Perhaps most encouraging from an Irish perspective was the move of their neighbours the United Kingdom (UK) to implement BIM on public works projects by 2016. This has been further complemented through the soft landings framework to ensure that the UK public sector not only builds intelligent assets but efficiently operates them into the future.

2.2.7.3 United Kingdom BIM Mandate

As of 2016 Level 2 BIM become a requirement on UK public sector projects. Level 2 BIM consists of all parties using their own 3D CAD models, but not necessarily working on a single, shared model (NBS, 2015). The purpose of a Level 2 BIM mandate by the UK was a result of the finding from a report commissioned by the UK Government showing that the UK does not get full value from public sector construction (Government Construction Strategy, 2011). This has seen a shift, where the UK Government has started to explore new ways of getting full value from public sector construction.

This innovative strategy for managing information through the lifecycle involved the implementation of BIM on all public works projects. In order for this to happen by 2016 it was critical that the industry was brought up to a Level 2 standard. Figure 2.4 lays out the roadmap to be followed by the UK in achieving its overall goal of a Level 3 standard. A Level 3 standard involves all parties accessing and modifying that same model, the benefit being that it removes the final layer of risk for conflicting information (NBS, 2015). This envisions an Integrated Web Service BIM Hub with a fully open process managed by a collaborative model server. The BIM maturity wedge in figure 2.4 represents levels of maturity with regards to the ability of the construction supply chain to operate and exchange information. The maturity model was also used to define the supporting infrastructure required at each level of capability and will be used by the BIM strategy team to prioritise development of the BIM infrastructure.

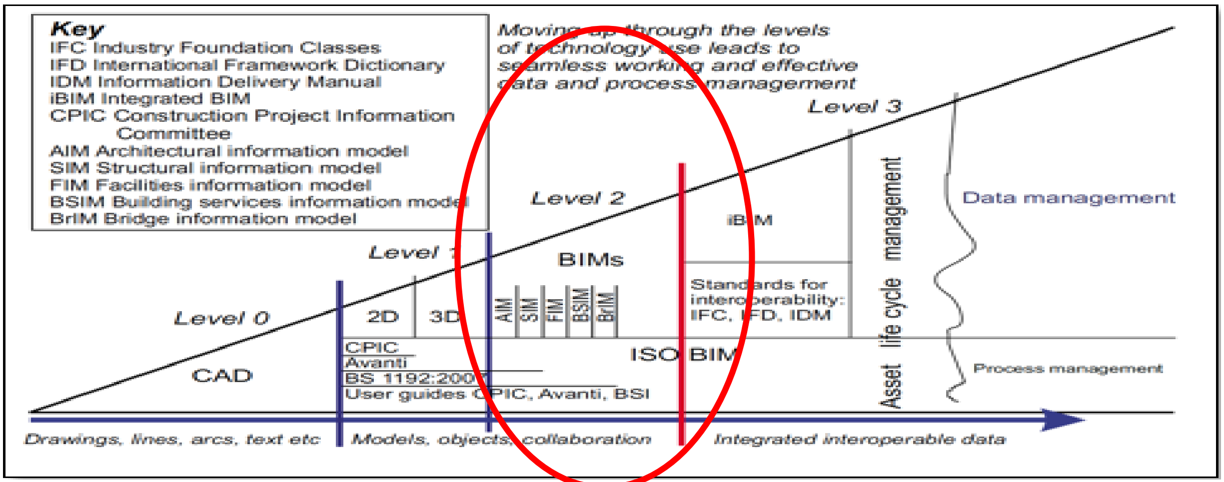


Figure 2.4: Bew Richards BIM maturity wedge: *Source: Pas 1192 -2 (2014, pp 7)*

The UK has issued in tandem with their Level 2 BIM initiative a suite of connected frameworks and guidelines. This includes a number of Public Assessable Specifications (PAS) and British Standards (BS) which offer best practice in information management for the capital/delivery and operational phase of construction projects using BIM. The Construction Industry Council (CIC) have also released best practice guides that deals with those aspects of BIM, which relate to Professional Indemnity Insurance (PII) and legal frameworks, in order to facilitate and promote the use of BIM. A number of guidance documents have also been created which include the Employer Information Requirements (EIR), which define what models need to be produced at each project stage together with the required level of detail and definition. The pre and post BIM Execution plan (BEP), which explain the supplier's methodology for delivering the project using BIM. These documents were complemented by 11 Regional BIM hubs whose primary focus was to raise awareness and facilitate the early adoption of BIM processes and working methods throughout the UK's construction industry.

A large part of this road map was to enhance FM practices within the public sector. Tancred (2012) highlighted that whilst BIM might have emerged from the construction of the built environment sector, it must not be ignored by the FM industry. This was further enforced by Rowland's (2012) were it was explained there were many benefits that BIM can bring FM by aligning the construction and design to the operational use of the asset.

This is a real opportunity to make a difference to the way projects are managed in working collaboratively with the construction and design industry (Rowland, 2012 pp 3).

One of the current frameworks now in place to capitalise on this opportunity was the Government Soft Landing (GSL) approach, which provides a process to ensure BIM was embedded and adopted into future developments, in a way that supports Facility Managers. This will be mandated in 2016 alongside BIM Level 2. The GSL will achieve this by using BIM visualisation capabilities to test users and operator's perceptions. Early involvement of the end user ensures that there was operational input and that both the design and construction were challenged to ensure that operational costs were maintained. The purpose was to create a golden thread which was a reference used to link all stages of the life cycle:

- *GSL will be used to reduce cost and improve performance of asset delivery and operation.*
- *All departments will appoint a GSL Lead to manage the GSL Golden Thread on all projects.*
- *All departments will actively manage aftercare during early operations, supported by the design and construction team.*
- *Post Operational Evaluation will be used as a collaborative tool to measure and optimise asset performance and embed lessons learnt.*
- *BIM will be progressively used as a data management tool to assist the briefing process* (*http://www.bimtaskgroup.org/gsl-policy-2/).*

The GSL has identified four focus areas where measurements, key questions and outputs have been identified along the project timeline. This process, as illustrated in figure 2.5, shows the different stages where the key client decision points and information exchanges were expected. It also identifies four areas to be used as the basis for KPIs to measure the GSL process. These KPIs were further addressed in Chapter Seven. The four areas are as follows:

1. Functionality and Effectiveness: Buildings designed to meet the needs of the occupiers; effective, productive working environments.
2. Environmental: Meet Government performance targets in energy efficiency, water usage and waste production.
3. Facilities Management: A clear, cost efficient strategy for managing the operations of the building.
4. Commissioning, Training and Handover: Projects delivered, handed over and supported to meet the needs of the End Users.

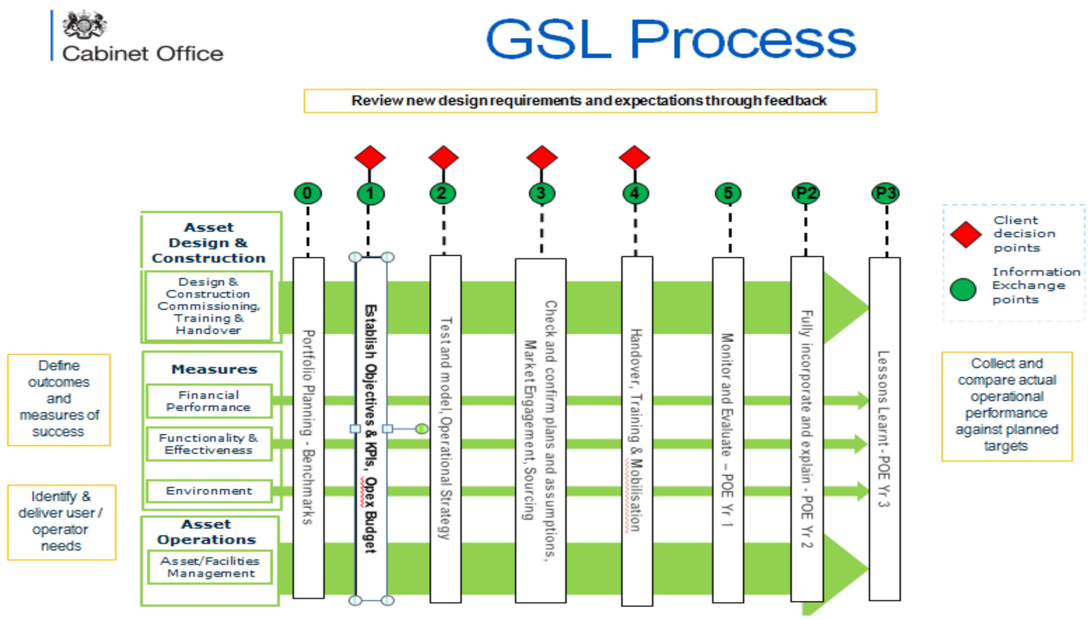


Fig 2.5: GSL Strategy- Source http://www.bimtaskgroup.org/gsl-summary/

Despite a number of high level recommendations and evidence, the Irish Government remained sceptical of an Irish mandate. They have not proposed that BIM be a requirement to qualify for Irish public works contracts, unlike the UK.

"Bigger architecture and engineering firms have invested in BIM certainly, but I would not be keen to impose BIM as a requirement on the lower end of the market place. There is a nervousness in small businesses about the need to make a substantial investment" (Paul Quinn, Irish Government Chief Procurement Officer for Public Service, 2015, pp 9).

There was strong evidence to suggest that following in the UK's footsteps and implementing BIM and a similar soft landings framework, could help create a more interactive and intelligent Government estate in Ireland. The current suite of frameworks promoted by the Irish Government do not focus strongly enough on long term life cycle costs and carbon emissions. The UK Government have shown the way through their ambitious BIM programme, which will focus on the end users by enhancing the public assets long into the future. One of the most interesting aspects of the GSL was involving the Facility Manager / end user earlier in the design / construction process. The benefits and difficulties of such a solution have been advocated as the literature review progresses.

2.3 EMERGING IMPORTANCE OF BIM AND ITS IMPACT ON THE FACILITIES MANAGEMENT PROCESS.

This section has investigated how BIM can advance the FM sector through a critical understanding of its application within the operational stage. To achieve this a review of FM in relation to ICT advancements was reviewed with particular focus on BIM. Once an understanding was gained it was explored in the context of current processes and relevance to the FM Discipline.

2.3.1 Evolution of BIM for FM

ICT was perceived to be a driver of FM innovations and was associated with the use or introduction of new technologies (Scupola, 2012). There are a number of Facility Management Systems (FMS) now in place with the overall objective to enable an organisation to be competitive by promoting best FM practices (Lunn and Stephenson, 2000). Brooks and Lilly (2006) observe that FM has moved away from traditional database engines aligned towards maintenance management applications and CAD programmes, towards space management programmes and the use of a web 'front end' enabling applications that can be accessed by recipients to view services irrespective of their geographical location.

The authors believe that this has now permitted the FM sector to move out of the shadows and into the mainstream where the Facility Manager can provide informed input into the decision making of the enterprise. Shen et al (2009) celebrates the fact that after many years of Research and Development (R&D), the AEC/FM industry has now started to embrace and utilise software systems that champion the concepts of integration and interoperability.

For FM to be effective, it was imperative that an effective information feedback process was implemented that ensures that the FM team remains aware of stakeholders views at all times. This process can be assisted through current computerised tools which have aided in the improvement of operation and maintenance activities (Liu and Issa, 2013).

These computerised tools include a number of Computer Integrated FM (CIFM) options that have been adopted in the FM sector:

- Computer Aided Facilities Management (CAFM) systems are tools for organising and managing various activities within the facilities assets, such as client contracts, stock, procurement, service, work history carried out on equipment; and the strategy used to manage the assets with the engineering instructions to do so (Elmualim and Johnson, 2009). Madritsch and May (2009) note that CAFM was increasingly becoming an indispensable standard technology for the successful implementation of FM as a strategic corporate concept.

- Computerised Maintenance Management Systems (CMMS) enable the Facility Manager, subordinates and customers to track the status of maintenance work on their assets and the associated costs of that work (Sapp, 2011). The author points out that CMMS are utilised by FM organisations to record, manage and communicate their day-to-day operations. CMMS was usually used for computer systems that assist in planning, managing, and analysing maintenance processes (Madritsch and May, 2009).
- Building Management Systems (BMS) is a computer based system linked to outstations to control building services components, such as sensors, valves, dampers and actuators. The outstations were designed with customised software to control energy-using plant and equipment, report on the plant's performance, and optimise building energy efficiency (SEAI, 2013).

Other high end emerging technologies for FM that have been used to advance the FM sector include Cloud Computing, Mobile Technology, Mobile and Radio Frequency Identification (RFID) Technologies, Augmented Reality (AR) and Sensor Data (Sabol, 2013).

One of the most significant technologies to impact on the FM sector was BIM. BIM technology and the standards developed around it, offers a way to knit various data intensive systems together, such as BMS, CMMS and CAFM (Gilmer, 2012). Through the use of middleware, data from the model can be integrated with Geographic Information Systems (GIS) and Building Automation Systems (BAS), which allows the Facility Manager an increased ability to analyse operational data including energy efficiency and Leadership in Energy and Environment Design (LEED) (Aguiler and Ashcraft, 2013). Existing middleware packages that can achieve this, in whole or in part, include FM: Systems by Autodesk, ArchiFM by Archicad, Bentley Facilities by Bentley, Onuma System - The Onuma System, EcoDomus and Zutec. BIM offers an opportunity in partnership with the correct processes for the integration of data systems over the life cycle of a facility (Teicholz, 2013). Figure 2.6 details how BIM for FM bridges the information gap between the AEC sector and the owner. This was achieved by a number of benefits which include;

- lower costs through more accurate and complete data;
- improved performance by having more accessible FM data that allows faster analysis that support more satisfied and productive users, and
- data from BIM integrated with current FM systems as CMMS, CAFM and BAS.

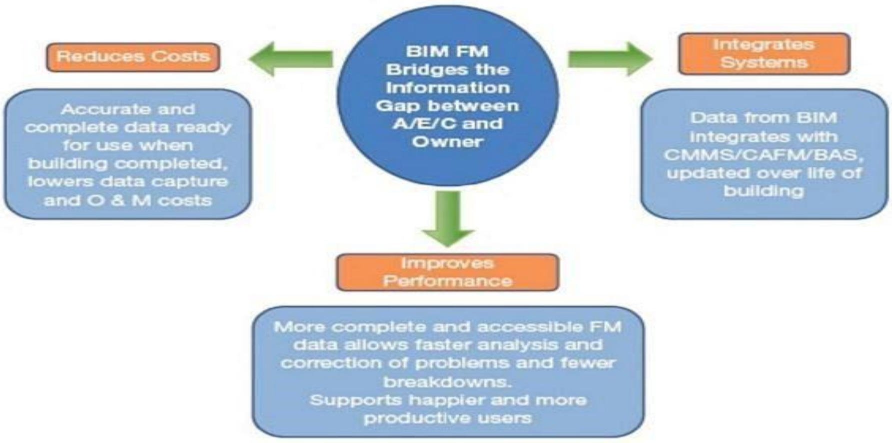


Fig 2.6: Main benefits that can be achieved from BIM FM integration - Source Teichloz (2013).

2.3.1.1 Integrating BIM and FM

BIM for FM has progressed over the years through ongoing research in regards to interoperability and quick efficient extraction of information from the model. Khemlani (2011) explains that while the basic functionality of FM applications does not change with BIM, it is how “intelligently” they get their building information that was affected. In order for these systems to be integrated, it is all about interoperability. Interoperability allows different vendors to carry out specific tasks by individual parties, that involves the sharing of data within a heterogeneous environment, where all parties have a common data model resulting in it becoming possible for building information to be created once, re-used and enriched in the rest of the building lifecycle (Shen et al., 2010).

Shen et al., notes that the AEC/FM industry has now started to embrace and adopt software systems that support and promote the concepts of integration and interoperability but were still behind other sectors e.g., manufacturing. This has also seen the formation of international agencies, such as, buildingSMART who have been set up to promote the open sharing of standards through interoperability. Sabol (2013) explains that buildingSMART alliance standards support user-driven initiatives for defining the information streams that will make the information model relevant to the facilities organisation for business use. This has seen the introduction and development of a number of standards that have been created to help ensure the final BIM process was rewarding. These current standards are detailed in the next section.

Industry Foundation Class (IFC): The IFC data model was developed by the National BIM Standard (NBIMS) buildingSMART. It is an open, neutral and standardised specification for BIM. IFC is a common data scheme that makes it possible to hold and exchange data between different proprietary software applications. The data scheme comprises information covering the many disciplines that contribute to a building from conception, through design, construction and operation to refurbishment or demolition. IFC can be used to exchange and share BIM data between applications developed by different software vendors, without the software having to support numerous native formats. As an open format, IFC does not belong to a single software vendor; it is neutral and independent of a particular vendor's plans for software development. The current IFC standard in circulations is now IFC4.

Construction Operation Building Information Exchange (COBie): Once you have this process in place COBie can be used to capture and record project handover data. The COBie format facilitates the delivery of building information during planning, design, construction, and commissioning for delivery to facility owners and operators (buildingSMART Alliance). The COBie scheme provides an open framework for the exchange and delivery of construction handover information (East, 2007). COBie identifies the contents deliverables for information exchanges during design, construction, commissioning, and closeout and archives them in a spreadsheet. East (2013) outlines that the automated production of COBie during planning, design, and construction can also reduce or eliminate the needs for expensive paper documentation that was so often simply discarded. The COBie approach as outlined by East (2012) was to enter the data, as it was created during design, construction, and commissioning as detailed in figure 2.7. COBie, a subset of IFC, can be viewed as an excel spreadsheet or as a database.

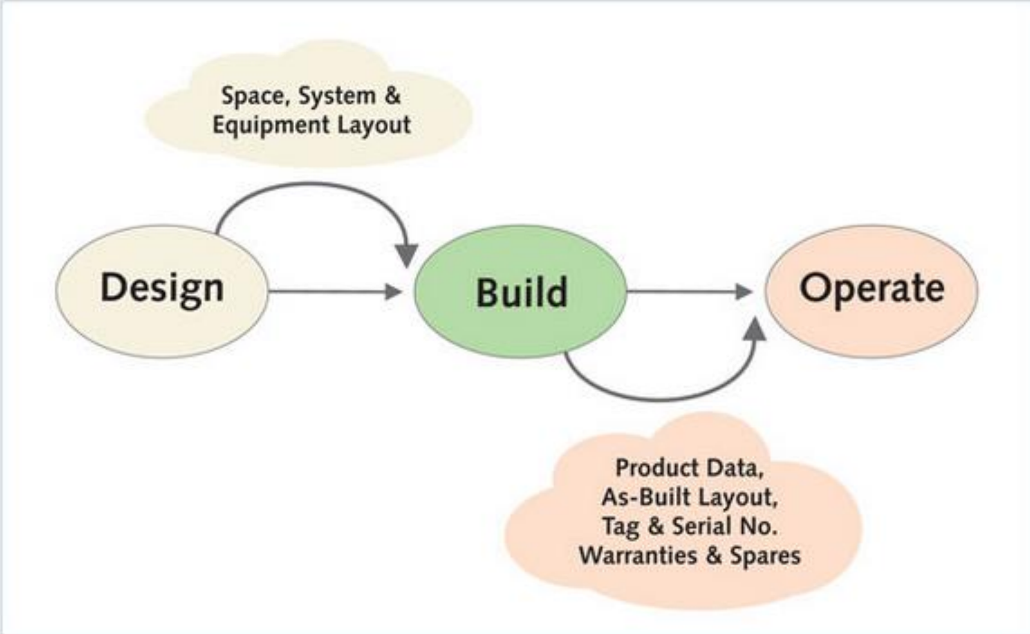


Figure 2.7: COBie Layout– Source BIM Task Group (http://www.bimtaskgroup.org/cobie-uk-2012/)

The diagram above consists of the following phases:

- Design: During the design stage the room areas, sizes, layouts and construction details are decided. All of the information associated with these aspects should be inputted into the model. At the end of this stage a spreadsheet can be produced with all of the rooms and areas in the building with associated room names and tags.
- Construction: The designed model will be taken by the construction team where makes, models, serial numbers, contact details and O&M information are linked into the COBie spreadsheets. They simply have to link the information to the equipment which has already been selected by the designers. By linking all of the manufacturers' technical data, O&M / User guides on equipment, the contactor is basically compiling their operation and maintenance manual as they go, rather than the process just being rushed at the end of the project.
- Commissioning: The commissioning stage is when all the as-installed or as-built information will be entered. Commissioning and testing records are inserted into the spreadsheets. The final as-built drawings are also produced and attached to the spreadsheet.

Anderson et al (2012) warn that with BIM and COBie that one needs to not only streamline the flow of information between programmes, but to address the interface for facility services crews, so they too can leverage these new datasets. Time spent training with new technologies and grappling with complicated interfaces means less time on the physical systems that need their attention. In an article published in AEC magazine (2014) it explained that COBie lacks definitions to support infrastructure projects such as roads, transport and civil engineering. COBie also requires some manual input of data and does not contain as much geometry as a corresponding IFC.

Sabol (2013) speculates that COBie may eventually be able to provide a structure for the seamless transfer of data from BIM applications to FM data systems but today's practice still relies on organising data through related spreadsheets and as a buildingSMART alliance Model View Definitions (MVD). Lavy and Jawadekar (2014) through a number of case studies that adopted COBie concluded that the data generated during the design and construction phases should be maintained and handed over to the FM department in a BIM-format, or in agreed interoperable formats through COBie, as this will increase the value of the data and also provide savings of time and money in the operations of the building throughout its life cycle.

Fast developments of BIM and the recent release of standards, such as COBie or IFC 2×4 are promising for future process automation, alignment of BIM with AEC/FM/ processes and efficient resource management through BIM in new and existing buildings (Volks et al., 2014 pp 24).

The goal of integrating BIM for FM was not to add another information system but to help regularise data delivery, clarify data ownership, and ease access to validated data (Sabol, 2013). The author adds that technologies and processes to support and fully integrate BIM with applications and data repositories within facilities organisations will be an ongoing challenge, as the technology is adopted within organisations. Such processes in place in the UK to guide the end user include PAS 1192 – 3, which was a specification for information management for the operational phase of assets using BIM. This combines BS 55000, which was the first set of International standards for asset management and PAS 55, which was explicitly focused on the optimal management of physical assets. These standards focus the client in the specification of the Organisational Information Requirements (OIR), which describe the information required by an organisation for asset management systems and other organisational functions. This will ultimately generate the Asset Information Requirements (AIR), which will form the basis for the creation of an Asset Information Model (AIM), a model that compiles the data and information necessary to support asset management. The creation of the AIM in tandem with these processes results in a more efficient FM process. Other existing international standards include the NBIMS standard and BIM Planning Guide for Facility Managers in the US, which sets about delivering detailed models that can be used during commissioning and operation to ensure facility functionality throughout the life of the facility.

Aguiler and Ashcraft (2013) further note that BIM for FM was still in its infancy, with the capturing and efficient use of digital information about its facility and assets and systems valuable to all parties involved in a project. Kelly et al., (2013) acknowledges that interoperability between BIM technologies and current FM technologies was still an issue and there was a need for open systems and standardised data libraries that can be utilised by any CAFM or asset management system. Without such non-proprietary format, facility owners and managers must enforce proprietary information systems or re-key information into a CAFM System. Johansson et al., (2014) adds that BIM was expected to support the integration of the AEC, preservation and maintenance/operation (FM) teams. Whilst such changes were expected, research indicates that this was not yet the case. They add that there was an urgent need to better integrate BIM research with FM.

The area of interoperability for BIM and FM is an ever expanding research domain which is demonstrated by buildingSMART through their ongoing efforts. A number of solutions now exist which has made the BIM for FM process a reality. However, there were still a number of ongoing concerns, which range from extracting information from the model directly to CAFM systems, poor interoperability between software and information overload. At present there was no one solution fits all and such a solution seems distant. One of the most important aspects of the BIM FM model was the adoption and use of the information with in it and how this was best deciphered to impact on the life cycle cost. Despite the ongoing interoperability issues and ongoing resources dedicated to extracting information from the model in the most complete format, it was the end user who will dictate the success of BIM for FM process. The relevance of how BIM can advance the FM discipline has been discussed in the next section.

2.3.2 Relevance of BIM to the Facility Management Discipline

The use of appropriate processes and technology was not merely an option but an essential component. (Brooks and Lilley, 2006).

Facility managers are continually faced with the challenge of improving and standardising the quality of the information they have at their disposal, both to meet day to day operational needs, as well as, to provide upper management with the reliable data for organisational management and planning (Sabol 2008 pp 4).

In specific relation to public estates BIM can attempt to streamline this process, as it can be used to digitise a detailed description of the building and the important elements that contribute to its ongoing O&M, as well as describing how each element was linked together (Furneaux and Kivvits, 2008). Ruiz (2010) advocates the Facility Managers were one of the first professionals to acknowledge the value of having buildings designed, built, and operated using BIM.

Coates (2011) outlines that historically building operators have often been provided with O&M manuals in hardcopy or electronic form. These documents have been provided several months after the building has been in operation, and may also take considerable time to be integrated into the systems used by the Facility Managers. This has resulted in a number of stakeholders, as observed by Brindal and Prasanna (2014) especially owners and operators now focusing on implementing BIM to support the FM and operations phase, as it can be a powerful new tool to enhance a building's performance and manage O&M activities more rewardingly throughout a building's life.

While some of the Facility Manager's needs were addressed by several existing FM information systems, as highlighted by Gerber et al., (2011), BIM provides significant possibilities for providing and supporting FM practices. Gerber et al., tested some of the application areas for BIM in assisting the FM team and in the process gathered the following information:

- **Locating Building Components:** Locating equipment was a time consuming job where there was a requirement to perform preventative maintenance. A BIM model can be used to visualise where M&E equipment is located and the display of relevant data connected to this equipment can also be viewed. In addition a link from the BIM model to FM databases could help provide specifications and maintenance history that will be utilised in diagnosing the problem.

- **Facilitating Real-Time Data Access:** The FM team need access to a number of databases, in order to perform accurate maintenance exercises. The BIM can allow effective and immediate access to information and can ultimately serve as a knowledge management database.
- **Visualisation and Marketing:** BIM provides a more reliable method of viewing space for the Facility Manager which allows them to perform what-if analyses. The use of walk through options and rendering tools have the potential to be used for marketing purposes through the creation of images of interior spaces and furniture.
- **Checking Maintainability:** BIM can help maintainability studies through addressing accessibility issues, such as ensuring sufficient access spaces for the removal of equipment i.e. virtual inspection of installed components.
- **Creating and Updating Digital Assets:** Digital assets were usually manually created or uploaded to the FMS once the building commissioning was completed. This manual exercise has the tendency to be error prone. The use of BIM throughout the design and construction, with the owners needs in mind, offers the opportunity to transfer these assets as soon as the commissioning was completed. Some of the digital assets include equipment and systems such as heating, ventilation and air conditioning (HVAC), important data as manufacturer / vendor information and documents that include specifications and warranties.
- **Space Management**: Traditional CAD files were used for managing space. BIM can visualise space and help easily understand underutilised spaces, required space requirements and track assets through multiple moves.
- **Planning and Feasibility Studies for Noncapital Construction:** BIM can be used to help with the renovating of the building. The model will already have historical data that can be used as a reference for the planned work.
- **Emergency Management:** BIM can assist emergency responders in locating and identifying potential emergency problems and pinpoint hazards through its graphical interface.
- **Controlling and Monitoring Energy:** Using BIM with an understanding of occupant behaviour can help produce what-if scenarios that could be analysed to simulate how energy systems will work.

- **Personnel Training and Development:** The BIM model can allow trainees to virtually walk through the model and, therefore, help them gain a better understanding of assigned zones.

Burcin et al., (2011) have detailed a number of areas where BIM can enhance FM practices; these include facility real-time data access, checking maintainability, creating and updating assets, space management, planning and feasibility studies for non-capital construction, emergency management, controlling and monitoring energy, personal training and development. Langdon (2012) outlines a number of benefits in the FM field when it comes to the BIM model including the;

- *creation of an FM database directly from the project (as built) model;*
- *ability to perform FM costing and procurement from the model; and*
- *ability to update the model with real-time information on actual performance through the life of the* building. (pp 11)

Kasprzak and Dubler (2012) explain that BIM was becoming one of the best ways in handing over accurate information and this assists in the decision-making process to help in the O&M phase of a building.

Changyoon et al., (2013) outlines that for successful FM one requires effective management of facility data which needs to be systematically stored through each stage of the lifecycle process. It can be challenging to organise and difficult to store complex facility data that can be accessed by FM systems. This was where BIM can improve FM, as it allows each component of a facility to be handled separately, which enables a range of maintenance information to be assigned to a particular component, as well as the visualisation capabilities of the model to grant quick identification of a problem area. Codinhoto et al., (2013) acknowledges that with BIM, the Facility Manager was better equipped to perform an interrogation of the reported problem which saves time and effort that would have been otherwise wasted looking for relevant and accurate information. The building has accurate geometrical information and the area to be repaired in the model has the relevant information and documentation attached.

Kelly et al., (2013) detailed that the main benefits that stemmed from BIM in FM included:

- Improvement to the current manual processes of information handover; improvement to the accuracy of FM data.
- Increase in the efficiency of work orders execution, in terms of speed, in accessing data and locating interventions. Such value was derived from the capability of BIM to provide a data-rich visual and integrated data environment.

Volks et al., (2014) also acknowledges that there were significant additional benefits for BIM that include valuable ‘as-built’ documentation, maintenance of warranty and service information, quality control, assessment and monitoring, energy and space management, emergency management and using structured up-to date building information to reduce errors with regards to deconstruction or retrofitting. Brindal and Prasanna (2014) point out that the model can help to automate the creation of inventory lists for equipment, populate current FM systems and reduce redundancy in the maintenance of facility data for FM activities. The authors list a number of benefits pertaining to various stakeholders that include:

- **Maintenance workers:** The model will reduce additional trips to locations by providing accurate field conditions and maintenance information about the area. It will also reduce costs for repairs by providing faster response times to emergency work orders.
- **Building operators:** The model can reduce the chances of incomplete equipment inventories by identifying and tracking facility equipment. The model can also identify hidden building components, hold a maintenance history of components and optimise building performance by comparing actual to predicted energy performance. The model can be further used for business analytics through integration of CMMS data that can help identify customer satisfaction or building performance issues.
- **Building occupants:** The model can increase satisfaction through quicker resolutions to unscheduled work orderd, as well as increase communication between tenants and building maintenance workers regarding scheduled work orders.

While not many current professional bodies exist that represent BIM for FM there has been working groups established. The IFMA have been active in the area which has seen the publication of the BIM for Facility Managers book by Paul Teicholz. The UK have set up a number of working groups in tandem with the 2016 mandate, with the BIM4FM group created to gather research in the area. The BIM4FM aim was to ensure that the industry works together to support and educate Facilities Managers, owners and occupiers, as well as developing stronger relationships with other members of the built environment supply chain.

2.3.2.1 BIM and FM Barriers

A number of problems still exist within the BIM for FM field. A survey conducted by Gerber and Kensek (2010) showed that "BIM for FM" was listed as one of the least interesting topics for both practitioners and students. Respondents reported a number of barriers that currently exist, which included a lack of software interoperability, resistance to fundamental change by large institutions, and lack of objective and scientific studies that quantify the value of BIM for FM. This claim was backed up by Wong and Jay (2010) who argue that despite the proliferation of BIM research interests, the development and application of BIM has been limited to certain phases of a building's life cycle. The authors who reviewed over fifty case studies of BIM research, were it was indicated that there was a lack of understanding and desire to using BIM in post-construction phases. The authors highlight the gap between the condition of assets and available maintenance budgets, as particular challenges. The authors add that new research in BIM needs to move beyond the traditional design and construction phases into managing the broader range of facilities and built assets.

Gerber et al., (2011, pp 438) further points out some of the technology, process and organisational related challenges that include:

- *Unclear roles and responsibilities for loading data into the model or databases and maintaining the model.*
- *Diversity in BIM and FM software tools, and interoperability issues.*
- *Lack of effective collaboration between project stakeholders for modelling and model utilisation.*
- *Necessity yet difficulty in software vendor's involvement, including fragmentation among different vendors, competition, and lack of common interests.*
- *Cultural barriers toward adopting new technology.*
- *Organisation wide resistance, need for investment in infrastructure, training, and new software tools.*
- *Lack of real-world cases and positive proof of return of investment.*

Arayici et al., (2012) warns that there was still a lack of clear evidence of how BIM could benefit decision-making in FM task by task. Aguiler and Ashcraft (2013) note that using BIM specifically for FM will depend to a large extent on how well the parties have defined the information to be input and exported from the model and whether the contract documents clearly define the contractual model, who owns what, and how data translation issues have been addressed. Sabol (2013) outlines further barriers that include current BIM software not being useful to a broad portion of facility workers, the BIM model being overloaded with information and maintaining the currency of BIM files over time. Sabol further warns that the best way forward may be the use of multiple applications with specific targeted capabilities for developing and utilising BIM data. Kelly et al., (2013 pp 197) also identified some of the barriers they faced. This includes:

- *The lack of tangible benefits of BIM in FM despite agreement about the potential of BIM in FM.*
- *The interoperability between BIM and FM technologies.*
- *The lack of clear requirements for the implementation of BIM in FM.*
- *The lack of clear roles, responsibilities, contract and liability framework.*
- *A lack of real-world case studies of BIM applications in FM.*

Codinhoto et al., (2013) in a case study analysis focused on ensuring that model updates would be performed systematically in order to avoid problems related to the accuracy of the information and required definition of protocols for data structuring. The FM team within the case study further acknowledged that any decision for using BIM must be linked to the solving of a problem, so as to avoid establishing costly and complex issues that were less efficient than simple solutions i.e. it may cost more to run through the process of changing a light bulb in the actual model than to actually just go and do it.

Liu and Issa (2013) outline that there was a need to move past using BIM for the design and construction phase and begin to embrace BIM for FM practices. The authors promoted the use of BIM at different phases of a facility's life cycle and warned that without understanding the requirements of the end user's needs will ultimately end in not contributing to improving the business processes.

Although BIM is gaining wide acceptance among Architects and Project Managers for efficient and effective design and construction management, the adoption of BIM in operations during post-construction phase is in its normative stage (Charlesraj, 2014 pp 996).

Volks et al., (2014) on reviewing 180 publications found that though BIM has significant benefits for FM when adopted in design, adopting BIM for FM after construction has many challenges. These include the automation of data capture and the modelling of uncertain data, objects and relations occurring in existing buildings in BIM. The authors explain that current data capturing faces obstacles that include capturing concealed or semantic building information under changing environmental conditions.

Kiviniemi and Codinhoto (2014) outlined that although for Facility Managers BIM software can be a powerful tool to enhance a building's performance and manage operations more efficiently throughout a building's life, this has not been realised due to most of the documented, quantifiable benefits of BIM being connected to the design and construction of the building, with relatively little hard evidence of BIM benefits in operation and maintenance activities. However, they do acknowledge that this may change due to the UK initiative of delivering electronic asset information through BIM. The authors warn that in general the model used throughout design and construction does not translate accurately enough for FM purposes, as it does not contain enough of the correct information. For that to be realised then a champion that was capable of managing BIM who was also an FM expert was necessary.

Love et al., (2015) acknowledges that despite the widespread benefits of BIM there has been a limited number of applications where it has been used for the purpose of managing and maintaining assets by owners. Some of the reasons for this include the required financial investment, a fear of interoperability between systems, lack of standardised tools and processes and understanding the required data for O&M. Kassem et al., (2015) add that BIM for FM is much less explored compared to other life cycle stages due to a lack of real world cases on BIM applications in FM. The authors summarise that as the FM industry was quite rigid in its approach to new technology, and unless BIM for FM benefits were clearly proven, its uptake in the FM industry will continue to be slow. The authors add that a lack of awareness by clients was exacerbated by a shortage of BIM skills and understanding by FM professionals, therefore, resulting in a vicious circle inhibiting BIM adoption in FM applications.

The added value of BIM in the operations stage has been marginal (Bosch et al., 2015). The reasons for this includes a lack of alignment between people, processes and systems which has resulted in clients facing difficulties in adopting BIM for FM despite using it for other phases of construction. One of the greatest challenges highlighted by Artan and Ergen (2015) was the level of understanding of Facility Managers and owners, who need to define the information needs in the FM phase.

This literature review has detailed how BIM can be used as a FM tool to better manage public sector assets. The BIM process permits the opportunity to frontload the design and shift project focus from design and construction to FM. With regards to the Irish public sector it can offer a partial solution in ensuring a smarter and more reactive public estate. The literature has critically detailed how this can be achieved and focused strongly on its relevance within the FM stage. Given that the Facility Manager will be the professional using the model during the operational stage, there was a suggestion that they could contribute their practical knowledge during the design stage to ensure the model represents the most practical solution.

Kassem et al., (2015) summarises that at present BIM data for FM was either lacking or inadequate due to being inaccurate, as the model has not been updated with any design changes made after the design phase. Facility Managers have traditionally been included in the building lifecycle in a very limited way and this has resulted in design decisions not usually being challenged for their impact on operational cost or maintenance. Aguiler and Ashcraft (2013) comment that 85% of the life cycle cost of a facility occurs after construction was completed demonstrating that the information needs of the Facilities Manager far outweigh those of the design and construction professionals. Despite enhanced FM being the goal of BIM, there was still reluctance and a lack of perceived benefits of having the Facility Manager involved earlier in the design phase. There remains a lack of clear evidence on what improved contribution the Facilities Manager can provide at the early design phase. This argument was explored in detail in the next section.

2.4 EARLY INVOLVEMENT OF THE FACILITY MANAGER IN THE BIM DESIGN PROCESS

This section establishes the role of the Facility Manager in both the traditional and BIM design process. In the process the current research gaps within this area have been established.

2.4.1 Argument for the Involvement of the Facilities Manager in the Design Process

The main role of a Facility Manager was the conversion of a physical product into a suitable and habitable built environment (De Silva, 2011). The Facility Manager has to be aware of the organisation's current business objectives and future financial goals and must possess the skills to ensure that the organisation's facilities support its corporate goals in achieving these objectives (Leifer, 2003).

The responsibilities of maintaining and managing the facility exist with the Facility Manager, despite the Facility Manager not been conversant with the design concept employed by the architect (Mohammed and Hassanain, 2010 pp 73).

The detailed design stage was the most extensive and complex stage, particularly in terms of the volume of information produced by the design team and the degree of detail (Mitchel et al., 2011). This fact coupled with a previous assessment made by Mobley and Khuncumchoo (2006), that contractors and designers have little awareness of downstream uses of information which, lead to the loss of, or a failure to record, important information can result in Facility Managers never receiving all necessary information.

A number of claims from academics have voiced the possible benefits of including the Facility Manager in the construction process. Hodges (2005) concludes that Facility Managers were in a unique position to view the entire life cycle process and with the proper financial and strategic planning tools can create long-lasting value to the organisation by developing, implementing and maintaining sustainable facility practices. The Facility Manager should at least play an active role in the briefing process before and during construction with a new niche role possibly being developed for Facility Managers (Kelly et al., 2005 and Eley, 2001).

Kelly et al., (2005) predicts that involving the Facility Manager in this process will result in operational issues being addressed from the onset, and the contribution of key data in developing and benefiting the briefing process and furthermore developing the organisation.

Enoma (2005) comments that FM at the design stage will add value to the facility by ensuring less ‘rework’, emphasising value for money, efficient control of the supply chain and team work. Enoma highlights some of the benefits of the involvement of a Facility Manager in the design process which include lower cost of procurement due to reduction in design alteration and rework, provision of a facility that was better suited to the needs of the end-user, a facility that was attractive to potential users and clients, a facility that was easy to run and maintain, controlled and managed. In order for the Facility Manager to take a more active part in the design they should strive to understand the procurement process and the point at which their contributions to the decision making process will be most valuable, as so to justify their inclusion in the team.

Shah (2007) argues that FM, if integrated early into the construction process, can help maximise sustainable construction potential, as well as, providing a new cost focus for buildings. Mohammed and Hassanain (2010) voice the concern that the responsibilities of maintaining and managing the facility exist with the Facility Manager, despite not been conversant with the design concept employed by the architect. The authors claim that direct involvement of the Facility Manager in the design stage has the potential to decrease future maintainability issues during the O&M stage and if introduced correctly with the design team will contribute to reducing the needs for repairs and alterations in the lifecycle of the building.

Mohammed and Hassanain suggest that a Facility Manager who was responsible for the maintenance management activities throughout the operational lifespan of the facility, if integrated with the design team, will make a greater impact on enhancing functionality, sustainability, economy, time and maintainability of projects. Current research and practice suggests that the role of the Facility Manager starts with the occupancy phase and it contributes very little, if any, to design, due to the prevailing notion that the expertise of the Facility Manager was considered by a majority of clients and professionals as operational in nature. The authors explain that in the traditional process of designing projects, the absence of the specific role attached to the Facility Manager in the integrated design team has contributed to the low participation of these professionals in the design stage. According to the authors there was a need for further studies on the extent of the detailed contributions of the Facility Manager to the individual members of the design team, especially to address the problem of maintainability right from the design stage.

De Silva (2011) observed that due to the failure to address FM problems right from the design stage, Facility Managers/ owners/users of high rise buildings face many concerns with the maintainability of the building. De Silva further speculates that Facility Managers can contribute significantly in the delivery of cost effective decisions for efficient maintainability of the facility. He further suggests that the information possessed by a Facility Manager was enriched due to their vast knowledge and experience, as well as the feedback from users of the building on operational and maintenance problems, could result in them becoming the "pathway" for providing such feedback. De Silva outlines that there was still little evidence reported of acquiring benefits from a Facility Manager during the project development phase. Meistad and Valen's (2012) involvement in three pilot case studies demonstrates how FM involvement improves the design phase of a construction project. They found that by involving the facility department in the design team had a positive effect on energy performance in the operation phase.

The benefit of early FM involvement was further supported by Brewer et al., (2013) who elaborates that through proactive FM involvement during the design phase can have the potential to improve occupant health, satisfaction, and productivity.

Failure to obtain FM input during a project's design phase would likely result in an asset's suboptimal contribution to a client's business needs (Brewer et al 2013., pp 76).

It was suggested back in 2001, by Brown et al., that the FM profession and the Project Management professions must amalgamate to some degree to recognise the professional management role which must be provided within construction projects, in order to improve the propensity for successful project outcomes. Brewer et al., (2013) in their research state that despite ten years passing, it would appear that Brown et el., (2001) vision has yet to be fully realised.

Meng (2015) carried out a number of interviews to explore the past, present and future of FM and found one third of interviewees suggested that FM professionals should be consulted during the design process.

In recent years there has been a more conscious move towards involving the end user in the design stage of public works projects. An example of this was the GSL framework in the UK. Their earlier involvement was predicted to help designers in achieving more informed decisions with regards to ongoing maintenance and cost of operations. The literature has established that early FM involvement, despite claims to the contrary, has the potential to address a number of future life cycle problems, which can be addressed during the design stage. This as evidenced was crucial when it comes to the management of public sector assets. The question to be addressed, considering the already established lack of recognition with regards to the Facility Manager's role in the traditional construction process, was how BIM and ICT education and training can offer an alternative platform for them to showcase their skills.

2.4.2 Early Involvement of the Facility Manager in the BIM process

In the past, Facility Managers have been included in the building planning process in a very limited way, implementing maintenance strategies based on the as-built condition at the time the owner takes possession (Azhar, 2011). Azhar claims that in the future BIM could allow the Facility Manager the opportunity to enter the design stage much earlier, which could lead to them influencing the design and construction, as the model can be used to visualise important information for stakeholders. For this to be a reality the industry will be required to develop acceptable processes and policies that can guide issues of ownership and risk management. This was an area that will require additional R&D from practitioners and researchers in the future.

Gerber et al., (2011) states that if leveraging BIM and FM were to work together then it requires a visionary owner that could lead and guide the process from beginning to end. The authors explain that clients, who wish to adopt the model for FM practice, should have enough resources and time to investigate areas, such as implementation, identify processes and possible benefits and ensure all training was in place. The authors further contend that as BIM models were primarily deliverables of architects, engineers and contractors, that in order to leverage the BIM model during operations and maintenance they should increase the control during design and construction to ensure that the post construction BIM requirements were satisfied. The authors warn that this may result in an upfront additional financial burden for the owners at the early stages of the project and will require continuous updating to remain useful, where the final model has the opportunity to target and reduce future O&M costs.

Coates (2011) further stresses that there were new opportunities for the client to control and develop a more efficient design process for multiple design teams. BIM has the potential to radically change how design and construction is conducted with the majority of cost savings and potential benefits existing in the building operation stage. The author adds that if this was to be a reality for the Facility Manager, it may require them needing licenses to use such tools, in order to manipulate the model as seen in the design stage.

Elmualim et al., (2010) emphasise that Facility Managers have a great role to play in advancing the sustainability agenda in the built environment and FM activities have a significant influence over how buildings and facilities were used, and, therefore, were tasked to promote and implement the sustainability policies. This means that the Facility Managers were at the forefront of implementing their organisation's vision and commitment towards the sustainability agenda. As already explained previously within the literature review, BIM holds the tools to ensure the most sustainable and carbon neutral building was produced. The Facility Manager along with these tools and their invaluable knowledge offer the potential to compute a number of quick simulations, which could possibly significantly reduce the carbon footprint of the building.

Holzer (2012) believes that architects typically assume that their capability to explore in early stage design was constrained by consultants who only want to model and analyse, as few options as possible, resulting in designers becoming suspicious about collaborating through BIM early on. The author comments that parts of the process change through BIM were achieved by making decisions earlier on in the design process, in which designers need to agree how to advance the design and documentation with stronger involvement of other collaborators, such as the engineers, the QS or the contractors. The author adds that it was important to establish a new dialogue and provide decision makers with direct access to the BIM model, even though they may not wish to manipulate the model themselves. Such a decision maker that could prove valuable was the Facility Manager.

Kasprzak and Dubler (2012) voice their concern that end users need to recognise the spend required to exchange information to their existing FM system. The authors warn that the project team must begin with a strong focus on the operational phase of the building and have an understanding of the information that was required to operate the building. This perspective allows project teams to identify the desired downstream uses of data. The Facility Manager was in a unique position to assist in this process. Yee et al., (2012) advocates early involvement of the building manager, as this will help provide an understanding of what data should be modelled. This has seen the GSA get only essential FM data, while meeting budget requirements.

Wang et al., (2013) advocates early FM involvement by designing a traveling path where FM personnel have to identify the components' location, getting access to the relevant documents, and finally, the maintenance information. By predesigning the travelling path in the maintenance job, travelling time was reduced and latent hazards could be avoided. Wang et al., were in the process of developing a framework for considering FM in the design stage with BIM. The purpose of such a framework seeks to avoid and reduce the potential issues, such as rework and inappropriate allocation of workspace in the operational phase. The application of such a travelling path demonstrates that the model if partnered with early Facility Manager involvement can address possible key FM concerns that may prove problematic during the operational phase. As the authors research aim was to create a series of KPTs to demonstrate the benefit of including the Facility Manager in the BIM design process, the work performed by Wang et al. (2013) provided an initial understanding that the Facility Manager can assist in the BIM process.

Kelly et al., (2013) highlights a number of procedural and cultural mind-set issues which included that unless BIM for FM benefits were clearly proven, its uptake in the FM industry will continue to be low. Other reasons why BIM for FM was not readily adopted, includes the need for Facility Managers to be involved earlier instead of at a very late phase in the project.

The time for FM to promote their discipline was now more than ever with the tools now been offered within the BIM process (Gannon et al., 2013). The authors claim that building owners were now in a unique position to demand change in the delivery of construction projects. The authors state that the technology was available, the costs have been quantified, and the global economy has forced the AEC sector to look for more economical solutions. The authors warn that like it or not, there was a need to change how one designs, builds and operates a facility. This attitude has been successful on several pilots within Penn State University and Pegula Ice Arena., where at any time, the designers, construction managers and Facility Managers had access to the latest attribute information and geometric data. As a result, they have developed and implemented information transfer protocols for major building systems, equipment was tagged when it comes on site, and the Facility Managers have asset information immediately.

Liu and Issa (2013) acknowledge that it was hard to get the Facility Manager involved early on in the design phase because the FM team may not have been created, as they were only considered once the operational phase has commenced. Thus acquiring the FM team's general knowledge, such as the data requirements of FM from the BIM database, which does not require the physical presence of the FM staff, can be a solution to this problem. Charlesraj (2014) suggested a knowledge based BIM for FM (K-BIM). He suggests that the development of the core competencies of FM can be facilitated by adopting the best practices of BIM and FM. This will mean that the BIM model will have knowledge driven data/information rather than being information-dependent. The stakeholders involved in this will be primarily Facility Managers and they will interact with the K-BIM for problem-solving or decision making. The Facility Manager in this framework was someone who has a significant amount of knowledge in the core competency areas of FM.

BIM brings Facility Managers closer to project conceptualization and pre-construction stages than they were in tradition processes of project development. BIM enables Facility Managers to optimize their management intelligence in different ways e.g. (1) by co-opting BIM's robust data across different project development stages; (2) by applying BIM databases to the entire project lifecycle (Olatunji and Akanmu, 2015 pp 110 & 111).

The authors ask the question if modellers and designers have the entire life cycle in mind and, if not, could BIM be assumed to add little value to FM processes. The authors conclude that BIM will only add value to the FM process once modeller or designers were able to share Facility Managers' values right from the very early stages of project life. Lindquist (2015) adds that involvement of the FM team in the early project stage was challenging, as there was a long time horizon between design and operation of a building. They further add that BIM will offer a new dimension to maintenance, as it will offer a thread between the building's lifecycle were involving maintenance teams early in building projects was strongly encouraged.

"*The supplement of professional inputs from Facility Managers during the conceptual design stage through the BIM concept towards a more efficient FM that will contribute in minimizing the possible waste of project resources (time, money, and materials), enables Facility Managers to obtain access to all of the life-cycle information of the project and offers the essential tools (i.e. monitoring, scheduling and integrating) to keep buildings running up to the required living standard*" *(Kattan and Jrade, 2015 pp188).*

They have suggested a framework that develops a model that will be used by the design team to integrate existing BIM tools with the data that can be gathered and generated by the owner, architect, and FM at the conceptual design stage of a project towards effective FM.

On reflection of the literature one can summarise that the inclusion of the Facility Manager in the design process was at the discretion of the owner and their budgetary constraints. Further to this the literature ascertains that there was little information available on their decision making directly impacting the efficiency of the model or in improving the FM process. If the Facility Manager was to justify their inclusion, there needs to be an understanding to what they can specifically contribute. While the reviewed literature has highlighted that they can have a significant impact, the key performance areas where they can specifically contribute was not reviewed, with regard to the BIM process. The next section has reviewed the current performance tools and processes in place that have been applied within the BIM process.

2.4.3 Performance Tools within the BIM Process

Kagioglou et al., (2001) defines a performance measurement system, as an information system which was at the heart of the performance management process and it was of critical importance to the effective and efficient functioning of the performance management system. This has been seen throughout the last two decades in a number of industries, primarily manufacturing, having introduced new methods and techniques to shift traditional paradigms, in order to improve their performance, which includes the creation of new philosophies, such as lean production/construction. The authors clarify that the main driver behind those philosophies was to optimise an organisation's performance both internally and externally, within its respective marketplace. The definition of performance measurement, by consensus in the business management community, can be defined as quantifying the efficiency and effectiveness of an action (McDougal et al., 2002). One of the most common performance measurement tools in the construction sector was the KPI. KPIs were in general good indicators of the performance of construction projects, as they provide a useful framework for measuring and comparing project performance for future studies (Chan and Chan, 2004). The authors further point out that they also furnish project managers, clients and other project stakeholders with useful information to implement a project successfully. The authors note that KPIs enable measurement of project and organisational performance throughout the construction industry and must consider the following factors:

- KPIs were general indicators of performance that focus on critical aspects of outputs or outcomes.
- Only a limited, manageable number of KPIs was maintainable for regular use. Having too many (and too complex) KPIs can be time and resource consuming.
- The systematic use of KPIs was essential as the value of KPIs was almost completely derived from their consistent use over a number of projects.
- Data collection must be made, as simple as, possible.
- A large sample size was required to reduce the impact of project specific variables.
- For performance measurement to be effective, the measures or indicators must be accepted, understood and owned across the organisation.
- KPIs will need to evolve and it was likely that a set of KPIs will be subject to change and refinement.
- Graphic displays of KPIs need to be simple in design, easy to update and accessible.

Barbuio (2007) says that KPIs were used because they highlight those aspects of performance that were integral above all others in providing insights on performance and how it can be improved. The concept of using indicators, as observed by Haponava and Jibouri (2009), to assess performance originates from the theory of benchmarking used in many industries for improving business processes and products. The concept involves measuring one or more aspects of the business and comparing it with the best in its specific sector. Underwood and Isikdag (2010) stress the requirement for metrics within the BIM process outlining that if one does not have metrics then there was no way to translate if there has been a measurable improvement.

Jung and Joo (2011) summarise that a BIM framework should be comprehensive enough to address all relevant BIM issues. However, at the same time, it needs to be concise enough, in order to present key issues in a systematic manner. Mom and Hseih (2012) identified five primary BIM KPIs that included quality, cost, time, safety and energy.

Barlish and Sullivan (2012) conducted a review of over 600 sources of information to analyse the current information available with regards to benefits derived from BIM utilisation, with the goals of:

1) determining the proper metrics for measurement of BIM benefits;
2) seeking the results or data of those metrics from a variety of projects; and

3) assisting in the further development and insight into an applicable benefits framework model to be applied to the case studies.

The authors found that no data existed on the methodology with which to calculate returns on other projects and how to form a valid comparison of Non-BIM vs. BIM methods to extract benefits. The data that was found was mostly taken from the contractors' perspective and so, therefore, lacked owner input, as well as no consistent approach within individual organisations. The authors concluded that the current methods for the evaluation of BIM and information systems related benefits were not sufficient, as they did not promote a dominant framework methodology and visibility to comparable data on other projects.

The authors reported (as illustrated in figure 2.8) that a value-based methodology and framework for the presentation of the benefits obtained from BIM utilisation was necessary by:

- Establishing metrics or KPI to collect to quantify the costs and benefits of BIM.
- Testing the metrics against case studies, specifically projects that were Non-BIM versus BIM in the same organization in order to minimize variables.
- Evaluating the resultant information from the case studies to quantify benefits and costs associated with BIM utilisation.
- Providing conclusions from the data.
- Validating the resultant framework model established to evaluate the net benefit or lack thereof from BIM.

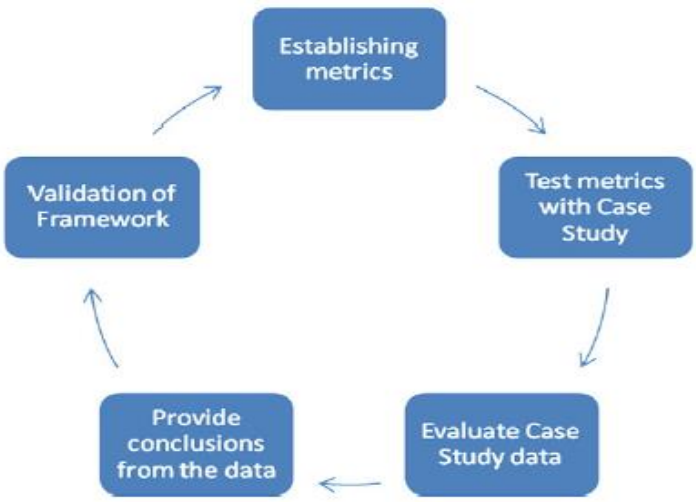


Figure 2.8: BIM assessment framework – Source Barlish and Sullivan (2012, pp 153)

The authors explained that the determination of what to measure and who to measure in construction projects were challenges in quantifying changes and benefit, and the term KPI and productivity were common terms, but authors identify them as lacking consistency. The authors reflect that KPIs were often not uniform across projects and can result in confusion to what should be measured and how to go about achieving this.

The authors conclude that it was suggested by the majority of the literature that KPIs were not incorrect but instead were not precise enough resulting in an overload of subjective measurements. The authors using established return and investment metrics established a framework for benefits measurements, in which it was found that the full potential of BIM has not been realised. It was noted full implementation was hindered by a lacking of business case for owners, with the potential of BIM in dimensions beyond 3D; notably scheduling, and sustainability. There was a need for a valid set of BIM metrics that will lay the foundations for a formal certification system, which can be employed by industry leaders and governmental authorities.

Mordue et al (2016) details a number of capability maturity models which include the NBIM 1-Capability Maturity Model, which was a tool to plot ones current location and plan ahead for ones goals for future aspirations. It addresses software issues and maturity levels. Another maturity model detailed was the Indiana University's BIM Proficiency Matrix. This was an evaluation tool used to access the proficiency of a respondent's skill at working in a BIM environment.

The literature detailed above provides a review of current performance tools currently adopted within the industry to measure BIM. None of the detailed performance tools concentrate on the BIM for FM process which has been explored in the next section.

2.4.3.1 BIM for FM Performance Tools

Park et al., (2013) suggested a number of KPIs to help quantify the benefits of BIM and validation methods. This involved:

- A BSC target of construction firms was established through analysis of strategies and goals of construction firms.

- BIM-used functions were analysed at each construction stage of planning, designing, construction, and maintenance, in order to produce a relevant KPI, based on the established performance areas.

The authors detail in regards to BIM for FM the following key measurement areas for BIM utilisation effects levels;

- for review of test operation,
- for establishment of operating manual;
- for establishment of maintenance system; and
- for repairs.

There was no evidence of early FM involvement in this paper and the KPIs detailed above offer no guidance for FM in the design stage.

Chen et al., (2014) highlights that though attempts to measure BIM implementation have been put forward, they only focus mainly on the final BIM Model, other than the process used to create it. These lack substantial theoretical and empirical justifications, with the reliability and validity of the models remaining questionable. The authors have proposed a BIM maturity matrix based on previous efforts through performing an empirical investigation of key factors for measuring BIM. The authors suggested four dimensions of technology, process, people and information. It was found that factors related to process and information were more important than factors of technology and people

When it comes to quantifying the BIM for FM there was very little active research. Sarkar et al., (2015) aimed to identify the KPIs that affect the usage of BIM as a FM tool. Through the use of a questionnaire aimed at the Indian AEC/FM sector they established 15 KPIs from 69 responses that were further grouped into five different components. These components are detailed in table 2.3

Components	Factor Interpretation (% Variance Explained)	KPI Included in the Factor
C1	O&M Process Reengineering **(18.404%)**	i16_Standardization of process & frequency of updating the BIM & database
		i15_Access to the database
		i30_Quick / in advance decision making
		i34_Facilitating access to real-time data
		i29_Ease of navigation, search and highlight elements within BIM
C2	Technical features offered by BIM **(15.498%)**	i27_Feature of 'customizable schedule' & 'shared parameters'
		i26_Parametric nature of BIM elements
		i25_Ease of usability / BIM interface
C3	Involvement of Client & Consultants in the process **(14.091%)**	i8_Demand / awareness of client to use BIM as FM tool
		i31_Potentiality of direct & indirect cost savings in using BIM as FM tool
		i3_Availability of as-built BIM (model) from consultants
C4	Role of Organization **(12.351%)**	i13_Leadership of BIM manager / team leader
		i12_Clarity of roles & responsibility for managing BIM & database
C5	Importance of As-Built Data **(10.423%)**	i2_Cost of information gathering
		i7_Reliability of collected as-built data

Table 2.3: BIM for FM KPIs – Source Sarkar et al (2015, pp 373)

This table details some areas were using a BIM model for FM purposes was of most benefit and the potential KPIs to measure these areas. The framework as intended was generic in nature and does not address the author’s research topic, as these KPIs were intended to offer guidance in how to use model. These KPIs do not offer any guidance of how the Facility Manager can play a role in the BIM process and focuses more on the technical aspects of FM than the strategic relevance.

Zadeh et al. (2015) detailed a BIM quality assessment approach for FM, where they described three critical areas that must be represented in the model, from a FM perspective, in order to avoid significant quality issues, including inaccurate, incomplete, or unnecessary information. The three detailed areas of FM include asset information, MEP systems and spaces. These three areas were assessed from the elimination of errors in the following areas:

- **Entity level:** Incomplete information was commonly found in the model from miss representation of elements. Assets in the model that require precise values i.e. information about the space they occupy in the building may be inputted inaccurately. This may lead to difficulties in sharing information with other trade discipline models as these assets through occupying the same spatial properties in the building were modelled differently in the architectural and mechanical models. This will make it difficult to merge models due to the same assets having different spatial properties within each model.
- **Model Incompatibility:** This was about model compliance with BIM standards and was an important quality issue i.e. whether or not the information within the model was compatible with specific data structures.

The authors advocate the use of this research to be deployed by owners to create suitable BIM-quality strategies and assure the quality of required information for operation in the early phases of the project. These areas could be possible categories in which early deployment of the Facility Manager could assist.

The UK GSL, as detailed previously, has made some strides within this area, where earlier stakeholder involvement has been utilised in a number of projects. The GSL will be measured through the following key areas from the early stage of design into post occupancy, as they pass through the whole BIM process:

- Environmental: The measurement of energy usage pre and post occupancy.
- Financial Management: The operational expenditure.
- FM and Commissioning, Training and Handover: Establishing a process and making sure the right people were employed at the right time.
- Functionality and Effectiveness: What was achieved at the end of the whole process and for what purpose?

There have been some positive results in recent pilots, as detailed by the UK BIM Task Group (2015) which includes:

1. Shonks Mill: The Environmental Agency engaged with the stakeholders on the project team through a half a day workshop. The workshop focussed on asking the groups to clarify their needs, targets and constraints which helped bring forward engagement on issues that otherwise would have been left until later in the project,

such as design constraints. Other areas included maintenance targets and data needed by the end user. The workshop reported a saving of at least 7 days and an understanding of the risks and constraints for the project.

2. Liverpool Prison: The Ministry of Justice (MoJ) decided to review their kitchen design standards, which involved a Post Occupancy Evaluation (POE) by the Technical Standards department on a kitchen refurbishment that had been completed 18 months before. This identified through structured questions with key staff from the operations, estate and technical standards team actions to achieve capital and significant operational improvements for future designs and specifications. Using the lessons learnt from the Liverpool POE and the GSL approach of engagement with end users, maintainers, designers and constructors and the 3D capabilities of BIM, a radical review of kitchen design commenced. This review of all kitchen design identified further significant changes to the MoJ standards that led to significant savings in the space required for kitchens, e.g., between 4% and 31% for a pastry prep area.
3. National Measurement Office – Advanced Metrology Laboratory: The users and operators determined the criteria for the plant operation and seven key science criteria. The FM team were treated, as integral to the process, and not just a support service through regular face-to-face meetings with the operators, scientists and client allowing pre-conceptions to be dispelled and a clear understanding to be established. These user groups reported to a Project Steering Group that advised the design team and Project Board of science and operator recommendations. It was estimated that the measure of 'laboratory time in use' could be increased by 10% through intelligent design and close involvement of all parties and time lost due to maintenance and lab catering modifications could also be reduced by the region of 25%.

The majority of the case studies above involve post occupancy evaluation and show little involvement of the Facility Manager in the actual BIM design process. They do not address early Facility Manager involvement and, therefore, lack sufficient guidance in addressing key areas. As a result, it was decided to establish a new terminology to hep demonstrate the benefit of early Facility Manager involvement in the BIM design process.

2.4.3.2 Establishment of Key Performance Task Terminology

The BIM for FM performance tools and KPIs detailed in the literature review were extremely generic and do not provide a focus or any particular guidance of where the Facility Manager's expertise can be best realised. While KPIs seek to measure a change in performance, the authors research aim was to provide guidance and demonstrate where the Facility Manager can have the greatest impact within the BIM design process. The purpose was not to measure this contribution but to establish areas based on the core competencies of the Facility Managers role, which they can offer a specific contribution. For the purpose of this research the author established a new terminology to achieve this research goal, which was KPT. The rationale for this new term was to avoid confusion and differentiate from similar terminologies as KPI were a quantifiable measurement is required. As KPT was a new term there was no existing literature at the time that could be reviewed.

2.5 PROPOSED CONTRIBUTION TO KNOWLEDGE

The literature has shown that despite the digital advancement that BIM for FM offers, there was still a clear lack of evidence, of the benefits the Facility Manager can bring to the design process, if integrated as a key professional much earlier in the design process. The reality was that the FM profession has not carved a clear career path, as seen with other professionals. It was the overreaching aim of this doctoral thesis to offer a contribution of knowledge to both the FM and BIM fields through the establishment of a suite of KPTs that can help demonstrate the benefits of early Facility Manager involvement in the BIM process. This can serve in helping to re-engineer the FM discipline in becoming an established key professional. This research will be focused toward the public sector. The research also established significant findings within the area of both FM and BIM within Ireland. This can be used as a springboard for what was hoped to be the eventual move towards new BIM processes within the Irish public sector.

Moving forward, the findings from the literature review were tested within the primary research. This included further interrogation of the role the Facility Manager currently occupies in the Irish public sector design process. Focus was also provided on establishing Ireland's current BIM awareness, with attention given to both the barriers and drivers that were currently in place with respect to the literature findings. Existing BIM KPIs that have been established in this chapter were also explored, so as to distinguish the authors proposed set of KPTs from existing research.

3 METHODOLOGY

3.1 INTRODUCTION

This chapter presents how all the major components of this research study including the samples, measures and methods of data collection, worked together to address the central research questions in the study. The central research question focused on how to best demonstrate early Facility Manager involvement in the BIM process for Irish public sector buildings. This has offered a new dimension to the FM profession, where carefully selected KPTs can assist to make a valid case for the Facility Manager to make a valued contribution to the design process through early deployment of their unique skillset. A mixed method approach was adopted which was broken into four distinct phases. Phase 1 used a combination of quantitative and qualitative procedures in the form of a case study and two cross-sectional surveys that collated the data to be tested in Phase 2. Phase 2 involved a three stage process, which established a set of KPTs to better understand the areas where the Facility Manager can have the greatest impact in the early design. These KPTs were further refined through a combination of action research and thematic analysis before entering Phase 4. This final phase utilised a public sector model from Phase 2 and a second model commissioned by the Department of Education and Skills (DoES), along with the expert analysis of a number of Facility Managers to validate the KPTs. The data collection and analysis tools included questionnaires, interviews, expert analysis, Nvivo and IBM SPSS which have been explained and justified through the course of this chapter.

3.2 RESEARCH DESIGN

The primary research technique adopted involved a mixed methods approach. This involved philosophical assumptions, the use of qualitative and quantitative approaches and the mixing of both approaches in the study (Creswell, 2009). Farrell (2011) outlined that some of the best results can be achieved by using analytical techniques, through a combination of both qualitative and quantitative data, to gain further insight into the meaning of the data collated.

In forming the basis of the research approach literature was explored on research philosophy. Saunders et al (2012) explains that before research begins one must consider their philosophical position, which will be approached through practical considerations and one's particular view of the relationship between knowledge and the process by which it is developed. He adds that there are three major ways of thinking about research philosophy: epistemology, ontology and axiology.

Epistemology is concerned about how the individual develops concepts of knowledge and knowing and applies them in the understanding of the world. This includes beliefs about the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides and how knowing occurs. It is concerned with the origin, nature, limits, methods and justification of human knowledge (Hofer and Pintrich, 2009). There are three approaches to this philosophy; positivism, realism and interpretivism. Positivism is a philosophical theory stating that positive knowledge is based on natural phenomena and their properties and relations (Macionis and Gerber, 2010). Maxwell (2012) explains that realism entails that entities exist independently of being perceived and is the view that theories refer to real features of the world. While interpretivism avoids rigid structural frameworks, such as in positivist research, and adopts a more personal and flexible research structure which are receptive to capturing meanings in human interaction (Edirisingha, 2012).

Saunders et al (2012) explains that while epistemology is concerned with what constitutes acceptable knowledge in a field of study, Ontology, on the other hand, is concerned with the nature of reality. The authors explain that Axiology is a branch of philosophy that studies judgments about value.

Creswell (2009) indicated the need for a wider philosophical consideration of the research questions to be investigated. Creswell referred to four main philosophical worldviews, namely postpostitivism, constructivism, advocacy and pragmatism. Essien (2010) describes this worldview as a set of presuppositions that are held about the basic makeup of our world and is shaped by far more than the surrounding physical world. These four worldviews can be defined as follows:

1. Knight and Ruddock (2008) outline that postpostitivism is a view where all knowledge is tied to observational forms of verification which attempt to collate knowledge on methodologically ordered experiences associated with scientific experimentation. Malina et al., (2011) explains that positivism is not about confronting “things themselves” because direct observation of a phenomenon is

subjective and hence not reliable. This view represents the traditional form of research and these assumptions hold true more for quantitative research than qualitative research, where one cannot be positive about claims of knowledge when studying the behaviour and actions of humans (Creswell, 2009).

2. The essence of all constructivism theories is that perceptual experience is viewed as more than a direct response to stimulation (Fellows and Liu, 2008). Creswell (2009) sees constructivism as an approach to qualitative research, with the research goal relying, as much as possible, on the participant's views of the situation being studied. The more open-ended the questioning the better, as the researcher listens carefully to what people say or do in a life setting.
3. A participatory/advocacy worldview holds that formal knowledge creates a sense of intellectual inferiority among the ordinary people, making them surrender to or look up to the formally educated for guidance to promote their lives (Reason and Bradbury, 2008).
4. Creswell (2009) outlined that pragmatists use a mixed methods approach for collecting and analysing data rather than subscribing to only one technique, as it provides the best understanding of a research problem. Saunders et al., (2012) explains that pragmatism is intuitively appealing, largely because it avoids the researcher engaging in what they see as rather pointless debates, about such concepts as truth and reality.

Figure 3.1 provides a summary of the main features of each of the four worldviews as outlined by Creswell (2009), which has led him to a decision upon a preferred data collection strategy.

Postpositivism	**Constructivism**
• Determination • Reductionism • Empirical observation and measurement • Theory verification	• Understanding • Multiple participant meanings • Social and historical construction • Theory generation
Advocacy/Participatory	**Pragmatism**
• Political • Empowerment issue-oriented • Collaborative • Change-oriented	• Consequences of actions • Problem-centered • Pluralistic • Real-world practice oriented

Fig 3.1 Four worldviews as defined by Creswell (Creswell, 2009, pp 6)

On analysis of all philosophical positions and worldviews the author found himself to be more aligned with the pragmatic worldview. The author gained considerable experience in the FM field, which has resulted in his chosen research goals been real world practice orientated. The research aims identified were primarily problem centered and were best aligned with the mixed methods approach facilitating different forms of data collection and enquiry. Hanson et al., (2005) detailed that for many mixed methods researcher's pragmatism has become the answer to the question of what is the best paradigm for mixed methods research.

When correctly applied, this technique, as advocated by Malina et al., (2011), can be beneficial as it can capture profoundly new empirical insights. Loo and Lowe (2011) are conscious of the weaknesses of this approach, as mixed methods need valid conceptual grounding in the real world of work.

It was the intention of the research to completely justify the selection of a mixed methods research strategy. As the chapter develops, the rationale for this approach becomes more obvious and remains in line with the pragmatic view inherent in the approach adopted.

3.3 MIXED METHODS APPROACH

Before adopting this approach one must become more knowledgeable, informed and familiar with the growing body of literature that surrounds a mixed methods approach to data collection. Creswell (2009) outlines three different mixed methods approaches.

1. **Sequential mixed methods:** The researcher seeks to elaborate on or expand on the findings of one method with another method i.e. begin with a qualitative interview for exploring purposes and follow up with a quantitative survey method with a large sample.
2. **Concurrent mixed methods:** The researcher converges or merges quantitative and qualitative data, in order to provide a comprehensive analysis of the research problem.
3. **Transformative mixed methods:** The researcher uses current theory based on a group i.e. gender, class and then adopts a position to shape this theory through focusing on an overreaching perspective, within a design, that contains both

quantitative and qualitative data. Within this approach could be a data collection method that involves a sequential or concurrent approach.

Creswell et al., (2011) breaks this down into six major strategies for inquirers to choose from in designing a mixed research proposal:

a) **The convergent parallel design:** The purpose of the convergent design is to obtain different but complementary data on the same topic. This design is used when the researcher wants to triangulate the methods by directly comparing and contrasting quantitative statistical results with qualitative findings for corroboration and validation purposes. It is an efficient design, where both types of data are collected during one phase of the research. Each type of data can be collected and analysed separately and independently, using the techniques traditionally associated with each data type.

b) **The explanatory sequential design**. This occurs in two distinct interactive phases. This design starts with the collection and analysis of quantitative data.. This first phase is followed by the subsequent collection and analysis of qualitative data. This design is most useful when the researcher wants to assess trends and relationships with quantitative data but also be able to explain the mechanism or reasons behind the resultant trends. Hanson et al., (2005) details that these designs are useful for exploring relationships when study variables are not known, refining and testing an emerging theory, developing new psychological test/assessment instruments based on an initial qualitative analysis, and generalising qualitative findings to a specific population.

c) **The exploratory sequential design**. This also uses sequential timing. In contrast to the explanatory design, the exploratory design prioritises the collection and analysis of qualitative data in the first phase. Building from the exploratory results, the researcher conducts a second, quantitative phase to test or generalise the initial findings. The primary purpose of the exploratory design is to generalise qualitative findings based on a few individuals from the first phase to a larger sample gathered during the second phase.

d) **The embedded design.** This design is a mixed methods approach where the researcher combines the collection and analysis of both quantitative and qualitative data. The premises of this design are that a single data set is not sufficient, that different questions need to be answered, and that each type of question requires different types of data. The focus on different questions means that the two types of results can be published separately.

e) **The transformative design**. This design involves the researcher using current theories based on a group of people and then attempt to shape this theory through working with the group and recommending specific changes, as a result of the research, to improve the social or professional standing of the population under study.

Phase one of the research used an explanatory sequential design. This approach involved the undertaking of a significant phase of research within the area of BIM and FM in the Irish public sector. This was important, as in 2011 at the time of this study there was very little research within the domain of either BIM or FM in Ireland. This approach suited best as it enabled the collection of data through two stages that could be used to inform each other. Phase 2 adopted a transformative design approach, where the Facility Manager, who otherwise would be peripheral figure in the design, was promoted to a key player.

The next step involved investigating the types of study available within both the qualitative and quantitative approaches that ultimately fed into a mixed methods framework. Mixed method research employs both approaches iteratively or simultaneously to create a research outcome stronger than either method individually (Malina Et al., 2011). However, one must evaluate the different approaches in each methodology in order for the correct selection of a mixed strategy.

3.3.1 Qualitative methods

Merriam (1998) identified five types of qualitative research methods compromising of ethnographic, phenomology, grounded theory, basic or generic qualitative study and case study. These approaches are detailed further below:

- **Ethnography** is a qualitative research method that is used to describe a culture which may consist of its origins, values, roles, and material items associated with a particular group of people (Byrne, 2001). Bell (2005) explains that this approach involves the studying of people within their environment by methods of data collection which capture their social meanings. The researcher can participate directly but must be careful not to impose on them.

- **Phenomenological** refers to a person's perception of the meaning of an event, as opposed to the event as it exists externally to that person (Offready and Vickers, 2010). Creswell (2009) explains that the procedure involves studying a small number of subjects through extensive and prolonged engagement to develop patterns and relationships of meaning.
- Traditional research designs usually rely on a literature review leading to the formation of a hypothesis. This hypothesis is then put to the test by experimentation in the real world. **Grounded theory** investigates the actualities in the real world and analyses the data with no preconceived hypothesis (Glaser and Strauss, 1967). It is a powerful way to collect and analyse data and further meaningful conclusions and aims to develop a substantive theory through comparative analysis and coding procedures (Karim et al., 2013 and Allan, 2003).
- The **Case Study Method** is an approach to studying a proposed research area, through the analysis of an individual case, and provides an opportunity for the intensive analysis of many specific details overlooked by other methods (Kumar, 2005). It allows researchers to retain the holistic and meaningful understandings of real life scenarios and help identify the various interacting processes, so as to understand their impact on the study under investigation (Yin, 2002 and Bell, 2005).

These were not the only qualitative methods that existed and further literature was explored on a number of other approaches. This included action research, which involves an iterative process involving researchers and practitioners acting together on a particular cycle of activities, including problem diagnosis, action intervention, and reflective learning (Avison et al., 1999). Narrative inquiry is the use of stories where data collection, interpretation and writing are considered a ‘meaning making’ process with similar characteristics to stories (Gudmunsdottir 1996). It involves reflective autobiography, life story, or portraying personal accounts of human experience (Bell, 2005). A number of analysis techniques were investigated to add further understanding and clarification. Amongst these where content analysis which is a research technique for making replicable and valid inference from texts to the contexts of their use, and discourse analysis which considers how language, both spoken and written, enacts social and cultural perspectives and identities (Krippendorff, 2004 and Madden et al., 2013). A further analysis explored was thematic, which is a method for identifying, analysing, and reporting patterns (themes) within data.

In drawing extensively from the literature detailed above, table 3.1 was developed to summarise and reflect on the qualitative research options. As stated throughout, the research follows four phases were a case study was used as a data collection vehicle for both Phase 1 and 2 and action research and thematic analysis for Phase 3. Table 3.1 helped inform the author to decide which qualitative approach was best suited to obtain the research goals.

3.3.2 Quantitative methods

Quantitative research places more emphasis on methodology, procedure and statistical measurement of validity and typically has a logical and linear structure (Eldabi et al., 2002). Christensen (2001) details five of these quantitative research methods; longitudinal study, correlative, survey, ex post facto and meta-analysis.

Longitudinal studies investigate developmental changes that take place over time by taking a single group of participants and measuring them repeatedly at selected time intervals, as so to note the changes that occur over time in the specified characteristics (Christensen, 2001). The longitudinal study provides a salient means for collecting data with respect to the age and development of the subject and can provide a marked insight into the process of change. Babbie (1998) details three types of longitudinal studies:

- Trend Studies: A given general population may be sampled and studied at different times. Though different persons are studied in each survey, each sample represents the same
- Cohort Studies: This focuses on the same specific population each time data are collected.
- Panel Studies: This involves the collection of data over time from the same sample of respondents. The sample for each study is called a panel.

A correlational study compares two or more different characteristics from the same group of people and explains how two characteristics vary together and how well one can be predicted from knowledge of the other (Diem, 2002). A predictive correlational study could predict a later set of data from an earlier set and could also use one characteristic to predict what another characteristic will be at another time.

Type	Description	Advantages	Disadvantages	Output
Ethnography	The studying of people in naturally occurring settings.	Helps to understand better why people act in the way they do and to see things as those involved see things.	Time must be taken to build trust and reality can be taken as independent.	Primarily, observational and interview data.
Phenomenological	The identification of the essence of human experiences about a phenomenon.	Rich and detailed description of the human experience.	As the samples are generally very small, it is hard to say if the experiences are typical.	The analysis of significant statements, the generation of meeting units and the development of a strategy.
Grounded Theory	The generating of theory based on data collected and analysed simultaneously as the research progresses. The process involves using multiple stages of data collection.	Produces a systematic and rigorous procedure and rich data from the experiences of individuals. Can result in unexpected knowledge.	The data leads to difficulties in establishing reliability and validity of approaches and information. It is difficult to detect or to prevent researcher-induced bias.	Generating categories of information (open coding) and then generating a story from the interconnection of these categories (selective coding).
Case study	Studying a social phenomenon through an analysis of an individual case which provides an opportunity for the intensive analysis.	Retaining the holistic and meaningful characteristics of real life events.	No way of knowing if that group is typical of other groups that may have the same title.	A detailed description of the setting or individual followed by the analysis of the data for themes or issue.
Action research	Research orientated towards direct practice.	Practitioners who use action research have the potential to increase the amount they learn consciously from their experience.	It is harder to do than conventional research, as you take on responsibilities for change as well as for research.	Put into action research results in order to directly effect a setting.
Narrative	The use of stories in which when data collection, interpretation and writing are considered a 'meaning making' process.	Allow voice to the researcher, the participants and to cultural groups – and in this sense they can have the ability to develop a powerful edge.	A trust relationship has to develop between researcher and storyteller.	Interview data.

Table 3.1 A Summary of the different types of qualitative research explored

In most cases, a survey aims to obtain information from a representative selection of the population and from that sample will be able to present the findings as being representative of the population as a whole (Bell, 2005). Babbie (1990) explains that survey research provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population. It includes cross-sectional and longitudinal studies using questionnaires or structured interviews for data collection, with the intent of generalising from a sample to a population. The standard type of survey is that of the cross-sectional type where data is collected at one point in time from a sample selected to describe some larger population at that time (Babbie, 1998).

An ex post facto study is used when experimental research is not possible, such as when people have self-selected levels of an independent variable or when a treatment is naturally occurring and the researcher could not "control" the degree of its use (Diem, 2002). The researcher starts by specifying a dependent variable and then tries to identify possible reasons for its occurrence, as well as, alternative rival explanations. This type of study is very common and useful when using human subjects in real-world situations and the investigator comes in after the fact.

Crombie and Davis (2009) explain meta-analysis as a statistical technique for combining the findings from independent studies. Meta-analysis of trials provides a precise estimate of treatment effect, giving due weight to the size of the different studies included. The validity of the meta-analysis depends on the quality of the systematic review on which it is based.

Other quantitative methods investigated included an experimental style, where the researcher seeks to determine if a specific treatment influences an outcome (Creswell, 2009). This impact was assessed by providing a specific treatment to one group and withholding it from another and then determining how both groups scored on the outcome. Bell (2005) details that experiments may allow conclusions to be drawn about cause and effect, but large groups are needed if the many variations and ambiguities involved in human behaviour are to be controlled. In drawing extensively from the literature detailed above, table 3.2 was developed to summarise and reflect on the quantitative research options.

Type	Description	Advantages	Disadvantages	Output
Longitudinal Study	Investigate developmental changes that take place at the time by taking a single group of participants and measuring them repeatedly at selected time intervals.	Provides a salient means for collecting data with respect to the age and development of the subject and can provide marked insight into the process of change.	As data is being collected at different times, those observation periods are pre-determined and cannot take into account whatever has happened in between those points.	The ability to show the patterns of a variable over time.
Correlative, Survey	Compares two or more different characteristics from the same group of people and explains how two characteristics vary together and how well one can be predicted from knowledge of the other.	Allows researchers to determine the strength and direction of a relationship so that later studies can narrow the findings down.	It cannot provide a conclusive reason for why there's a relationship.	Shows a relationship between characteristics at the same point in time.
Survey	Provides a quantitative or numeric description of trends, attitudes, or opinions of a population by studying a sample of that population.	Obtains information from a representative selection of the population and from that sample will be able to present the findings as being representative of the population as a whole.	Can only provide a snapshot of that moment and is not fit to make conclusive observations about the direction of any given association between variables.	Researcher can generalise results to a population.
Ex Post Facto	Non experimental research technique in which pre-existing groups are compared on some dependent variable.	Useful when using human subjects in real-world situations and the investigator comes in after the fact.	It cannot acquire as much data as an experimental design.	Shows effects of a presence or absence of an independent variable on a dependent variable.
Meta-analysis	This is a statistical technique for combining the findings from independent study.	Offers the opportunity to critically evaluate and statistically combine results of comparable studies or trials.	A high chance of bias, where the researcher collecting the data will pick specific studies that only provide the outcome that the researcher is looking for.	Calculates a weighted average of a common measure.
Experimental style	Provides a specific treatment to one group and withholding it from another and then determining how both groups scored on the outcome.	This tests the impact of a treatment outcome, controlling all other factors that might influence that outcome.	Large groups are needed if the many variations and ambiguities involved in human behaviour are to be controlled.	Allows conclusions to be drawn about cause and effect.

Table 3.2 A Summary of the different types of quantitative research explore

3.3.3 Overview of Research Strategy

Given the array of methods available to collate data it was necessary to break down the collection of data into four distinct phases. The rationale for this approach was detailed below in were each phase serves as its own but interconnected research methodology with regards to the establishment, refinement and validation of the KPTs.

Phase 1: In 2011 BIM was only beginning to have traction in Ireland and there was very little research at the time published on the area (Scully et al., 2012). Whilst the area of BIM for the FM industry was gaining interest among international governments, particularly in the UK due to the 2016 BIM mandate, there was little by way of traction for BIM by Irish public authorities. There was little Irish research to draw on involving the Facility Manager in the construction process. Previous research performed in 2010 and published in 2012 was used as a starting point (McAuley et al., 2012a). At this time, it was decided to collect a large sample of data. An explanatory sequential design approach was adopted in two distinct phases. The first phase involved a qualitative-based case study. This phase was followed by two separate but related cross-sectional type surveys. The questions for the first BIM related survey was informed by the case study analysis, which in turn provided the questions to be applied to a more focused survey on early FM involvement with BIM. Phase 1 of the research ultimately served as an exploratory study of the current state of the art practice of BIM within an Irish setting, as that time. The findings from this phase of the research resulted in number of early design target areas associated with early Facility Manager involvement in the BIM design.

Phase 2: The next phase of the research was structured around a transformative design, were research findings from Phase 1 and the literature review provided the basis for testing. A longitudinal-based panel approach was adopted within a qualitative-based case study. The results from this study was triangulated against the data collected in Phase 1. The findings from this phase of research resulted in the first draft of the proposed KPTs.

Phase 3: The penultimate phase involved conducting further analytical rigor on the research collected through the first two phases of the research. This phase of data collection involved a process of thematic analysis. The rationale for this was to ensure that the KPTs were strongly focused towards the public sector and to ensure that all data previously collected had received a high level of analytical rigour. In order to ensure this the author spent time within an environment that attempted to adopt BIM in a public works project. This involved action research with interviews the main data tool adopted. This new data along with the previous two phases presented a number of synergies, patterns and themes across all of the studies. This defined and shaped the intended research goals even further before being validated in the final phase. This ultimately resulted in a refined set of KPTs more aligned to the public sector.

Phase 4: The final phase of the primary research was a rigorous validating of Phase 2 and 3 results. The KPTs were validated through the process of empirical validation. This is the empirical investigation, of properties, of newly designed artifacts before they are transferred to practice. An artifact is anything designed for a useful purpose, such as a new notation, technique, method, algorithm, device or organisation structure (Wieringa, 2014). Through empirical evaluation the artifact can be evaluated to validate that it actually works for its intended users and in its intended environment (Kehily and Underwood, 2015). Chin (2002) refers to empirical evaluation as the appraisal of a theory by observation in experiments. The key to good empirical evaluation is the proper design and execution of the experiments, so that the particular factors to be tested can be easily separated from other confounding factors. The rationale for selecting this method was due to the lack of maturity of BIM within the Irish public sector at the time, which made the testing of the KPTs unachievable.

This phase included using two public sector BIM case studies. The first project involved a Coastguard station located in Greystone Harbour and the second project involved a special needs school to be located in Wexford. Both projects were used to investigate through expert Facility Manager analysis if the established KPTs were valid. An expert in this case is someone widely recognised as a reliable source whose facility for judging or deciding rightly, justly or wisely, is accorded authority and status by their peers, or the public in a specific well distinguished domain. An expert is more generally a person who has extensive knowledge or ability based on research, experience or occupation in a particular area of study (Cuff, 2016). In this case Facility Manager one was selected due to their previous participation in a case study detailed in the paper McAuley et al. (2012a), were they played an important role in contributing to a sports hospital's strategic goal by implementing a number of FM initiatives. The second Facility Manager had significant knowledge of BIM for FM and had been involved in developing an FM software product on a number of high profile projects. The overall research strategy adopted is shown in figure 3.2

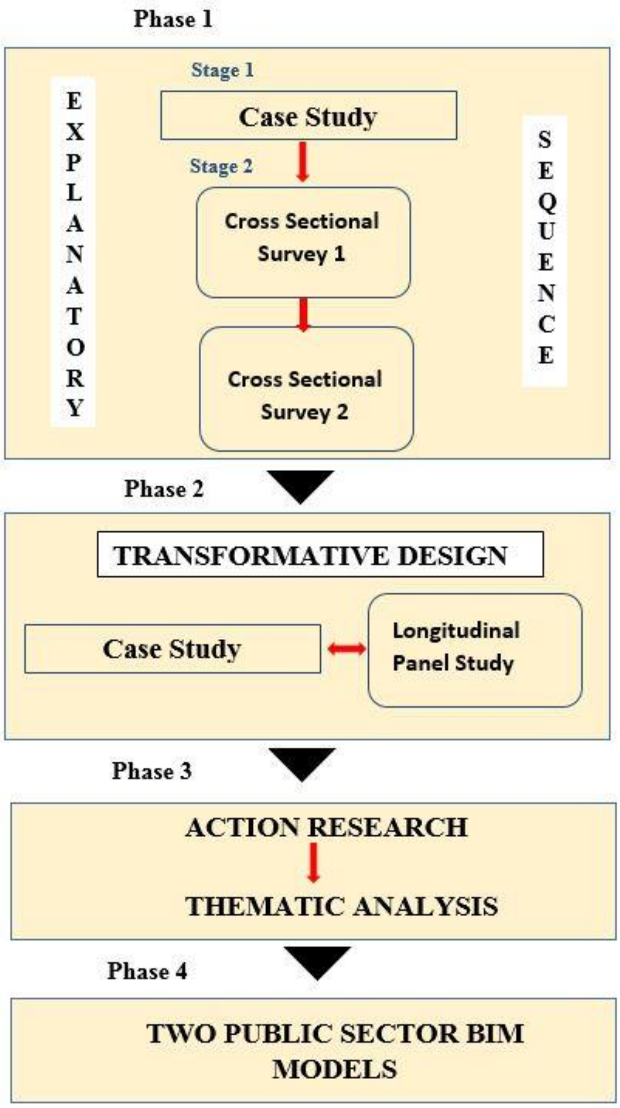


Fig 3.2 Selected primary research approach

3.4 DETAILED PRIMARY RESEARCH

This section provides specific details of the selected primary research approach and how data was collected, analysed and reported.

3.4.1 Phase 1 – Stage 1

This stage involved an iterative explanatory sequential design process, whereby the data collected in one stage contributed to the data collected in the next stage (Driscoll et al., 2007). The overreaching aim of this stage of the research was to establish if BIM was a viable alternative for the Irish public sector. A case study was selected, as they encourage investigation of particular instances within the research subject and were bounded by time and activity that could enable strong conclusions to be formed (Fellows and Liu, 2008, and Creswell, 2009). There was a choice of three different types of case study categories. These included exploratory, which explored any phenomenon in the data which served as a point of interest to the researcher. A descriptive case study, which described the natural phenomena which occur within the data in question. Finally, an explanatory case study, which provides focus on studies that examined the data closely both at a surface and deep level, in order to explain the phenomena in the data (Yin, 2002 and Zanial, 2007). An exploratory case study was selected, as this approach is flexible and open towards a phenomena and no hypothesis is formulated in advance, therefore, allowing the researcher to approach the case study in a fluid manner (Swanborn, 2010).

In the first instance a first-hand simulated pilot case study was observed in 2011, which encouraged an in-depth investigation of particular interfaces between discipline team members working with BIM. This pilot project was facilitated by the RIAI and CitA. The project involved a full professional team working in conjunction with the DoES on a generic primary school project and took place over a four-day period. The main goals of the workshop were to:

- raise awareness and promote a higher level of understanding of BIM;
- demonstrate a more effective way for teams to collaborate;
- assess / demonstrate some of the BIM software tools currently available in the market and;
- validate designs through digital analysis.

The data was collected mainly through direct observation, documentation and in formal interviews. The collection of documentation from the workshop permitted an efficient and stable approach, as they are outside the researcher’s influence (Swanborn, 2010). Interviews helped to gather information in an efficient way but also allowed the researcher to gain a to access to key personnel. Three types of interview techniques presented themselves on review, which included informal conversational interviews, semi-structured interviews and standardised, open-ended interviews. A semi-structured interview process was selected, as the interviewer during this process is free to explore, probe and ask questions deemed interesting to the researcher (Patton, 1990 and Berry, 1999). This was deemed the most suitable approach due to the environment created within the workshop. Direct observation provided a further means to record data that led to a deeper understanding than the interviews and served as a complementary process that helped to develop an insight in the process at hand (Hoepfl, 1997 and Swanborn, 2010). The author was cautious of this approach, as it could have potentially lead to personal bias (Bell, 2005, Zanial, 2007 and Swanborn, 2010). Elements of bias include the researcher's observations and interpretations were reliability and validity were difficult to determine.

The author recognised that the pilot participants represented only a small cross section of the AEC sector who were all firmly in favour of BIM. The results did not reflect the general Irish AEC/FM population and further research was needed to gain an understanding of the industries awareness. This ensured the results from the workshop were reassessed in a non-biased atmosphere. It was agreed that the best approach was to conduct an extensive survey aimed at a disparate cross-section of the AEC/FM Sector.

3.4.2 Phase 1 – Stage 2

The second stage of the sequential design was a two-part survey. The first survey was structured around the results from the observational case study in Stage 1. The survey was targeted at a cross-section of the Irish AEC sector, in order to gauge the level of support for the introduction of BIM to assist in achieving the vision of the CWMF in Ireland. Ultimately, it aimed to explore the current adoption of BIM, in both the private and public domain, so as to gain a deeper understanding of the current adoption and awareness levels of BIM.

A cross-sectional type survey was selected, where a population relevant to the research interests was chosen. A sample of respondents from this population was selected to conduct the survey (Babbie, 1998). An online pilot survey was initially distributed to a small number of leading BIM experts in Ireland. A number of open-ended questions were included in the survey, so as to offer the respondents more freedom in expressing their opinion. Closed questions were included to determine the respondent's attitude in respect to a statement.

A number of results were ranked using rank correlation, which allowed a numerical measure of the degree of similarity between the ranking characteristics or factors in two different populations. Cross-tabulations of the results provided a way of analysing and comparing the results for one or more variables to demonstrate the similarity or difference in response to one group. This will involve the use of IBM SPSS Statistics software. The survey and pilot results provided answers on BIM awareness and adoption in Ireland and to a certain point on BIM with respect to the FM profession, but did not focus strongly enough within this area. Stage two of the sequential design answered these questions through a more focused survey on the area of BIM for FM on public works projects in Ireland. This survey followed a similar strategy to the first survey.

The second survey was again piloted with a group of experts to assist in its design. The particular sample population was chosen with the assistance of the Irish Property and Facility Management Association (IPFMA). The purpose of the survey was to gauge the level of support for the introduction of BIM to assist in managing the public sector estate. This generated a total of 38 company responses from a total sample size of 80 businesses. The responses to the survey provided a snapshot of the current Irish FM sector and the technologies that were commonly in place within the private and public sector at that time.

In order to avoid any bias within the questionnaire it was sent to a group of leading practitioners and academics to ensure that none of the questions were leading. The application of IBM SPSS ensured a traceable audit of results, so that elements of bias were eliminated. The results from the survey established a number of potential areas where their early involvement can be of significant benefit within the BIM design process. These early design target areas provided the basis for testing which led to the eventual establishment of the KPTs. IBM SPSS Statistics software was again used to conduct cross-tabulations and rank correlation. The two surveys and the RIAI CitA pilot helped formulate an alternative solution for the design, construction and operation of future Irish public works projects. The results from phase one laid the foundations for this approach. The version of Phase 1 process is illustrated in the figure 3.3.

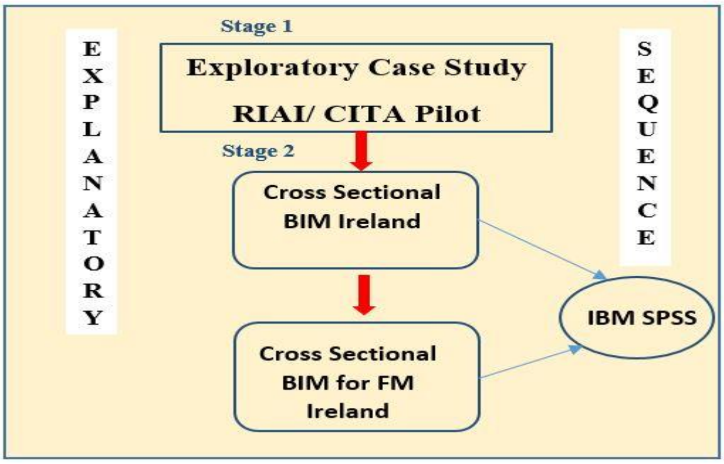


Fig 3.3 Detailed breakdown of Phase 1 of the primary research

3.4.3 Phase 2

Phase 1 results along with the findings from the literature review were further tested in the second phase of the primary research. This involved a second case study which was observed with established KPIs over the course of a ten-month period. The mixed methodology method selected involved a transformative design approach. The rationale for choosing this approach was motivated by the decision taken by the pilot team involved in the case study, shifting project focus from design and construction to FM through to early FM involvement.

The case study was descriptive in nature. The case study in question involved a virtual project that was identified by a team of Irish professionals who were willing to experience and disseminate practical lessons on the potential benefits/risks involved in utilising BIM from an FM perspective. This pilot project was located in a setting involving complex topographical locations making it challenging to design in 2D. This resulted in an enhanced brief being suggested to the Client for the creation of a virtual model for a village setting. The model case study chosen was an existing community centre, which required extensive refurbishment. The pilot team set about creating a sustainable and functional building. With the case study building selected a number of leading Irish AEC sector companies where approached, including a Local Authority representative who all indicated that they were interested in working on this project. This resulted in an attempt to incorporate all professions into an IPD type environment, which included the FM Team at the early design stage.

The core competency areas of the Facility Manager's role were established by cross referencing established international standards identified in the literature review. These key competency areas were then compared against areas where the Facility Manager can have the greatest impact in the design, which were based on the findings from Phase 1. Finally, a review of established BIM KPIs were compared and mapped against both the established core competencies and the particular areas that benefited most from earlier Facility Manager involvement.

The KPIs were tested through a longitudinal study framework, as this enabled the investigation of the developmental changes of the pilot team that will take place over the pilot time frame. This approach involved multiple or "repeated" measurements on each subject and provided a unique opportunity to understand the pilot team's development over the course of the pilot (Hegarty et al., 2013). Semi-structured interviews were also used throughout. This process involved on-going interactions with all the pilot team members to help further validate the KPI's accuracy The results from the KPIs were mapped against the core competency areas of the Facility Managers role and the early design target areas where they can have the greatest impact. This established a set of KPTs that can be used to demonstrate the benefit of introducing the Facilities Manager at an early stage in the BIM process on public sector projects. As similar with Phase 1 the author used IBM SPSS to avoid any bias within the analysis of the KPIs. Samples of the interviews are provided in Appendix 4 to ensure the transparency and validity of the interview process.

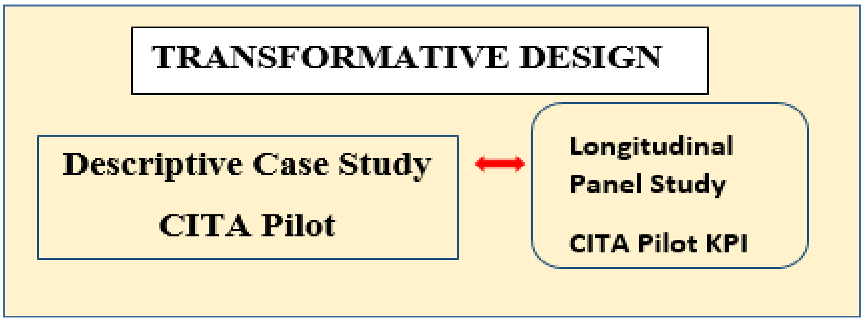


Fig 3.4: Detailed breakdown of Phase 2 of the primary research

3.4.4 Phase 3

The next phase of the research involved refinement of the KPTs to ensure they were focused towards the Irish public sector. An opportunity presented itself to observe a OPW project. This permitted the observation of current collaboration processes in place at the time within the OPW. The project involved the construction of a new BIM designed Coast Guard Station and boathouse with suitable modern facilities in Greystones Harbour on the east coast. The researcher worked within the architecture team and was responsible for creating the model and inputting specification into it. The creation of the model and linking up with other public sector departments permitted a strong insight into early FM practices and the role of the Facility Manager. The model was also used in Phase 4 of the research.

The methodology chosen in observing and participating within the case study could be best described as action research. Action research is a reflective process that allows for inquiry and discussion as components of the research. This can be a collaborative activity among colleagues searching for solutions to real problems experienced (Ferrance, 2000). Rather than dealing with the theoretical, action research allows practitioners to address those concerns that are closest to them, ones over which they can exhibit some influence and make change. Action research requires action in the fields of both practice and research, so to a greater or lesser extent, it will have characteristics of both routine practice and scientific research (Tripp, 2005). This approach enabled the author to experience first-hand the current maturity of BIM in the public sector and the involvement of the FM department in the process. Interviews were used as the main data collection tool.

After completion of the action research the next stage was to further refine the KPTs to reflect the findings. This stage of the strategy involved a thematic analysis of the data collated which also included data from the earlier sources identified in Phases 1 and 2. The rationale for this was to ensure all data received a high level of analytical rigor and that any particular areas that could contribute to the KPTs was not previously missed.

Thematic analysis is widely used as an analytic approach across methods by case study researchers, qualitative researchers in general, and scholars of the humanities, because of its power to yield insightful interpretations that are contextually grounded (Mills et al., 2010). Thematic analysis is not a research method in itself but rather an analytic approach and synthesizing strategy used as part of the meaning-making process of many methods (Mills et al., 2006). Mills et al., provides five purposes of thematic analysis, as means of (1) seeing, (2) finding relationships, (3) analysing, (4) systematically observing a case, and (5) quantifying qualitative data. Braun and Clarke (2006) describe a six phase process to thematic analysis which has now become the predominant approach. These phases are as summarised in table 3.3.

Phase	Description of the process
1. Familiarising 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 data relevant to each potential theme.
4. Reviewing themes:	Checking in the 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.

Table 3.3: The different phases of thematic analysis – source Braun and Clarke (2006, pp 35)

Mills et al., (2006) suggested the use of Nvivo software, which is a computer-assisted qualitative data analysis software specifically designed for thematic analysis of qualitative data, with theory-building capabilities. It is chosen for thematic analysis as it is less labour intensive than manually assigning and analysing codes though paper transcripts. Bazeley (2007) reports that Nvivo can assist qualitative research in five ways:

1. **Managing data:** Organise and keeps track of the many disorgansied records that go into making a qualitative project.
2. **Manage ideas**: Organise and provides rapid access to conceptual and theoretical knowledge that has been generated in the course of the study, as well as the data that supports it.
3. **Query data**: Asks simple questions or complex questions of the data and have the program retrieve from its database all information relevant to determining an answer to those questions.
4. **Graphical Model:** Show ideas or concepts being built from the data and the relationship between them, and to present those ideas and conclusions in visual displays using models and metrics.
5. **Report from the data:** Using contents of the qualitative database, including information about and in the original data sources, the ideas and knowledge developed from them, and the process by which these outcomes are reached.

The adoption of Nvivo permitted a greater rigour of analysis and showed a clearer path to the reader in how codes and themes where generated. The use of this software also ensured that the results would not be affected by bias, as all statements and findings could be tracked through the established nodes and subsequent interview transcripts. The process adopted in utilising the software is shown in Table 3.4.

Analytical Process (Braun & Clarke, 2006).	Braun and Clarke Practical Application in NVivo	Strategic Objective	Iterative process throughout analysis
1. Familiarizing yourself with the data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideasImport data into the NVivo data management tool	Data Management *(Open and hierarchal coding through NINVO)*	Assigning data to refined concepts to portray meaning
2. Generating initial codes:	Phase 2 – Open Coding- Coding interesting features of the data in a systematic fashion across the entire data set, collecting data relevant to each code		
3. Searching for themes:	Phase 3 - Categorisation of Codes – Collating codes into potential themes, gathering all data relevant to each potential theme		Refining and distilling more abstract concepts
4. Reviewing themes:	Phase 4 – Coding on - Checking if the themes work in relation to the coded extracts (level 1) and the entire data set (level 2), generating a thematic 'map' of the analysis	Descriptive Accounts *(Reordering, 'coding on' and annotating through NVIVO)*	
5. Defining and naming themes:	Phase 5 - Data Reduction - On-going analysis to refine the specifics of each theme, and the overall story [storylines] the analysis tells, generating clear definitions and names for each theme		Assigning data to themes/concepts to portray meaning
6. Producing the report	Phase 6 –Generating Analytical Memos - Phase 7 – Testing and - Validating and Phase 8 Synthesising Analytical Memos. 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	Explanatory Accounts *(Extrapolating deeper meaning, drafting summary statements and analytical memos through NVIVO)*	Assigning meaning Generating themes and concepts

Table 3.4: Nvivo phases of thematic analysis – source Nvivo training material

This process produced a traceable audit of all the information collected. It allowed for key themes to be established that may have been missed if this process was not adopted. This more importantly was reflected within the KPTs and resulted in more focused performance criteria. The Phase 3 process is illustrated in figure 3.5.

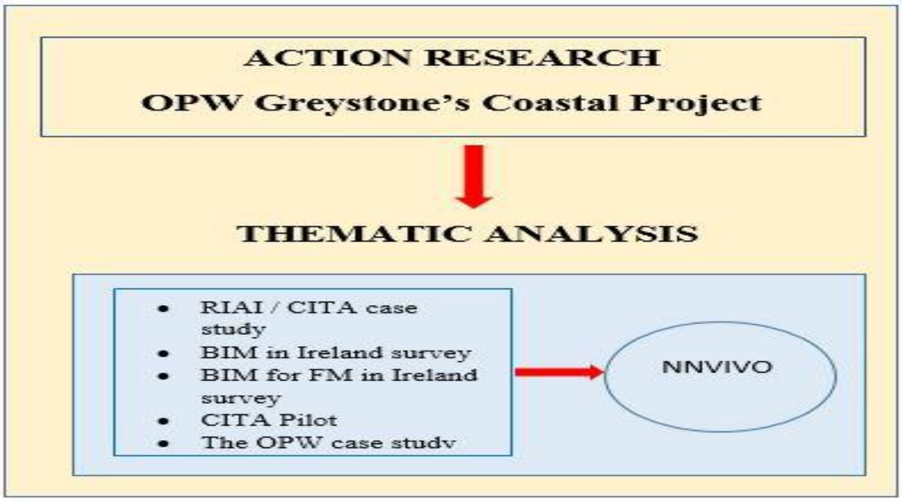


Fig 3.5: Detailed breakdown of Phase 3 of the primary research

3.4.5 Phase 4

The final phase involved validating the KPTs on two Irish public works projects using BIM technologies and processes at varying degrees of maturity. Phase 3 of the research involved, as discussed previously, a three-month placement working in the OPW on a live BIM project. It was observed that though FM was of high importance to the OPW, that the Facility Manager in this instance had no contribution to the design or construction. The same model used for this project was reassessed through expert analysis with two expert Facility Managers, which included suggestions and contributions to improving the overall workflow based around the presented KPTs. One of the experts had no knowledge of BIM, while the second was familiar with BIM and its associated processes. A second model commissioned by the DoES to explore BIM and its associated processes was explored through the same methodology. This model had also received no Facility Manager input during its production.

The expert analysis of the expert Facility Managers was incorporated into the revised set of KPTs that formed the basis of the proposed contribution to knowledge. An updated version of Phase 4 is illustrated in figure 3.6.

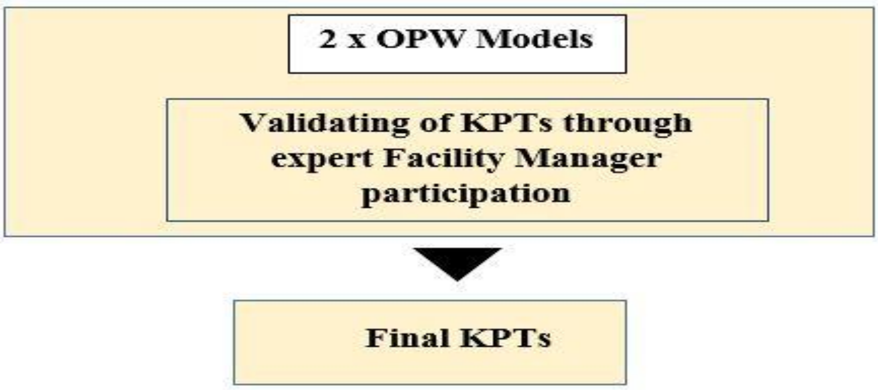


Fig 3.6: Detailed breakdown of Phase 4 of the primary research

3.5 SUMMARY

This chapter has outlined data collection methods utilised to conduct the primary research, intended to produce a contribution to knowledge. It was decided that a mixed method approach would be most appropriate given the topic. After an in-depth critical investigation into mixed method methodologies and accompanying quantitative and qualitative processes, it was ultimately decided that the best way forward would be to split the primary research into four different phases. This research methodology was extensive and provided a fully traceable roadmap for the creation of these KPTs.

4. EXPLORATORY CASE STUDY 2011: USE OF BIM ON PUBLIC WORKS CONTRACTS IN IRELAND

4.1 INTRODUCTION

In 2011 the UK construction industry was on a trajectory towards a Level 2 BIM Mandate on all capital funded projects by 2016. The UK BIM Mandate has had a dramatic impact on the AEC Sector in Ireland, with businesses turning towards BIM, as clients increasingly specify its use on Irish projects. In addition, training organisations responded by offering programmes and events to feed the appetite of BIM. This chapter focused on a complementary initiative instigated by the RIAI in partnership with Autodesk to facilitate a design workshop to demonstrate the potential that BIM could potentially bring in design coordination of publically funded construction projects in Ireland.

The selected case study involved observing a simulated design workshop of a generically designed primary school project. The workshop aimed to showcase BIM as a more efficient and effective way for project teams to collaborate, therefore promoting a higher level of understanding and adoption of BIM within the construction industry. The workshop which took place over a four-day period in late 2011 was officially observed by the DoES and was facilitated by CitA. The author availed of an invitation to document and observe the outcome of the workshop

4.2 PURPOSE OF STUDY

The main purpose of the observation study was to;

1. To conduct an exploratory study of BIM with respect to it offering a more rewarding methodology for the procurement and management of public sector assets.

The observation study provided a full professional design team and a public sector commissioning client the opportunity to experience first-hand the applicability of using BIM on a public works project. In particular, the pilot team sought to establish if BIM could assist in achieving some of the specific goals of the CWMF.

4.3 METHODOLOGY

The workshop was held over four days with a number of subsequent presentations given to industry leaders. Qualitative data was gathered following attendance at workshop presentations through five semi-structured interviews with members of the participating team. The main benefit from this direct observation was the richness of the data received, due to the direct interaction with individuals on a one-on-one basis and with individuals in a collaborative group setting. This in turn provided a deeper insight for the author into the potential for BIM to improve the outcomes of design-coordination of public funded construction projects. All interview data was recorded and analysed later in an external environment from the workshop, further to this data was gathered from the collection of documentation from the workshop and subsequent industry presentations. Some of these documents have been collated in Appendix one to provide further insight into the workshop.

4.4 OVERVIEW OF PILOT

The workshop involved the digital deconstruction of an existing primary school building model and rebuilding it using BIM technologies. An illustration of the BIM model and its components are shown in figure 4.1.

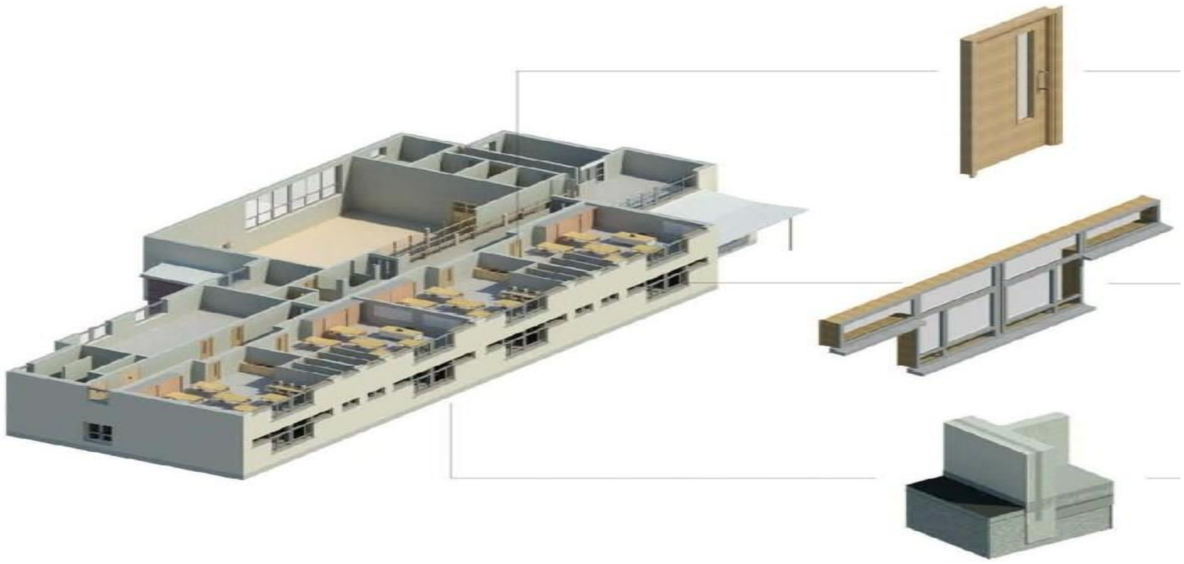


Figure 4.1: Primary School Model from the RIAI Workshop

The pilot involved the participation of a large number of project stakeholders comprising of a number of leading design professionals operating in the Irish AEC/FM sector. This included consulting engineers, services engineers, architects, and consultants as illustrated in figure 4.2.

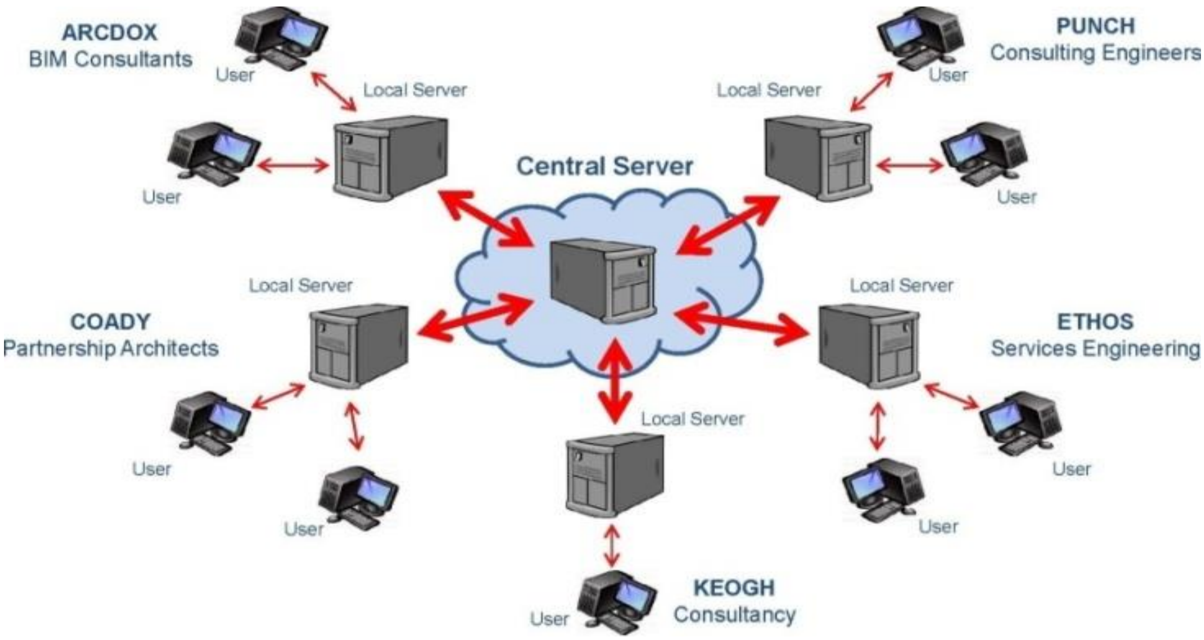


Figure 4.2:.RIAI Workshop Pilot Team

Greater detail on the case study design can be located in chapter 3. Information on participants and programme of activities for the four days of the workshop are included in Appendix 1.

The BIM model was developed to respond to client specific requirements using a visual communication tool to meet their expectations. The design team was provided with a digital brief with the overall goal to design a BIM model of a standard generic DoES school. This model was broken down into its elemental components to facilitate the design team to work on specific components. The various professionals all worked on their own model, which was synchronised within a central server, allowing all participants of the workshop to monitor each other's work, therefore, facilitating collaboration.

4.5 RESEARCH QUESTIONS

In addition to the general purpose of raising awareness of the potential for BIM in improving design coordination and the downstream benefits this could bring, the pilot sought to investigate if the greater use of BIM could help assist in addressing the goals of the CWMF, namely:

Can the use of BIM technologies and collaborative workflow processes lead to;

1. greater cost certainty at contract award stage ensuring, as far as practicable, that the accepted tender prices and the final cost were the same;

2. the award of contracts on the basis of a lump-sum fixed-price;
3. rebalance risk;
4. better value for money; and
5. more efficient delivery of the projects on publically funded projects?

4.6 FEEDBACK FROM INTERVIEWS

The following contains a summary of the key points raised from the informal interviews held. All the interviewees were asked how BIM in relation to the workshop project could help address the five goals of the CWMF. Further to this, all interviewees were asked to expand on any general observations or suggestions they may have in advancing the BIM process with regards to public sector projects. A sample transcript from one of the interviewees is included in Appendix 1.

4.6.1 Interview one – BIM Consultant

Specific observations on BIM meeting the objectives of the CWMF

The interviewee was of the view that BIM enables the deployment of the architect a lot earlier in the project; this would allow the QS to perform earlier cost analysis exercises. BIM facilitates a very simple collection of data and quantities that everyone can use, which all leads to greater cost certainty. There was an opportunity to avoid unnecessary risk as "*you can build the building virtually before you have to build, so you can see the clashes so it doesn't happen on site*". If these clashes could be addressed at an early stage, it could cost very little and save time. The interviewee believed that the real savings for the contractor was in clash detection and the coordination of the design team's information with each other. This was seen as important in reducing risk, which was a key area of contention within the GCCC forms of contract. He explained that the BIM process can achieve the CWMF goals, such as, better value for money, and in theory have a better thought out and planned building.

General Observations

The BIM consultant claimed that the Irish Government needed to be more forward thinking, as there was a fear they would be left behind by the UK. He added that people were tired of the traditional system and the recession has added to the current feeling of disgruntlement within the industry. The biggest drivers in his opinion would be the contractors. He concluded that if the contractor was going to make a profit out of the GCCC forms of contracts, then they need to be assured of design quality / accuracy and be able to clash detect everything through BIM.

4.6.2 Interview Two – BIM Energy Consultant

Specific observations on BIM meeting the objectives of the CWMF

The energy consultant clarified that energy efficiency was not normally a priority at the design stage and decisions on materials selection, amongst other things, were purely driven on cost. The BIM process permitted a different and more sustainable method of construction to be undertaken, which helped designers concentrate on energy efficiency and improved carbon construction performance. The BIM workshop allowed the designers to create four mass models at different orientations and to perform exercises in concept energy analysis, so as to choose the most economical and sustainable building possible. The energy model was inputted with weather predictions to aid in orientation data, internal floor areas, the number of people who will use the structure, cost of electricity and fuel, average lighting power, exterior wall area, window area, etc. to enable an accurate analysis to be performed. He further explained that through the analysis tools within Revit one could perform daylight analysis for a classroom, which in turns helps the architects to select different window sizes. This type of analysis can ensure CWMF goals, such as. more efficient delivery of projects and value for money from both the client and contractor’s perspective. It can further reduce carbon emissions associated with operating public sector assets.

General Observations

The energy consultant added that BIM was slow on the uptake because people were quite concerned, as they did not see themselves as gaining a benefit through the use of BIM. The interviewee added that the QS profession can particularly benefit, as they can get more accurate quantities.

4.6.3 Interview Three – Service / M&E Engineer

Specific observations on BIM meeting the objectives of the CWMF

The M&E Engineer believed that BIM helps identify and avoid risks that may occur on site. It also assists in helping the contractor produce more accurate estimates. The interviewee believed that BIM can add more cost certainty and can take away a lot of design risk associated with the contractor’s cost. There can also be exercises prepared in which the running cost can be compared against concept energy analysis helping ensure the most efficient design solution was chosen. He believed that this all leads to a more efficient public sector estate.

General Observations

The interviewee explained that energy efficiency was sometime not considered and decisions on materials selection amongst other things were purely driven on cost. Sub-Contractors can spend up to 3 weeks estimating, while with Revit, they could generate quantities quickly. He added that he sees the Government strongly focusing on BIM in the future in order to remain competitive.

4.6.4 Interview Four – Civil Engineer

Specific observations on BIM meeting the objectives of the CWMF

The interviewee believed that the main benefit of BIM in regards to the CWMF is when it comes to conflict resolution. A 3D Model allows numerous sections and elevations to be easily generated. This enabled the designer to see where problems are and potential M&E clashes can be identified and eliminated. This in turn will result in less conflict management on site. Also by examining specific tasks on site, through associated 4D software packages, will allow the Project Manager to give priority on site to the assigning of resources and logistics.

General Observations

The interviewee explained that BIM can help the designer when it comes to safety through the power of enhanced visualisation.

4.6.5 Interview Five – Client (Department of Education and Skills)

Specific observations on BIM meeting the objectives of the CWMF

The DoES representative observed that the greatest benefit of BIM was cost certainty and conflict resolution. He was impressed with how sophisticated and refined the design can be. He detailed how having accurate weather input would allow more efficient buildings to be designed. He also added that he was quite impressed by the input of the quantity surveyors, at such an early stage.

General Observations

The DoES representative reported that they would like to see handover documentation eventually provided in a BIM format, which would be available to all service engineers. He added that given the fact that the DoES do not employ Facility Managers, but instead relies on principal teachers and the Board of Management for building maintenance, makes the aim of ensuring appropriate infrastructure for learning environments more difficult.

4.6.6 Industry Presentations

A subsequent presentation was given by a representative of the OPW in late 2011, which was a useful summary of the status that the OPW held in respect of BIM at that time.

The OPW noted that despite the apparent benefits that BIM would have on publically funded projects under their remit, it would still require “an act of faith” for the Irish Government to fully embrace it. There were a number of challenges noted by the OPW representative. The structure of the OPW was made up of between six or seven different departments with only two or three departments of a technical nature. Despite this there was at the time consensus that the OPW was prepared to invest in BIM software and appropriate computing hardware. At the time this was the biggest investment in IT in the past ten years. It was observed at the time that the majority of the other departments within the OPW were oblivious to the potential that BIM could bring to the management of the public sector estate. The OPW representative acknowledged that a great advantage of BIM was that it works in a collaborative environment. It was also acknowledged that the GCCC forms of contracts, has not improved this collaboration and, if anything, has made things more conformational. In addition, it was noted that an adversarial culture was compounded by the collapse of the banking sector and general depressed state of the economy in 2011.

The OPW representative was of the opinion that a fundamental change in OPW culture was required. Instead of the seven current departments, there might potentially be one large department with all the buildings potentially detailed on a BIM based database.

A number of presentations were given by members of the workshop to different industry groups. In particular, a presentation was given by certain delegates of the workshop to the GCCC detailing the results of the pilot. The delegates explained how the workshop derived results across all sectors and disciplines and strongly advocated the application of BIM to become mandatory on future public works projects. It was explained how the BIM model helped identify eventualities that may occur on site and subsequently aided in avoiding these eventualities. It was conveyed how the BIM process added a greater cost certainty and reduced a significant amount of the design risk associated with contractor's cost. Through the collaborative process of everyone working on the same model this enabled the design team to see what the other disciplines where doing and fostered a greater team ethic throughout the design process. The delegation detailed how the workshop enabled the design team to identify areas of possible clash detection and instantly confront them before they went to site. This, in turn, resulted in the reduction of conflicts and Requests for Information (RFI's), which were very expensive on site. The workshop team explained that the project manager by examining specific tasks on site, through a BIM model, allowed them to prioritise on site, which resulted in a better, well thought out and managed building. There was also the benefit from extracting digital data directly from the model, on each component, to develop a digital management tool to aid the Facilities Management process.

4.7 CONCLUSION

Based on the interviews and industry presentation the objective of the CWMF were revisited. The answers from the different workshop interviewees with respect to the five goals of the CWMF were cross referenced with each other. The findings from the cross reference of the interviews were complimented with the findings from the industry presentation. It was found through the analysis of the workshop, that BIM could help address in part the following specific goals of the CWMF:

1. **Greater cost certainty**- BIM provided a greater cost certainty at contract award stage, as the mass model studies allowed design teams to design to a cost, rather than cost to a design. The pilot team were in agreement on this and believed that BIM can help ensure greater cost certainty and conflict resolution. It was noted in the pilot that BIM can help take away a lot of design risk through its visualisation functionality.
2. **Award contracts on the basis of a lump-sum fixed-price** - The BIM model provided exercises in design, programming, cost and value management and concept energy analysis for the pilot team. The QS was involved earlier in the design process, in order, to draft estimate costs for the project. It was observed in the pilot that eventualities could be assessed and eliminated. This allows a more accurate financial assessment for a contract with a fixed price.

3. **Rebalance the risk** - The risk factor was better predicted by having a virtual model, which enabled clash detection. The design team in the pilot identified areas of possible clash detection and generated digital RFIs in response to this. The contractor predicted with more accuracy and, therefore, was in a stronger position to absorb the risk.
4. **Value for Money** - BIM enabled a whole life cycle approach, through its unique access to a combination of energy analysis tools that complement the BIM process. This approach offered much greater value for money to the client, as it addressed his/her needs over the structures life. This was seen through the creation of 4 distinct models that were easily assessed for CO_2 emissions before the most preferred design was selected.
5. **Efficient delivery of the projects** – BIM enablesd testing of design solutions to provide a more responsive building design to the client brief, and, better coordination of all project information.

The pilot represented a tentative, but nonetheless important first step on Ireland's journey of discovery towards obtaining further knowledge in regards to BIM. The workshop promoted BIM and showcased its use to senior members of the construction industry and the public sector. The participants where universally positive about the impacts that BIM could have on their profession and in realising the goals of the CWMF. There was agreement that these technologies could assist the public sector contracts, as BIM has the capacity to ensure that all team members are working from the same data and that the implications of alternative design proposals could be evaluated with comparative ease. The workshop participants were of the opinion that the UK Government's move to demand BIM Level 2 by 2016 will lead to the elimination of coordination errors and subsequent expensive variations. The key lesson learnt from the pilot included that BIM can have a place in the Irish AEC, but was still a relatively unknown entity.

Though the results were extremely positive, all representatives admitted that it would be a number of years before BIM could be deployed on public sector projects in Ireland. A significant restructuring of organisations like the OPW would be required and a substantial act of support from the heads of Government would be necessary. The workshop attendees criticised a notable lack of incentive from the Government and a reluctance to incorporate more change, due to the recent introduction of the GCCC forms of contract, as possible barriers. This fact, coupled with the fear of legal implications, such as, who owns the BIM model and which profession will carry most liability for the model, had left the Irish AEC/FM sector in an uncertain stance towards the implementation of BIM on public works.

4.9 FURTHER STUDY

The pilot participants represented only a small cross section of the AEC sector who were all firmly in favour of BIM. The results did not reflect the general Irish AEC/FM population in Ireland and further research was needed to gain an understanding of the industries awareness. It was agreed that the best approach would be to conduct an extensive survey aimed at a disparate cross-section of the AEC/FM Sector. This would enable the collection and strong analysis of quantitative data. Chapter 5 contains the approach and analysis of the survey results.

The findings from this stage of the research provided the author with the confidence that his proposed research topic was achievable. Due to the lack of research and knowledge in the domain of BIM within Ireland at the time, it was important that this exploratory research was performed, so as to ensure there was an adequate cultural and technical platform available to establish and validate the KPTs.

5. BIM IN IRELAND SURVEY 2012

5.1 INTRODUCTION

The previous chapter focused on the first phase of the research in the sequential design concentrating on a qualitative case study, where the use of BIM was observed on a simulated public works pilot project. The author concluded that BIM can offer a more rewarding methodology for the Irish public sector in both the design and management of its assets. These findings were also evident in the literature review conclusion in Chapter 2. As detailed in Chapter 4 the workshop analysis did not reflect the general Irish AEC/FM population and further research was needed to gain an understanding of the industries awareness. The further validation of the workshop results ensured that any bias that may have been represented in the data was further evaluated.

This chapter presents the results of the next phase of the research, which involved a questionnaire survey on the use of BIM in Ireland in 2012. The results show that the Irish construction industry was at a very early stage of adoption and knowledge of BIM at that time. The findings show that whilst there was a significant level of awareness of BIM in Ireland in 2012, the AEC/FM sector was still uncertain, as to the exact definition of BIM, and its direct relevance for the FM sector. It was, however, acknowledged that there would be an increasing importance placed on BIM within the next 5 years in Ireland. Given the presence of the UK BIM mandate and its introduction in 2016, the author also took the opportunity to compare the results of this survey with the National Building Specification (NBS).

5.2 METHODOLOGY

The survey methodology involved a two tier approach comprising of a planning and implementation phase, which is illustrated in figure 5.1.

5.2.1 Planning process

The planning process was further broken into four different tasks that included:

1. Selection of research question.
2. Overall presentation to sample.
3. Consideration of ethics.
4. Design of survey sample

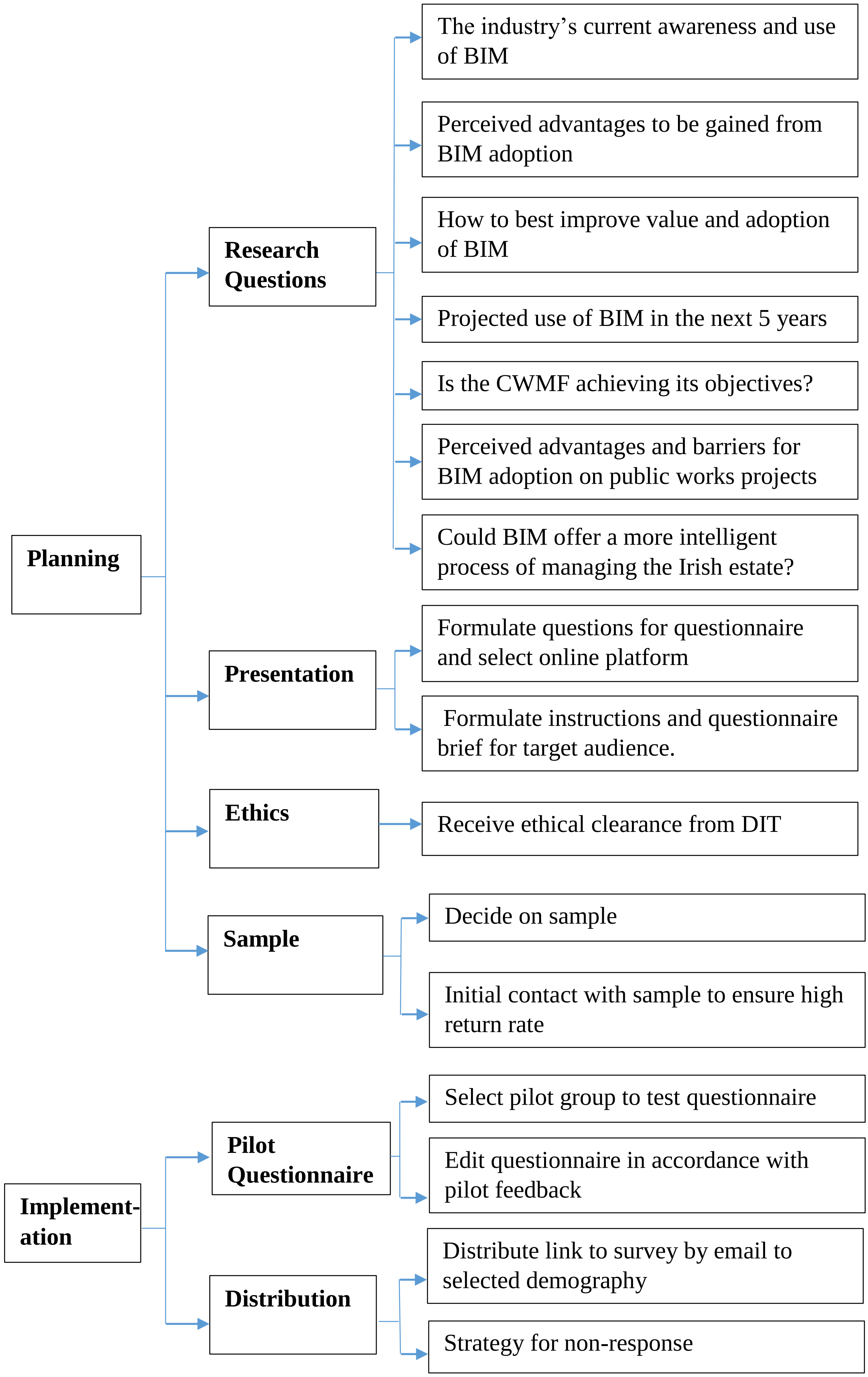


Figure 5.1 BIM in Ireland Survey Design (Adopted from Hore, 2010 pp 85)

Creswell (2009) suggested key criteria to be addressed during any survey design. These included

- **Identify the purpose of the survey research:** The purpose of the survey was to gauge the level of support for the introduction of BIM to assist in achieving the vision of the CWMF.
- **Identify why a survey is the preferred type of data collection procedure for the study:** This method represented the preferred tool in collecting a large sample of data for analysis.
- **Indicate whether the survey will be cross sectional or longitudinal:** A cross-sectional type survey was chosen, as this will be a single time description.
- **Specify the form of data collection i.e. self-administered, questionnaires, interviews and structured observations.** For the purpose of this survey questionnaires were selected as the main tool for data collection.

The findings of the literature review in Chapter two, combined with the lessons learned from the RIAI/DoES pilot outlined in Chapter four, provided the basis for the research questions. The research questions focused on three key areas, namely:

1. Establish the current adoption level of BIM and its perceived importance in the near future in Ireland.
2. Investigate the respondent's experiences, within public sector projects, with particular reference to the CWMF. Also explore if BIM could offer a more rewarding alternative to what was currently in place.
3. The final section focused on BIM in regards to managing the Irish Government Estate, with particular reference to the area of FM.

The questionnaire was structured specifically into the following four sections to complement the above research questions.

1. **Respondent Details:** All respondents were asked to indicate what sectors their organisation primarily operated within, their profession and the extent of their international work. In addition, they were asked about their current awareness and use of BIM.
2. **Use of CAD and BIM**: All respondents were asked what categories of CAD tools would their business utilise and to indicate their level of support in regards to improving the value and adoption of BIM within the Irish AEC / FM Sector.

Respondents were also asked what they believed their projected use and overall importance of BIM will be within the next 5 years.

3. **Use of BIM on Public Sector**: This section provided a filter to distinguish which respondents have experience of working within the CWMF. This was linked to validating the outcomes of the pilot study collated in Chapter 4.
4. **The Government Estate and BIM:** All respondents were asked if BIM can offer a more efficient alternative in regards to the management of the Irish public sector estate in respect to carbon, and operations and maintenance (O&M) benefits. Once again these questions were linked to validating the outcomes of the pilot study collated in chapter four.

Presentation

An online questionnaire was created through the Survey Monkey resource. A background to each section of the survey was embedded into the online questionnaire, in order to ensure that respondents were fully aware of the purpose of the survey. The survey monkey resources also provided functionality that made it easier to capture and analyse survey responses.

Ethics

All research students in the Dublin Institute of Technology (DIT) were required to comply with DIT Research Ethics guidelines. This promoted good ethical research and scholarly practice, emphasising integrity and rigour. This process involved gaining approval for cover letters/emails that accompanied online surveys, and completion of risk statements, in advance of the distribution of the questionnaire. After consultation with the DIT Ethics Committee approval was given to send out the questionnaire.

Sample

The author chose not to limit the survey to professionals within the AEC/FM Sector, but to extend it out to educational and IT sectors also. It was agreed to utilise the CitA member database, which consisted of 141 members, which catered for a broad cross-section of stakeholders within the Irish AEC/FM and training sector. A sample size of 113 organisations were chosen from this database. This sample represented a balanced representation of the industry, as not all of the organisations in the CitA database were practicing or had even heard of BIM. BIM at the time was viewed as a high level approach and a number of organisations did not have any knowledge of the technology or processes involved. The main

CitA contact within that organisation was emailed a link to access and complete the survey. A total of 90 responses were received with table 5.1 summarising the response distribution from each sector. The selected companies contacted can be located in Appendix 2.

Sector	**%**
Architecture	27%
Quantity Surveying	13%
Contractors	13%
Engineering	15%
Consulting	10 %
Suppliers	1%
Facilities Managers	6.%
Training and Education	11%
IT Vendors/Business Service	5%

Table 5.1: Responses to BIM in Ireland Survey 2012

The response represented a balanced distribution of the sample, with the exception of architecture, which was the most responsive grouping. From the author's perspective this was both encouraging and understandable given the proactivity evident in the previous chapter in the RIAI community.

5.2.2. Implementation process

The implantation phase focused on the piloting and formal distribution of the questionnaire.

<u>Pilot Questionnaire</u>

An online pilot survey was initially distributed to a small number of knowledgeable BIM persons in Ireland. Two members from the RIAI Workshop (detailed in chapter four) and two senior academics were selected to complete a pilot survey. The pilot survey is located in Appendix 2. The main feedback included deleting question three which asked the respondent to indicate what geographical region they worked in. Further requests for change included question 6 where the wording was edited. Question 10 was also reworded to add a further option of "we do not intend to invest in BIM software in the next 5 years". It was also suggested that question 14 needed to be more specific in regards to exactly what was happening in the UK in relation to the mandate in 2016, as references to BIM techniques were not clear. The remaining suggestions included information on typos and the need to spell out acronyms. Overall the survey pilot team did not object to any questions and believed it was formatted in such a way where expert BIM knowledge was not necessary.

Distribution and Response

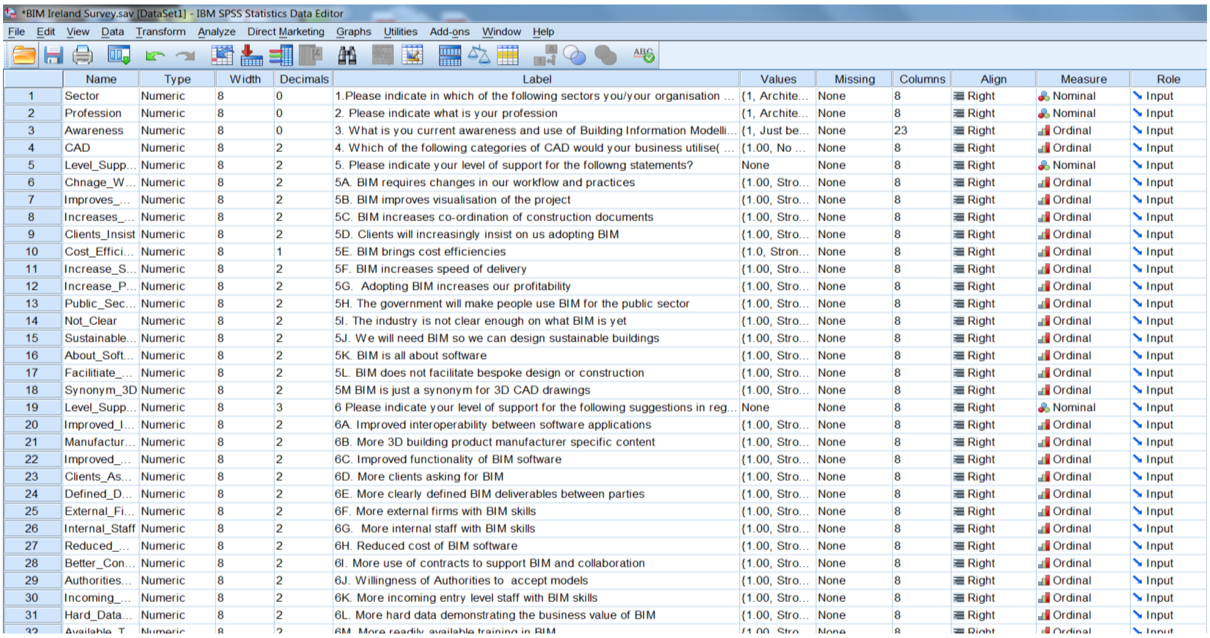
As detailed previously a total of 113 organisations were selected from the CitA membership community to partake in a survey. A total of 90 responses were received. As the survey did not request participant contact information and multiple responses could be completed per organisation, it was difficult to ascertain the number of individual organisations that replied. However, as IP addresses were recorded and given that they are unique for an organisation, it can be estimated that a total of 72 different organisations replied to the survey. A date was fixed for completion of the survey which the author extended by ten days in order to generate more responses. The implementation phase focused on the piloting and distribution of the questionnaire.

5.3 QUESTION SELECTION

The author chose that questions would predominantly be asked within, a closed ended format, as it was felt given the unfamiliarity from some of the sample in regards to BIM, that an open ended format could prove to be too demanding. As this survey was intended to feed into a more detailed FM focused survey, it was decided that close ended questioning would make the analysis less challenging. However, one open ended question was included to ensure those who had used or were aware of BIM had an opportunity to provide some qualitative feedback. The closed nature of the questions was purposefully varied, ranging from closed-ended with ordered choices and partially closed-end questions. Some of the questions were designed on a contingency basis, so that they were only applicable to a certain section of the respondents who met the set credentials. The questionnaire is presented in Appendix 2.

5.4 METHOD OF RESULTS

The author used the programme IBM SPSS Statistics 21 to analyse his results. This programme was a DIT nominated analytical software used for analysing survey results. This software providesd the entire analytical process, from planning to data collection to analysis, reporting and deployment. The first step was to input the results of the actual survey into this programme. A screenshot of this process is shown in figure 5.2. The process for using this software can be found in Appendix 2.



	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Sector	Numeric	8	0	1.Please indicate in which of the following sectors you/your organisation ...	{1, Archite...	None	8	Right	Nominal	Input
2	Profession	Numeric	8	0	2. Please indicate what is your profession	{1, Archite...	None	8	Right	Nominal	Input
3	Awareness	Numeric	8	0	3. What is you current awareness and use of Building Information Modelli...	{1, Just be...	None	23	Right	Ordinal	Input
4	CAD	Numeric	8	2	4. Which of the following categories of CAD would your business utilise(...	{1.00, No ...	None	8	Right	Ordinal	Input
5	Level_Supp...	Numeric	8	2	5. Please indicate your level of support for the followng statements?	None	None	8	Right	Nominal	Input
6	Chnage_W...	Numeric	8	2	5A. BIM requires changes in our workflow and practices	{1.00, Stro...	None	8	Right	Ordinal	Input
7	Improves_...	Numeric	8	2	5B. BIM improves visualisation of the project	{1.00, Stro...	None	8	Right	Ordinal	Input
8	Increases_...	Numeric	8	2	5C. BIM increases co-ordination of construction documents	{1.00, Stro...	None	8	Right	Ordinal	Input
9	Clients_Insist	Numeric	8	2	5D. Clients will increasingly insist on us adopting BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
10	Cost_Effici...	Numeric	8	1	5E. BIM brings cost efficiencies	{1.0, Stron...	None	8	Right	Ordinal	Input
11	Increase_S...	Numeric	8	2	5F. BIM increases speed of delivery	{1.00, Stro...	None	8	Right	Ordinal	Input
12	Increase_P...	Numeric	8	2	5G. Adopting BIM increases our profitability	{1.00, Stro...	None	8	Right	Ordinal	Input
13	Public_Sec...	Numeric	8	2	5H. The government will make people use BIM for the public sector	{1.00, Stro...	None	8	Right	Ordinal	Input
14	Not_Clear	Numeric	8	2	5I. The industry is not clear enough on what BIM is yet	{1.00, Stro...	None	8	Right	Ordinal	Input
15	Sustainable...	Numeric	8	2	5J. We will need BIM so we can design sustainable buildings	{1.00, Stro...	None	8	Right	Ordinal	Input
16	About_Soft...	Numeric	8	2	5K. BIM is all about software	{1.00, Stro...	None	8	Right	Ordinal	Input
17	Facilitiate_...	Numeric	8	2	5L. BIM does not facilitate bespoke design or construction	{1.00, Stro...	None	8	Right	Ordinal	Input
18	Synonym_3D	Numeric	8	2	5M BIM is just a synonym for 3D CAD drawings	{1.00, Stro...	None	8	Right	Ordinal	Input
19	Level_Supp...	Numeric	8	3	6 Please indicate your level of support for the following suggestions in reg...	None	None	8	Right	Nominal	Input
20	Improved_I...	Numeric	8	2	6A. Improved interoperability between software applications	{1.00, Stro...	None	8	Right	Ordinal	Input
21	Manufactur...	Numeric	8	2	6B. More 3D building product manufacturer specific content	{1.00, Stro...	None	8	Right	Ordinal	Input
22	Improved_...	Numeric	8	2	6C. Improved functionality of BIM software	{1.00, Stro...	None	8	Right	Ordinal	Input
23	Clients_As...	Numeric	8	2	6D. More clients asking for BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
24	Defined_D...	Numeric	8	2	6E. More clearly defined BIM deliverables between parties	{1.00, Stro...	None	8	Right	Ordinal	Input
25	External_Fi...	Numeric	8	2	6F. More external firms with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
26	Internal_Staff	Numeric	8	2	6G. More internal staff with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
27	Reduced_...	Numeric	8	2	6H. Reduced cost of BIM software	{1.00, Stro...	None	8	Right	Ordinal	Input
28	Better_Con...	Numeric	8	2	6I. More use of contracts to support BIM and collaboration	{1.00, Stro...	None	8	Right	Ordinal	Input
29	Authorities...	Numeric	8	2	6J. Willingness of Authorities to accept models	{1.00, Stro...	None	8	Right	Ordinal	Input
30	Incoming_...	Numeric	8	2	6K. More incoming entry level staff with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
31	Hard_Data...	Numeric	8	2	6L. More hard data demonstrating the business value of BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
32	Available_T...	Numeric	8	2	6M. More readily available training in BIM	{1.00, Stro...	None	8	Right	Ordinal	Input

Figure 5.2 SPSS View of BIM in Ireland Survey 2012

5.4.1 Analysis of Results

The author adopted a descriptive method of analysing the results. A number of questions were analysed using cross tabulation and, in some instances, rank correlation was used. Cross tabulation allowed an understanding of different, but related, questions within different sectors and rank correlation measuring the degree of similarity between two sectoral groupings within the sample.

Q1. Please indicate in which of the following sectors you/your organisation primarily operate?

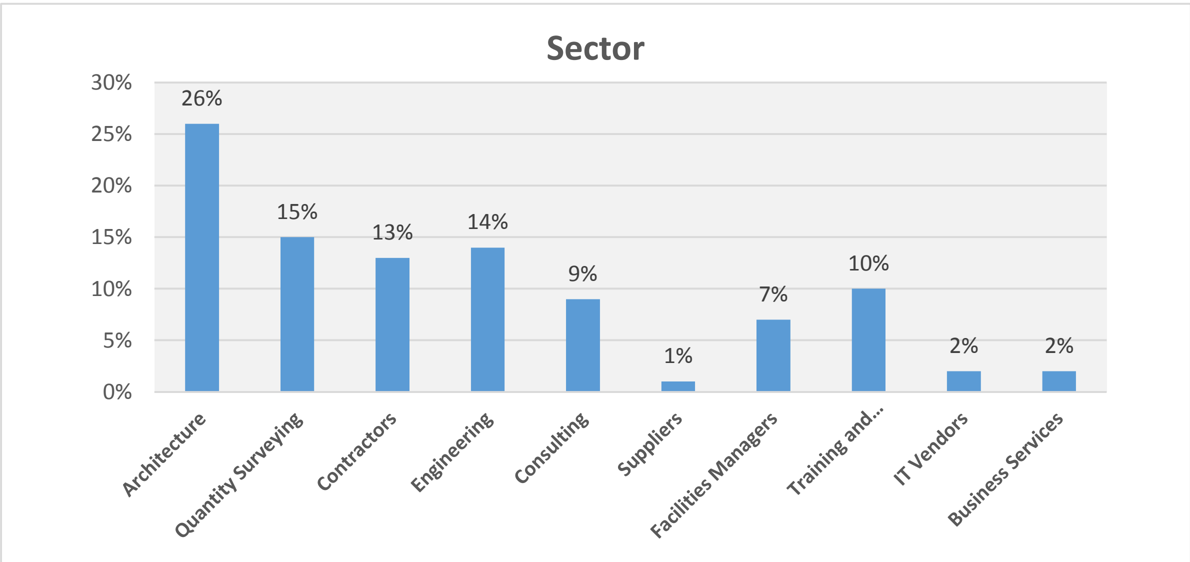


Figure 5.3: Distribution of BIM in Ireland Survey 2012

This closed question with ordered choices enabled respondents to be placed into different sectors, so that cross tabulation can be performed.

From the analysis of the results the following observations were made.

1. The greatest response rate came from the architecture sector which represents 26% of the survey population. A further 51% consists of the key professions of Quantity Surveying (QS), engineering, consultants and contractors. The remaining 23% was predominately made up of Facility Managers and professionals within the training and education sector. The results are illustrated in Figure 5.3.

Q2. Please indicate what your profession is?

This partially close ended question enabled a further breakdown of the professionals that responded to the survey, therefore helping to understand how BIM is perceived in individual professions. The results are illustrated in Figure 5.4.

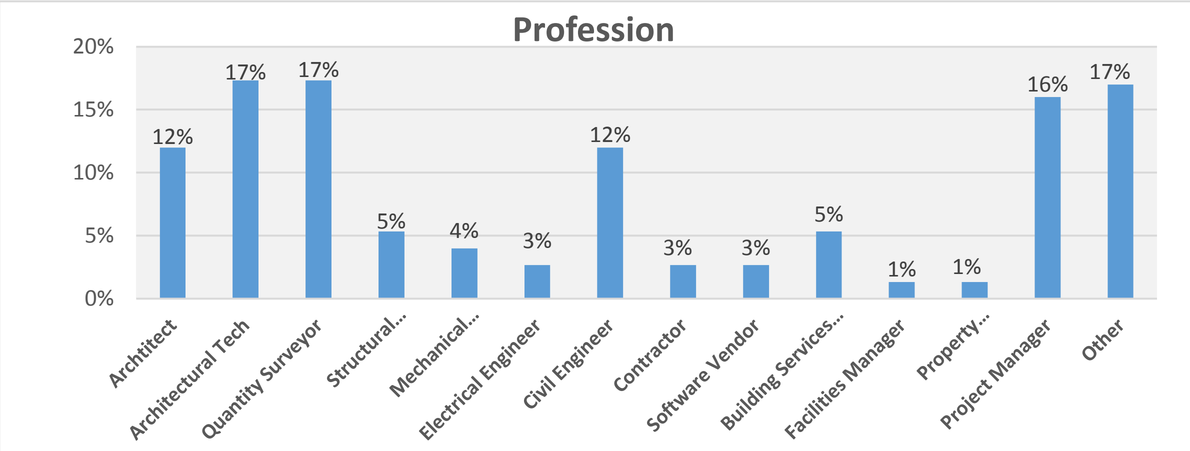


Figure 5.4: Professional breakdown of the survey sample for the BIM in Ireland survey

From the analysis of the results the following observations were made.

1. The greatest response was generated from the architectural technologist and QS profession who both had 17% of the response rate. The project management profession represented 16% of the survey return, with both architects and the civil engineering professions contribution 12% each to the makeup of the survey.
2. A cross tabulation was performed in IBM SPSS on the results from the chosen sector against the stated profession. The results are shown in table 5.2.

		2. Please indicate what is your profession														
		Architect	Architectural Tech	QS	Structural Engineer	Mechanical Engineer	Electrical Engineer	Civil Engineer	Contractor	Software Vendor	Building Services Engineer	Facilities Manager	Property Developer	Project Manager	Other	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	8	12	0	0	0	0	0	0	0	0	0	0	2	1	23
	Quantity Surveying	0	0	12	0	0	0	0	0	0	0	0	0	1	0	13
	Contractors	0	0	1	0	0	0	2	1	0	2	0	0	1	4	11
	Engineering	0	0	0	1	2	1	4	0	0	1	0	0	1	1	11
	Suppliers	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
	Facilities Managers	0	1	0	0	1	0	0	0	0	0	2	0	2	0	6
	Training and Education	1	0	0	0	0	1	1	0	1	0	0	0	2	3	9
	IT Vendors	0	0	0	0	0	0	0	0	1	0	0	0	0	1	2
	Business Services	0	0	0	0	0	0	0	1	0	0	0	1	0	0	2
	Consulting	0	1	0	3	0	0	1	0	0	1	0	0	2	0	8
Total		9	14	13	4	3	2	8	2	2	4	2	1	11	11	86

Table 5.2: Cross Tablulation of chosen professional sector against stated profession for BIM in Ireland Survey

The results show that the architecture and QS section was as expected made up of architectural technologists, architects and QS respectively. A small group of three project managers, placed themselves as working within these sectors. A further 13% represent the contractor group who were scattered throughout in differing professional categories. The engineering group broadly broke down into structural, mechanical, electrical and building services engineers, with the civil engineers having the strongest presence. The FM group represented 7% overall and were from a varied professional background. As previously discovered in the literature the FM profession was facing an identity crisis, as it consisted of the makeup of numerous professions (Price, 2001, Grimshaw, 2007, Jay and Ooi, 2001, Mobley and Khuncumchoo, 2006, and Coenan et al., 203). These views were aligned with how the FM profession was perceived in Ireland. The 10% within the training and education sector consisted of engineers, project managers, architects and software vendors. This sample also proved that there was a balanced distribution of the sample.

3. The other professions that were manually inputted through the “Other” option include a number of IT consultants, accountant, marketing, structural steel detailer, planning officer and draughtsman to name a few

Q3 What is your current awareness and use of Building Information Modelling (BIM)?

This closed question with ordered choice was presented to better understand the respondent's level of BIM awareness. The results are illustrated in Figure 5.5.

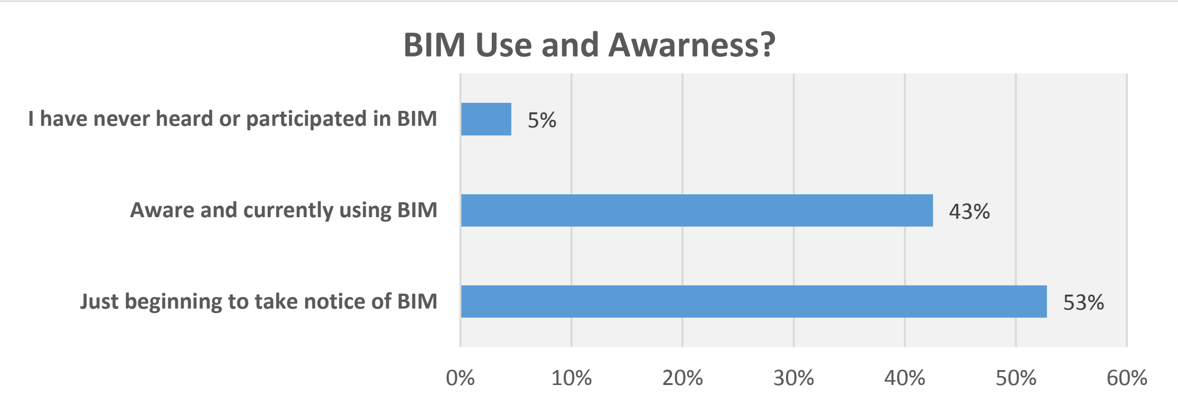


Figure 5.5: BIM use and awareness of respondents within the BIM in Ireland survey 2012.

From the analysis of the results the following observations were made.

1. The results from this question were quite balanced with 43% stating that they were aware of and using BIM compared to 53% reporting that they were just beginning to take notice of BIM. 5% of the sample surprisingly reported not to have heard of BIM. Comparing these results to a survey carried out by the NBS (2012) for the UK, it was found that BIM awareness was at 54% for those just aware of BIM and 39% for those who were aware and currently using BIM. The similarities in results was encouraging from an Irish perspective moving forward. Compared to internationally, as evident from the NBS International BIM Report (2013), Irelands awareness at that time was behind Canada (64%), Finland (65%) and New Zealand (57%).
2. A cross tabulation was performed in IBM SPSS on the results from the chosen sector against current BIM awareness. The results are shown in table 5.3

		3. What is you current awareness and use of Building Information Modelling (BIM)?			
		Just beginning to take notice of BIM	Aware and currently using BIM	I have never heard or participated in BIM	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	12	9	1	22
	Quantity Surveying	10	3	0	13
	Contractors	7	4	0	11
	Engineering	3	5	3	11
	Suppliers	0	1	0	1
	Facilities Managers	4	1	0	5
	Training and Education	5	4	0	9
	IT Vendors	0	2	0	2
	Business Services	1	1	0	2
	Consulting	3	5	0	8
Total		45	35	4	84

Table 5.3: Cross tablulation of chosen professional sector against current BIM awareness in Ireland.

The architecture and engineering sectors both reported that they were aware and currently using BIM. In regards to the architecture sector, this result was expected given that BIM was viewed predominately as a design tool. The training and education sectors also featured as having a high level of awareness which would be expected given their core activity is developing skills in BIM. The majority of respondents, however, reported that they were only beginning on their journey with BIM.

The results conclude that there was a relatively strong awareness of BIM within the survey sample.

Q4. Which of the following categories of CAD would your business utilise?

This partially closed question sought to formulate an understanding within the sample as to the level of use of CAD and BIM. The results are illustrated in Figure 5.6.

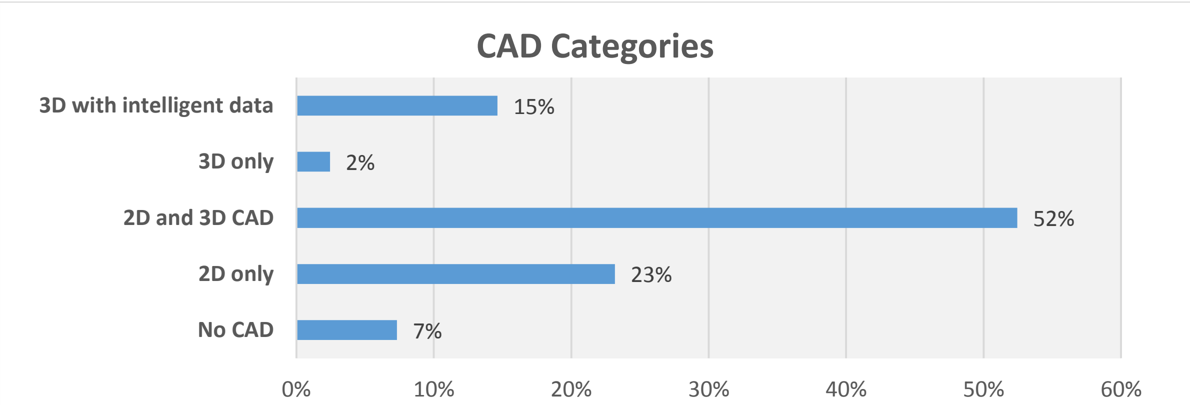


Figure 5.6: The different levels of CAD and BIM practiced by respondents in the BIM in Ireland survey 2012

From the analysis of the results the following observations were made:

1. A total of 54% of respondents reported using 3D CAD in some form. Only 15% reported usage of 3D CAD with intelligent data i.e. BIM.
2. The results would contradict the earlier reported figure of 43% of respondents that claim to be using BIM. This could indicate that a large sample of the survey believe that through the use of 3D design tools they were participating in the BIM process. This would further indicate that the industry was still not aware of what BIM truly is and has confused it with 3D CAD.
3. A cross tabulation was conducted on the BIM awareness and CAD usage. Table 5.4 shows the respondents that indicated previously that they were aware and using BIM did not associate this with use of intelligent data.

		4. Which of the following categories of CAD would your business utilise(Multiple Answers Permitted)?						
		No CAD	2D only	2D and 3D CAD	3D only	3D with intelligent data	Other	Total
3. What is you current awareness and use of Building Information Modelling (BIM)?	Just beginning to take notice of BIM	4	16	20	1	1	2	44
	Aware and currently using BIM	2	1	19	1	11	0	34
	I have never heard or participated in BIM	0	1	3	0	0	0	4
Total		6	18	42	2	12	2	82

Table 5.4: Cross tablublation on respondents BIM awareness against current their type of CAD and BIM usage.

4. Respondents who had reported in the previous question that they were not using CAD indicated they were involved in other areas of the BIM process that did not relate to using 3D design tools. Some respondents who also practiced 3D CAD stated they have not heard or participated in BIM.
5. The results suggested that a more accurate assessment would indicate that 16% of the industry was practicing true BIM related practices, while 25% were involved in some form of 3D modelling practices.

Q5 Please indicate your level of support for the following statements?

This closed question, with ordered choices, presented a number of statements for respondents to consider. These statements were based on previous data collated. The list of statements and results are illustrated in figure 5.7.

From the analysis of the results the following observations were made.

1. A number of statements were designed to gauge the level of BIM awareness of the survey sample. The mean for each choice is shown in table 5.5. The closer the value is to 1 means that the respondents were in strong agreement while the closer the value is to 5 means that they where is strong disagreement.

	5A.	5B.	5C.	5D.	5E.	5F.	5G.	5H.	5I.	5J.	5K.	5L.	5M.
Mean	1.704	1.610	1.667	2.390	2.111	2.220	2.488	2.415	1.988	2.753	3.585	3.683	3.988
N	81	82	81	82	81	82	82	82	82	81	82	82	82
Std. Deviation	.7322	.6805	.6124	.9130	.8062	.8892	.9060	.9552	.7453	.9815	.9680	.8872	.9362

Table 5.5: The mean value for researched findings commonly associated with BIM

Results from table 5.5 show that the large majority were in agreement that BIM improves visualisation (5B), increases co-ordination of documents (5C) and brings cost efficiencies (5E). These were obvious and well known benefits of BIM. The sample also disagreed that BIM is not a synonym for 3D drawings (5M) and is not just software (5K), which despite previous assumptions indicated that the sample was aware that BIM is a process and not just a tool. A large section agreed that the industry was not clear on the exact meaning of BIM (5L). Results further show that if BIM was to become mainstream then there will need to be a change to current workflows and practices (5A). These were important concerns and demonstrate some of the reservations the industry had at the time of the survey.

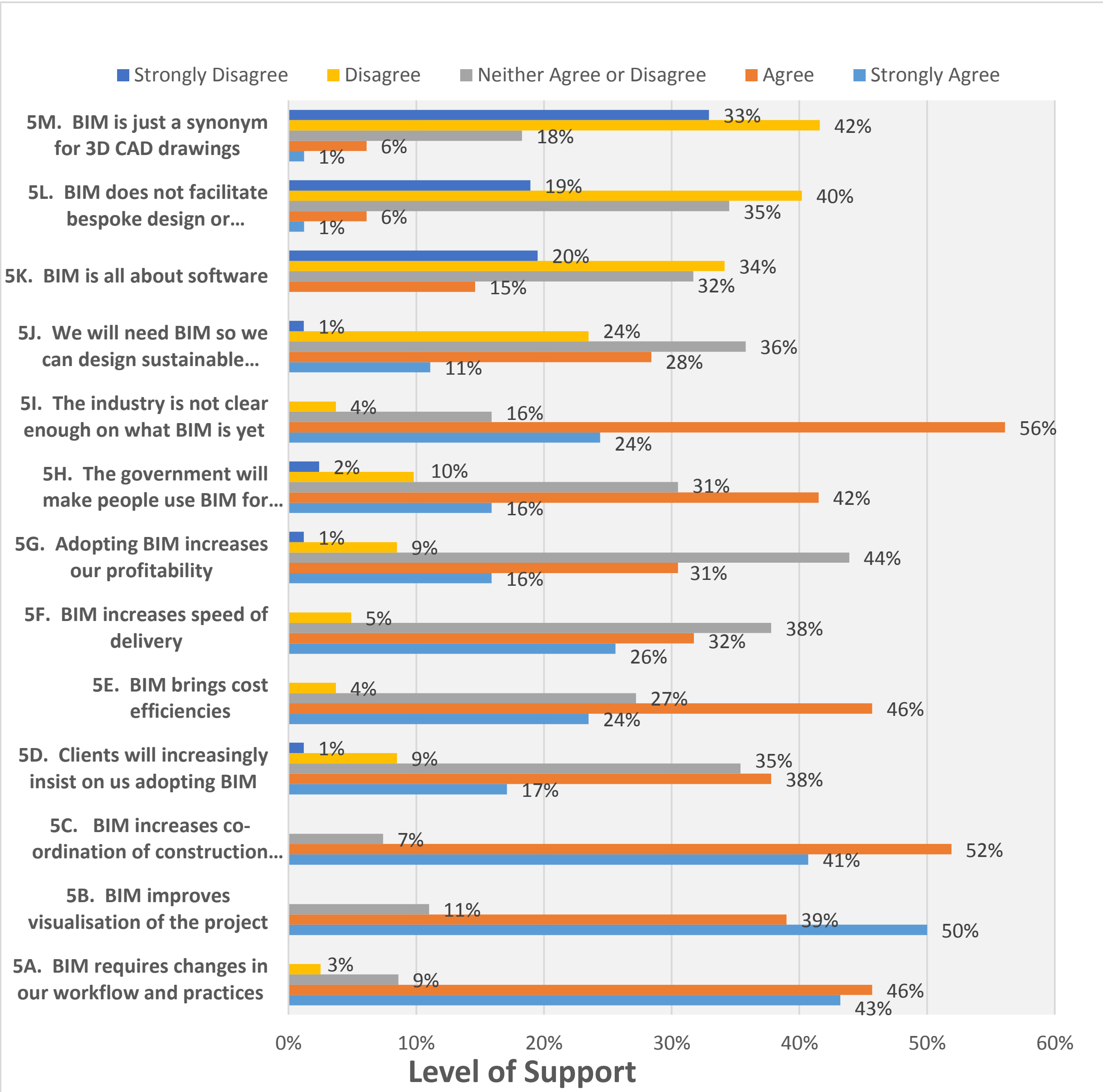


Figure 5.7: Level of support for researched findings commonly associated with BIM in Ireland Survey 2012

The Irish AEC sector in general as seen through the analysis was in agreement towards the benefits of BIM that have been previously voiced by Eastman et al., (2011), Godager. (2011) and Azhar. (2011). These benefits range from earlier collaboration, increased design efficiency and better value for money.

Q6 Please indicate your level of support for the following suggestions in regards to improving the value and adoption of BIM within the Irish AEC / FM Sector.

This partially closed question sought to understand what actions would best serve in helping to increase BIM awareness and adoption within the Irish AEC/FM sector. These statements were based on previous data collated. The list of statements and results are illustrated in Figure 5.8.

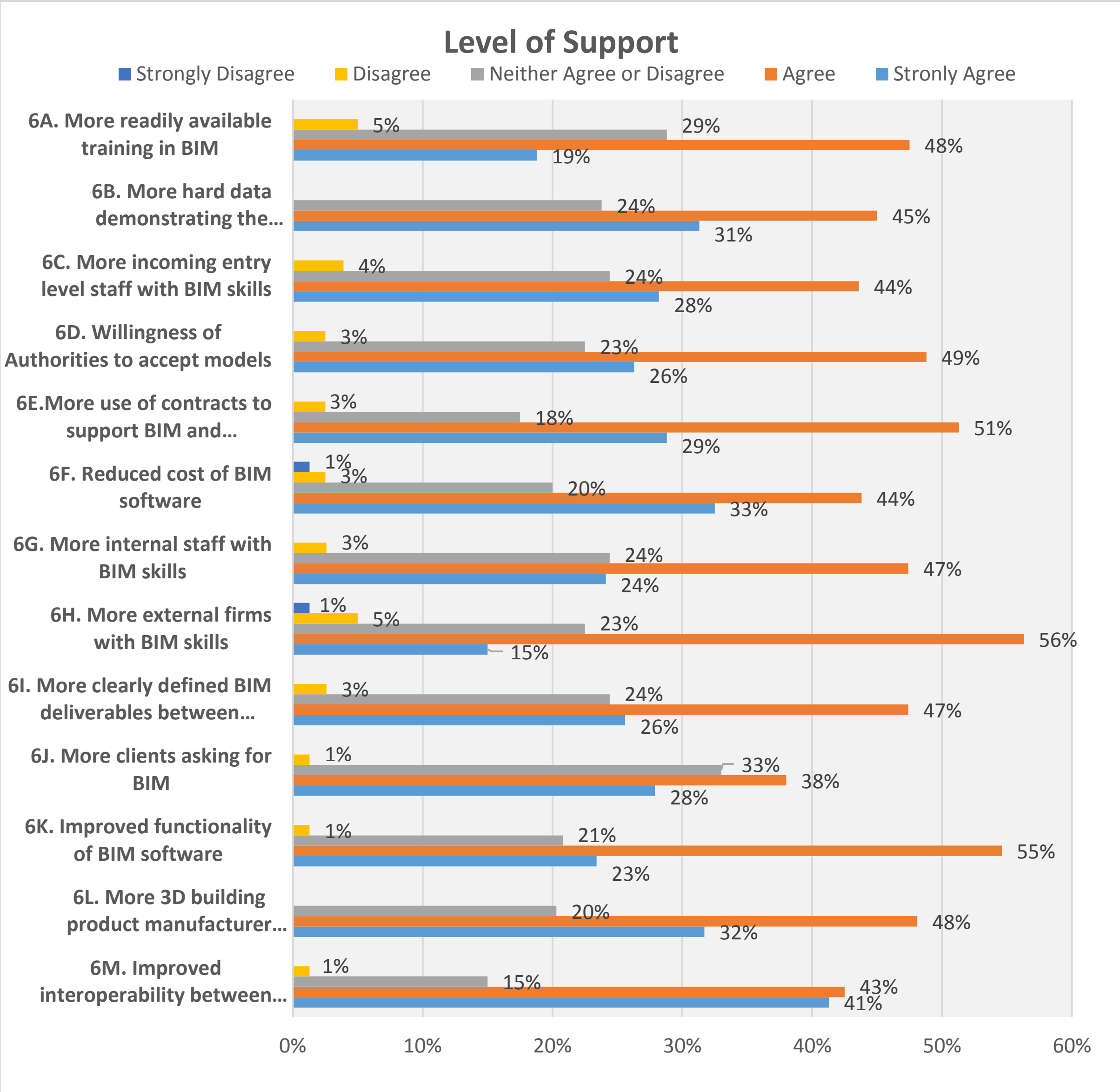


Figure 5.8: Level of Support for suggestions to better help increase BIM adoption within the BIM in Ireland Survey 2012

From the analysis of the results the following observations were made.

1. Respondents agreed strongly with the statements presented as indicated in Table 5.6.

	6A.	6B.	6C.	6D.	6E.	6F.	6G.	6H.	6I.	6J.	6K.	6L.	6M.
Mean	1.7625	1.8861	2.0000	2.0759	2.0385	2.2125	1.9241	1.9625	1.9375	2.0125	2.0385	1.9250	2.2000
N	80	79	77	79	78	80	79	80	80	80	78	80	80
Std. Deviation	.75042	.71589	.70711	.81291	.78031	.80652	.65579	.86337	.75211	.77122	.82874	.74247	.80190

Table 5.6: The mean value for suggested intiatives to increase BIM adoption

With such a strong agreement rate for all the suggested drivers it was difficult to suggest any key suggestions that were significantly preferred above others. The two primary drivers, as recognised through the best mean value in table 5.6, included the need for more readily available training in BIM (6A) and for further business case examples (6B). This was aligned to the findings of the previous questions in where it was discovered that the sample population would like further education on the clear meaning of BIM. The requirement for further education and case study examples would help address these concerns.

2. Some additional suggestions from respondents included the addition of BIM modules to current taught courses in 3rd level institutions; the need to invest in technical support for BIM; concern about the cost of software and the need for people to become more involved in understanding the process involved i.e. IPD and the need for the GCCC to actively look into the use of BIM on Irish PWCs.

Q7 What do you believe your projected use of BIM will be in 5 years?

The respondents projected use of BIM in their businesses in the next 5 years is illustrated in Figure 5.9.

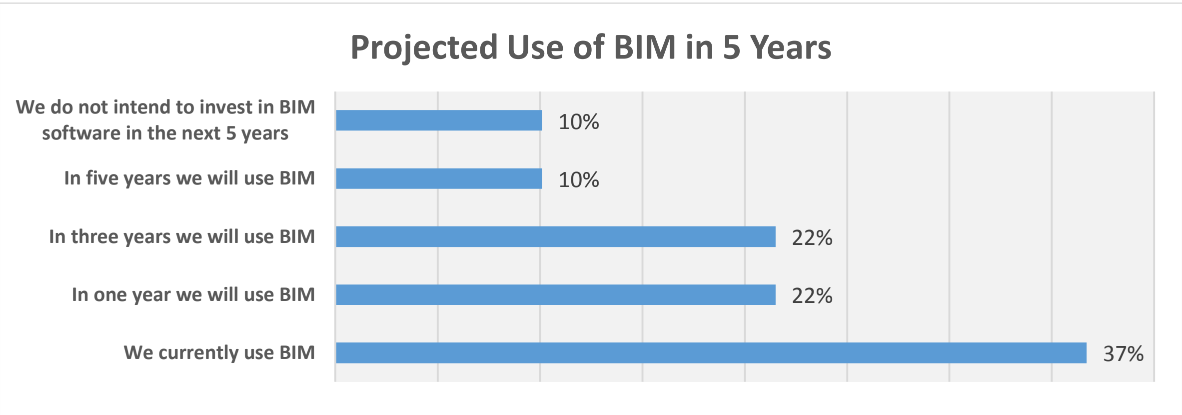


Figure 5.9: Projected use of BIM in 5 years from participants within the BIM in Ireland Survey 2012

From the analysis of the results the following observations were made.

1. The results show that 37% of respondents were currently using BIM. An encouraging 43% believed that they will be engaging with BIM in the next three years. 10% of the sample did not see the need to invest in BIM.
2. A cross tabulation was performed using SPSS on current BIM use and awareness against the projected use in 5 years. The results are detailed in table 5.7 below.

		7. What do you believe your projected use of BIM will be in 5 years?					
		We currently use BIM	In one year we will use BIM	In three years we will use BIM	In five years we will use BIM	We do not intend to invest in BIM software in the next 5 years	Total
3. What is you current awareness and use of Building Information Modelling (BIM)?	Just beginning to take notice of BIM	1	12	16	7	4	40
	Aware and currently using BIM	28	3	1	1	0	33
	I have never heard or participated in BIM	0	2	0	0	2	4
Total		29	17	17	8	6	77

Table 5.7: Cross Tabulation of the current BIM use and awareness against the projected use in 5 years

The cross tabulation highlights a number of inconsistencies in the results, with some respondents indicating that they were aware and using BIM, yet only intended to start to use it in the next 1-5 years. Also a small group despite, not hearing of BIM intend to use it in the next year. A more realistic figure was that 40 % were using BIM, with 17% expecting to use BIM in the next year, 23% expecting to use BIM in the three years, 10 % expecting to use BIM in the five years and 11% not intending to invest in BIM.

3. It can be concluded from the results that given the already established figure of 15% were truly using BIM processes, a remaining 74% of the industry plan to be using BIM technologies in the next 5 years. Comparing this combined 89% figure against the NBS survey (2012), the UK expect to have a 93% usage rate within 5 years. Given that the UK have had a five-year implementation plan in place, the figure proposed by Ireland appeared unrealistic. As evidenced from previous literature findings at that time Ireland was only taking tentative steps towards BIM. A proposed 5-year figure of 89% adoption rate was optimistic.

Q8 What do you believe the importance of BIM will be in in five years?

This partially closed question asked respondents to acknowledge what importance they believe BIM will have in the next 5 years. The results are shown in Figure 5.10

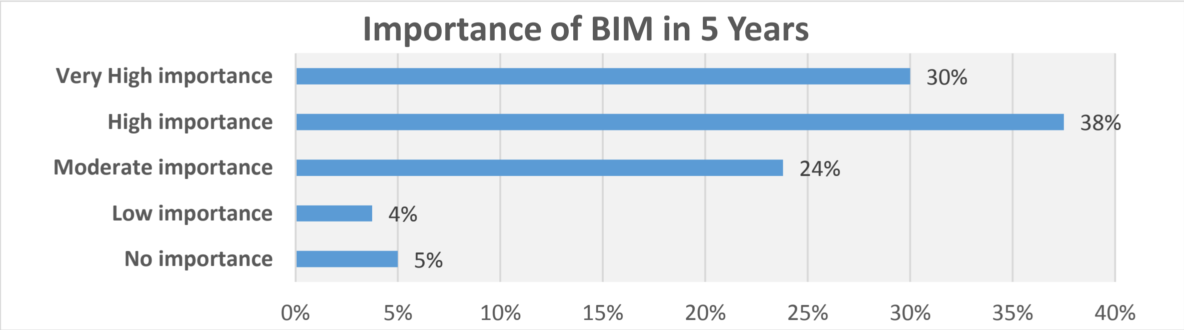


Figure 5.10: Projected importance of BIM in 5 years of participants within the BIM in Ireland Survey 2012

From the analysis of the results the following observations were made.

1. 68% of the survey sample believed that BIM would be of very high-to-high importance within the next 5 years. There was only 8.8% of the survey who indicated low to no importance.
2. A cross tabulation was performed in IBM SPSS to explore how the various sectors viewed the importance of BIM within the next 5 years. The greatest support streams from architecture section, with the remaining as contracting, engineering, training and education, as well as the FM sector also in support. Table 5.8 shows the support indicated from each sector.

		8. What do you believe the Importance of BIM will be in in five years?					
		Very High importance	High importance	Moderate importance	Low importance	No importance	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	10	5	6	1	0	22
	Quantity Surveying	1	8	0	1	1	11
	Contractors	3	4	3	1	0	11
	Engineering	4	2	5	0	0	11
	Suppliers	0	1	0	0	0	1
	Facilities Managers	0	4	2	0	0	6
	Training and Education	4	2	2	0	0	8
	IT Vendors	0	1	0	0	0	1
	Business Services	1	0	0	0	0	1
	Consulting	3	3	1	0	1	8
Total		26	30	19	3	2	80

Table 5.8: Cross tabulation of projected importance of BIM in 5 years within each sector.

3. With a 68% confidence level reported in respect to the significance of BIM in construction within the next 5 years, it was apparent back in 2012 that BIM would be an important tool to be utilised by the Irish AEC/FM within a relatively short period of time.

Q 9 *Do you have any experience in working within the Capital Works Management Framework (CWMF) and the Government Construction Contracts Committee (GCCC) forms of contract?*

This question sought to identify which respondents had experience in working with the CWMF and GCCC PWC. The results are shown in Figure 5.11.

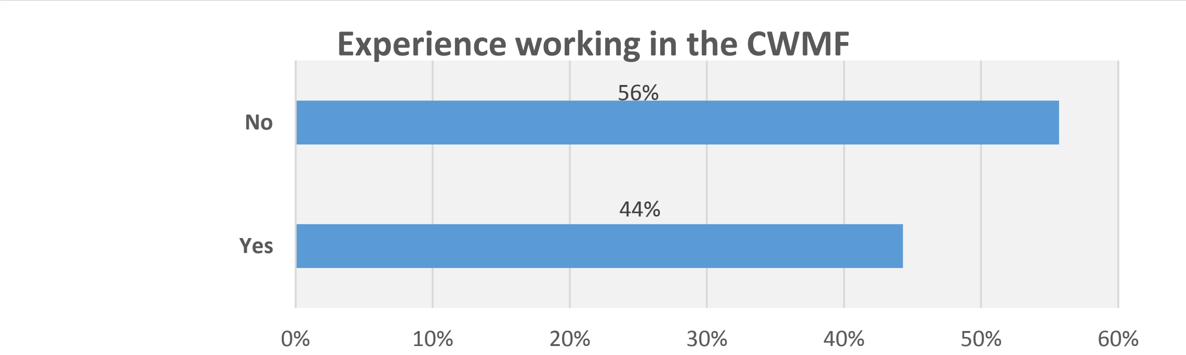


Figure 5.11: Experience of BIM in Ireland survey members who have worked within the CWMF

From the analysis of the results the following observations have been made.

1. A total of 44% reported that they had experience of working within the CWMF framework. Table 5.9 represents a cross-tabulation performed on SPSS of the professions who have worked with the GCCC PWC. The architecture, QS and FM sector reported the greatest level of experience. The number of Facility Managers who worked within the CWMF was surprising owing to the fact, as detailed in the literature they do not become actively involved until after completion of the project. As the FM sector in this survey was quiet disperse the Facility Managers in questions may have participated in another role.

		9. Do you have any experience in working within the Capital Works Management Framework (CWMF) and the Government Construction Contracts Committee (GCCC) forms of contract?		
		Yes	No	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	8	14	22
	Quantity Surveying	10	1	11
	Contractors	3	7	10
	Engineering	2	9	11
	Suppliers	0	1	1
	Facilities Managers	5	1	6
	Training and Education	2	6	8
	IT Vendors	0	1	1
	Business Services	0	1	1
	Consulting	4	3	7
Total		34	44	78

Table 5.9: Breakdown of the different professions within the survey who have worked on the GCCC forms of contract.

Q10 Have these contracts based on your experience achieved their main objectives within the following areas?

Respondents were asked to indicate their level of agreement in respect to the vision of the GCCC contracts in delivering on particular objectives. The results are shown in Figure 5.12.

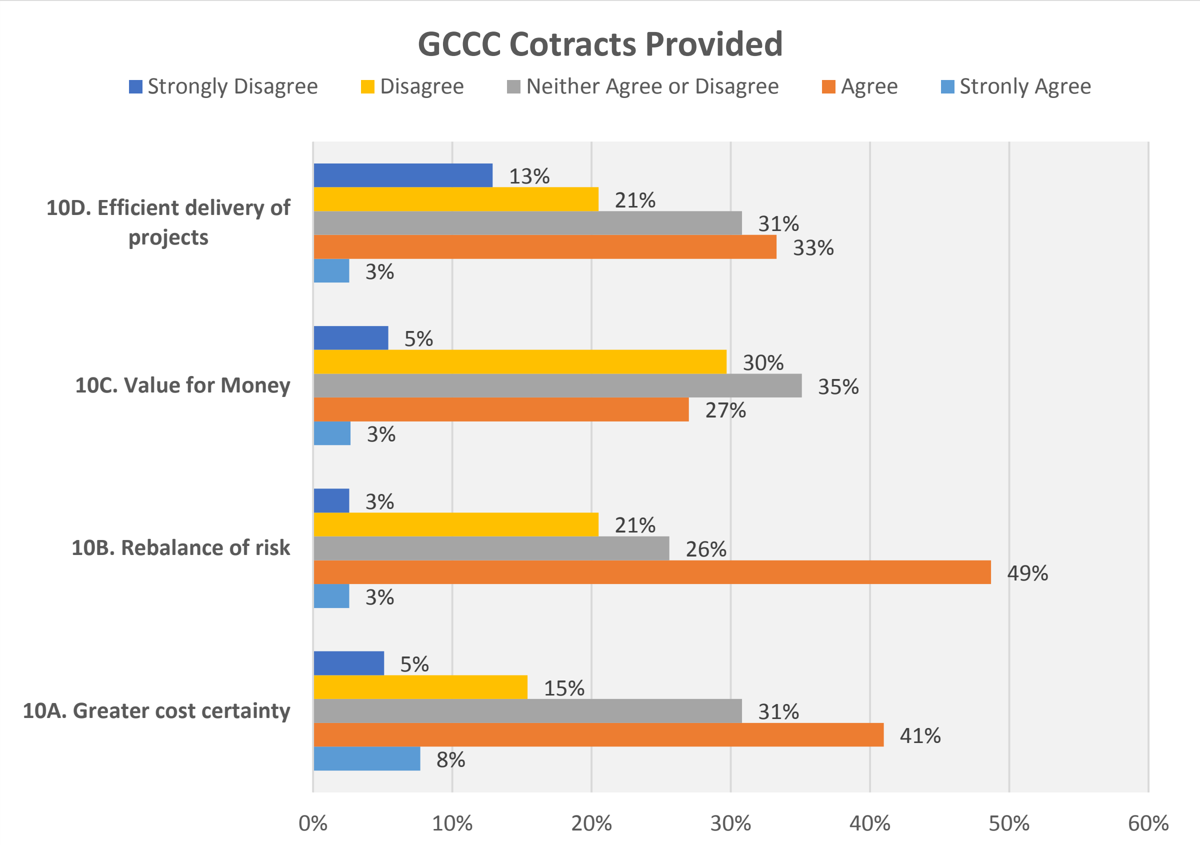


Figure 5.12: Level of support in respect to the GCCC forms of contract achieving their goals.

From the analysis of the results the following observations have been made.

1. It can be seen that there was moderate agreement in respect to the options offered to the respondents. Some scepticism was evident in respect to the value for money offered by these contracts. In regards to greater cost certainty and rebalance of risk the mean (as shown in table 5.10) would indicate the respondents would agree that these objectives were been achieved. The main support for these contracts in achieving their objectives come from the architecture sector. The greatest opposition comes from the QS and contractor sector. As the aim of the GCCC contracts was to push more risk onto the contractor, as well as the difficulties associated in pricing a fixed price contract, it was expected that these two sectors would be in opposition.

	10A. Greater cost certainty	10B. Rebalance of risk	10C.Value for Money	10D. Efficient delivery of projects
Mean	2.6923	2.7179	3.0811	3.0769
N	39	39	37	39
Std. Deviation	1.00404	.91619	.95389	1.08542

Table 5.10: Mean value of support for the GCCC forms of contract reaching its objectives.

2. One of the survey participants attributed the fact that these contracts were achieving greater cost "*was due to current market conditions as a result of the recession*".

   Two respondents noted that these *"contracts deliver poor value, bad quality and will be the end of team work on projects"* and "*the intention with the GCCC form of contract was good but from experience there were issues that need to be addressed. Incorporating BIM with this restrictive contract will undoubtedly raise more issues"*

   The results and feedback received have shown a high level of uncertainty as to the CWMF achieving its goal, despite at that stage being in circulation since 2007. As the GCCC suite of contracts were reviewed in 2014 due to their continued opposition, would indicate the findings of the survey at the time in 2012 were reflective of the ongoing concerns associated with them. The analysis also shows that despite the call for BIM adoption that the industry still has concerns in line with previous statements made by McAdam (2010), Eastman et al., (2011), Holzer (2011) and Marasini and Patlakas (2012).

Q 11: There is a plan for a phased five-year development within the UK that public works projects will be required to use BIM from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government client would have an estate that was smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions. This strategy will effectively mean that all companies that wish to tender for a public works projects in the UK by 2016 must use a BIM model throughout the whole construction lifecycle in order to be considered as a viable candidate. Based on your extensive or brief knowledge of BIM do you believe that the Irish Government should follow in the footsteps of the UK?

This partially closed question provided focus on the UK mandate and explored the level of support in regards to Ireland following a similar methodology. The results are shown in Figure 5.13.

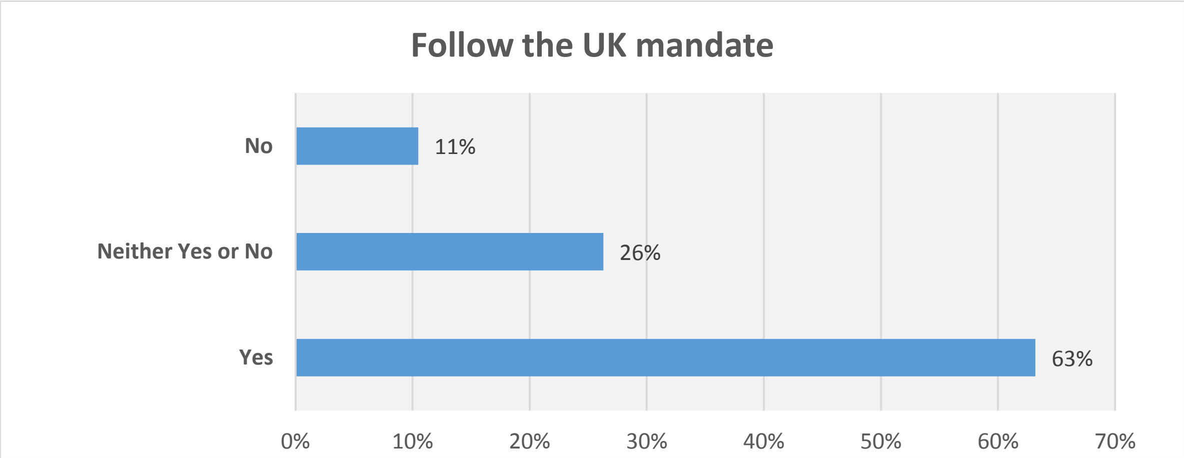


Figure 5.13: Support in Ireland for a similar mandate as the UK Mandate

From the analysis of the results the following observations have been made.

1. 63% of the sample were in favour of a BIM mandate in Ireland, similar to that in the UK from 2016. The strongest support comes from the architects, followed by the QS, contractors. The sector which shows the greatest resistance comes from the Engineering section. A reason for this could be that BIM was seen predominately as a design tool and there possibly was a lack of knowledge to how it can benefit the Engineering profession. Table 5.11 illustrates the support from each sector for a similar mandate as the UK.

		11. Based on your extensive or brief knowledge of BIM do you believe that the Irish Goverment should follow in the footsteps of the UK?			
		Yes	No	Neither Yes or No	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	15	3	3	21
	Quantity Surveying	7	1	3	11
	Contractors	7	1	2	10
	Engineering	2	3	5	10
	Suppliers	1	0	0	1
	Facilities Managers	4	0	2	6
	Training and Education	4	0	3	7
	IT Vendors	1	0	0	1
	Business Services	1	0	0	1
	Consulting	6	0	1	7
Total		48	8	19	75

Table 5.11: Professional sector support for an Irish mandate similar to the UK/

2. Some of the comments provided by participants were strongly orientated towards a BIM mandate and "*once the benefits of BIM become widely known through the UK*

Governments experience, it will be only a matter of time before the Irish Government follows suit".

Other supporting comments believe we were in a strong position and "*why re-invent the wheel and for that matter add costs to the industry, the UK have already done this*.

A warning voiced by one respondent includes the "*timescale as outlined above may not be appropriate and it is vital that procedures are kept fair, neutral and transparent, and that awarding of multiple contracts to any one firm is limited over a given period of time to prevent cronyism".*

Others called for a firmer approach from Government as the "*full benefits of BIM such as its lifecycle costing ability will not be adopted/utilised without Government intervention and if not, this would be a lost opportunity"*

Some concerning challenges included the "*client not having the BIM resources or ability to manage the buildings"* and a *"need to see what benefits there are, as well as the availability of staff with the relevant skills may be an issue".*

Other prevalent fears included if a mandate is implemented "*that government if they are not careful will restrict the competition and therefore increase cost"* and *"larger practises winning government work as they have greater abilities"*. One respondent feared that as *"an SME, we are currently struggling to survive. In order to implement BIM, the costs are prohibitive, therefore we may be left behind".*

Despite the support for BIM implementation there were still a number of significant concerns to be addressed by the Irish government to negate people's fears. These include a stagnated economy at the time and unpresented downturn in the construction sector.

Q 12 *Using your extensive or brief knowledge of BIM please indicate your level of support for the following suggestions in the use of BIM in meeting the 5 CWMF objectives? These statements were based on previous research from the pilot case study and presented respondents with five choices. The respondents were asked to indicate their level of agreement with each one.*

This partially closed question was asked to further validate the findings of the pilot study, in regards to BIM offering more certainty in respect to the key targets of the CWMF. The results are shown in Figure 5.14.

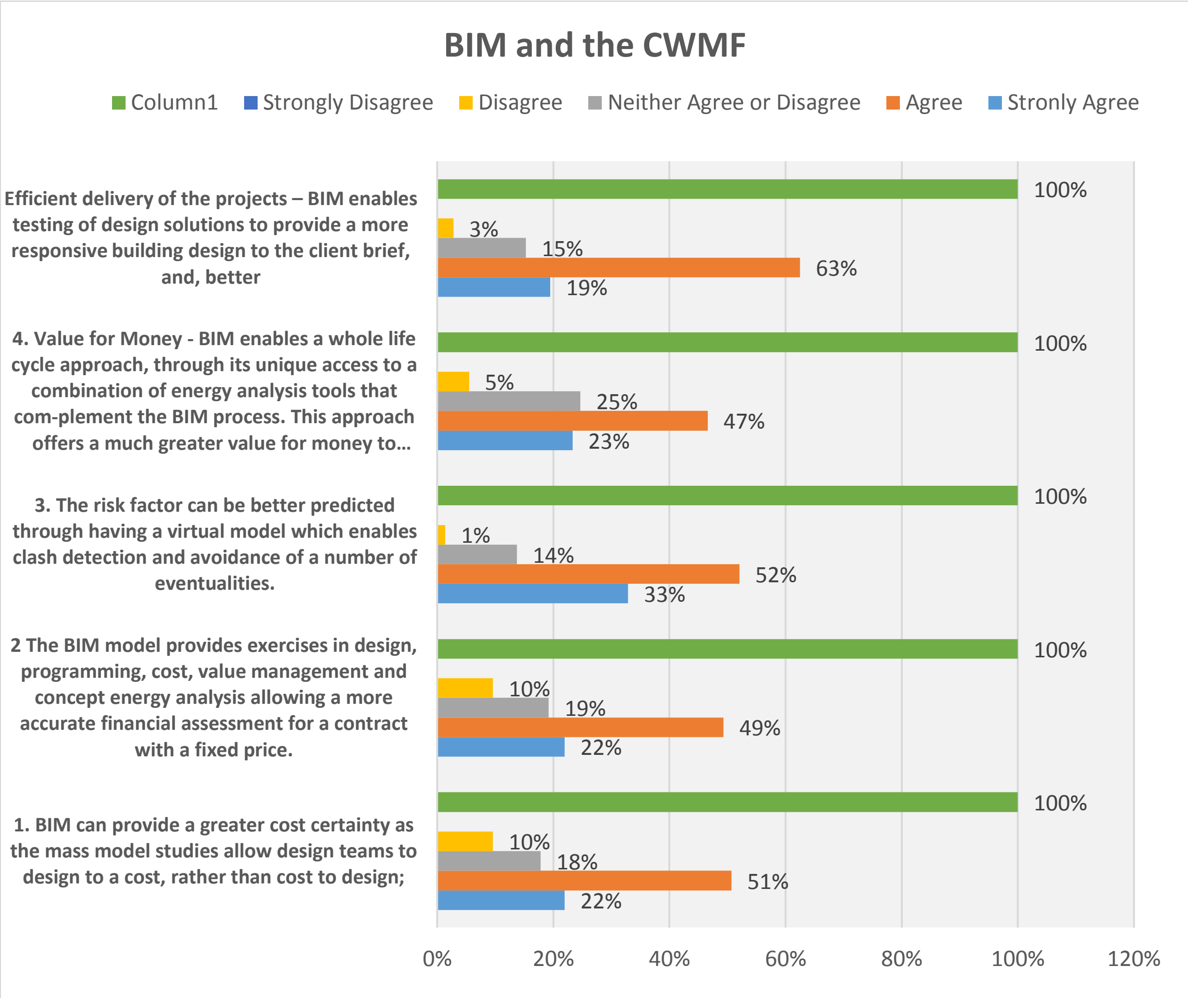


Figure 5.14: The use of BIM in achieving the objectives of the CWMF

From the analysis of the results the following observations have been made.

1. All respondents were asked to indicate their support for the introduction of BIM in achieving the goals of the CWMF. A calculated mean can be seen in table 5.12.

	12A. BIM can provide a greater cost certainty	12B. The BIM model provides a more accurate financial assessment for a contract with a fixed price	12C. The risk factor can be better predicted through having a virtual model	12D. Value for Money - BIM enables greater value for money to the client as it addresses their	12E. BIM enables a more efficient delivery of the projects
Mean	2.15068	2.1644	1.8356	2.1233	2.0139
N	73	73	73	73	72
Std. Deviation	.876724	.88213	.70738	.83242	.68161

Table 5.12: Mean value for BIM realising the CWMF objectives

2. The results show that the mean average across the sample shows broad agreement in regards to BIM assisting the objectives of the CWMF. The strongest indication of agreement was that BIM can help better predict the risk factor.
3. Some of the comments provided by participants include that *"BIM will likely reduce much of the repetitive work such as scheduling and hopefully reduce rework due to errors, however, this time may be replaced by other value adding processes. Therefore, time taken during the design phase may not actually be reduced, but may be more productively used"*.

   Another respondent stated it *"depends on the timescale involved in allowing companies to get up to date with the technology, if the timescale is short then companies already using BIM will have an unfair advantage over others and it will mean a lot of companies being unable to tender"*.

   A further respondent recorded warned that the objectives of the CWMF *"will only be fully achieved as long as the design process is allowed appropriate time / resources and thus appropriate fees. This could be undermined by competing firms reducing fees on basis of faster output thus leaving no allowance for improved design"*

   Comparing mean values from Q10 were respondents were asked to indicate their level of agreement towards the GCCC forms of contract achieving the goals of the CWMF, one can see that BIM can offer a greater certainty in achieving these goals through the higher recorded mean value. This would also further validate the outcomes from the workshop. There was still an underlying concern before this could happen, with a fear that it will create an elitist AEC sector were only the large organisation will benefit from BIM.

Q13 By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. There are at present robust tools existing within BIM to help in reducing significant carbon emissions through performing analyses on energy performance, lighting and HVAC systems. Taking into consideration your knowledge of BIM do you believe that BIM can ensure a smarter and carbon free estate for the Irish Government?

This partially closed question was asked to help formulate an informed opinion in regards to BIM playing a significant part in Ireland's ongoing carbon initiatives. The results are shown in Figure 5.15.

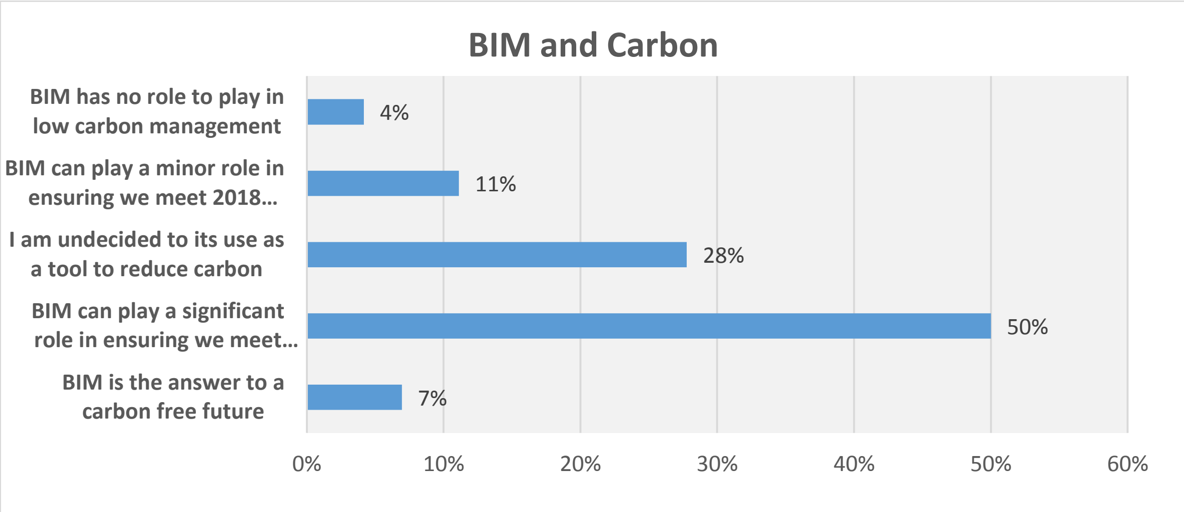


Figure 5.15: The application of BIM in helping Ireland to achieve ongoing carbon initiatives

From the analysis of the results the following observations have been made.

1. There was an encouraging 68% of respondents who believed that BIM can be used as a tool to manage carbon. The results detailing support by each professional sector are detailed in table 5.13. It can be seen that the sector most in agreement that BIM can play a significant to major role were Architects, QS and Contractors. Given the strong representation of Architects and QS using BIM it made sense that they would be the professions that strongly understand the interactive capabilities offered by BIM with regards to carbon.

		13. By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. There are at present robust tools existing within BIM to help in reduci					
		BIM is the answer to a carbon free future	BIM can play a significant role in ensuring we meet 2018 targets	I am undecided to its use as a tool to reduce carbon	BIM can play a minor role in ensuring we meet 2018 targets	BIM has no role to play in low carbon management	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	0	12	6	2	0	20
	Quantity Surveying	2	5	4	0	0	11
	Contractors	0	3	3	2	1	9
	Engineering	0	1	1	4	1	7
	Suppliers	0	1	0	0	0	1
	Facilities Managers	0	4	2	0	0	6
	Training and Education	1	4	3	0	0	8
	IT Vendors	0	0	1	0	0	1
	Business Services	0	1	0	0	0	1
	Consulting	2	4	0	0	1	7
Total		5	35	20	8	3	71

Table 5.13: Sector breakdown for support of BIM helping Ireland to achieve carbon initiatives.

2. Notable comments from the sample included *"in the absence of localised up-to-date data, any model produced will yield inaccurate data, and will in fact serve the*

opposite purpose by misleading analysts during the process as to a real time position".

Another respondent further detailed that there was a *"need to improve building standards and 'adjust' occupier behaviour to ensure that the theoretical BIM analyses becomes reality"*.

Q14 *The BIM model used during the initial design and construction stage can be used effectively in the FM and the deconstruction stage, ultimately resulting in a whole life cycle BIM model. In regards to FM, it is noted that the BIM model can ensure amongst other things Improved space management, efficient use of energies and streamlined preventive maintenance.. What is your views in regards to the usefulness of BIM in been used a FM tool to manage a Public Works Project?*

The results are detailed in Figure 5.16.

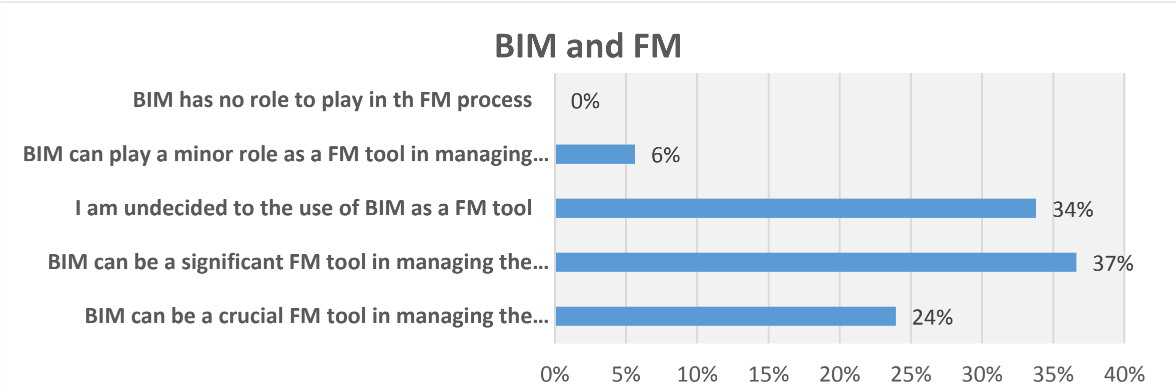


Figure 5.16: Support for BIM offering a more rewarding FM process for the Irish public sector.

From the analysis of the results the following observations have been made.

1. The results show that 60% believe that BIM can assist from a FM perspective in managing the public sector estate in some form. 34% were still unsure that BIM can be a useful tool when it comes to offering a more rewarding FM process within the public sector. Table 5.14 shows that the sector most in agreement was that of the Architecture, Consulting, FM and Training. A strong selection of Architects, contractors and QS were unsure if it could be a useful tool. The results are encouraging as the literature has shown that the overreaching goal of the BIM process was to offer a more rewarding platform in managing the public sector estates. A strong number of professional sectors indicated that they were aware of the benefits of BIM in that respect.

		15. The BIM model used during the initial design and construction stage can be used effectively in the Facilities Management (FM) and the deconstruction stage, ultimately resulting in a whole life cycle BIM model. In regards to FM it is noted that the BIM				
		BIM can be a crucial FM tool in managing the Govermnents estate	BIM can be a significant FM tool in managing the Govermnents estate	I am undecided to the use of BIM as a FM tool	BIM can play a miner role as a FM tool in managing the Govermnents estate	Total
1.Please indicate in which of the following sectors you/your organisation primarily operate:	Architecture	5	7	8	0	20
	Quantity Surveying	2	3	5	0	10
	Contractors	0	2	6	1	9
	Engineering	0	4	1	2	7
	Suppliers	1	0	0	0	1
	Facilities Managers	3	2	1	0	6
	Training and Education	5	1	2	0	8
	IT Vendors	0	1	0	0	1
	Business Services	0	1	0	0	1
	Consulting	1	5	0	1	7
Total		17	26	23	4	70

Table 5.14: Sector breakdown for support of BIM for FM in the Public Sector

2. A spearman correlation was conducted through SPSS to investigate any correlation between the suggested uses of BIM as a carbon and as a FM tool. The results of the spearman correlation are detailed in Table 5.14. This table shows a weak correlation found between the two question (S (= .559, n = 71, p < .000). This could suggest that at present there was more of an understanding in regards to BIM been adopted more for carbon initiatives as seen in the UK, than as a management tool for public assets. As BIM was only gaining momentum in Ireland the specialised use for BIM for FM was still largely undeveloped.

			BIM and Carbon	BIM for FM
Spearman's rho	13. BIM and Carbon	Correlation Coefficient	1.000	.559**
		Sig. (2-tailed)	.	.000
		N	72	71
	14. BIM for FM	Correlation Coefficient	.559**	1.000
		Sig. (2-tailed)	.000	.
		N	71	71

**. Correlation is significant at the 0.01 level (2-tailed).

Table 5.15: Spearman correlation to establish is there a relationship between for BIM as a carbon and FM tool

3. A number of relevant comments from respondents included *"If we can adopt and use FM models properly, that will be a truly great achievement, and a testament to our commitment to BIM*".

   One respondent added that they were not *"convinced there will be "one model to rule them all" but instead versions of numerous databases filtered which are filtered accordingly to whoever and whatever info is needed*".

   At present as evidenced through the results there "*hasn't been enough focus on the topic, particularly for existing stock/facilities"*

Q16. If the Irish Government decided to follow the UK standards to implement a level 2 BIM (File Based Collaboration and Library Management) requirement by 2016 what in your opinion do you perceive to be the biggest advantage / barrier and how best should they go around ensuring its success?

This open ended question generated a number of responses, with the general consensus that BIM implementation will mean a more efficient Irish AEC/FM sector across the board, that in turn will produce more jobs. Some of the commentary included to "*centralize all government departments responsible for construction activities for collaborative purposes"* and ensure *"key persons from the AEC/FM sector involved from the beginning"*.

Some respondents called for a measures to be implemented in tandem with BIM such as to "*promote / incentivise full design including the education of Client's as to the consequences of incomplete design on both the product and its cost"*.

Some concerns voiced include the fact that BIM "*is a good tool but is not suitable for all projects and needs to find its level in industry in appropriate buildings"*.

Others felt that *"if the government doesn't mandate its use, then it will be used against them by contractors and/or design-build teams to profit from the inefficiencies that currently exist; contractors who can mandate their own BIM models potentially will have more information themselves and thereby manage the contract to their own ends"*.

5.5 SUMMARY OF FINDINGS

5.5.1 General Findings.

The following were the key findings from this survey:

- There was a strong awareness of BIM within the survey sample. The architecture and engineering sectors both represent the two largest professions that are aware and currently using BIM.
- There was a high level of 3D tools been used within the industry, in partnership with 2D tools. A total of 77% reported they were still using 2D tools in some aspect, possibly indicating that the industry was still not ready to move from 2D process.
- A good knowledge was demonstrated within the sample in regards to the researched benefits of BIM i.e. improved visualisation, better co-ordination of documents and

enhanced cost efficiencies. The industry was still not clear on what BIM is but showed an understanding that its entails more than just software.

- With 16% already using BIM processes, a further 74% of the industry expect to use BIM technologies in the next 5 years.
- The respondents who had experience in working within the CWMF are still undecided if it has achieved its objectives.
- 67% believed Ireland should follow a similar methodology of the UK of working towards a 5 year BIM implementation date.
- The strong majority of the survey believed that BIM can help achieve the key objectives of the CWMF in particularly predicting risk.
- 68% survey sample agreed that BIM can assist in helping the public sector to achieve carbon targets.
- 60% stated that BIM can assist from a FM perspective in the better management of public sector assets.
- There was a belief that BIM implementation can result in a more efficient Irish AEC/FM sector across the board that will produce more jobs. The biggest concerns range from the cost of software, to the critical upskilling of staff, that could respond to such an implementation.

5.5.2 Facilities Management findings in BIM for Ireland survey

The key findings in regards to the limited response from the FM sector for the BIM in Ireland survey were analysed. Despite this limited response it helped provide a very basic understanding of how BIM was perceived in the FM sector. The results though no way indicative of the views of the Irish FM sector helped inform the next phase of the research. The results include that the current makeup of the FM sector was diverse with only two respondents working as Facility Managers. The vast majority of Facility Managers were only just beginning to take notice of BIM with one respondent currently practicing. There was also a strong response from within this group, with regards to the intention to use in BIM in the next 5 years. All of the sector see BIM being of high to moderate importance in the next 5 years.

The majority of Facility Managers have worked within the CWMF and were undecided if the GCCC forms of contracts have achieved the frameworks goals. Two thirds of the group indicated that they believed the Irish Government should adopt a similar approach to the UK, as BIM can play a significant part in achieving carbon targets. Half of the Facility Mangers believed that BIM can be a crucial FM tool in managing the Governments estate.

A survey based around BIM for FM was carried out in the next stage of the sequential design to further support these results.

5.5.3 Comparison to International reports

NBS BIM Report 2013

This report was carried out by the National Building Specification in late 2012, as an indicator to the level of BIM adoption by the UK. The key findings compared to the survey conducted by the author are detailed in the table 5.15 below, where comparisons can be made.

Question	UK%	Ireland %
Using 2D and 3D CAD	35%	77%
Using 3D Only	4%	2.% (Possibly 16% if include 3D with intelligent data)
Aware and currently using BIM	39%	41% (calculated at 16% using actual BIM processes)
Just Aware of BIM	54%	53%
We currently use BIM	43%	41%
In one year we will use BIM	77%	59%
In three Years we will use BM	91%	81%
In five years we will use BIM	93%	90%

Table 5.16: Irish Survey vs NBS UK Survey

The results from both surveys were very similar with Ireland matching the awareness rate and currently practicing BIM figures. As the UK figures cannot be broken down to the level of detail in the authors survey it would have been interesting to interrogate the actual BIM usage rate. Ireland also intended to match the UK’s five-year plan, with expected differences where both countries will be at the three and five year milestones. Despite the large differences in responses there were encouraging results from an Irish perspective moving forward. The results could indicate given the proximity of both countries to each other that Ireland was aware of ongoing BIM initiatives in the UK. A reason for this may be that failure to acknowledge ongoing BIM development would impact international business opportunities within that sector.

NBS International BIM Report 2013

This report was carried out by the National Building Specification in late 2012 as an indicator to investigate the level of adoption of BIM internationally. The three counties surveyed included Canada, Finland and New Zealand. The key findings compared to the survey conducted by the author are detailed in the table 5.16, where comparisons can be made.

Question	Ireland	Canada %	Finland	New Zealand
Aware and currently using BIM	41% (calculated at 16% using actual BIM processes)	64%	65%	57%
Just Aware of BIM	95%	96%	87%	98%
We currently use BIM	41%	66%	67%	57%
In one year we will use BIM	59%	84%	85%	77%
In three Years we will use BM	81%	93%	90%	92%
In five years we will use BIM	90%	97%	92%	95%
The industry is not clear enough on what BIM is yet	96%	68%	60%	69%

Table 5.17: Irish Survey vs NBS International Survey

The figures here indicated that the above detailed three countries were ahead of Ireland and the UK when it comes to BIM awareness and using BIM. Ireland was also expected to have a steeper adoption curve but does expect to reach similar levels in the next five years. At that moment the industry was very unclear of what BIM is compared to other international sectors.

5.6 CONCLUSION

The previously analysed workshop presented a number of findings that required further validating. As previously demonstrated in the literature review the area of BIM in Ireland at 2012 was underdeveloped and there was little published research. A survey was required to analyse if BIM could be an alternative solution towards the current frameworks in place in the Irish public sector.

It could be concluded from the findings that in 2012 there was a significant level of awareness of BIM in Ireland. Despite this sections of the AEC/FM sector were uncertain to what BIM actually is and further education was needed to address this. The perceived greatest advantages resulting from BIM was through the use of the model for visualisation and in reducing waste on site. There was a strong belief that in the next 5 years this relatively new methodology will become more relevant. There was a call from within the survey that Ireland should follow the UK in mandating BIM. As results from the pilot indicated, and reinforced within the analysis of the survey, a leap of faith will be required to achieve this. There was a fear, as to be expected with the recent introduction of the GCCC forms of contracts that BIM implementation may result in creating an industry where only the larger contractors can survive. Other prevalent fears included the cost to implement BIM along with its associated processes. The overall consensus was that the goals of the CWMF can be achieved more intelligently through BIM. The FM Sector within this survey, though very limited, voiced their support for BIM to be used on government projects.

The survey and pilot results provided some answers on BIM in Ireland and to a certain point on BIM for FM in Ireland, but did not focus strongly enough within this area. In order for BIM to address key FM criteria within the public sector one must know more about the FM sector in Ireland i.e. current O&M formats, software been used, BIM for FM adoption and the perceived barriers and drivers. The role of the Facility Manager was also required to be understood and their current position within the design process. The second part of stage two of this sequential design answered these questions through a more focused survey on the area of BIM for FM on public works projects in Ireland.

The results from this survey have enforced the findings of the workshop and ensured that there was an adequate cultural and technical platform available to establish and validate the KPTs.

6. BIM FOR FM IN IRELAND SURVEY 2013

6.1 INTRODUCTION

The relevance and importance of BIM in Ireland back in 2012 was evident in the previous chapter. The target date off 2016 for the implementation of the UK mandate had provided a significant influence on the perceived importance that BIM had within Ireland. The author sought to extend the reach of the BIM research question into the operation and maintenance phase of construction projects. While the sequential design to date had provided invaluable information on BIM in Ireland, the author progressed to focus on BIM as a FM tool. The FM Sector within the previous survey, though very limited, voiced their support for BIM. The majority of the FM sector detailed within the BIM in Ireland survey that worked with the CWMF, were undecided as to whether its objectives were been effectively met. This phase of the research built on these findings and also focused on the positive contribution that the Facility Manager can bring through his/he earlier involvement on a construction project.

This chapter presents the results of the next phase of the research, which involved a questionnaire survey on the use of BIM for FM in Ireland in 2013. At the time of the survey BIM for FM was relatively unknown within the public sector, thus it was decided to extend the survey to Facility Managers operating in the private sector also. The survey sought to explore the role of the Facility Manager in the design process and to establish if he/she can make a valid contribution. The results show that there was little involvement of the Facility Manager during the early stages of construction, despite a strong claim to the significant benefits that this approach would bring to the construction team. There was a belief that the Facility Manager should have an advisory role within the design and construction phases, as he/she can help streamline the design briefing process through their knowledge of facility operations. It was evident from the results that there had been little progress towards the use of cutting edge technologies by the Irish FM sector to streamline maintenance and further enhance lifecycle management. On a more positive note, significant knowledge was evident among respondents with a range of suggestions how BIM could assist in the delivery of more manageable facilities.

This final stage of the sequential design adopted a methodology, which involved the distribution of an online cross-sectional questionnaire in collaboration with the Irish Property and Facilties Management Association (IPFMA).

6.2 METHODOLOGY

The survey methodology involved a two tier approach to a planning and implementation stage as similarly adopted in the previous chapter. This approach is shown in figure 5.1.

6.2.1 Planning process

The planning process was further broken into four different tasks that included:

1. Selection of research question.
2. Overall presentation to sample.
3. Consideration of ethics.
4. Design of survey sample

This process followed the same framework as the BIM in Ireland Survey conducted in 2012, a link this to methodology can be found on page 102.

The findings of the literature review, the exploratory BIM observational study and the BIM in Ireland survey collectively contributed to the basis for the research questions chosen in this more focused survey, namely:

1. Establish the current practice and support for the early involvement of the Facility Manager in the design and construction process.
2. Investigate the respondent’s current position in regard to the importance of ICT and in particular BIM, as a future process to support FM services not just at the handover stage but throughout the entire project lifecycle.
3. Explore the current views in respect to how the Facility Manager and ICT / BIM can help to better manage both newly and existing public sector facilities and structures.

The questionnaire was structured specifically into the following four sections to complement the above research questions.

1. **Respondent Details:** All respondents were asked what type of facilities / sector their organisation was primarily involved in.
2. **Early involvement**: All respondents were asked what level the Facility Manager was involved and whether they felt they could make a significant contribution in the design and construction phases of a project.
3. **FM and Information Communication Technology (ICT) Working Together:** All respondents were asked what software they currently used in their daily work and the

potential that ICT can play in providing a softer landing in the O&M phases of a construction project. Respondents were asked about the potential for BIM in adding value to the O&M phase.

4. **ICT as a FM tool in managing the Government's state facilities:** In the final section respondents were asked whether the Irish Government should take a similar stance to the UK in implementing BIM on publically funded projects.

Presentation and Ethics

This process followed the same structure as the BIM in Ireland Survey conducted in 2012, a link this to methodology can be found on page 105.

Sample

The survey was designed and distributed in collaboration with the IPFMA, who was the professional body representing the FM profession in Ireland. The objective of the IPFMA was to develop and maintain excellence in terms of skill and professional conduct in all aspects of the market, through the provision of education, training, professional development and regulation of its members. The aim of the survey was to gauge the level of support for the introduction of BIM to assist in managing the public sector estate. The IPFMA offered the opportunity for the survey to reach a large and established database. It was agreed that a random sample of 80 organisations would be selected from within the IPFMA database that represented both public and private organisations. Before a survey was issued an online questionnaire was created with 15 questions, which was originally piloted by the Board of Directors of the IPFMA. After a number of changes were incorporated, it was then distributed to the IPFMA target population. This generated a total of 38 company responses from a mix of small to large enterprises.

6.2.2 Implementation process

The implementation phase focused on the piloting and distribution of the questionnaire.

Pilot Questionnaire

An online pilot survey was initially distributed to the five senior board members of the IPFMA for comment. The pilot survey can be located in Appendix 3. The feedback included that the survey needed reconstructing and that the survey was too detailed. There was a particular concern that respondents would not be aware of BIM and that they would not have sufficient knowledge to complete the survey. This suggested from an early stage that knowledge and education of BIM was not seen as a priority within the Irish FM sector at the time.

The feedback received required a fundamental redesign of the survey. The total number of questions was reduced from 23 to 15 and more emphasis was placed on early FM involvement rather than BIM. Other comments included that the “survey was not particularly well constructed and does not ask the right questions” and “not a lot of people know about BIM and even if they did, they have not had direct experience of it”. Other comments included that “the questions did not seek a sufficient level of detail”.

Distribution and Response

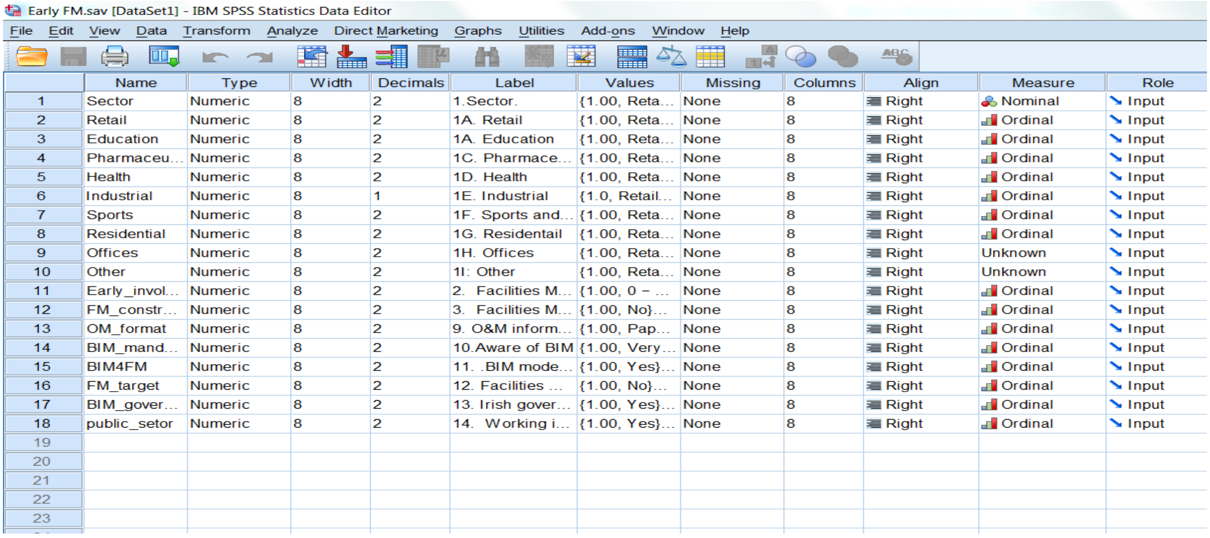
A total of 80 organisations were selected randomly from the IPFMA membership community to partake in a survey, which resulted in a total of 38 responses received. As the survey did not request participant contact information it was decided that the option of multiple responses should be disabled within the survey monkey platform. This ensured that only one response could be generated from the same IP address. A date was fixed for completion of the survey.

6.3 QUESTION SELECTION

It was decided that questions would be a mixture of open and closed questions, as it was felt that most of the respondents would like to add their own insight into a number of questions. The inclusion of open ended questions generated both qualitative and quantitative data that could be analysed to help establish some key criteria that were explored in the second phase of the research. A copy of the questionnaire can be found in Appendix 3.

6.4 METHOD OF RESULTS

The programme IBM SPSS Statistics 21 was used to analyse the results. This software provided the entire analytical process, from planning to data collection to analysis, reporting and deployment. The first step was to input the results of the actual survey into this programme. An image of the screenshot is shown in Figure 6.1. The process for using this software can be found in Appendix 2.



Early FM.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Sector	Numeric	8	2	1.Sector.	{1.00, Reta...	None	8	Right	Nominal	Input
2	Retail	Numeric	8	2	1A. Retail	{1.00, Reta...	None	8	Right	Ordinal	Input
3	Education	Numeric	8	2	1A. Education	{1.00, Reta...	None	8	Right	Ordinal	Input
4	Pharmaceu...	Numeric	8	2	1C. Pharmace...	{1.00, Reta...	None	8	Right	Ordinal	Input
5	Health	Numeric	8	2	1D. Health	{1.00, Reta...	None	8	Right	Ordinal	Input
6	Industrial	Numeric	8	1	1E. Industrial	{1.0, Retail...	None	8	Right	Ordinal	Input
7	Sports	Numeric	8	2	1F. Sports and...	{1.00, Reta...	None	8	Right	Ordinal	Input
8	Residential	Numeric	8	2	1G. Residentail	{1.00, Reta...	None	8	Right	Ordinal	Input
9	Offices	Numeric	8	2	1H. Offices	{1.00, Reta...	None	8	Right	Unknown	Input
10	Other	Numeric	8	2	1I: Other	{1.00, Reta...	None	8	Right	Unknown	Input
11	Early_invol...	Numeric	8	2	2. Facilities M...	{1.00, 0 – ...	None	8	Right	Ordinal	Input
12	FM_constr...	Numeric	8	2	3. Facilities M...	{1.00, No}...	None	8	Right	Ordinal	Input
13	OM_format	Numeric	8	2	9. O&M inform...	{1.00, Pap...	None	8	Right	Ordinal	Input
14	BIM_mand...	Numeric	8	2	10.Aware of BIM	{1.00, Very...	None	8	Right	Ordinal	Input
15	BIM4FM	Numeric	8	2	11. .BIM mode...	{1.00, Yes}...	None	8	Right	Ordinal	Input
16	FM_target	Numeric	8	2	12. Facilities ...	{1.00, No}...	None	8	Right	Ordinal	Input
17	BIM_gover...	Numeric	8	2	13. Irish gover...	{1.00, Yes}...	None	8	Right	Ordinal	Input
18	public_setor	Numeric	8	2	14. Working i...	{1.00, Yes}...	None	8	Right	Ordinal	Input
19											
20											
21											
22											
23											

Figure 6.1: SPSS View of BIM FM in Ireland Survey 2013

6.4.1 Analysis of Results

A descriptive method of analysing the results was adopted. A number of questions were analysed using cross tabulation and, in some instances, rank correlation was used. Cross tabulation allowed an understanding of different, but related, questions within different sectors and rank correlation measured the degree of similarity between two sectoral groupings within the sample.

Q1. Which type of facilities / sector is your organization primarily involved. Please tick as many of the appropriate options that apply.

The majority of respondents worked mainly in the Residential and Offices sectors. Education and Retail also accounted for a large proportion of the sample. Figure 6.2 summarises the response distribution from each sector. The high response rate from the Education and Health sectors showed a good response from the public sector within the survey. The results are illustrated in Figure 6.2.

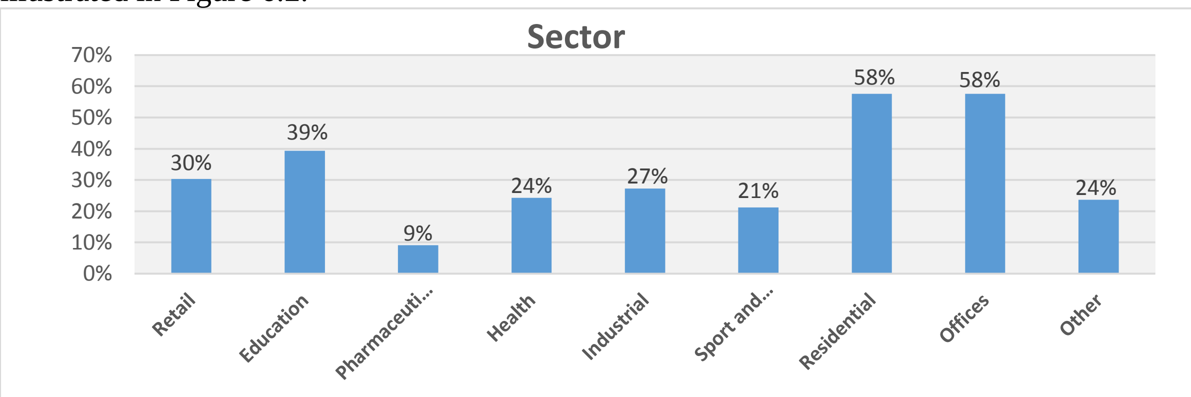


Figure 6.2: Breakdown of sector response within the BIM for FM survey 2013

Q2. In your experience are Facility Managers involved in the design and/or construction phases of a project. Please indicate below to what level the Facility Manager is involved in either of these two phases.

Over half of the respondents reported that they witnessed little involvement in the design and/or construction phases of a project. The results are illustrated in Figure 6.3.

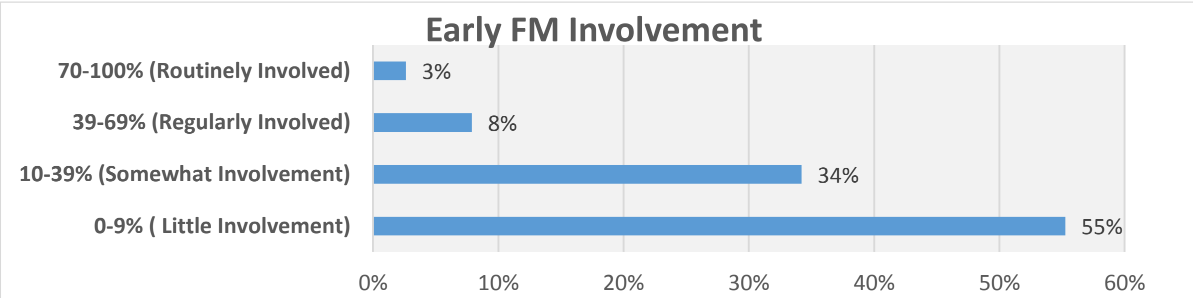


Figure 6.3: Early involvement of the Facility Manager in the design and/or construction phases of a project.

From the analysis of the results the following observations have been made.

1. A further 34% have acknowledged that there has been some involvement. Only 8% acknowledged that the Facility Manager was regularly involved, with only one respondent claiming that it was practice for them to be routinely involved.
2. A cross-tabulation was performed in IBM SPSS on the results from the chosen sector against early Facility Manager involvement, so as to gain an understanding of which sectors mainly engaged with the Facility Manager in the design and/or construction phases. The results are shows in table 6.1.

Sector	**Facilities Manager Involvement**				
	0-9%	10-39%	39-69	70-100%	Total
Retail	8	1	0	1	10
Education	7	6	0	0	13
Pharmaceutical	3	0	0	0	3
Health	2	6	0	0	8
Industrial	5	4	0	0	9
Sports & Leisure	6	1	0	0	7
Residential	13	5	1	0	19
Offices	9	6	3	1	19
Other	6	2	1	0	9

Table 6.1: Cross Tabulation of chosen professional sector against early Facility Manager involvement for BIM for FM survey Ireland

The office sector had the greatest early Facility Manager involvement, with a total of three different respondents claiming that they were regularly involved in the construction process. A further 6 more respondents reported that the Facility Manager had some involvement in the construction process for the Office sector. The Education and Health sector also reported some isolated signs of early Facility Manager engagement. This would indicate that early Facility Manager involvement was practiced, in some instances, on public works projects. The Retail, Pharmaceutical, Sports and Leisure show very little early engagement.

Q3. It has been suggested that if the Facility Manager was integrated early into the construction process, it could help maximise sustainable construction potential, as well as providing a new cost focus for building. In your opinion based on this quote and your knowledge should the Facility Manager have a role in the design and construction phases of a project?

Over 60% of the sample agreed that Facility Managers should have a role in the design/construction process. The results are illustrated in Figure 6.4.

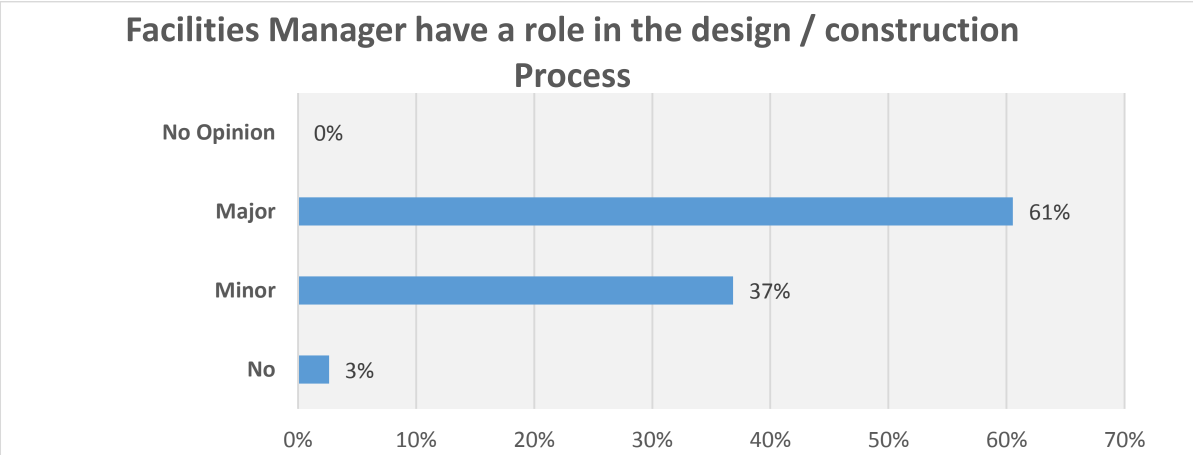


Figure 6.4: BIM for FM results if the Facility Manager should have a role in the design / construction process.

From the analysis of the results the following observations were made.

1. A further 37% believe that this approach would have a minor impact on the construction process. Only one of the respondents reported no impact. The fact a strong majority were in favour to this approach was to be expected given that the respondents were all practicing in the FM Sector and would be in favour of promoting their own role.

2. A cross-tabulation was performed in IBM SPSS to compare the Facility Managers routine involvement in the design / construction process against the impact they can make from their early involvement. The results are show in table 6.2.

		3. Facilities Manager role in the design and construction phases			Total
		No	Minor	Major	
2. Facilities Manager involved in the design/construction proccess.	0 - 9%	1	11	9	21
	10 - 39%	0	3	10	13
	39 - 69%	0	0	3	3
	70 - 100%	0	0	1	1
Total		1	14	23	38

Table 6.2: Cross tabulation of early involvement of the Facility Manager against the perceived benefits of their involvement in the construction process.

The results show that those who regularly to routinely see the Facility Manager involved in the construction process have claimed that there could be major benefits realised. The majority of respondents who indicated they have seen the Facility Manager somewhat involved have also indicated he/she could have a major impact.

3. Respondents were encouraged to explain their answer. A list of the most informative answers can be found in Appendix 3. Some of the key responses included that *"by getting insight from the Facility Manager in the early construction / design stages could highlight areas that could be changed to improve the running costs of the building"*.

   Others noted that their involvement would be *"important in relation to more complex M&E systems, where one would expect FM issues to be considered by the designer"* and their *"in depth knowledge of the FM in running of the client's business makes perfect sense to utilise their expertise in the design and construction"*.

   Further positive contributions include that their involvement may result in the *"better utilization of the work space and more practical layout of the office from the services point of view"*.

   One respondent acknowledged that *"it was vital that the FM has a major involvement in the installation of M&E in a facility as they are the ones who will have to live with consequences. This was especially important in relation to the provision of power and heat with regards to prioritising life cycle costs"*.

   The responses from respondents who have seen somewhat to routine involvement of the Facilties Manager in the construction process, have seen the greatest benefits come from the elimination of non-required items in regards to M&E, improved selection of

O&M and practical applications, contributing to floor layouts and determining plant equipment. There was a concern in regards to the cost of this approach and the realisation that such costs would be dictated by the client and may be eliminated to save money. The consensus though was that the Facilties Manger should have role in the construction process, as their diverse knowledge could offer a professional service that could impact the building output. These findings were aligned with the literature review were it was suggested that the Facility Manager has the potential to become a critical strategic tool for an organisation (Madritsch and Ebinger, 2011 and Saleh et al., 2011).

Q4. It is accepted that almost 4 % of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility. It is suggested that the Facility Manager is in a position to address some of these improvements and help increase productivity. In what way can the Facility Managers make a major or minor contribution to the design and construction phases to increase productivity?

This open ended question sought to provide a better understanding of where the Facility Manager can have the greatest impact in the construction process. The suggested areas from the survey respondents in where the Facility Manager can have the greatest impact have been assigned accordingly based on reviewed literature in were the Facility Manager can best contribute to the design process. From the analysis of the results the following observations can be made.

A summary of the key responses are shown in Table 6.3.

Area	Contribution
M&E	• Ensure that selected equipment was not only functional but can be easily maintained and spares easily sourced. This will result in no downtime of M&E items impacting on the organisation financially. • Ensure that all items specified were affordable and easy to repair. • Provide first-hand knowledge of service layouts.
O&M	• Provide knowledge of the building that other professionals may not have in regards to ongoing maintenance issues. This can help address problems that may impact the business in the future. • Highlight areas of concern in regards to common running costs and target these areas before they impact on the financial goals of the organisation. • Improve the selection of the maintenance and practical applications through previous knowledge of similar equipment / items.
Energy Management	• Practical advice about energy saving strategies that work/don't work in similar buildings. of this type. This can position the organisation moving forward in regards to ongoing legislation changes.
Space Management	• Contribute practical knowledge to floor layouts and utilising workspace layouts. This will increase worker. productivity and ensure spaces were correctly utilised.
Occupant Behaviour	• They can provide designers with information on how users will interact and therefore address user concerns from the beginning i.e. amount of people working. • Can help streamline the design process, as they know what the clients want and therefore avoid costly design.

Table 6.3: Suggested areas in were early Facility Manager involvement can contribute to the design stage.

The Facility Manager as evident from the responses could contribute to the M&E and O&M design. He/she have a unique skillset that can be applied in selecting plant that can be easily maintained and help highlight areas of maintenance concern through knowledge of existing buildings. Further comments suggest he/she can impact the energy consumption by contributing to sustainability strategies and also help in enhancing space utilisation through applying their practical knowledge to floor layouts. A common thread within the responses was that the Facility Manager has a strong understanding of occupant behaviour and this knowledge can help streamline the design process, as he/she know what the clients want therefore avoiding costly design changes. A detailed list of the responses can be found in Appendix 3.

The research results were in agreement with statements made previously by Hodges (2005), Enoma (2005), Mohammed and Hassanain (2010) and De Silva (2011) in that failure to address FM problems right from the design stage can result in the maintainability issues further down the lines. There was an understanding as discussed within the literature by Meistad and Valen (2012) that the Facilities Manager can help address these issues.

Q5, What are the main arguments for and against for the Facility Manager being strongly involved in the early stages of the construction process?

This open ended question further establishes the argument for the inclusion of the Facility Manager in the construction process. It also provided the opportunity for any concerns to be raised. A summary of the key points raised both for and against the earlier involvement of Facility Managers are shown below.

For

- The building can be tailored to meet the exact requirements of the occupants and they can ensure the Clients requirements were met.
- First-hand knowledge of service layouts.
- Streamline the design process.
- Feedback on how the building was used and practicality of operating the facility.
- Optimise a building layout to increase performance.

Against

- Too many bodies already involved in the construction process with the addition of another ultimately resulting in another person required to sign off on particular aspects.
- The Facility Manager may have a personal opinion that they may try force on the design team.
- Not enough construction experience and too much interference, while also lacking the technical and material cost skills.
- Will result in a cost increase upfront but in the long term the running costs will be lower.

In regards to respondents who have seen little to no involvement of the Facility Manager some arguments made included:

For

- Zoning areas and locating points for servicing units.
- Building can be designed to be proactive to daily requirements instead of being reactive.

- The Facility Manager has an in-depth understanding of how the building has been used so will be best placed to assist in design decisions.
- Early intervention and collaboration can result in less potential disruption and ensure all possibilities and requirements were covered.

Against

- Arguments against would be that he/she were taking some of the overseeing role away from the project architect.
- The Facility Manager may slow down the design process with obscure suggestions i.e. their focus was entirely on cost or sustainability, to the detriment of the overall whole.
- An additional fee and further party added to the team.
- Lacking in knowledge of the construction process.
- The Facility Manager may not understand the cost of installation.
- What was their qualification? Do they hold PI insurance? Whom were they employed by?

There was no doubt from the analysis that there was a high level of support for the inclusion of the Facility Manager in the construction process. Despite this there were still significant concerns towards their involvement. These concerns range from a lack of understanding of the construction process, to a lack of confidence of their contribution to the design process. There was also a fear that they may disrupt the flow of information between the different professionals, as they aim to establish their contribution and, therefore, become a hindrance. A detailed list of the responses to this question can be found in Appendix 3.

6. There are at present initiatives in Ireland, so as to reduce greenhouse gas emissions by up to 20% by the year 2020.By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. How much of an impact can the Facility Manager play in ensuring these targets are achieved if introduced in a consultant role at the beginning of the project?

Figure 6.5 clearly shows that the majority of respondents agreed that if they were involved earlier in the design and/or construction process they could contribute to an overall reduction in the generation of greenhouse gases.

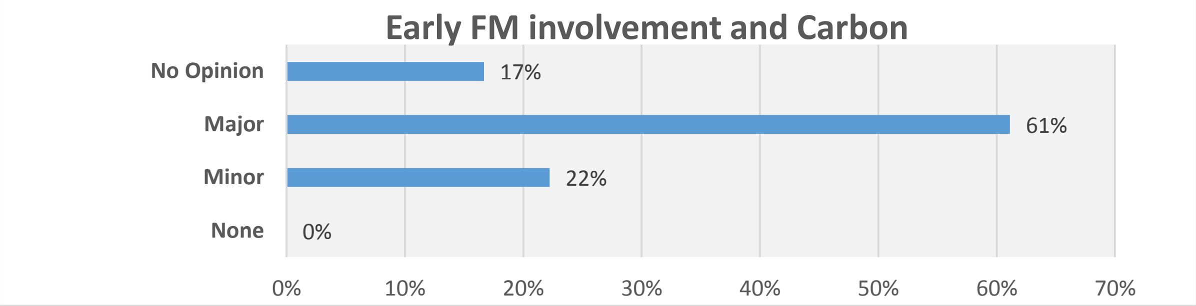


Figure 6.5: Contribution of the Facility Manager in reducing carbon through earlier involvement

Some of the key responses include that *"the FM can drive a programme to reduce energy savings"* and can advise on "*energy saving strategies that work in similar buildings of this type"*.

Other positive contributions involve them *"specifying operations and maintenance regimes"* and *"advice on user behaviour and requirements"* on similar buildings that could help target energy concerns before they arise.

A number of respondent's state that the Facility Manager can impact the M&E specification as they *"can be more prescriptive in developing the performance specification and be involved in the approval process"*.

A number of concerns raised include that they may have *"too much influence and affect delivery of the construction project"* and what their contribution to the design would be considering *"why a professional design team comprising of the different professions cannot make appropriate decisions during the design stage"*.

The general consensus was that despite these concerns the Facility Manager has a unique knowledge base that can influence a design team to help realise a more sustainable structure. A detailed list of responses can be found in Appendix 3.

Once more there were a number of positive contributions which the Facility Manager could provide if integrated into the contraction process. However, there was concerns in that he/she might have an adverse effect on other design disciplines. Table 6.4 expands, on table 6.3, and combines the responses from the open ended questions received from the first six questions of the survey. This table details both the contributions and concerns that were predicted because of including the Facility Manager in the design process. This table will form an important part of the research later in the thesis.

Area	Contribution	Concern
M&E	• Can assist in determining plant equipment, and in the process eliminate non required items and, therefore, avoid unnecessary spend. • Ensure that selected equipment was not only functional but were easily maintained and spares easily sourced. This will result in no downtime of M&E items impacting on the organisation financially. • The FM, as a consultant, can be more prescriptive in developing the performance specification for M&E equipment and can be involved in the approval process • Ensure that all items specified were affordable and easy to repair. • Provide first-hand knowledge of service layouts.	• Too many bodies already involved in the construction process with the addition of another may ultimately result in another person required to sign off on particular aspects. • They may have a personal opinion they may try force on the design team. • Not enough construction experience and too much interference while also lacking the technical and material cost skills. • Slow down the design process with obscure suggestions. • Taking some of the overseeing role away from the project architect. • An additional fee. • They may not understand the cost of installation.
O&M	• Provide knowledge of the building that other professionals may not have in regards to ongoing maintenance issues. This can help address problems that may impact the business in the future. • Highlight areas of concern in regards to common running costs and target these areas before they impact on the financial goals of the organisation. • Improve the selection of the maintenance and practical applications through previous knowledge of similar equipment / items. • Use their knowledge to ensure the building was designed to be proactive to daily requirements. • Apply their knowledge of current operations and maintenance regime at the design stage to target possible concerns.	
Energy Management	• The Facility Manager can influence the building's occupiers to be more sustainable through constant communication in promoting energy agendas. • Practical advice about energy saving strategies that work/don't work in similar buildings of this type. This can position the organisation in regards to ongoing legislation changes. • The FM can drive a programme to reduce energy savings and if brought in at early design stage, and	

	involved in the process will allow him/her take ownership of the targets. • Apply their knowledge of implemented energy management strategies and the management of resources required to monitor them.	
Space Management	• Contribute practical knowledge to floor layouts and utilising workspace layouts. This will increase worker productivity and ensure spaces were correctly utilised.	
Occupant Behaviour	• They can provide designers with information on how users will interact and therefore address user concerns from the beginning i.e. amount of people working and requirements for maintenance. • Can help streamline the design process, as they know what the clients want and therefore avoid costly design	

Table 6.4: Expanded table of suggested areas in were early Facility Manager involvement can contribute to the design stage

Q7, What IT software do you use to support your FM processes e.g. Computerized Maintenance Management Systems (CMMS) and Computer Aided Facilities Management..

A wide variety of IT software were identified as been used by the respondents to support the FM process, namely:

- CAFM, CMMS and BMS systems.
- CompuCal which was a web-based application that handles both calibration management and maintenance planning.
- Cylon Building Management System and Sage SalesLogix Client for corrective actions and document digital building files to aid with O&M of buildings.
- InControl DFM which was a software used to create digital building files to aid with O&M of buildings.
- SAP which was a software that manages business operations and customer relations.
- Spreadsheets for FM purposes.
- CAD based FM system for FM i.e. Revit.

The most common IT software reported by the sample was a mixture of CAFM, CMMS and BMS which represented 25% of the sample. Other common IT solutions for FM included spreadsheets which was represented by 12% of the survey sample. A large sample of the survey was not using any FM software and failed to supply an adequate answer to the question. No respondent, however, specifically mentioned BIM. Revit was detailed as a tool used by two of the respondents, but in what capacity in respect to BIM for FM purposes was unknown.

The Irish FM sector though stagnant in areas showed encouraging signs of adopting strong FM systems detailed within the literature, these included CAFM, CMMS and BMS. However, there was a lack of adoption to high end emerging technologies such as BIM, but more importantly the process that comes with it.

Q8. There are a number of inefficiencies that exists in the construction process (legacy problems) that the Facility Manager must try and rectify after handover of the building. How in your opinion can ICT be successfully deployed to address these inefficiencies?

All responses to this open question are presented in Appendix 3C. It was evident that the respondents were quite knowledgeable on BIM and its potential to address inefficiencies in building production and handover.

Some of the more notable responses referred to BIM as a tool that can address inefficiencies in the construction process through *"the co-ordination of drawings, both for construction and for as-built use after handover for manuals and maintenance, can only help to minimise deficiencies and aid cost reduction during the running of a building".*

"The BIM process, if properly implemented during the design development and construction of a project, offers a vastly improved means of communicating and co-ordinating project designs to relevant stakeholders. Through improved communication one affords themselves an opportunity to improve design outcomes".

Other suggestions include requests for *"simplified BMS and operational manuals, hosted on the cloud"* and providing *"digital information that can immediately be "consumed" into FM systems, without requiring information to be manually recreated"*.

Other notable responses included the requirement to *"utilise integrated solutions across the plan build operate lifecycle"* and *"careful planning and execution with CAFM assistance"*.

The results show an appreciation of ICT in addressing inefficiencies in the construction process. A number of respondents also stressed the importance of targeting these inefficiencies from the very start. Despite a relatively low number of the sample reporting the use of high end

FM packages there was still an appreciation of the possibility of ICT playing a key role in the design stage in addressing the legacy problems faced by the Facility Manager. The solution advocated throughout the research of a more focused ICT approach through BIM and earlier involvement of the Facility Manager offers a potential solution in targeting these legacy issues.

Q9. It is now widely recognized that Operation & Maintenance (O&M) represents the greatest expense in owning and operating a facility over its life cycle. In what format is O&M information usually provided / required by your organization? Please select all that apply:

Figure 6.6 illustrates that over a third of respondents reported that O&M information was mainly paper-based. It was encouraging to see that the remaining two thirds of the sample received the O&M information digitally but none reported receipt of a BIM model.

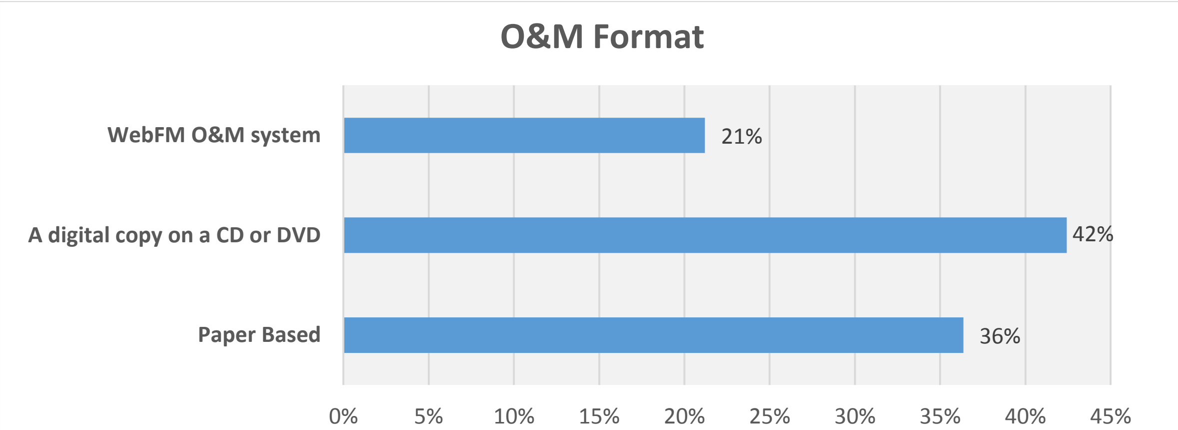


Figure 6.6: How O&M Format is accessed at present through organisations within the BIM for FM survey.

The analysis would reflect that despite a number of high end FM systems in place that a number of respondents still prefer or were required to work from a paper or digital based O&M Manual. The two respondents who were using the 3D platform Revit were accessing O&M information from a digital copy on a CD or DVD or paper based. This would indicate that while Revit may be used for some basic FM solutions as space management it was not the primary tool used to manage their day to day FM activities.

Some interesting comment's received included *"that as a result of legacy of bad file management, files were stored in all formats in one's organisation"* and *"that clients usually do not specify and so therefore get a pile of paper"*.

Q10. How aware are you of the current interest and debate in respect to Building Information Modelling (BIM)? Please tick one

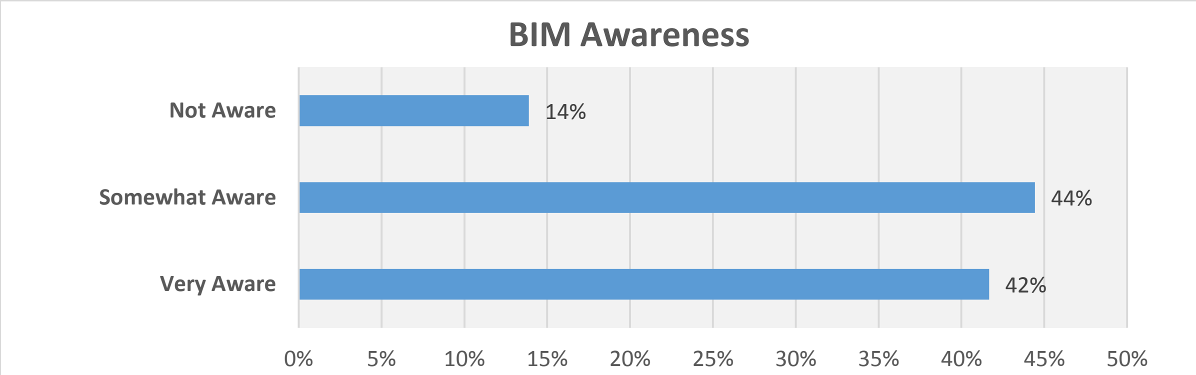


Figure 6.7: Current awareness and interest of the debate in respect to BIM

The majority of respondents were aware of the BIM, with only 14% reporting that they had no knowledge. This was unsurprising given the extent of press and media coverage of BIM matters in recent years. The results are illustrated in Figure 6.7. 1. The results are low compared to the BIM in Ireland survey, with 43% stating that they were aware of and using BIM compared to 53% reporting that they were just beginning to take notice of BIM.

Q11. Have you any experience in using a BIM model for Facility Operation and Maintenance. If you answered yes then please indicate if you have any experience in using a BIM model for Facility Operation and Maintenance.

Figure 6.8 illustrates that only 23% of the sample reported having experienced working with BIM when it came to FM related practices.

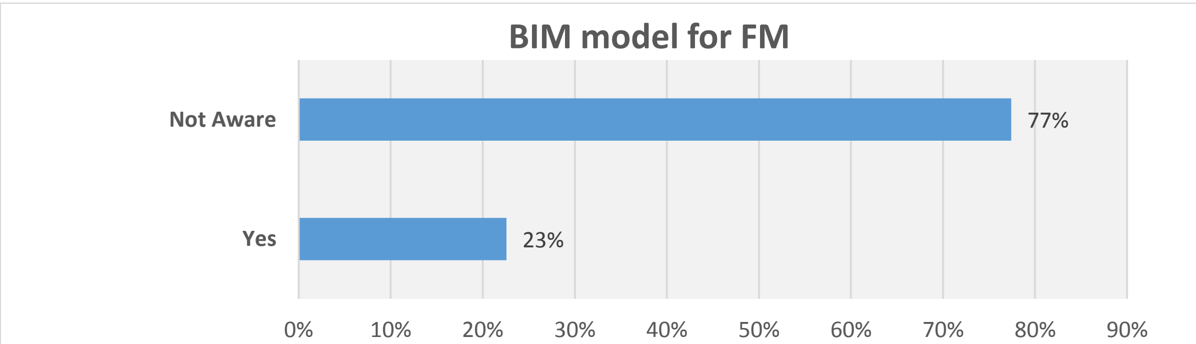


Figure 6.8: Experience in using a BIM model for Facility O&M

When asked to elaborate on how they were using the BIM models for O&M the most informative responses from the sample included a *"seamless flow of FM information between the BIM model and different exports such as COBie & IFC File"*.

Other comments recorded noted that one respondent was using the *"BIM to model structural alterations in existing buildings to ensure the existing utilities can be maintained or diverted where necessary"*.

One respondent noted that at the time his organisations was currently *"undertaking in-depth reviews of how to best promote the use of BIM systems on future projects, this will look at BIM from both the construction and FM perspective"*.

Other comments though not BIM specific involved using a *"CMMS system to control schedule and maintain the PMs for the building and subsequent equipment"* and a *"trial with One Look systems that covered a number of FM related areas.*

A more realistic figure after exploration of the results was that just 5% of the survey have experience using a BIM model for facility O&M. The remaining 18% despite stating yes were using non BIM related FM practices.

There appeared to be a lack of understanding with regards to BIM for FM in Ireland with only a very small fraction of the collected research using this process. A lack of actual BIM adoption and cutting edge technologies in the Irish AEC/FM sector were cited for reasons for this. As BIM in 2012/2013 was starting to get attention in Ireland it would be acceptable that it had not made an impact on the FM profession to date. Some of the reasons for lack of adoption were aligned to previous literature findings as described by Wong and Jay (2010) and Gerber et al., (2011), in where an understanding of BIM had only been applied to the design stage and the existence of cultural barriers toward adopting new technology.

Q12 There is a plan for a phased five-year development within the UK whereby public works projects will be required to use BIM from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government as a client would have a public sector that was smarter and better equipped to face a low carbon economy. Do you believe that the Irish government should take a similar stance to the UK and mandate the use of BIM?

Figure 6.9 clearly shows that the majority of respondents agreed that they were in favour of a similar stance as seen in the UK for a BIM mandate. All responses to this open question are presented in Appendix 3C.

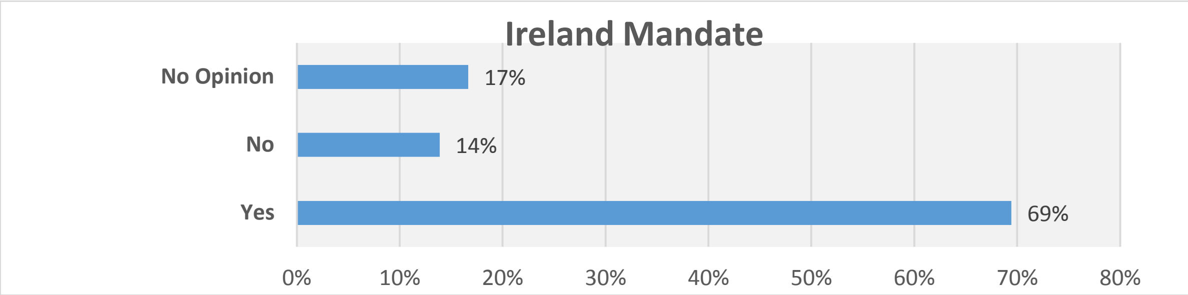


Figure 6.9: Poll if Ireland should follow the UK stance and implement BIM

The respondents were asked to expand on the rationale for their choice with some of the pro mandate sample stating that *"historically one has followed the UK and given that we have such a close relationship one can see the Irish Government following suit"*.

Other informative responses expanded on the application of the model at the FM stage in that it can be *"used to create a FM system to operate and maintain the building"* and by *"investing in the design stage, where changes are least costly to make, would vastly improve the ROI for government by having buildings which were cheaper to run"*.

Some of the anti-mandate responses included that *"it will take a long time to fully integrate BIM as the industry is slow to adapt to change"* and that forcing the *"public sector to accept a mandate would lead to many pickets and angry people"*.

A further notable comment describes *"BIM as merely a tool and can be a vague tool. A T square and calculator could technically be called BIM. BIM has been around for almost twenty years and still doesn't integrate well with other platforms. It is not suited to bespoke Architectural work and leads to a design by Excel type approach"*.

A general consensus was that if a mandate was to become a reality *"the government will have to significantly fund training and investment in BIM technology"* and *"additional quality marks in tender submission"*. This was a similar response to the BIM in Ireland survey and stresses that a mandate will need to be government lead. A full breakdown of all the responses can be located in Appendix 3.

Q13 Do you have any experience in working within the Public Works Sector in regards to Facilities or Property Management of existing Government assets?

22% of the survey sample have worked on public works contracts from an FM perspective. The results are illustrated in Figure 6.10.

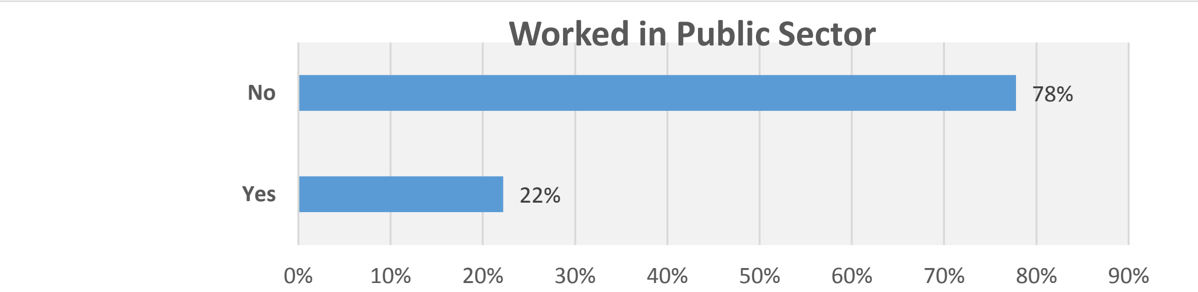


Figure 6.10: Response rate within the BIM for FM survey of people who have worked in the public works sector in regards to facilities or property management of existing Government assets.

Some of the key comments from the respondents who have worked in these contracts include that *"decisions were all based on short term costs and not life cycle"* and there was a *"lack of coordination between designers, constructors and operators"*.

Other notable comments include that there was a *"low level of use/ reference to O&M"* and *"other than design guidelines produced by government departments where it is only assumed that maintenance issues were considered, there was no FM input into any of the projects"*

Despite the low response rate for this question the Facility Managers that responded were generally concerned with the lack of foresight put into the O&M of the building after construction.

6.5 SUMMARY OF FINDINGS

6.5.1 General Findings

The following were the key findings from the survey:

- Over half of the respondents indicated that there had seen little involvement of the Facility Manager in the construction process.
- A strong majority claimed the Facility Manager can have a major impact if introduced in some capacity to the construction process.
- The key contributions and concerns for early involvement of the Facility Manager were detailed in table 6.4. Some of the key areas in which they can impact the

design include M&E, O&M, energy management, space management and occupant behaviour.

- Some of the barriers toward early Facility Manager involvement included that the construction process was already too congested and the Facility Manager may not have enough knowledge of the design process. They may slow down the design process with obscure suggestions and could possibly take some of the overseeing role away from the project architect.
- The most common IT software used by the sample was a mixture of CAFM, CMMS and BMS which represented 25% of the sample. No respondents, however, specifically mentioned BIM.
- Respondents demonstrated a knowledge of BIM with an understanding that BIM can be applied to address inefficiencies.
- Over a third of respondents reported that O&M information was mainly paper-based. The remaining two thirds of the sample received the O&M information digitally but none reported receipt of a BIM model.
- The majority of respondents were aware of BIM, with only 14% reporting that they had no knowledge.
- Only two respondents were actively using a BIM model for O&M purposes.
- The majority of respondents agreed that they were in favour of a BIM mandate similar to the UK.
- 22% of the respondents worked within the public sector in property and asset management. The Facility Managers that responded were generally concerned with the lack of foresight put into the O&M of the building after construction.

6.5.2 Comparison to International Reports

The findings were compared to the BIM4FM UK Task Group Survey carried out in 2013, which explored the uncertainty of BIM amongst those that will access the data. There were synergies between the two reports with the author’s survey focusing strongly on early Facility Manager engagement and establishing the current ICT practices and inefficienes within the public and private sector. The following comparisons can be made between the two surveys:

- The awareness of BIM in the UK was at 65% amongst FM professionals while in the Irish survey it was at 86%.

- The UK survey recognised a number of opportunities for Facility Managers, owners and occupiers that included lifecycle management (75%) and the possibility of earlier FM involvement in the design. Other noted improvements included improved efficiencies (68%) and carbon reductions (63%). The area of lifecycle improvement within the Irish survey was seen as a significant benefit of BIM adoption. Also, the area of early FM involvement was a key area covered in the survey with significant research output.
- The chief concerns in regards to BIM, within the UK survey, included cost (51%), integration with current technology (51%), training (35%), data management (33%) and time (33%).

The two surveys though different in nature offered similar results when analysed and suggest that the two countries were aware of the BIM 4 FM initiative. As seen with the BIM in Ireland survey, the similarities in results suggest that the Irish FM sector were aware of ongoing BIM initiatives in the UK, with regards to the better management of the public sector estates.

6.6 CONCLUSION

The results from the survey show that there was little involvement of the Facility Manager during the early stages of construction. There was a belief that the Facility Manager should have an advisory role, within the design and construction phases, as he/she can help streamline the design briefing process through their knowledge of facility operations. It was felt however that this involvement could interfere with the design team. There was been little move towards using cutting edge technologies within the Irish FM sector. It was however, evident that respondents were knowledgeable in respect to ICT in improving the overall FM process, which included the use of an integrated BIM packages. There was an overwhelming call for the implementation of BIM on public sector projects to help Facility Managers reduce environmental impacts and operating costs.

The two surveys and the RIAI CitA pilot project helped formulate an alternative solution for the design, construction and operation of future Irish public works projects. This alternative solution involves the partnership of BIM and early Facility Manager involvement. This approach was justified through the findings of Phase 1 of the research. The next phase of research builds on these results, through applying the findings to help establish a set of KPTs. These KPTs have enabled a better understanding of the areas where the Facility Manager can have the greatest impact in the early design.

7 ESTABLISHMENT OF KEY PERFORMANCE TASKS

7.1 BACKGROUND INFORMATION

This chapter focuses on Phase 2 of the primary research involving a transformative design approach. The selected case study was the 2013 CitA Technology Pilot. The purpose of the pilot was to offer the opportunity to observe lessons learnt and report on the potential benefits and risks experienced by the pilot team. The overarching aim of the pilot was to shift project focus from design and construction to the FM through the use of integrated technologies and the adoption of smarter workflows..

The research involved creating a set of KPTs that can be used to better understand the areas where the Facility Manager can have the greatest impact in the early design. Research performed in Chapter Two identified a number of key competency areas associated with the role of the Facility Manager. These competency areas were mapped against research performed in Phase 1, where a number of early design target areas were established that offered the greatest potential for the Facility Manager to impact from their earlier involvement. These were then mapped against a number of established performance indicators identified in Chapter Two, which were tested and refined to produce a set of KPTs to be used later in the thesis.

Data was gathered from a combined collection of documentation, surveys, key interviews and the on-going interaction with all pilot team members. The study confirms that the FM team, if properly utilised, can help further co-ordinate the thoughts of the designer with the end user.

7.2 PURPOSE OF STUDY

The key objectives of the pilot were to:

1. Deliberately shift project focus from design and construction to the FM and operation/ phase of a project.
2. Focus on the integration of the FM team into the design phase of a project.
3. Investigate the use of a variety of ‘BIM' authoring and interface tools/ technologies and other ICT to streamline the efficiency of the FM process.
4. Focus on the real value created by the FM team, with an attempt to quantify this value during the process.

5. Produce a set of KPTs that can demonstrate the benefit of introducing the Facility Manager at an early stage in the BIM process on public sector projects

7.3 METHODOLOGY

The observation was carried out on a virtual project that was piloted by a team of Irish professionals who wanted to test and experience a proof-of-concept BIM pilot to identify the potential benefits/risks involved in utilising BIM from an FM perspective. A full list of pilot participants can be located in Appendix 4. Through the integration of the team and using smarter workflows and technologies to facilitate more collaborative practice, resulted in an improved workflow value for all involved, particularly the Client and Facility Manager.

7.4 PILOT DETAILS

7.4.1 Outline Design

The subject building selected was located in a village in North County Dublin, known as Rowlestown. The building was a community centre which was in need of some form of refurbishment. A small group of enthusiastic member organisations of CitA was keen to demonstrate how this building could be designed using BIM technologies. Survey data was provided for the project through three combined methods that consisted of firstly setting up a Global Positioning System (GPS) grid of the area, and then secondly an Unmanned Aerial Vehicle (UAV) was flown over the area capturing digital information. Thirdly this data was combined with a laser scan of the building. Using a cloud-based solution provided by Team Platform, a full colour point cloud was produced. An illustration of this point cloud is shown in figure 7.1

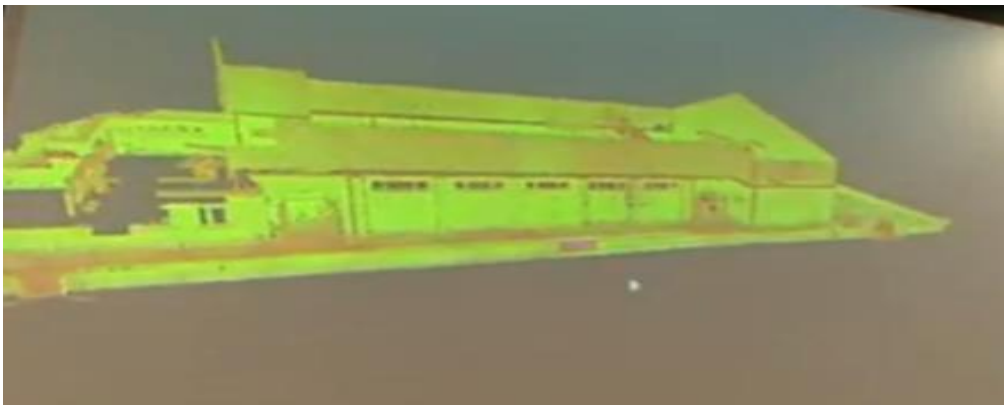


Fig 7.1: Point Cloud of the existing building used for the technology pilot 2013

Before scheme design could commence there were a number of different BIM standards considered for use on the project. The AEC (UK) BIM Standards were consulted before modelling began and it was decided that file naming conventions would be adapted. All the library objects were renamed with a Uniclass 2 format. The 3D terrain model received from survey data was then imported into Archicad, which was further taken through Google Sketchup. The point cloud data was imported into Google Sketchup. The team received a complete model of the building, which was 30GB in size. The survey information originally imported into the platform of Archicad took up to 8 hours to import. A simplified model (300 Mb) was used with a 20-million-point cloud setting filter distance, which took only an hour and half to import, thus creating a simplified 3D model picture. Through combined point cloud data and orthorectified imagery a building model was constructed. As textures were applied to the model, it became more realistic and gave a good platform to make decisions, from which sections and elevations were easily generated, as illustrated in figure 7.2

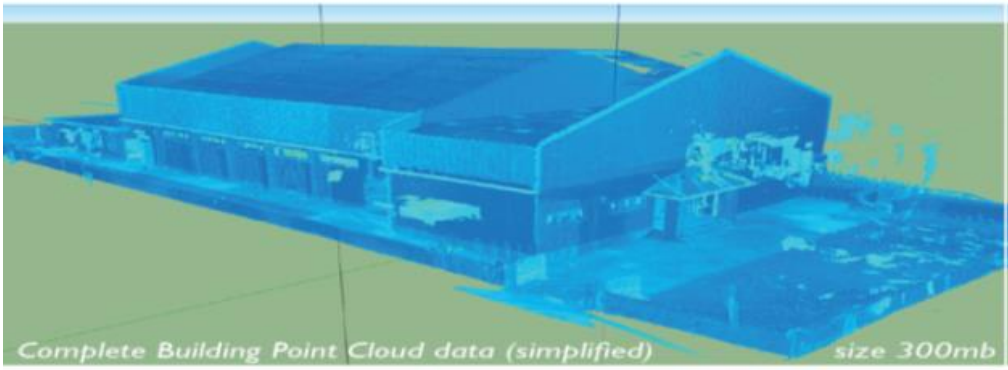


Fig 7.2 Complete Building Point Cloud Data (Simplified) of building used of the technology pilot 2013

7.4.2 Scheme Design

A meeting took place with the public sector client and a brief was created during the pilot. This brief involved two phases of the project with Phase 1 ultimately aiming to re-evaluate the current structure and produce a solution for a more functional building. This was based around the Client’s needs, which includes better thermal comfort, enhanced artificial lighting, improved acoustics, upgrade to the Crèche, as well as the addition of a shop unit. The FM team were involved in the Client meeting and provided feedback on some of problems associated with the day to day operation of the building. Phase 2 would involve an upgrade to the Crèche, as well as the addition of a shop unit. The building’s interior was modelled so that an informed design could be undertaken and visualised by the FM Team. This also resulted in the Client and planning authorities being able to easily understand the design intent. Figure 7.3 shows an illustration of the 3D model that represented the existing building, while figure 7.4 represented the 3D model after the Client's design considerations had been incorporated.

Fig 7.3: Model of existing building used for the technology pilot in Rowlestown 2013

Fig 7.4: Model of scheme design in context for the technology pilot building 2013

7.4.3 M&E Design

The project team included the Facility Manager who worked alongside the M&E designer. The internal space was divided into four different areas of retail, office and general use areas, meeting rooms, general purpose hall and crèche. The first task was to reduce the energy cost and so therefore, it was important each of the internal elements were assessed to establish the possible U-value that could be achieved. The M&E consultants conducted heat analysis and cooling loads on these elements. In terms of ventilation and heating there was not a passive solution that lent itself to the hall. It was agreed to reuse the original floor ducts and put a package unit at ground floor for maintenance purpose for easy access. This would improve the ventilation through the space by providing heating and cooling, so it could modulate to match the occupancy levels.

A plant space was created in a hidden area behind the roof by the architect. The Facility Manager assisted the M&E specialist in the selection and placement of equipment. He also contributed to conversations on the placement of this equipment in regards to ease of access. Fan coil units were placed in the meeting room areas, as these areas would fluctuate quite differently from one day to the next depending on occupancy levels. The crèche was treated as an independent area, so it could be metered separately with the idea to put a small heat pump for underground heating to avoid high surface temperature for the children. This ensured that there could be heat ventilation circulation so that the place could be heated without having to open all the windows. This concern was raised by the Facility Manager which resulted in a change in the design.

There was a deck area and directly below it was the plant room. The Air Handling Unit (AHU) package unit was placed there and the heat pump located within a room beside it. This was also designed with a view to provide ease of access to ensure that all future maintenance could easily take place. A BMS was considered to allow the option to control running costs and a web alert or sms alert was to be sent to designated people to inform them if the building needs attention. Figure 7.5 represents an illustration taken from the model of the crèche and the suggested plant layout.

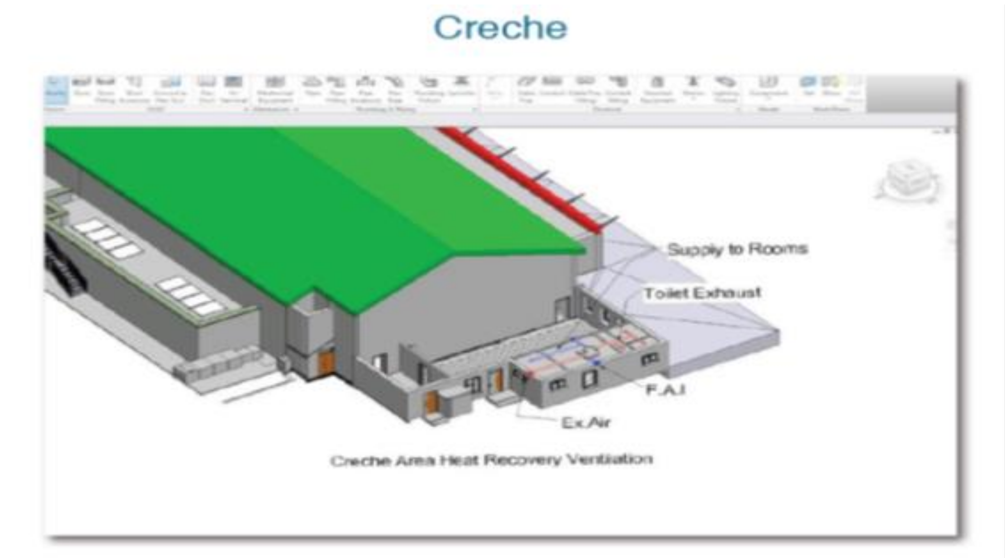


Fig 7.5: Image of the crèche and plant layout taken from the BIM Model.

7.4.4 Quantity Surveying Input

The model incorporated all the structural and M&E information. An outline specification was prepared for the benefit of the Quantity Surveyor (QS), with all elements being classified in accordance with Uniclass 2. The objective of the project QS was to produce a cost plan from both 2D and 3D information. The IFC file was uploaded into the Exactal software tool Cost X that supports BIM. Digital design data was used to accurately estimate quantities and costs. Despite the mapping issues being frustrating and tedious, there were significant benefits for the QS because any changes to the model could be filtered quite easily.

7.4.5 Contractor Input

Synchro was used for site logistics and mapped with a project schedule. It also allowed for a number of construction methodologies to be examined. The contractors followed a construction sequence that involved site set up, demolitions, sub-structure, superstructure, external envelope, M&E services, internal finishes and site works. The model permitted a Health & Safety (H&S) assessment to be carried out where a number of precautions could be accurately estimated. Clash detection was also performed throughout this process. Figure 7.6 shows an illustration of some of the temporary works modelled on the site. Figure 7.7 illustrates the layout of the site compound, as detailed in the model.

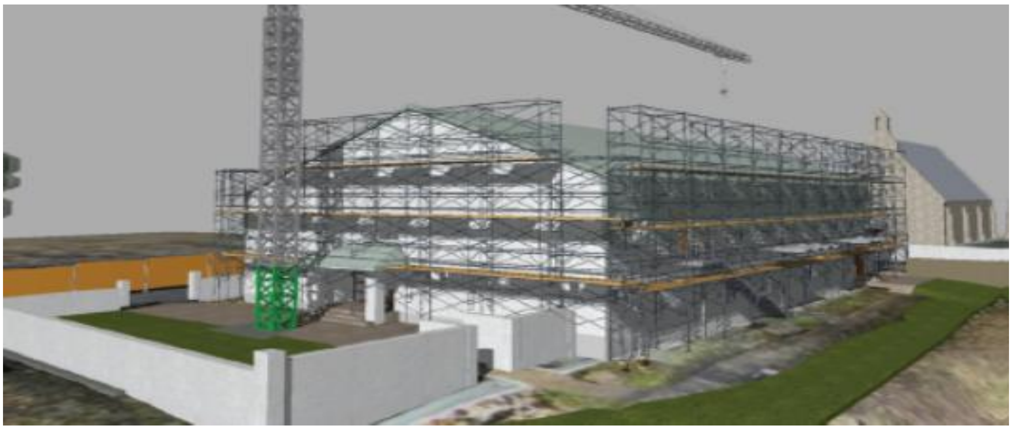


Fig 7.6: 4D Design illustrating aspects of H&S for the technology pilot 2013

Fig 7.7: 4D design illustrating the logistics and site layout of the technology pilot 2013

7.4.6 Fabrication Input

A full manufacturing schedule of parts, as well as drawings of items, such as stairs where weights were calculated was produced. The model produced files for the Computer Numerical Control (CNC) machines, which was a process used in the manufacturing sector that involves the use of computers to control machine tools. These were exported to a German standard known as Deutsche Stahlbau Verband (DSTV). This was a simple format that machine handlers could easily use. A manufacturing team who specialised in pre-fabricated BIM structures was introduced into the project team, so as to allow for a number of pre-fabricated elements to be modelled. The IFC file was imported into Tekla Structures where obstructive and irrelevant surfaces were filtered out, so as to identify what products could be used for the building. Figure 7.8 illustrates the possibilities of where the building could use pre-fabrication techniques.

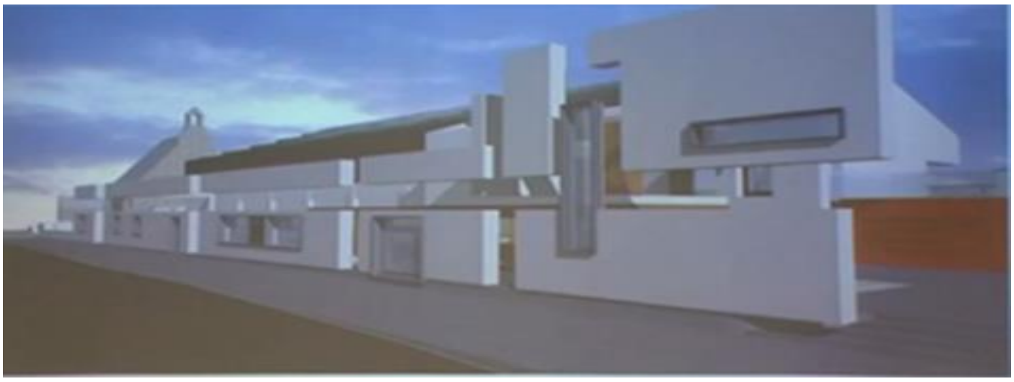


Fig 7.8: Pre-fabrication solution suggested within the technology pilot. 2013

7.4.7 FM Input

The FM team played an active role throughout the pilot. COBie was discussed as a standard to deliver information at the beginning of the project but it was decided to use the FM team's in-house software. This in-house software was called InControl DFM. InControl DFM produced an interactive file that was used as the interface for the documentation of the project. The FM through IFC data and in house software produced part of a digital handover document for the Client. As this was the preferred tool to deliver information to the Client, as well a lack of knowledge in regards to COBie, it was agreed not to adopt this standard. The FM team worked with the project team to select the most important assets to be modelled and provided an end-user focus throughout the project timeframe. They assisted in the design and layout of the M&E plant room, so as to ensure ease of access for maintenance purposes. Further details on the pilot can be located in Appendix 4.

To achieve the stated research outcomes of the pilot the methodology involved a two stage process:

- Stage 1 – Creating an online tool to measure the KPIs and a viable method of collection and analysis. A longitudinal panel study was selected.
- Stage 2 - Interviewing of pilot team members. This involved carrying out semi-structured interviews with the key stakeholders involved within the pilot.

7.5 KEY PERFORMANCE TASKS SELECTION

In order to establish a valid set of KPTs within the pilot a three stage process was adopted. The rationale for selection of a three stage process was that it enabled the triangulation of both the core competencies and early design target areas associated with the role of the Facility Manager, with existing BIM KPIs. The triangulation of these three performance areas resulted in the establishment of common criteria which has served as the basis of the KPTs. This triangulation process involved:

1. Defining the core competency areas of the Facility Manager's role by reference to established international standards identified earlier in the literature review. These competencies mainly focused on the contribution of Facility Managers in the handover and operational phase of a new build project.
2. These key competency areas were then compared against areas where the Facility Manager can have the greatest impact in the design and construction phases, which were examined in Chapter Six.
3. Finally, a review of established BIM KPIs were compared and mapped against both the established core competences and the particular areas that would benefit most from earlier Facility Manager involvement. The overall selection process is illustrated in figure 7.9. The final analysis of the KPIs described in section 7.7 produced the KPTs which are represented in figure 7.9 as the blue circle.

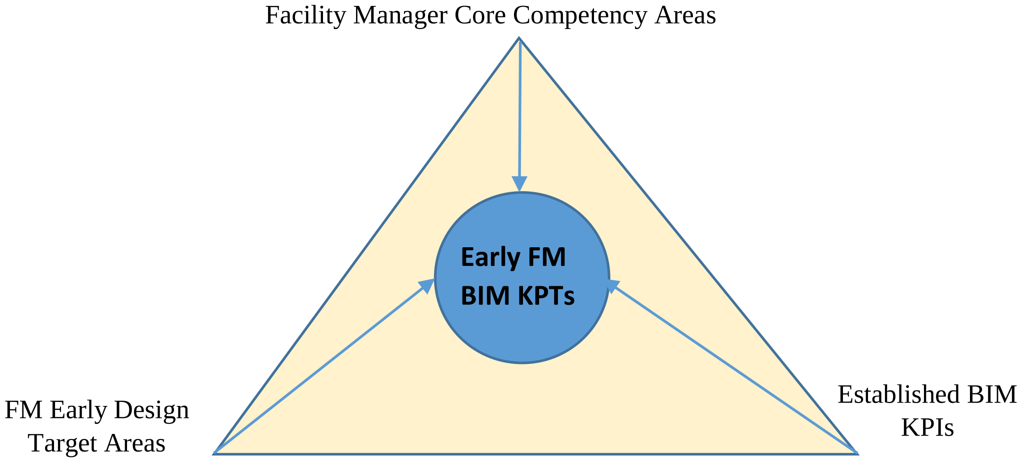


Fig 7.9: Early Facility Manager BIM KPTs selection approach

7.5.1 Key Competency areas of the Facility Manager's role

The literature associated with key competencies of Facility Managers was previously reviewed. The current accepted standards of the IFMA 2009 and BSI 2007 were critically reviewed and synergies in respect to competencies were identified. Table 7.1 represents a cross reference of the services provided by the FM team at a strategic, tactical and operation level, as detailed in BSI 2007, against the most relevant core competency areas of the Facility Manger that were detailed in IFMA 2009. This enabled an understanding of where both standards overlap, and in doing so, illustrated the most prevalent competencies expected within the Facility Manager's role.

From a direct comparison of the IFMA 2009 and the BSI 2007 standards, the following competencies appear to be given equal importance within both;

1. Communication;
2. Emergency preparedness and business continuity;
3. Leadership and financial / sustainability strategy;
4. Operations and maintenance; and
5. Hard and soft project management.

Some of the competency areas such as, "leadership and strategy", "environmental stewardship and sustainability" and "finance and business" have been combined, as they overlap in some instances. The combination of these areas will also ensure all competencies areas were sufficiently well covered. These areas were represented within the core competency area "leadership and financial / sustainability strategy". This was similar for the "human factors" and "project management" core competencies which were represented by the core competency area "hard and soft project management".

Technology can be used to enhance all of these competencies and the use of BIM can be seen as the portal to offer the Facility Manager the opportunity to contribute to the design process, which they have had difficulties in achieving through traditional practices. The main output for all of these key areas was to enhance the value of the real estate and property management in question. An illustration of the core competencies that define the Facility Manager's role and responsibilities are outlined in Figure 7.10.

This was divided into the following three levels:

1. Level 1 – This represents the selected technology that will be adopted to enhance each of the core competencies, which in this instance will be BIM. BIM has been chosen as a result of an extensive literature review and phase of research, were it was found that it has great potential to streamline the FM process.
2. Level 2 – This represents the five established core competencies where BIM will be applied.
3. Level 3 – This level represents each core competencies divided into a strategic, tactical and operational level.

These competencies were unique to the Facility Manager as they have a tacit knowledge with regards to each one of these areas through practical experience. The purpose of establishing these areas was to determine if the Facility Manager could apply their knowledge within these competencies during the design process.

7.5.2 Identifying Early Facility Manager Contribution

The next stage of the KPT selection process involved comparing those early design target areas identified in Chapter Six (Table 6.4) and cross-referencing them to the most suitable core competency. This will enable an understanding of how early involvement of the Facility Manager can enhance each one of the core competencies. This will establish were the five core competencies associated with the role of the Facility Manager can be enhanced by their earlier involvement within the design area of M&E, O&M, energy and space management. This data is presented in table 7.2. On interrogation of table 7.2 the following conclusions have been made:

- **Communication**: The Facility Manager can provide designers with information on how users will interact and therefore address "*Energy Management***"** concerns from the beginning.
- **Emergency preparedness and business continuity**: The Facility Manager can impact "*Energy Management"* concerns by offering practical advice about energy saving strategies therefore positioning the organisation moving forward in regards to ongoing legislation changes. They can help to ensure the selection of "*M&E"* equipment was responsive to change and does not affect the organisations long term business goals. They can also provide knowledge of the building that other professionals may not have in regards to ongoing *"O&M* "issues, therefore helping to address problems that may impact the business in the future. They can also offer advice in the area of *"Space Management"* through assisting in the selection and provision of spaces during design for possible future expansion of the organisation.
- **Leadership and financial / sustainability strategy:** The early involvement of the Facility Manager can drive an *"Energy Management"* programme to reduce energy savings if brought in at early design stage. They can assist in determining "*M&E"* plant equipment and in the process eliminate non required items therefore avoiding unnecessary spend. The Facility Manager can also highlight areas of concern in regards to common "*O&M"* costs and target these areas before they impact on the financial goals of the organisation. Finally, they can hep in the area of "*Space Management"* through contributing their practical knowledge in utilising workspace layouts to increase worker productivity.
- **Operations and maintenance**: The early involvement of the Facility Manager can highlight areas of concern in regards to ongoing running costs therefore affecting issues related to "Energy Management". With "M&E" they can provide first-hand knowledge of service layouts and ensure that all items specified were affordable and easy to repair. They can improve the selection of "O&M" applications and use their knowledge to ensure the building was designed to be proactive to daily requirements instead of being reactive.
- **Hard and soft project management:** Through early involvement they can apply their knowledge of implemented *"Energy Management"* strategies and the management

resources required to monitor them. They can translate concerns from staff members in regards to particular "*M&E*" and "*O&M*" issues which can be incorporated into the design.

The early Facility Manager BIM KPTs selection approach previously illustrated in figure 7.10 has now been updated to include these findings. Figure 7.11 illustrates the updated revision of this approach.

7.5.3 BIM KPIs

The third part of the early Facility Manager BIM KPTs selection approach involved cross referencing existing BIM KPIs against both the established core competences and early design target areas. It was decided that the best approach was to have a wide scope of KPIs that could help measure the complete BIM process, while also being able to concentrate on the role that the Facility Manager could occupy within the design. The reason for this was that the pilot involved a transparent environment where all pilot companies had open communication and access to each other's work. This also resulted in an attempt to incorporate all professions into an IPD environment, which included the FM Team. As the FM Team would not normally be involved in a traditional process it permitted the opportunity for its early input and how it prefers the information to be delivered. This enabled the opportunity to investigate if the Facility Manager could play a role in other construction related areas outside of their normal environment.

The framework established by Barlish and Sullivan (2012), as previously described was adopted. The rationale for selection of this framework was due to both its relevance to the pilot and its simplicity. The framework was based on a review of over 600 sources of information were the suggested framework was proposed as the dominant framework methodology. This framework was easily applied within the pilot case study. This involved a five step process of establishing the KPIs, testing the metrics against case studies, evaluating the resultant information from the case study to quantify the benefits, provide conclusions from the data and validating the KPIs. Suni and Zhou (2010) previously described five primary BIM KPIs of quality, cost, time, safety and energy which were incorporated into the KPI selection. These headings were expanded to include sub KPIs as a result of interaction with the pilot team who requested particular areas of interest to be monitored.

IFMA – Core Competency Area	IFMA – Facility Manager Core Competency Contribution	BSI 2007: Strategic Level Long Term Objectives	BSI 2007: Tactical Level Medium Term Objectives	BSI 2007: Operational Level Day to Day Objectives
Communication	Communication plans and processes for both internal and external stakeholders.	Maintaining relations with authorities, lessees and tenants, strategic partners, associations etc.	1. Monitoring compliance to laws and regulations. 2. Communicating with internal or external service providers on a tactical level.	1. Collecting data for performance evaluations, feedback and demands from end-users. 2. Communicating with internal or external service providers on an operational level.
Emergency Preparedness and Business Continuity	Emergency and risk management plans and procedures.	Initiating risk analysis and providing the direction to adapt changes in the organisation.	Adapting to and reporting on changes.	
Environmental Stewardship & Sustainability	Sustainable management of built and natural environments.			
Finance & Business	Strategic plans, budgets, financial analyses, procurement.	Defining the Facility Management strategy in compliance with the organisation's strategy.		
Human Factors	Healthy and safe environment, security, FM employee Development.			
Leadership and Strategy	Strategic planning, organize, staff and lead organization.	Policymaking, elaborating guidelines for space, assets, processes and services.	1. Implementing and monitoring guidelines for strategies. 2. Developing business plans and budgets.	Reporting to tactical level.
Operations and Maintenance	Building operations and maintenance, occupant services.	1. Supervision of the Facility. 2. Active input and response.	Translating facility management objectives into operational level requirement.	Receiving requests for service e.g. via a help desk or service line.
Project Management	Oversight and management of all projects and related contracts.	1. Initiating service level agreements (SLAs) and monitoring key performance indicators (KPIs). 2. Management organisation.	1. Defining SLAS and interpreting KPIS (performance, quality, risk and value). 2. Managing projects, processes and agreements. 3. Managing the facility management team. 4. Optimising the use of resources.	1. Monitoring and checking the service delivery processes. 2. Monitoring the service providers.
Quality	Quality Best practices, process improvements, audits and measurements.			
Real Estate and Property Management	Real estate planning, acquisition and disposition.	Managing the impact of facilities on the primary activities, external environment and community.		
Technology	Facility management technology, workplace management systems.			

Table 7.1: Core competencies of the Facility Manager (IFMA) cross referenced with the actions of the FM team at a strategic, tactical and operational level (BSI 2007)

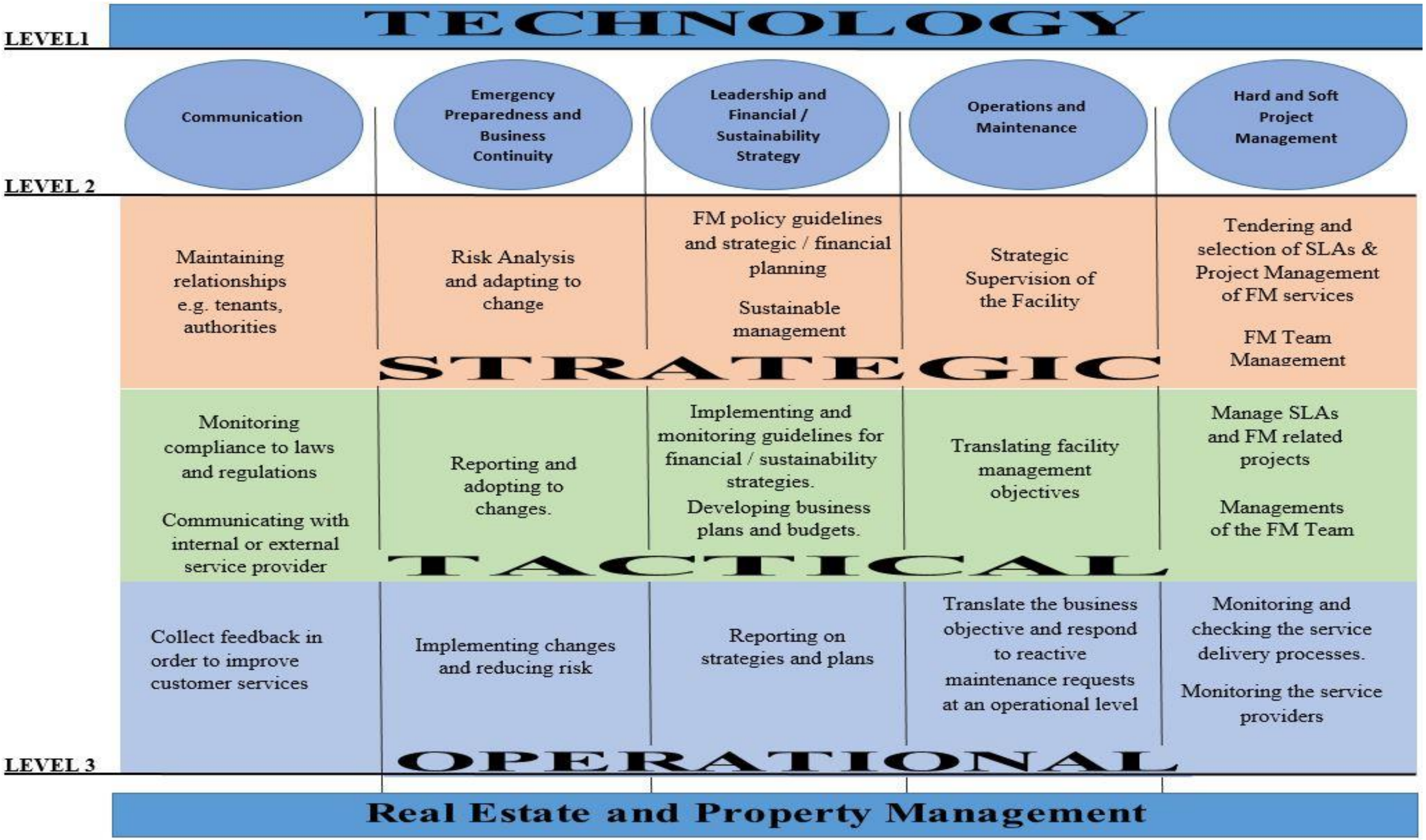


Fig 7.10: Early Facility Manager BIM KPTs selection approach Revision 1

	Communication	Emergency Preparedness and Business Continuity	Leadership and Financial / Sustainability Strategy	Operations and Maintenance	Hard and Soft Project Management
Energy Management	They can provide designers with information on how users will interact and therefore address user concerns from the beginning i.e. amount of people working, requirements for maintenance, who will operate the facility, etc.	Practical advice about energy saving strategies that work/don't work in similar buildings of this type. This can position the organisation moving forward in regards to ongoing legislation changes.	1. The FM can drive a programme to reduce energy savings and if brought in at early design stage, and involved in the process will allow him/her take ownership of the targets. 2. Practical advice about energy saving strategies that work/don't work in similar buildings of this type. This can position the organisation moving forward in regards to legislation.	Highlight areas of concern in regards to ongoing running costs.	Apply their knowledge of implemented energy management strategies and the management resources required to monitor them.
M&E		Help to ensure the selection of M&E equipment that is responsive to change and does not affect the organisations long term business goals.	1. Can assist in determining plant equipment and in the process eliminate non required items and therefore avoid unnecessary spend. 2. Ensure that selected equipment is not only functional but are easily maintained and spares easily sourced. This will result in no downtime of M&E items impacting on the organisation financially. 3. The FM as a consultant can be more prescriptive in developing the performance specification for M&E equipment and can be involved in the approval process.	1. Ensure that selected equipment is not only functional but are easily maintained and spares easily sourced. This will result in downtime of M&E items impacting on the organisation financially. 2. Ensure that all items specified are affordable and easy to repair 3. Provide first-hand knowledge of service layouts.	Can translate concern from staff members in regards to particular M&E issues. These concerns can be incorporated into the design and therefore result in a more streamlined management process once the building is operational.
O&M		Provide knowledge of the building that other professionals may not have in regards to ongoing maintenance issues. This can help address problems that may impact the business in the future.	Highlight areas of concern in regards to common running costs and target these areas before they impact on the financial goals of the organisation.	1. Improve the selection of the maintenance and practical applications through previous knowledge of similar equipment / items. 2. Use their knowledge to ensure the building is designed to be proactive to daily requirements instead of being reactive. 3. Apply their knowledge of current operations and maintenance regimes at the design stage	Can translate concerns from staff members in regards to particular O&M issues. These concerns can be incorporated into the design and therefore result in more streamlined management process once the building is operational
Space Management		Provision of spaces during design for possible expansion of the organisation.	Contribute practical knowledge to floor layouts and utilising workspace layouts. This will increase worker productivity and ensure spaces are correctly utilised.		

Table 7.2: Cross tabulation of core competencies and early design target areas of the Facility Manager

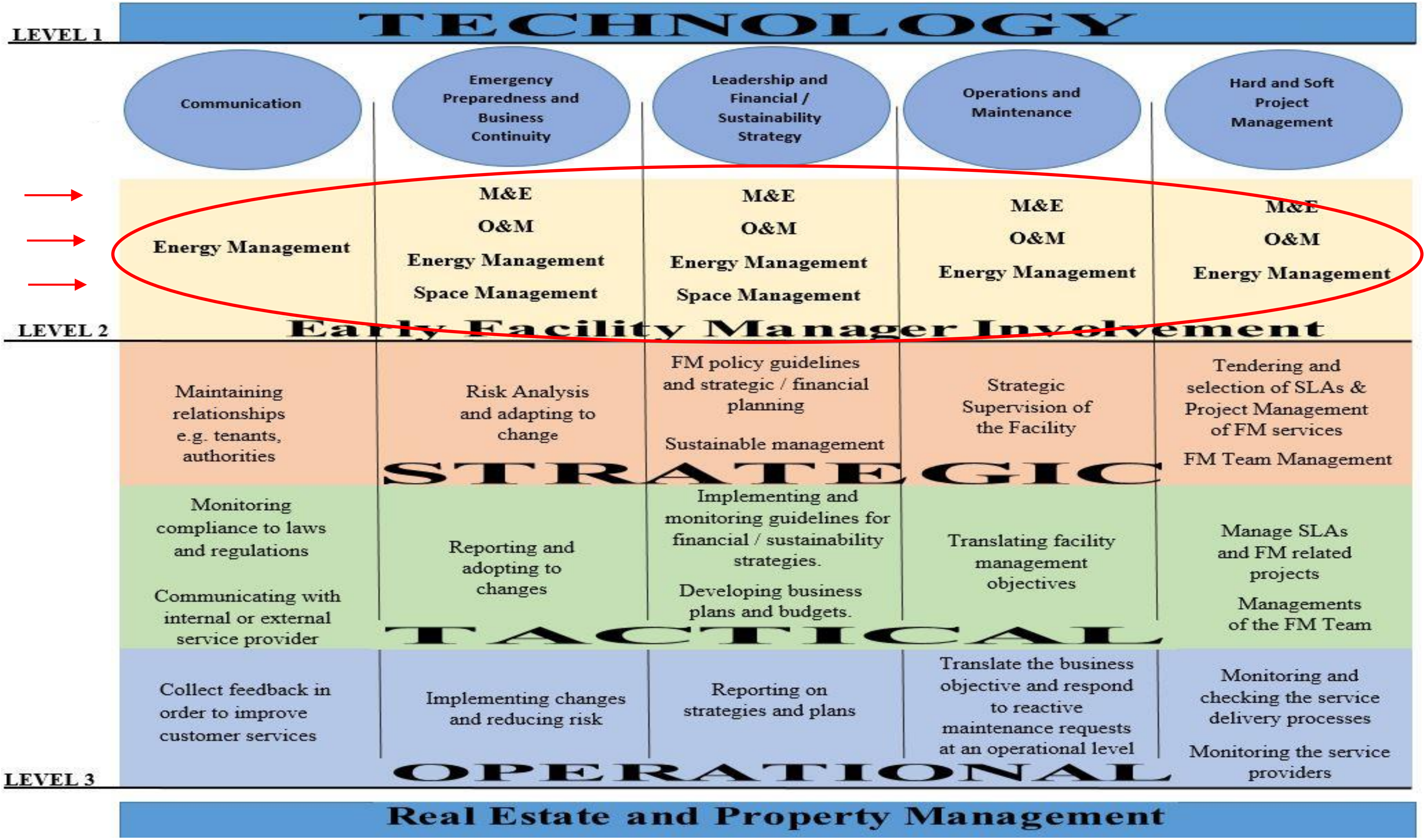


Fig 7.11: Early Facility Manager BIM KTIs selection approach Revision 2

In regards to KPIs designed around BIM for FM, it was decided that the UK GSL KPIs would be used as a good starting point. The reason for this was that the literature review had established them as one of the strongest BIM for FM KPIs in practice. Another key reason was that the pilot had adopted British Standards (BS) 1192:2007. As a result, it was discussed with the pilot team that the BIM for FM KPIs should be UK relevant with the GSL the obvious choice. The three KPIs of Environmental, Financial Management, Functionality and Effectiveness would be included in the pilot. These performance criteria were further expanded. An example of this was the GSL KPI for "Functionality and Effectiveness". The aim of this KPI was to measure what was achieved at the end of the whole process and for what purpose. This was more of a statement than an actual measurement criterion and, therefore, did not provide sufficient guidance. In regards to the Technology pilot, the "Functionality and Effectiveness" KPI was broken into two different sub KPIs of "maximising construction potential" and "maximising sustainability potential". These sub KPIs were based on reviewed literature and findings from the primary research in regards to the Facility Manager's contribution in the construction process.

The FM and construction team engagement will also need to be measured for value and barriers associated with the involvement of the Facility Manager with the design and construction team.

Taking into account all of this information, as well as all of the pilot aims and KPI suggestions, a set of proposed KPIs were forwarded to members of the pilot team which included the FM team. No suggestions for improvement were made and the pilot team was satisfied to progress with the agreed set of KPIs.

The understanding of early Facility Manager involvement and establishment of the KPTS was the key research objective. However, for the purpose of the pilot additional KPIs were established to measure the overall pilot progress. As the research was based on the Facility Manager's contribution, only the relevant KPIs pertaining to this will be detailed. A full list of all the KPIs can be located in Appendix 4. The following FM related KPIs, as well as a selection of other relevant KPIs were chosen, so as to establish their contribution.

4D Technologies: Time and Safety (KPI 1 & 2)

- Time: This measured the benefits of using a 4D scheduling and planning approach and the possible reduction in the pilot programme.
- Safety: This measured health, safety and environmental considerations.

5D Technologies: Budget (KPI 3)

- Budget: This will aim to measure the savings in regards to how the adoption of current technologies can result in savings for the project.

Early FM Involvement: Environmental, Financial Management, Functionality and Effectiveness, and FM and Construction Team Engagement (KPI 4, 5, 6 & 7).

- Environmental: The measurement of energy usage pre and post occupancy.
- Financial Management: The operational expenditure.
- Functionality and Effectiveness: This measured if the facility was fit for purpose.
- FM and Construction Team Engagement: This measured the value associated with the involvement of the Facility Manager with the design and construction team.

The KPIs detailed above examined a high level involvement of all professionals and were used to establish how the Facility Manager interacts with different professional disciplines when they get the opportunity to be involved earlier in the design phase of a building project. Figure 7.12 represents the final KPT selection approach which was used in the pilot to demonstrate early involvement of the Facility Manager.

7.6 TESTING OF THE KPIS

The second and third stage of Barlish's and Sullivan's (2012) process required testing and evaluating the metrics in the case study. It was decided early on that it would be difficult to quantify the KPIs as there was no examples of base measurements i.e. the cost of traditional scheduling techniques with regards to the community centre, or a similar structure, which could be then compared against cost savings from using 4D technologies. It was decided that the best approach was to measure a change in the pilot team's personal development and perceived contribution from using BIM processes and technologies. This was complemented by on-going interactions with all pilot team members to help further test the KPI's accuracy. Each of the project team members was emailed an online link to complete the survey. The survey questionnaire can be located in Appendix 4. Each question had five options. Table 7.3 explains the Likert scale interpretation.

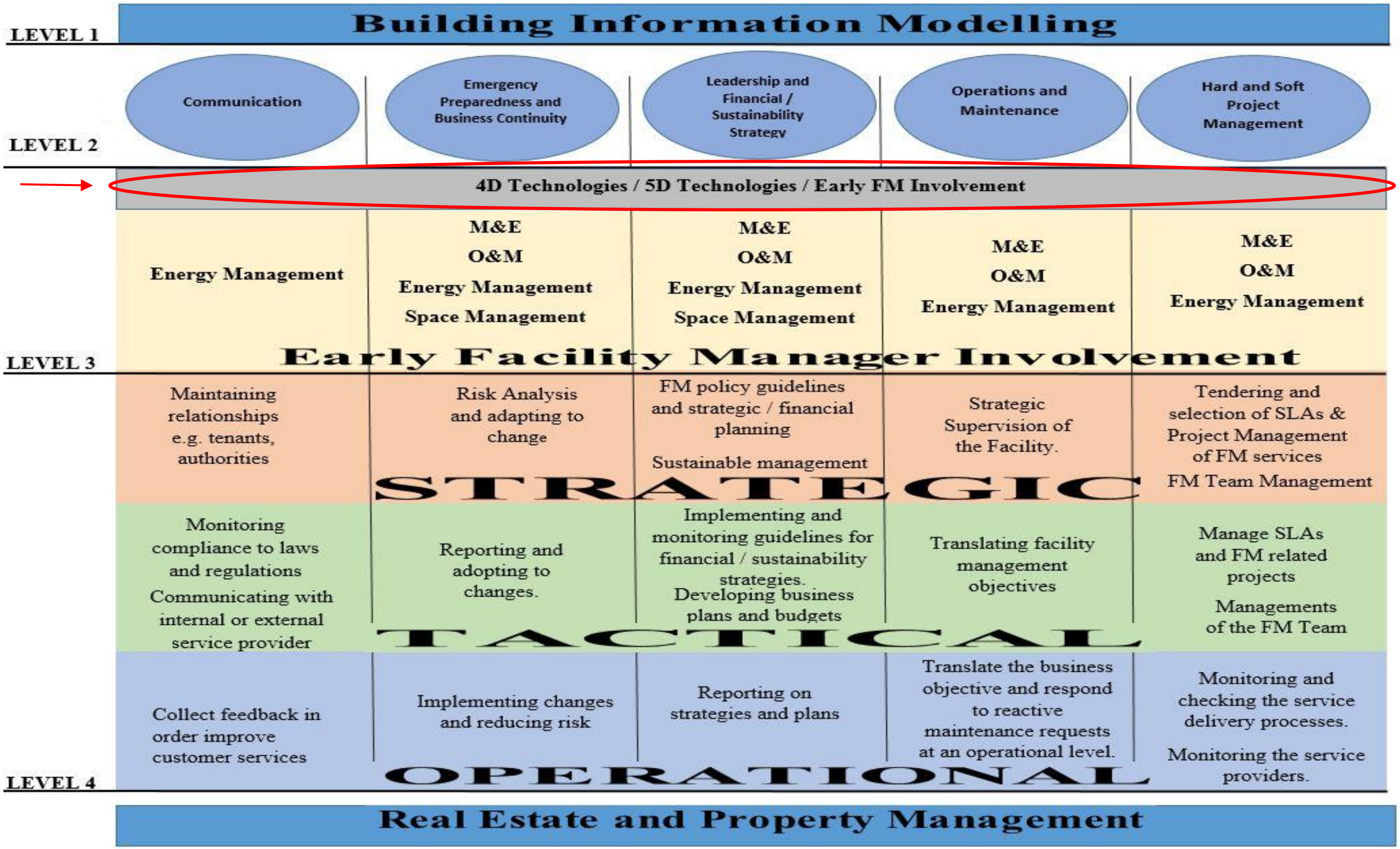


Fig 7.12: Early Facility Manager BIM KPTs selection approach Revision

Score	Meaning
1	No Change
2	Little Change
3	Some Change
4	Significant Change
5	Much Change

Table 7.3: Likert-type scale interpretation

The respondents were presented with 14 questions in the survey. The following breakdown of question types were used:

- **Partially Close-Ended:** Respondents were provided with answer choices but also with the opportunity to add further information on each of the KPIs. This permitted the respondents to enter additional information about their experience in regards to the KPI in question. This represented a total of 11 questions.
- **Open-Ended Question:** A number of open-ended questions were asked so respondents could voice their opinion on subject matter

The programme IBM SPSS Statistics 21 was used to analyse the results. This again involved inputting all the quantitative data into the software and converting this to an assigned value scale.

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- **Partially Close-Ended:** Respondents were provided with answer choices but also with the opportunity to add further information on each of the KPIs. This permitted the respondents to enter additional information about their experience in regards to the KPI in question. This represented a total of 11 questions.
- **Open-Ended Question:** A number of open-ended questions were asked so respondents could voice their opinion on subject matter

7.6.1 Sample and Response Rate

A total of 15 organisations were involved in the pilot. Further information on the pilot team members is provided in Appendix 4. Each organisation was asked to complete a survey at the mid-way point and at the end of the pilot. A total of 10 organisations responded to the final survey. This represented a 66% response rate. A date was fixed for completion of the survey which was extended by ten days in order to generate more responses. The implementation phase focused on the distribution of the questionnaire.

7.6.2 Questionnaire

4D Technologies

<u>Time (KPI 1)</u>

The results showed the Facility Manager experienced "no change" within this KPI and despite early involvement he did not have any input into any 4D practices. There was no evidence to suggest that the Facility Manger could contribute in reducing the pilot programme or adding any additional knowledge in regards to site logistics or using the model to highlight areas that may require a further constructability review.

<u>Safety (KPI 2)</u>

The results also showed that the Facility Manager experienced "no change" within this KPI and his earlier involvement did not lead to any improvement in safety.

5D Technologies

<u>Budget (KPI 3)</u>

The Facility Manger once again recorded "no change" in their current skillset in this area, as this is an area they do not traditionally participate in. The QS Team member, however, commented that early involvement of the Facility Manager in partnership with BIM *"could have resulted in more accurate costing exercises between the two professionals based on the selection of O&M equipment that would be more responsive to sudden change within the organisation".*

Early FM Involvement

Environmental (KPI 4)

80% of the pilot participants advocated that the Facility Manager could assist the design team with evaluating sustainability options. There was an understanding that BIM technologies has given the Facility Manager the opportunity to convey their knowledge within this area. The QS observed that *"early FM involvement can inform the design and avoid the designing of non-environmentally friendly systems"*. Table 7.4 summarises the final breakdown of results for this KPI assessment.

	No Change	*Little Change*	*Some Change*	*Significant Change*	*Much Change*
Evaluating Sustainability Options	20%	0%	50%	30%	0%

Table 7.4: Impact of environmental KPI - CitA technology pilot 2013

Financial Management (KPI 5)

77% of participants claimed that early Facility Manager involvement, in partnership with BIM, could help reduce future operational expenditure. The QS suggested that the Facility Manager can use BIM to "*inform the design and avoid waste of unwanted systems"*. The Structural Engineer added that early Facility Manager involvement in the BIM process will ultimately result in "*the people who procure and have to operate a building over its lifetime actually get what they thought they were going to get"*. It was noted within the responses that BIM, in collaboration with early Facility Manager input, can offer the opportunity to optimise/streamline the facility according to its needs, not just for finances but occupant comfort and satisfaction. The QS BIM Consultant argued that *"as QSs do not know what components were good or bad in a building, early FM interaction can assist in providing practical information that may result in better selection of equipment."*. Table 7.5 details the final results of the KPI assessment.

	No Change	*Little Change*	*Some Change*	*Significant Change*	*Much Change*
Operational Expenditure	22%	0%	33%	44%	0%

Table 7.5: Impact of operational expenditure KPI - CitA technology pilot 2013

Functionality and Effectiveness (KPI 6)

70% of the pilot participants reported advantages across the board in regards to BIM enhancing functionality and effectiveness as a result of earlier involvement. Two separate KPIs were presented which aimed to understand if BIM along with early involvement could offer the opportunity to suggest design edits that could increase the constructability and the sustainability potential of the building. The QS added that the Facility Manager's input into the BIM process has enabled the design team to better understand "*which products/systems suit their business / requirements.*" The Architect acknowledged that the Facility Manager's *"advance knowledge in regards to FM systems has offered advanced ways to simulate and optimise the systems to be installed"*. Table 7.6 details the final results of the KPI assessment.

	No Change	***Little Change***	***Some Change***	***Significant Change***	***Much Change***
Maximising Construction Potential	20%	10%	40%	30%	0%
Maximising Sustainability Potential	20%	10%	50%	20%	0%

Table 7.6: Impact of functionality and effectiveness KPI - CitA technology pilot 2013

FM and Construction Team Engagement (KPI 7)

This KPI sought to gain an understanding of whether people's mind-set had changed in regards to the involvement of the Facility Manager in the construction process as a result of using BIM. 77 % of participants agreed that the Facility Manager could add positive change by earlier involvement. The QS further added that *"they do not foresee any barriers apart from cost i.e. the Client may not see the benefit of paying a Facility Manager from an early stage to be involved in the design"*. The land surveying team stated that *"early FM involvement was a must for the functionality of the project, bringing in new skills at an early stage can only be beneficial, for energy use/ building layout"*. The Structural Engineer commented that *"one must start with the end in mind and in this case start by clarifying employer requirements, especially what they want to manage (or not) over the life of the facility"*. The Architect noted that it was *"important to have the Facility Manager involved early on, as the consultant has requirements on how objects were encoded to contain as much COBie data as possible"*. Table 7.7 details the final results of the KPI assessment.

	No Change	***Little Change***	***Some Change***	***Significant Change***	***Much Change***
The Facilities Manager can bring added value / change to the design team.	11%	11%	22%	44%	11%

Table 7.7: Impact of FM and Construction Team Engagement KPI - CITA Technology Pilot 2013

Results Summary

Table 7.8 details the final KPI rating for both the pilot team and the FM team. The numbers represented in the "final KPI Pilot Team" column is the mean value of the ten organisations that responded to the survey. The closer the figure is to 5 means the pilot team received much change while the closer to 1 means no change. The highest rated KPI from the Facility Manager's perspective was the FM contribution to assist in improving operational expenditure. There were synergies between the pilot team's results and the Facility Manager in regards to them assisting in evaluating sustainability options. The project team would not be familiar with the Facility Manager working as part of the design team and therefore had no understanding of his/her contribution in this respect. The use of BIM technologies, as evident in the final result for KPI 7, has enabled the Facility Manager to add positive change through their earlier involvement.

	KPI	**Final KPI Pilot Team**	**Final KPI FM Team**
1	Time	2.6	1.0
2	Safety	2.8	1.0
3	Budgets	2.6	1.0
4	Evaluating sustainability options	2.9	3.0
5	Operational Expenditure	3.0	4.0
6A	Maximising construction potential	2.80	3.00
6B	Maximising sustainability potential	2.70	3.00
7	The Facility Manager can bring added value / change to the design team	3.30	3.00

Table 7.8: Pilot Team Vs FM Team KPIs for the Technology Pilot

7.6.3 Project Team Interviews

A number of interviews were also conducted to further investigate the appropriateness of the KPIs. Interviewees were selected on the basis of their experience in using BIM. The interview methodology was described in detail in Chapter Three. A sample transcript from one of the interviewees was included Appendix 4. The persons interviewed are listed in Table 7.9.

Role	Selection Rationale
Project Architect	The Chief Architect who was responsible for creating the 3D Model and had interaction with the Facility Manager throughout.
Structural Engineer	The interviewee was an advocate of lean construction and BIM in Ireland for a number of years. He was working alongside the Facility Manager from an early stage.
4D Consultant	The interviewee had worked within the area of 4D BIM for a number of years and has served as a consultant in this area.
QS/5D Consultant	The interviewee had worked within the area of 5D BIM for a number of years and has served as a consultant in this area.
Facility Manager	The interviewee had extensive experience as a Facility Manager for over ten years.

Table 7.9: Pilot Team interviewees

Project Architect

One of the primary advantages of the pilot was enabling the whole construction team, including the Facility Manager, to collaborate and use the model as a medium of communication. The Architect acknowledged that by having the Facility Manager involved earlier led to better validation of the model e.g. issues with zones. In future he suggested that he would like to see the Facility Manager involved at the early design stage, as he/she could provide key information on maintenance systems. He was of the opinion that BIM could be used as a visual tool to explain and focus the design team on eliminating spend on maintenance. The Architect also stated that in cases where the Architect has not identified all areas of safety with regard to maintenance that "*the FM professional can highlight areas that may need further focus when it comes to safe maintenance*".

Structural Engineer

The Structural Engineer questioned "*if the Facility Manager was not involved, how can we design FM related items if we don't know how it's going to be operated*". He believed that the design was better when the FM Team were involved at an early stage. He stated that the

"Facility Manager was a key professional and getting them to meet all the team enabled him/her to find out what he/she needed and what kind of information was required".

4D Consultant

The 4D specialist argued that at present the Client does not fully understand what BIM is and still does not understand its full value. He added that in *"terms of costs, the ability to change the design and have these changes make a positive impact on the construction project is always going to be at the start of the project".* C*onstructability was becoming a key performance area and by bringing contractors and FM professionals in at an earlier stage, they can make the key decisions that influence the construction process".* He further added that FM people have a unique set of skills that cannot be provided by other professionals, *"to me it seems ridiculous not to bring the FM people in at an early stage because FM was a deliverable".*

QS/5D Consultant

The QS was concerned that the Client's focus tends to be on the capital expense not the operational cost of the building. He added that there was a *"disconnect with designers or model authors who were not aware of how models will be used downstream, something that looks good to them in 3D, when one peels back the layers, may reveal gaps".* He further added that QS were only responsible for costing the capital expense which represents approximately a sixth of the whole life cycle costs. He was of the opinion that a possible spend of an extra 2-3% on capital costs could reduce the operational costs significantly. He further adds *"that as an industry, there was a need to look at outcomes of building projects rather than just getting to the end of the defects liability period".*

Facility Manager

The Facility Manager was concerned that there were insufficient finances set aside for proper handover documentation and it was an afterthought in most jobs. He believed that the BIM process can help address this, as it enables a more pragmatic design. He further added as *"it costs six times more to operate and maintain than it costs to build a facility, so if you make a small saving on the build, then you may get a big payback on the operating and maintenance side".* The Facility Manager was however pessimistic of this becoming widespread in the foreseeable future.

Summary

In summary it was found that the project team were in agreement that the Facility Manager can play a significant role throughout the BIM process. The Facility Manager can help advise the design team of the Client's overall needs and should be engaged by the Client at early design stage to assist in evaluating the long term design from initial concepts onwards. The FM team believe that it could help streamline the needs of the Client to focus on the total costs over the lifecycle of the building and not just on the construction budget. Despite the lack of involvement of the FM team in certain areas within the overall pilot design, there was still a strong belief that they can better help co-ordinate the thoughts of the designer with the end user. These KPIs were used to focus on the Facility Manager's contribution but were also used to understand their engagement with other project members.

The next phase of the KPT process involved eliminating the KPIs that were not FM related and associating the remaining KPIs to the core competency areas of the Facility Manager and the established early design target areas identified earlier.

7.6.4 Positioning the KPIs within the Early Facility Manager BIM KPTs Selection Approach

A KPT selection approach was created for early Facility Manager involvement in the BIM process, as illustrated in figure 7.12. The findings of the CitA Technology Pilot were translated back to this selection process, in order to establish the areas that have experienced the greatest benefit from early Facility Manager involvement.

In order to narrow the KPIs down and specifically assign them to the FM core competency areas and established early design target areas concerning early Facility Manager involvement, a matrix was created. The purpose of the matrix was to match the KPIs to areas in where the Facility Manager made a contribution in enhancing an associated core competency. This was achieved by matching the KPI to an early design target area within the core competency which was previously established in table 7.2. This matrix is illustrated in figure 7.13.

Fig. 7.13: Facility Manager KPI early involvement matrix.

Facility Manager did not contribute   Facility Manager contributed / may contribute

In reviewing the Facility Manager KPI early involvement matrix it could be seen that a number of KPIs can be eliminated at this stage. These include the KPIs for both time and safety with regards to 4D Technologies, as early Facility Manager involvement did not influence any of the core competencies. The following sub sections detail precisely how the early involvement of the Facility Manager in relation to the KPI recording has influenced a core competency, through focusing on a particular early design target area, as a result of applying BIM processes and technologies.

7.6.4.1 Communication:

Table 7.10 summarises the relative importance that both the pilot and FM team placed on the KPIs presented under the competency area of communication. The closer the figure is to 5 represents the pilot team receiving “much change” while the closer to 1 represents “no change”.

Early FM Target Area	Associated KPI	Mean KPI Pilot Team	Final KPI FM Team
Energy Management	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.7	3.0

Table 7.10: FM core competency area of communication KPI output

This competency area requires the Facility Manager to monitor and comply with laws, regulations and sustainable strategies, as well as the external service providers. The results from table 7.10 reflects how early Facility Manager involvement can target this competency, with the performance areas of "*evaluating sustainability strategies*" and "*maximising sustainability potential*" both scoring highly. In the pilot the Facility Manager suggested a number of energy saving solutions such as, underfloor heating, so as to keep within guidelines associated with children falling or climbing through open windows. Addressing these concerns from the beginning could help better realise communication processes during the operational stage.

Another part of the communication competency was communicating with the end-user and using this information to improve customer services. This feedback can be translated to help in reducing *"operational expenditure"* when it comes to systems in the building. In the pilot the Client / Facility Manager was able to feedback a number of operational energy concerns with regard to the original building such as poor lighting in certain areas, special focus in regards to heating and insulation, as well as a number of problems with the crèche. This information was incorporated by the design team into the final model.

7.6.4.2 Emergency Preparedness and Business Continuity

Table 7.11 summarises the relative importance that both the pilot and FM team placed on the KPIs presented under the competency area of emergency preparedness and business continuity. The closer the figure is to 5 represents the pilot team receiving "much change" while the closer to 1 represents "no change".

Early FM Target Area	Associated KPI	Mean KPI Pilot Team	Final KPI FM Team
O&M	3. Accuracy of predicting budgets	2.6	1.0
	5. Operating Expenditure	3.0	4.0
M&E	3. Accuracy of predicting budgets	2.6	1.0
	5. Operating Expenditure	3/o	4.0
Energy Management	4. Evaluating sustainability options	2.9	3.0
	6B. Maximising sustainability potential	2.9	3.0
Space Management	5. Operating Expenditure	3.0	4.0
	6A. Maximising construction potential	2.8	3.0

Table 7.11: FM core competency area of Emergency Preparedness KPI output

The Facility Manager was required to ensure business continuity by implementing change and adopting risk policies when necessary. A number of opportunities presented itself in the pilot to impact this competency area during construction. Table 7.11 shows that within the area of

"O&M", "M&E" and "Space Management" the Facility Manger scored highly in the performance area of *"operational expenditure*" when it comes to targeting this competency. It was recorded in the pilot that a Facility Manager could inform the design team which products/systems can best position the organisation to react to a sudden change in business direction. The Facility Manager advised on the location of the plant room in the pilot project. This space was required to minimise impact on possible future expansion plans. A decision was made, that required the allocated plant space to be as functional as possible. The Facility Manager assisted in this exercise. This exercise helped with *"maximising construction potential"* as the correct selection of spaces and layout of equipment reduced the requirement for unnecessary construction spend. This all contributed to positioning the organisation to respond to change and adopt risk policies.

It was suggested the Facility Manager can work with the QS to provide a greater "*accuracy in predicting budgets "*in targeting the areas of "O&M" and "M&E". This was not within the traditional job description of the Facility Manager, however, suggestions were made that through the use of 5D technologies there was potential synergies between the two professions. The costing expertise of the QS and the tacit knowledge of the Facility Manager with regards to O&M / M&E equipment can offer a more practical whole life cycle costing exercise.

Table 7.11 shows that within the area of "Energy Management" the Facility Manger scored highly in the performance area of *"evaluating sustainability options"* and *"maximising sustainability potential".* There was evidence to suggest that if the Facility Manager contributed his/her knowledge at an early stage, within the area of energy management policies, he/she can provide a focus for the selection of more responsive FM-related equipment. This equipment was better positioned to react to a sudden change in the organisation's business strategy.

7.6.4.3 Leadership and Financial / Sustainability Strategy

Table 7.12 summarises the relative importance that both the pilot and FM team placed on the KPIs presented under the competency area of leadership and financial / sustainability strategy. The closer the figure is to 5 represents the pilot team receiving "much change" while the closer to 1 represents "no change".

Early FM Target Area	**Associated KPI**	**Mean KPI Pilot Team**	**Final KPI FM Team**
M&E	3. Accuracy of predicting budgets	2.6	1.0
	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.o	4.0
	6B. Maximising sustainability potential	2.9	3.0
O&M	3. Accuracy of predicting budgets	2.6	1.0
	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.9	3.0
Energy Management	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.9	3.0
Space Management	5. Operating Expenditure	3.o	4.0
	6A. Maximising construction potential	2.8	3.0

Table 7.12: FM core competency area of Leadership and Financial / Sustainability Strategy KPI Output

The Facility Manager was responsible for the implementation of sustainability strategies and in assisting the organisation achieve its financial goals. A number of opportunities presented themselves in the pilot to impact this competency area during construction. Table 7.12 shows that within the area of "O&M", "M&E", "Energy and Space Management" the Facility Manger scored highly in the performance area of *"operational expenditure*" when it comes to targeting this competency. The Facility Manager has a knowledge of the costs of operating a building which can be used in the design to address areas of operational concern. The BIM model has the opportunity for exercises in space management which the Facility Manager can use as a visual tool to offer advice on best layout options, from previous experience, to help increase worker productivity.

It was suggested that the Facility Manager could work with the QS to provide a greater "accuracy in predicting budgets "in targeting the areas of "O&M" and "M&E". This, as was seen for the "Emergency Preparedness and Business Continuity" competency, can help the Client become more financially aware of the impact of choosing items on a lowest price basis.

Table 7.12 shows that within the area of "O&M", "M&E" and "Energy Management" the Facility Manger scored highly in the performance area of *"evaluating sustainability options".* The selection of M&E equipment, as well as O&M-based criteria, will have a direct impact on future energy management plans. His / Her practical knowledge about energy saving strategies will help ensure that decisions on key FM equipment take into account the wider considerations of both the financial and sustainability strategies down the line.

The *"maximising construction potential"* KPI was recorded in the performance area of "Space Management**".** As described for the "Emergency Preparedness and Business Continuity" competency, potential improvements can be achieved through the correct selection of spaces and layout of equipment, therefore reducing the requirement for unnecessary construction spend. This will contribute to the financial goals of the organisation.

7.6.4.4 Operations and Maintenance

Table 7.13 summarises the relative importance that both the pilot and FM team placed on the KPIs presented under the competency area of operation and maintenance. The closer the figure is to 5 represents the pilot team receiving "much change" while the closer to 1 represents "no change".

Early FM Target Area	Associated KPI	KPI Team	KPI FM
M&E	3. Accuracy of predicting budgets	2.5	1.0
	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6A. Maximising sustainability potential	2.9	3.0
O&M	3. Accuracy of predicting budgets	2.5	1.0
	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6A. Maximising sustainability potential	2.9	3.0
Energy Management	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6A. Maximising sustainability potential	2.7	3.0

Table 7.13: FM core competency area of Operations and Maintenance KPI Output

The Facility Manager was responsible for the strategic supervision of the facility. A number of opportunities presented themselves in the pilot to impact this competency area during construction. Table 7.13 shows that within the area of "O&M", "M&E" and "Energy Management" the Facility Manger scored highly in the performance area of *"operational expenditure"* when it comes to targeting this competency. The Facility Manager's knowledge retained from years of operating a building can assist the design team in the selection of energy focused O&M and M&E equipment and materials. This will assist in the reduction of reactive maintenance requests once the building was operational. The selection of such equipment will be reflected in the model which will have the most relevant information stored within it to assist with the maintenance phase.

Table 7.13 shows that within the area of “O&M”, “M&E” and “Energy Management” the Facility Manger scored highly in the performance area of *“evaluating sustainability options”* and *“maximising sustainable construction”.* The Facility Manager will have to implement sustainability strategies after the construction period, which proves to be an extremely difficult task given that the initial spend has already been sanctioned. With his/her unique knowledge of both O&M and M&E equipment he/she can assist in the selection of equipment that was easier to maintain. If a stronger focus was placed on future O&M requirements, this will better position the Facility Manager to manage escalating energy demands. This was seen in the pilot in which the Facility Manager assisted the M&E specialist in the selection and placement of equipment that would best suit the end users’ needs and concerns, for example in the crèche.

As discussed previously in the “Emergency Preparedness and Business Continuity” and the “Leadership and Financial / Sustainability Strategy” competencies, the Facility Manager can work with the QS to provide a greater *“accuracy in predicting budgets”* in targeting the areas of “O&M” and “M&E**”**. It was suggested more realistic whole life cycle costs could have been realised through their partnership

7.6.4.5 Hard and Soft Project Management

Table 7.14 summarises the relative importance that both the pilot and FM team placed on the KPIs presented under the competency area of hard and soft project management. The closer the figure is to 5 represents the pilot team receiving “much change” while the closer to 1 represents “no change”.

Early FM Target Area	**Associated KPI**	**KPI Team**	**KPI FM**
M&E	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.7	3.0
O&M	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.8	3.0
Energy Management	4. Evaluating sustainability options	2.9	3.0
	5. Operating Expenditure	3.0	4.0
	6B. Maximising sustainability potential	2.8	3.0

Table 7.14: FM core competency area of Hard and Soft Project Management KPI Output

The Facility Manager will be responsible for the management of FM related projects, as well as his/her team. A number of opportunities presented themselves in the pilot to impact this competency area during construction. Table 7.14 shows that within the area of "O&M", "M&E" and "Energy Management" the Facility Manger scored highly in the performance area of *"operational expenditure"*. The more user-friendly and efficient the FM equipment the easier it will be for the Facility Manager to manage his/her team in the daily operation of the building. Incorporating their knowledge of common O&M requirements provides a unique opportunity to reduce the chances of that piece of equipment needing reactive maintenance. Earlier access to the model will expose the Facility Manager to the application of BIM technologies. This better understanding can be applied in teaching the FM team how to best apply the model in the operation phase.

Table 7.14 also shows the Facility Manger scored highly in the performance area of *"evaluating sustainability options"* and *"maximising sustainable construction"*. The selection of O&M and M&E products will have a direct impact on future energy management plans. The Facility Manager will be in a stronger position to manage external utilities companies in regards to SLAs e.g. electricity and gas as he/she will not be reliant on the external provider to reduce energy bills alone, as he/she already has the equipment and maintenance regimes in place to achieve this from earlier involvement.

7.7 ESTABLISHMENT OF KPTS

The analysis has shown a number of tasks which the Facility Manager if introduced in the BIM design stage can influence. These tasks were based on improving a number of competency areas post construction that were unique to the Facility Manger with regards to their role in the operation of a building. By supplying knowledge of these competency areas within the design and through aligning them with the established early design target areas demonstrated a contribution could be made from early Facility Manager involvement. The KPIs helped provide a broad guidance of exactly were these improvements in the BIM process could be achieved, with relation to the core competencies and early design target areas. Based on the analysis within this chapter the following KPTs have been suggested to demonstrate the benefit of introducing the Facility Manager at an early stage in the BIM process on public sector projects. These KPTs detail the areas that are unique to the Facility Manager's role and how they can be applied in the BIM governed design to offer a more rewarding process and ultimately offer an enhanced FM practice. The following sections, as a result of the KPI analysis, detail how these KPTs can influence the core competencies associated with the role of the Facility Manager through focusing on the designated early design target areas.

7.7.1 O&M KPTs

The research has shown that the performance area of O&M can be improved through earlier involvement of the Facility Manager in the BIM process on public works projects. The core competency areas of "Emergency Preparedness and Business Continuity", "Leadership and Financial / Sustainability Strategy", "O&M" and "Hard and Soft Project Management" can be improved through involving the Facility Manager in the BIM process. The research has shown, the KPT of O&M can provide improvements by focusing on the following five areas:

1. Operational

- *Reducing operational expenditure in regards to the selection of O&M products:* The Facility Manager has unique knowledge in the requirements of operating a building. This can be applied to ensure that operational concerns were addressed in the design phase.
- *Enhance Design for safety:* The Facility Manager's assistance in partnership with BIM can help provide a focus on safety in regards to maintenance.

2. Functionality

- *Reduce the functionality risk with regard to O&M***:** The Facility Manager can apply their knowledge to provide an understanding on how the building will be required to function on a daily basis and therefore reduce the functionality risk associated with O&M.

3. Validation

- *Improve the practicality of the FM model for the operational phase:* This will ensure that the model was populated with the most relevant O&M information, which can be practically used by the FM Team.

4. Access

- *Enhancement of design to be more maintenance friendly with regards to accessibility:* The Facility Manager can assist in the design of a more practical layout of O&M services and equipment to reduce concerns in regards to access. This will ensure that the FM team can put into effect sound maintenance regimes and time was not wasted in trying to access equipment.

5. Budgets

- *Improve lifecycle costing estimates for O&M based products:* The Facility Manager's practical knowledge of O&M equipment can be used in partnership with the QS, to ensure that a more FM focused life cycle approach.

Figure 7.14 provides a summary of the O&M KPTs for early involvement of the Facility Manager in the BIM process.

7.7.2 M&E KPTs

As revealed in the research the performance area of M&E can be improved through earlier involvement of the Facility Manager. The core competency areas of "Emergency Preparedness and Business Continuity", "Leadership and Financial / Sustainability Strategy", "O&M" and "Hard and Soft Project Management" can all be enhanced through a combination of BIM and early Facility Manager involvement. The following four areas within the KPT of M&E, if targeted, can provide the following improvement:

1. Operational

- *Reducing of operational costs in regards to the selection of M&E based equipment:* The Facility Manager can provide knowledge of what M&E systems and parts work most efficiently during the operation phase. This can ensure that the Client was made financially aware of the impact of choosing items on a lowest price basis.

2. Functionality

- *Reduce the functionality risk associated with M&E equipment:* The Facility Manager can apply their knowledge to provide an understanding on how the building will be required to function on a daily basis and therefore reduce the functionality risk associated with M&E.

3. **Access**
   - *Maximise space and ensure ease of access for maintenance purposes for M&E equipment:* The Facility Manager can use their knowledge to ensure that the building services layout was provisioned to ensure ease of access for maintainability purposes.
4. **Budgets**
   - *Improve lifecycle costing estimates for M&E based products:* Their practical knowledge of M&E equipment can be used in partnership with the QS to ensure that there pricing reflects a more focused life cycle approach.

Figure 7.15 provides a summary of the M&E KPTs for early involvement of the Facility Manager in the BIM process.

7.7.3 Energy Management KPTs

By involving the Facility Manager earlier in the BIM process, the performance area of Energy Management can be improved. The core competency areas of “Communication”, “Emergency Preparedness and Business Continuity”, “Leadership and Financial/ Sustainability Strategy”, “O&M” and “Hard and Soft Project Management” can be improved through involving the Facility Manager in the BIM process. By focusing on the following two areas within the KPT of Energy Management, this can assist in providing the following improvements:

1. **Environment**
   - *Reduce the environmental impact through the selection of environmentally friendly equipment:* The Facility Manager can assist in evaluating sustainability options and aligning them with laws, regulations and external service providers. This can be achieved through specifying equipment that was functional but also energy conscious. Their practical knowledge in regard to energy saving strategies will help ensure that decisions on key FM equipment take into account wider environmental considerations.
2. **Energy**
   - *Reduce energy costs through the selection of internal energy efficient systems / materials:* The Facility Manager can apply their knowledge of implemented energy / sustainability programmes in similar buildings. This can assist in the selection of equipment and materials that can help reduce energy costs in the operational phase.

Figure 7.16 provides a summary of the Energy Management KPTs for early involvement of the Facility Manager in the BIM process.

7.7.4 Space Management KPTs

The performance area of Space Management can be enhanced on BIM governed public works projects through earlier involvement of the Facility Manager. The core competency areas of "Emergency Preparedness and Business Continuity" and "Leadership and Financial / Sustainability Strategy" can be improved through involving the Facility Manager in the BIM process. The research has shown that the KPT of Space Management can provide improvements by focusing on the following three areas:

1. **Floor Layout**
   - *Enhancement of work space and practical layout***:** The Facility Manager can use the BIM model for exercises in space management to offer advice on best layout options, from previous experience, to help increase worker productivity.
2. **Construction Waste**
   - *Reduce construction waste by eliminating unproductive spaces:* The Facility Manager can assist with the correct selection of spaces and layout of equipment, which will reduce unnecessary construction spend associated with these spaces.
3. **Space Provision**
   - *Maximise space utilisation and allocate spaces for future expansion:* The Facility Manager can ensure that spaces were correctly identified and provisioned for future expansion.

Figure 7.17 provides a summary of the Space Management KPTs for early involvement of the Facility Manager in the BIM process.

7.8 SUMMARY

The pilot established that the Facility Manager could have a positive effect and can offer a contribution to the early stage design in the BIM process. Deliberately shifting project focus from design and construction to the FM and operation/ phase of a project can enable the Facility Manager to contribute towards the design of the model. As an integral member of the IPD team it offered an environment where he/she could offer practical advice within a number of areas. In order to understand the value created by the FM Team a number of KPIs were created. These were tested and analysed and then mapped to the relevant competencies and early design target areas associated with the Facility Manager. This produced a number of potential performance tasks which the Facility Manager can add additional value to by participating earlier in the BIM design process. These performance areas highlighted that a number of opportunities exist within O&M, M&E, energy and space management, in which the Facility Manager can offer a contribution. The complete suite of KPTs are listed in table 7:15. The next step was to refine these KPTs on an Irish public works projects before final validation.

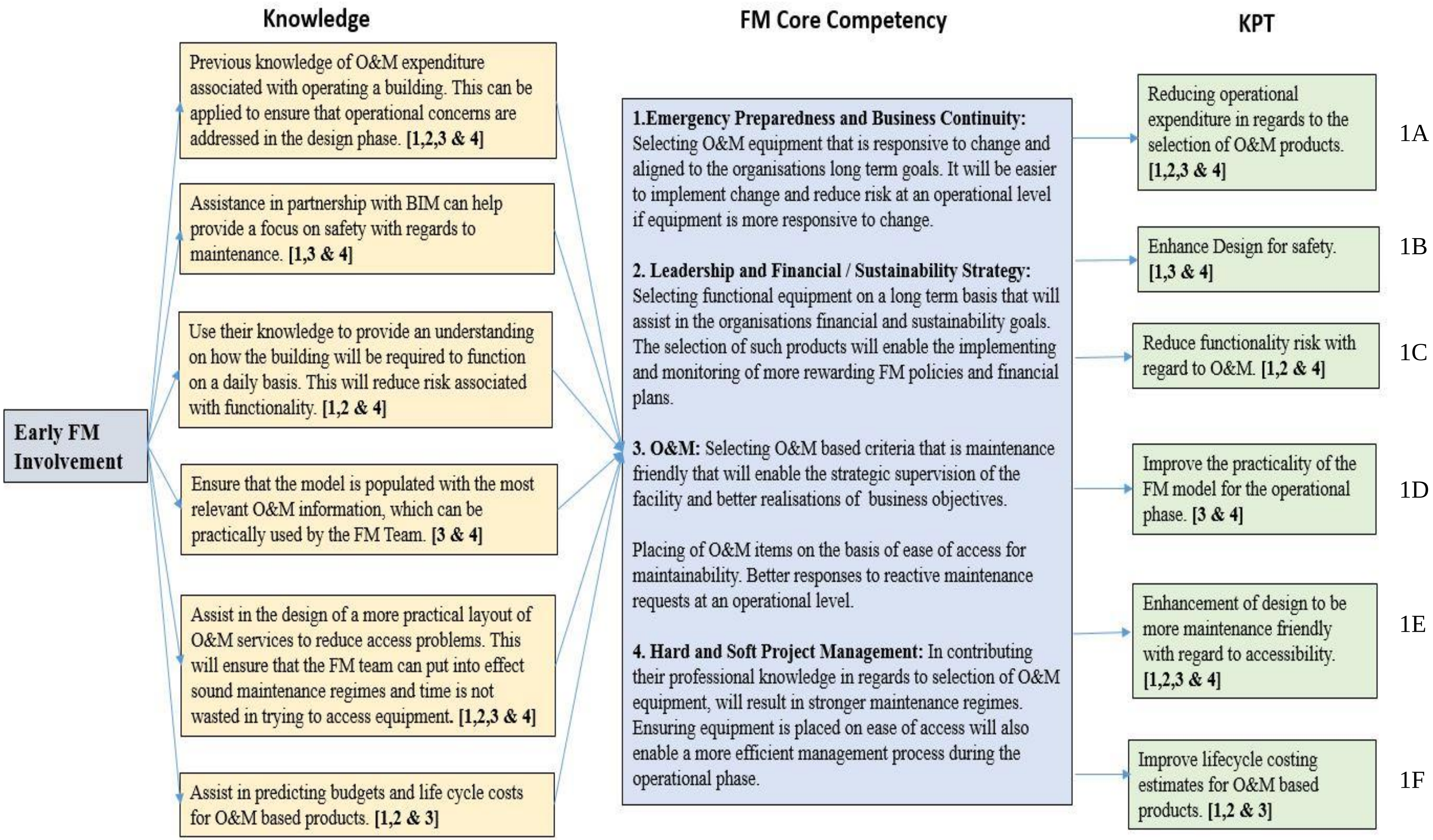

Fig 7.14: O&M KPTs for early involvement of the Facility Manager in the BIM process Revision 1

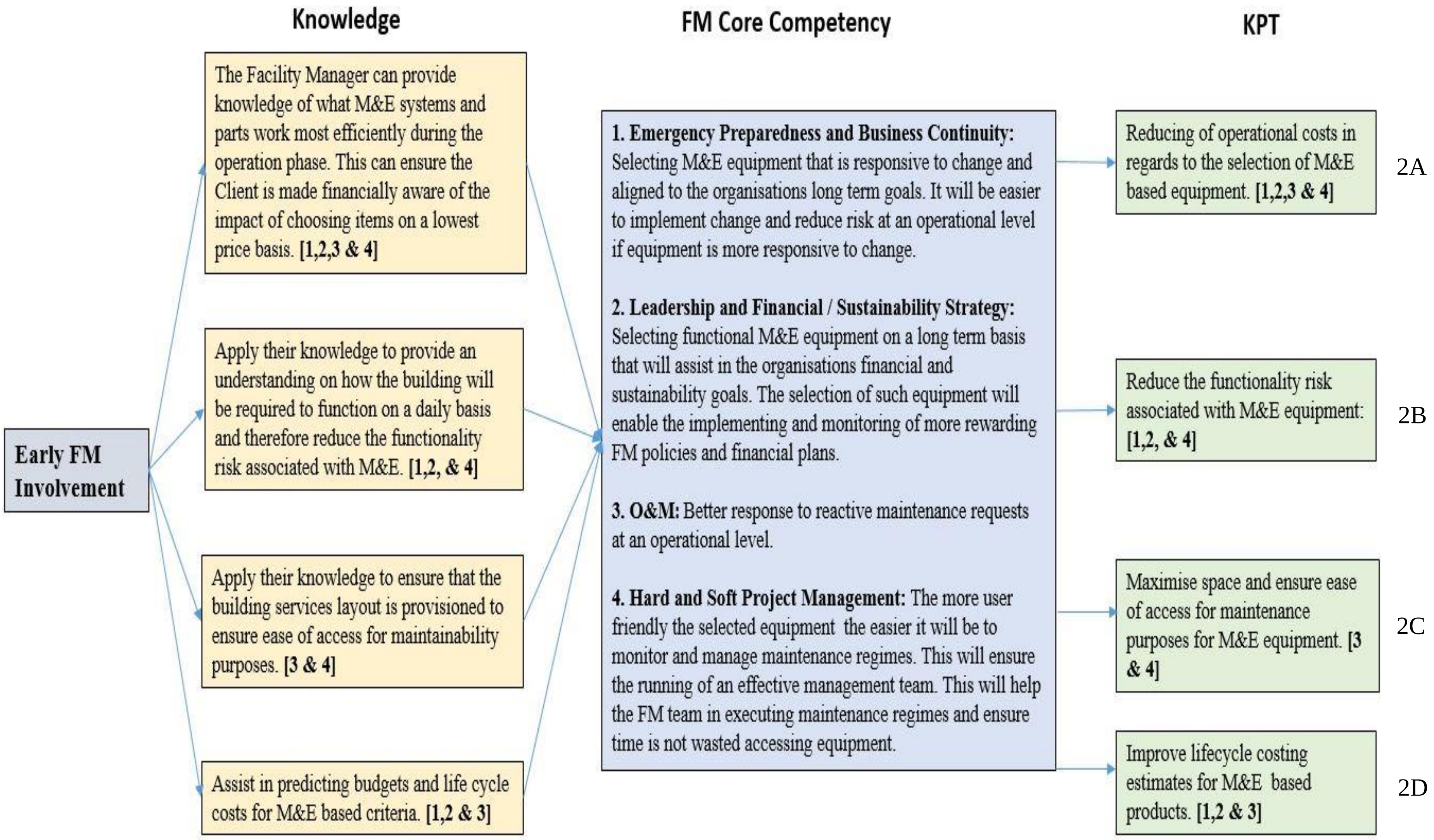

Fig 7.15: M&E KPTs for early involvement of the Facility Manager in the BIM process Revision 1

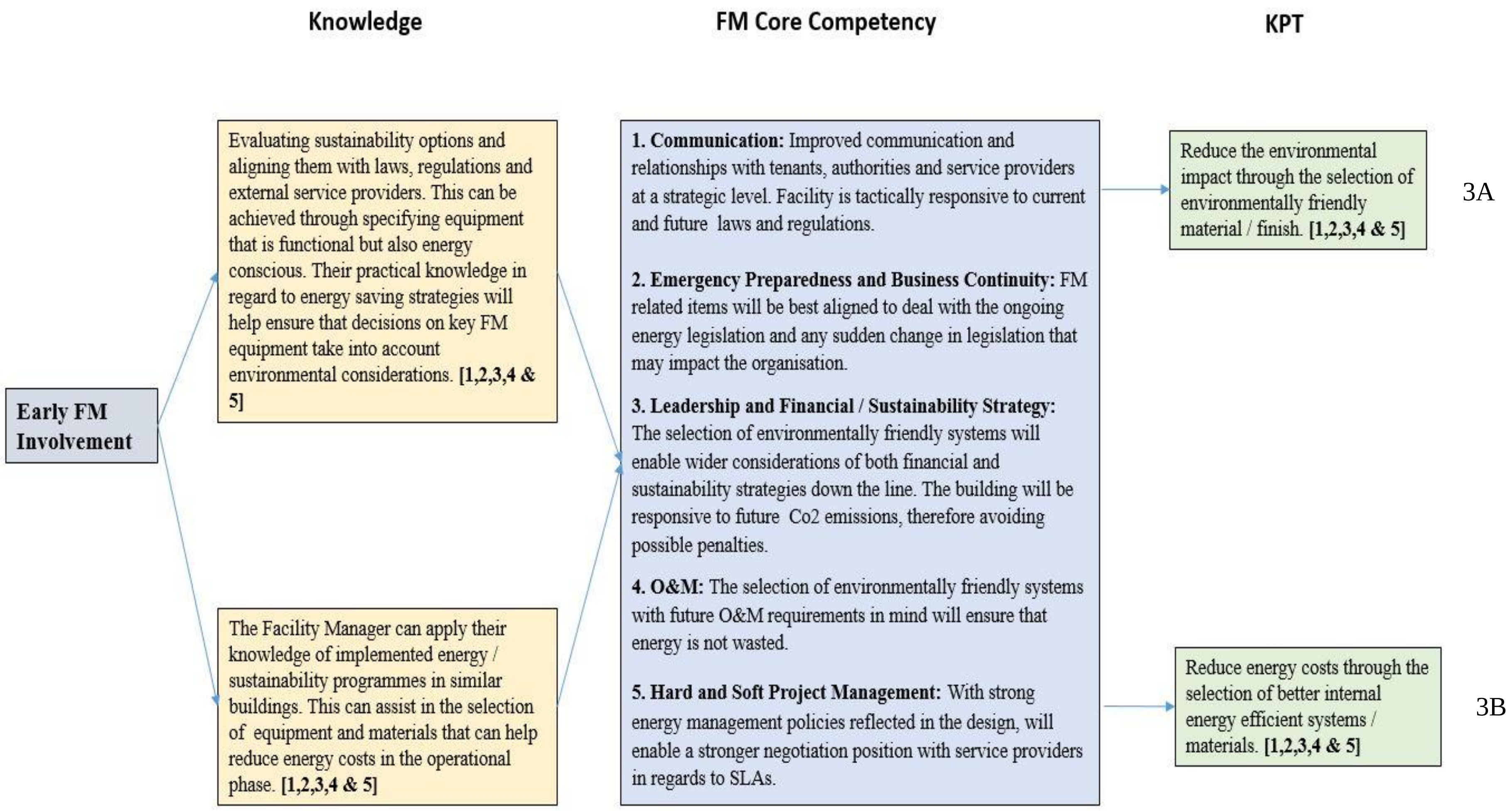

Fig 7.16: Energy Management KPTs for early involvement of the Facility Manager in the BIM process Revision 1

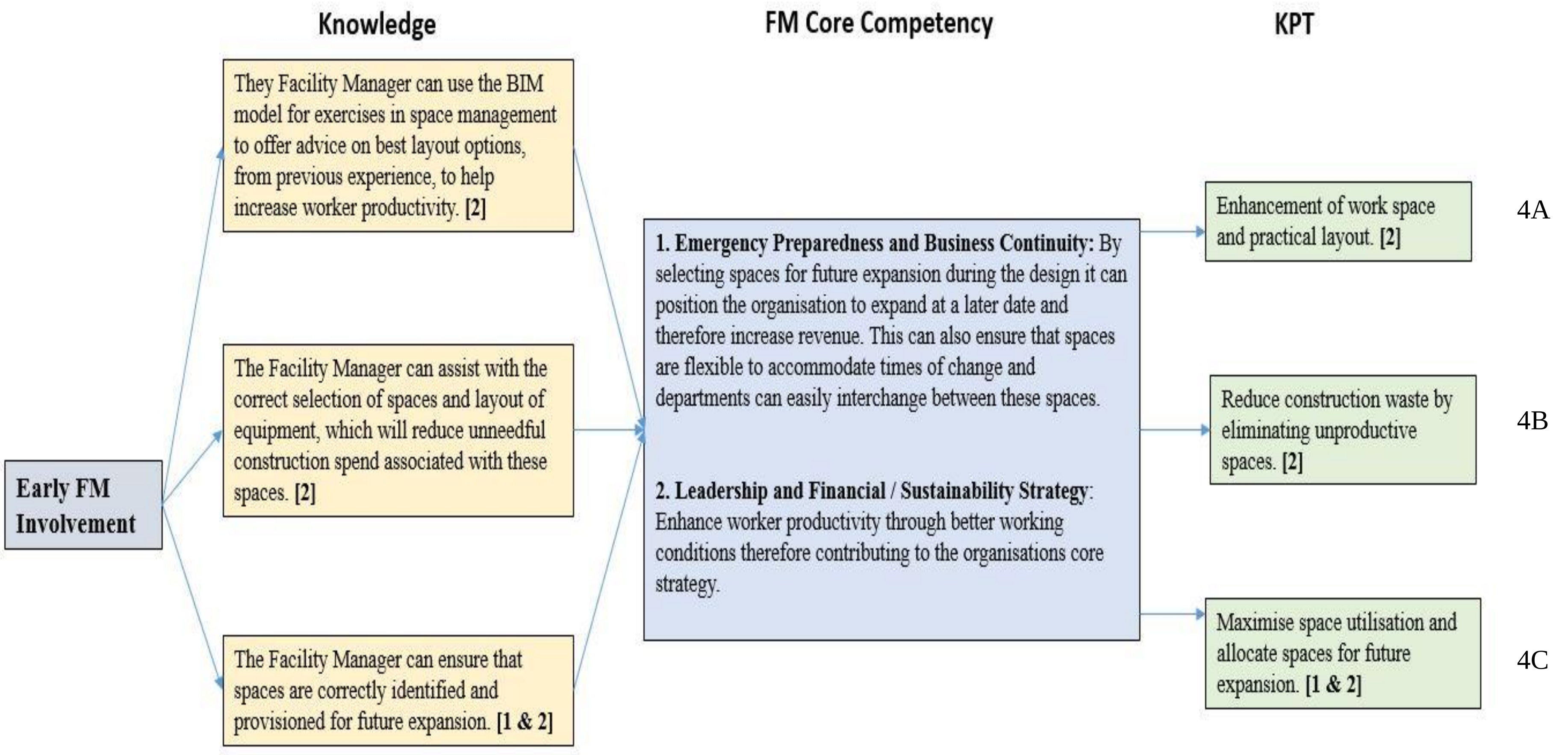

Fig 7.17: Space Management KPTs for early involvement of the Facility Manager in the BIM process Revision 1

Early Facility Manager Involvement in the BIM Process for Public Works Projects			
O&M	**M&E**	**Energy Management**	**Space Management**
1A. Reducing operational expenditure with regard to the selection of O&M products	**2A.** Reducing of operational costs in regards to the selection of M&E based equipment	**3A.** Reducing impact on external environment through the selection of environmentally friendly material / finish.	**4A**. Enhancement of work space and practical layout.
1B. Enhance Design for safety	**2B.** Reduce the functionality risk associated with M&E equipment	3**B.** Reducing energy costs through the selection of better energy efficient systems/materials:	**4B.** Reduce construction waste by eliminating unproductive spaces.
1C. Reduce functionality risk with regard to O&M.	**2C.** Maximise space and ensure ease of access for maintenance		**4C**. Maximise space utilisation and allocate spaces for future expansion.
1D. Improve the practicality of the FM model for the operational phase.	**2.D**. Improve lifecycle costing estimates for M&E based products.		
1E. Enhancement of design to be more maintenance friendly with regard to accessibility.			
1F. Improve lifecycle costing estimates for O&M based products.			

Table 7:15: Early Facility Manager involvement in the BIM process for Public work projects KPTs Revision 1

8 REFINEMENT OF KEY PERFORMACNE TASKS

8.1 INTRODUCTION

The research has sought to identify the KPTs that would be of most benefit to demonstrate early Facility Manager contribution within a BIM supported design process. This chapter provides a greater appreciation of the key concerns of the Irish public sector in respect of project performance and how FM was perceived in the delivery and management of the public sector estate. A number of core areas have been identified where the Facility Manager can contribute. In order to further refine these KPTs it was decided to perform an extensive scientific analysis of all qualitative data recorded to-date. The purpose of this was to ensure that there was a high level of analytical rigor, so as to justify the KPTs in advance of final refinement of the results in the field. It was also important that any validation of the KPTs in the field represented a solution which was directly relevant to the public sector. To accomplish this the author spent three months working on a public sector project and collecting data to form part of the refinement analysis.

During these three months in 2014 the author immersed himself within the Architectural Department of the OPW within the design phase of a Coastal Sea Rescue Station. The OPW's main aim was to provide a new Coast Guard Station and boathouse in Greystones Harbour, Co. Wicklow to enhance maritime safety along the Greystones coastline. The project offered a unique opportunity, as it was the only live OPW project using BIM technologies at that time. BIM tools were used specifically for this project to increase design productivity and to provide valuable feedback on its use, as a preferred design tool and methodology.

The BIM design team at the time consisted of one full time and one-part time Architect who were responsible for model detailing. Autodesk Revit was the sole software used on the model. The author's role, as well as assisting in the model design, involved producing a detailed project management schedule. The model was shared through a Revit syncretised central repository system enabling instant changes to the model to be viewed and accepted by the other team members. This offered the opportunity to participate and observe first-hand the current BIM practices within the OPW. No other departments within the OPW were involved in the modelling process.

The sharing of information from the model was quite traditional despite the use of sophisticated BIM tools like Autodesk Revit. As Revit enables one to export to a number of different CAD formats, the model was exported as a 2D representation of the 3D model, which could then be opened in Autodesk AutoCAD. This was the preferred medium of choice of transferring information to the QS and M&E teams. Despite the use of BIM software there was no input from the Property Maintenance Department who were responsible for maintaining the value and condition of the State's property portfolio.

It was observed that BIM was in its infancy in the public sector but there was a strong interest in promoting it as a valuable tool in the procurement and management of public sector assets. No interaction between the Property Maintenance Department and the design team generating the model was observed. In regards to the Property Maintenance Department it would appear that it was confined to an operational role and were not viewed as possessing the skills to contribute to the design stage. Despite the results of Phase 1 and the Technology pilot, it was evident that the OPW was not in a position, nor, do they have the required experience to implement BIM.

During the three months of action research observational data was collected in the form of the model and through a review of existing BIM processes within the OPW. Further to this a total of four interviews were conducted with OPW personnel. Details of these persons are outlined in table 8.1. A sample transcript from one of the interviews can be located in Appendix 5.

Role	Selection Rationale
Project Architect and BIM Modeller	The person who was primarily responsible for the creation of the model. The author worked with him on a daily basis.
Chief Architect	The person who was responsible for the overall design of the Greystones coastal project.
Head of Information and Systems	This person who was responsible for the adoption of ICT related systems within public sector buildings.
Head of Property Maintenance	The person who was responsible for the property maintenance activities within public sector buildings.

Table 8.1: OPW Interviewees

The data collected during the three months ensured that the KPTs reflected a balanced solution that was relevant to the public sector. This formed an important part of the thematic analysis.

8.2 PURPOSE OF STUDY

The main purpose of the thematic analysis was to:

1. Further establish the key areas of concern for Irish public sector assets.
2. Further research the current role of the Facility Manager within the public sector.
3. Ensure all data from previous findings has been included in the selection of the KPTs.
4. Refine the current set of KPTs for the early involvement of the Facility Manager in the BIM process.

Data was analysed through the processing of qualitative data through thematic analysis. Table 8.2 is a reminder of the qualitative data collected, which equated to a total of 19 sources. It was decided to treat each survey as one response i.e. the BIM in Ireland survey had 38 participants who provided open ended responses to ten questions totalling 223 comments, this will be treated as a single source. Each interview was treated as a single source.

8.3 METHODOLOGY

The methodology for this section was detailed in Chapter 3 and follows the process set out by Braun and Clarke (2006). Nvivo 10 was selected as the qualitative analysis tool, due to it being a DIT nominated software. This enabled access to a student version of the software, as well as training provided by DIT. The first phase involved interrogating the research and generating nodes within each piece of primary research. This involved manually scrolling through all the data and systemically coding lines of text to the relevant nodes. The second phase involved developing categories which consisted in the collating of codes into themes. This involved going through each of the nodes and then organising them into categories. The third phase involved reviewing the categories to ensure the coded themes worked in relation to the extracts. This involved reviewing the categories and breaking down the now restructured categories into sub-categories to offer a more in-depth understanding. The next phase of the thematic analysis involved defining and naming themes and the reduction of data. Memos where further linked to the analysis, as this enabled one to record the ideas, insights, interpretations or growing understanding of the material in the project. Important aspects of the interview or data were recorded through annotations. This permitted the recording of comments, reminders or observations about specific content in a source or nodes. A more detailed description of using this software can be found in Appendix 5.

Primary Research	Number of Sources	Data Collection Tool	Type
RIAI CitA Pilot	5 Sources	Unstructured Interviews / conversations	1. BIM Consultant 2. Energy Consultant 3. Service Engineer / M&E 4. Civil Engineer 5. Client – DoES
	1 Source	Presentation	OPW Presentation
BIM in Ireland Survey	1 Source	Survey - Open Ended Questions	A total of 126 comments from 9 open ended questions were inputted into Nvivo.
BIM for FM Survey	1 Source	Survey - Open Ended Questions	A total of 223 comments from 10 open ended questions were inputted into Nvivo.
CitA Technology Pilot	1 Source	KPI Survey 1 - Open Ended Questions	A total of 56 comments from 11 open ended questions were inputted into Nvivo.
	1 Source	KPI Survey 2 - Open Ended Questions	A total of 55 comments from 11 open ended questions were inputted into Nvivo.
	5 Sources	Semi Structured Interviews	1. Chief Architect 2. Structural Engineer 3. 4D Consultant 4. QS/5D Consultant 5. Facility Manager
OPW BIM Project	4 Sources	Semi Structured Interviews	1. BIM Model Designer 2. Chief Architect 3. Head of Information and Systems 4. Head of Property Maintenance

Table 8.2: Collected qualitative research to date

8.4 REFINEMENT OF KPTS – ESTABLISHING THEMES

The data collected during the action research was integrated with previous data collected during the first two phases of research. This would ensure that all collated data to date would receive a high level of cross reference and analytical rigor. The purpose of this was to ensure the KPTs reflected a solution that was relevant to the public sector and that no potential criteria concerning the proposed set of KPTs was over looked during previous undertaken analysis.

To refine the KPTs, the thematic analysis aimed to establish the core problems associated with the management of Irish public sector assets and the core areas where the Facility Manager can contribute. To achieve this the following nodes have been created, in order to establish a number of sub-themes from the research:

1. Management of Irish Public Sector Assets
2. Key Performance Tasks

Table 8.3 identifies the nodes in relation to the number of sources coded i.e. a total of 19 different elements of primary research were coded. “Citations coded” refer to how many times this theme was coded within all of the primary research. A theme could be coded multiple times within one element of primary research.

Theme		Sources Coded	Citations Coded
Theme 1	Management of Irish Public Assets	8	196
Theme 2	FM Key Performance Areas	13	349

Table 8.3: Breakdown of the themes outputted from the Thematic Analysis

8.4.1 Theme 1: Management of Irish Public Assets

The application of Nvivo resulted in the production of four key nodes that were best used to describe the most important sections of the data. The themes from the first key node titled “Management of Irish Public Assets” are outlined in table 8.4. This table details the four themes that were used to examine the most prevalent concerns when it comes to the management of Irish public sector assets. Further focus was placed on the role of the Property Maintenance Department who were responsible for daily O&M requirements in the public sector. Further themes have been associated with examining existing barriers for early Facility Manager involvement in the design process and the current use of BIM in relation to FM activities within the public sector.

Theme 1: Management of Irish Public Assets	Sources Coded	Citations Coded
Government Estate Problems	7	51
Government Facility Management	7	66
Early Facility Manager Involvement	6	36
BIM for FM	5	43

Table 8.4: Breakdown of Theme 1 - Management of Irish Public Asset

8.4.1.1 Government Estate Problems

Government Estate Problems	Sources Coded	Citations Coded
Improper Use of Building	3	13
Poor O&M Documents	4	10
Lack of technical staff	3	9
Reactive Maintenance	3	9
Funding	2	6
Poor Completion of Works	2	4

Table 8.5: Breakdown of sub-theme - Government Estate Problems

In establishing any criteria that could be used as a basis for early Facility Manager involvement, it was paramount that current problems within the Irish estate were assessed. Within the “Government Estate Problems” included in table 8.5, the most prevalent sub-theme was the “Improper use of the Building”. This included buildings that were designed for specific purposes being refitted for an entirely different use.

“So we have buildings with too many people in them, trying to do the wrong thing. That has a very negative impact on a building and *ultimately that puts pressure on the building fabric” (Head of Property Maintenance, OPW, 2014).*

This was supported by other OPW representatives

“We need to get people to buy into using the building the way it was designed” (Head of Information and Systems, Estate Portfolio Management, OPW, 2014).

This problem was accompanied with other prevalent themes that included poor “O&M Documents” and a “Lack of Technical Staff” involved in the operation of the building. The Head of Property Maintenance reported that there were no technically qualified building officers in any State buildings.

“We design and we procure and we construct a building and then we hand over to largely inexperienced people and wait to get the call when something goes wrong”

Therefore, the lack of qualified estate staff was identified as the cause of staff being unable to understand O&M documentation. A respondent from the BIM for FM survey who worked in the public sector as a Facility Manager claimed that there was a *“low level of training of users to use/ reference O&Ms”*. This statement was supported by the Head of Property Maintenance who reported that some of the decentralised offices that were built by developers were falling into disrepair. These buildings were reported not to have safety files due to previous disputes with contractors. This has added to their view that the handover process was flawed. This also accounts for the sub-theme of "Poor Completion of Works". It was reported that at best O&M information was provided in a CD format. However, there was still evidence of boxes full of hard copy documents that never arrived at the intended destination.

This has ultimately resulted in an additional sub-theme of "Reactive Maintenance". This was despite the introduction of a Measured Term Maintenance (MTM) Contract to provide reactive and planned maintenance services for Government offices in the Dublin Region. These contracts implement programmes of planned maintenance works, drawn from regular inspections of State property. The MTM contract aimed to deal with the day-to-day maintenance needs of both OPW and the Client Departments occupying State property. Under this MTM contract, a helpdesk was set up to provide a 24-hour maintenance action line to cater for all property maintenance emergencies. Despite these contracts there was still a recorded expenditure in the region of €3 million per annum in Dublin alone in providing a reactive and planned maintenance service for existing buildings.

The current state of the FM related work was regrettably described as "*primitive, but that's the reality"* by the Head of Property Maintenance. This led to the sub theme of "Funding" in which since January 2013 a new circular stated that money goes to the property maintenance section instead of the individual departments, so there can be a move from reactive to planned maintenance. The reason for this was that since 1994 each Government Department funded its own maintenance, which it in turn prefunded the OPW to carry out. This resulted in departments not focusing on long term maintenance. This has caused the Property Maintenance Department in 2014 having to provide unnecessary expenditure on rectifying previous legacy issues.

The fact that there was still €3 million per annum been spent on reactive maintenance, as a result of ongoing legacy issues demonstrated that there was not enough focus provided on life cycle costs during the design. As the Property Management Department were the people who were reacting to these maintenance requests, it would enforce the argument that they have a unique knowledge within this area, which can help address these FM concerns at the design. A progressive step has been taken through ensuring that money goes to the property maintenance section. However, further actions were required to be sanctioned if the ongoing reactive maintenance procedures were to be targeted.

8.4.1.2 Government Facility Management

Government Facility Management	Sources Coded	Citations Coded
Facility Managers role	6	17
Team Co-ordination	4	13
Life Cycle Concerns	4	12
Lack of Knowledge	3	10
Standards	4	8
M&E	3	6

Table 8.6: Breakdown of sub-theme- Government FM

Within the "Government Facility Management" theme, as detailed in the table 8.6, the most prevalent sub-theme was the "Facility Manager's Role". This was to be as expected, as it was important to establish how the Facility Manager was perceived in the public sector system. As reported previously there were no technically qualified building officers in any State buildings, in which the district inspectors were responsible for inspecting the properties. The only buildings, reported to have building managers were third level institutions. The DoES representative for the RIAI Pilot reported that at present primary and secondary level schools did not have Facility Managers but have Principals and a Board of Management who were responsible for building services and maintenance.

The Head of Property Management in the OPW reported that property maintenance essentially provides a reactive team of maintenance professionals who respond to maintenance requests.

"Was not seen as a specialist area with any specialist knowledge, it's a service, it's a maintenance service."

The Facility Manager was thus confined to an operational role within the OPW and, despite high reactive maintenance costs, the need for a skilled technical person to be present in the State buildings was not a priority.

The second highest recorded sub-theme within the government FM node was "Team Co-Ordination". In the BIM for FM survey it was reported that two of the respondents who worked on public sector projects previously experienced a lack of coordination between designers, constructors and operators. It was also reported within the survey by one of the respondents that *"other than design guidelines produced by government departments there was no FM input into any of the projects"*

The third and fourth highest sub-themes were "Life Cycle Concerns" and a "Lack of Knowledge". There appeared to be a complete lack of attention paid towards the final handover of a project. The Head of Property Maintenance in the OPW reported *"snagging and the final retention become something that's squeezed in. This has seen concerns being placed on the running and energy costs, as well as the building fabric. These concerns need to be addressed despite a lack of knowledge of technically qualified staff to understand it"*.

The OPW introduced the European "Standards" of FM (ISEN 15221) with the aim to provide a consistent, standard method for data collection, benchmarking analysis and reporting on performance of property assets. The OPW were providing a strong focus on increasing workstations in relation to net floor area. They aim was to capture the total workstations in relation to both part and full time staff. This should provide an understanding of the vacant and underutilised workstations. This at the moment was the strongest focus in regards to the EU standards.

The "M&E" nodes represents the strategic FM branch of the government. The M&E Department within the OPW appears to take the lead in any form of strategic FM and have maintenance contracts in place. Any high level maintenance concerns in regards to plant would be discussed if required with the M&E Engineers. The Chief Architect from the Greystones project acknowledged that the M&E Department would regularly assist in the plant layout and maintenance around plant. She added that *"because our M&E engineers were also involved in maintenance, they were very aware of what problems would arise in maintenance. The M&E department provide the strategic FM branch of our service"*.

The analysis has provided an insight into how the Facility Manager was perceived within the OPW. They were viewed purely as having a role at the operational stage. Any key maintenance decisions were to be made primarily by the Architect and M&E engineers despite them not possessing the skillset that contributes towards the core competencies of a Facility Manager.

Despite as witnessed within the action research, that there was understanding within the OPW that BIM can offer an enhanced FM practice, no FM input was provided from the people who will be responsible for maintaining the building under consideration.

8.4.1.3 Early Facility Manager involvement

Early Facility Manger involvement	Sources Coded	Citations Coded
Construction Role	5	12
Feedback on the Building	4	8
Lack of construction knowledge	4	7
Better understanding of the building	3	5
Uniformed of the construction process	3	4

Table 8.7: Breakdown of sub theme - Early Facility Manager Involvement

In understanding the position of the Facility Manager in the public construction process the sub-theme of "Early Facility Manager" involvement was identified, as detailed in table 8.7. The main sub-theme developed was that of his/her perceived "Construction Role" within the OPW. As already established, the Facility Manager's responsibilities were mainly absorbed by the district inspector and accommodation officers, who in some instances worked as a clerk of works on construction projects. Despite this, the Chief Architect for the Greystones project viewed the benefits of having the district inspector involved as they were *"familiar with the building while it's being constructed"*.

The current practices in the OPW would be in contrast to the results of the BIM for FM survey in where the Facility Manager was seen to have potentially a major impact if introduced in some capacity to the construction process. A number of respondents who worked within the public sector in an FM capacity recorded that the Facility Manager could have a major input through providing operational "Feedback on the Building". The current practices within the OPW were also not aligned with the outcomes of the Technology Pilot, were it was found that the Facility Manager can have a key role in the BIM process. This has resulted in the sub-themes of "Feedback on the Building" and "Better Understanding of the Building".

There were also a number of concerns in that the Facility Manager, in whatever role, was not viewed as having the capabilities to assist in the construction process. The BIM Modeller from the Greystones project claimed that when it comes to FM related issues *"we know from our experience that it was not good enough. It's not really FM people who are telling us that, it's us, as architects, designing it in the first place"*

This has resulted in the sub-themes of "Lack of Construction Knowledge" and "Uniformed of the Construction Process". The BIM for FM survey raised a number of perceived concerns with his/her involvement that included, at present there were too many bodies already involved in the construction process and a possible lack of construction experience which will impact the design process. The Architect and BIM modeller for the Greystones project had also largely dismissed the role of the Facility Manager in contributing to the construction stage.

Despite the positive results from the BIM for FM survey and Technology Pilot, the involvement of the Facility Manger was at present not viewed as a solution to addressing a number of public sector inefficiencies.

8.4.1.4 BIM for FM

BIM for FM	Sources Coded	Citations Coded
Property Management	4	14
BIM awareness in the OPW	4	12
M&E	3	9
Lack of knowledge	4	8

Table 8.8: Breakdown of sub-theme- BIM for FM

There was a strong concurrent belief that any application of BIM technologies or processes would ultimately best serve as a “Property Management” tool.

“The greatest potential long term is as a facilities management tool. Ultimately we are making the model to hand it over to facilities management to manage the building” (Chief Architect, Greystones Project, 2014).

“The future of BIM in the OPW will be in the maintenance of the estate and not in the building. The FM side of it is very much off the radar and the OPW is not an exception in this” (RIAI CITA Pilot OPW representative, 2011).

“BIM Awareness in the OPW” was being led by the architectural section. The structural, civil, M&E and quantity surveyors were also all aware of BIM. There was no apparent awareness of BIM within the “Property Maintenance Department”. When it came to strategic FM decisions, the “M&E” Department would provide that service. The Head of Property Maintenance was aware of BIM but it was something that was of little interest, as more pressing matters, such as the improper use of the building and poor documentation control were of priority. Despite BIM offering an enhancement to a building’s performance and the management of O&M activities, there was still a “Lack of Knowledge” as to how it could be adopted for these purposes within the OPW.

8.4.1.5 Theme 1 Summary

The theme of "Management of Irish Public Assets" aimed to establish prevalent themes with regards to the operation of public sector assets. It was discovered that the most prevalent themes with regards to public sector estate problems involved the improper use of the building, lack of documentation, staffing concerns and a lack of knowledge in the operation of the building. It was discovered that public sector buildings, apart from third level institutions, do not have Facility Managers but instead use district inspectors and accommodation officers. This results in these professionals contacting the Property Maintenance Department through a helpdesk that has ultimately resulted in a reactive-based maintenance division. This was despite the use of MTM contracts to provide reactive and planned maintenance services.

The concept of FM was not lost on the Irish public sector, as seen through recent initiatives, such as the P and its commitment to adopting current European FM standards, with a focus on maximising workstation spaces. The public sector has also sought to commission a number of public works projects, such as the Greystones Coastal project where the use of 3D design tools has been advocated. Other public sector authorises were using BIM on elements of public works project, such as the National Development Financial Agency (NDFA) on the Grangegorman Development Project and the proposed new Children's Hospital by the Health Service Executive (HSE). The drafting of the GCCC medium term strategy also detailed that BIM can be used as a powerful risk management tool that can help assist the State in realising its value for money objectives. Local government agencies, such as Fingal County Council have advertised for a BIM implementation consultancy service to assist with the department's transition to BIM, advice on IT requirements and supply additional training. Despite some positive moves with regard to BIM the OPW was not in a position, nor, do they have the required experience to implement BIM. This insight was supplemented through recent announcements made by the Irish Government Chief Procurement Officer for Public Service in 2014 within the Irish Building Magazine, when he reported that they were not proposing that BIM would be a requirement to qualify for Irish public works contracts.

Despite BIM being advocated as one of the greatest benefits to the public sector from an FM perspective, the property maintenance sector was not engaging with BIM. Early FM input during design and construction was usually restricted to the district inspector or accommodation officer. When consulted they usually operate as a clerk of works and have little opportunity to contribute to the construction process. The Property Maintenance Department was usually overlooked, as they were not viewed as possessing any additional knowledge to that of the Architect or M&E engineer. The OPW, who were charged with the operation and maintenance of the majority of public buildings in Ireland, were excluding the people who will be responsible for operating the building and have confined them to an operational contribution in targeting reactive maintenance issues. The findings of this theme have been used to help in the refinement of the KPTs, so as to ensure they address the key concerns now faced by the Irish Public Sector. Figure 8.1 illustrates the key findings from Theme One.

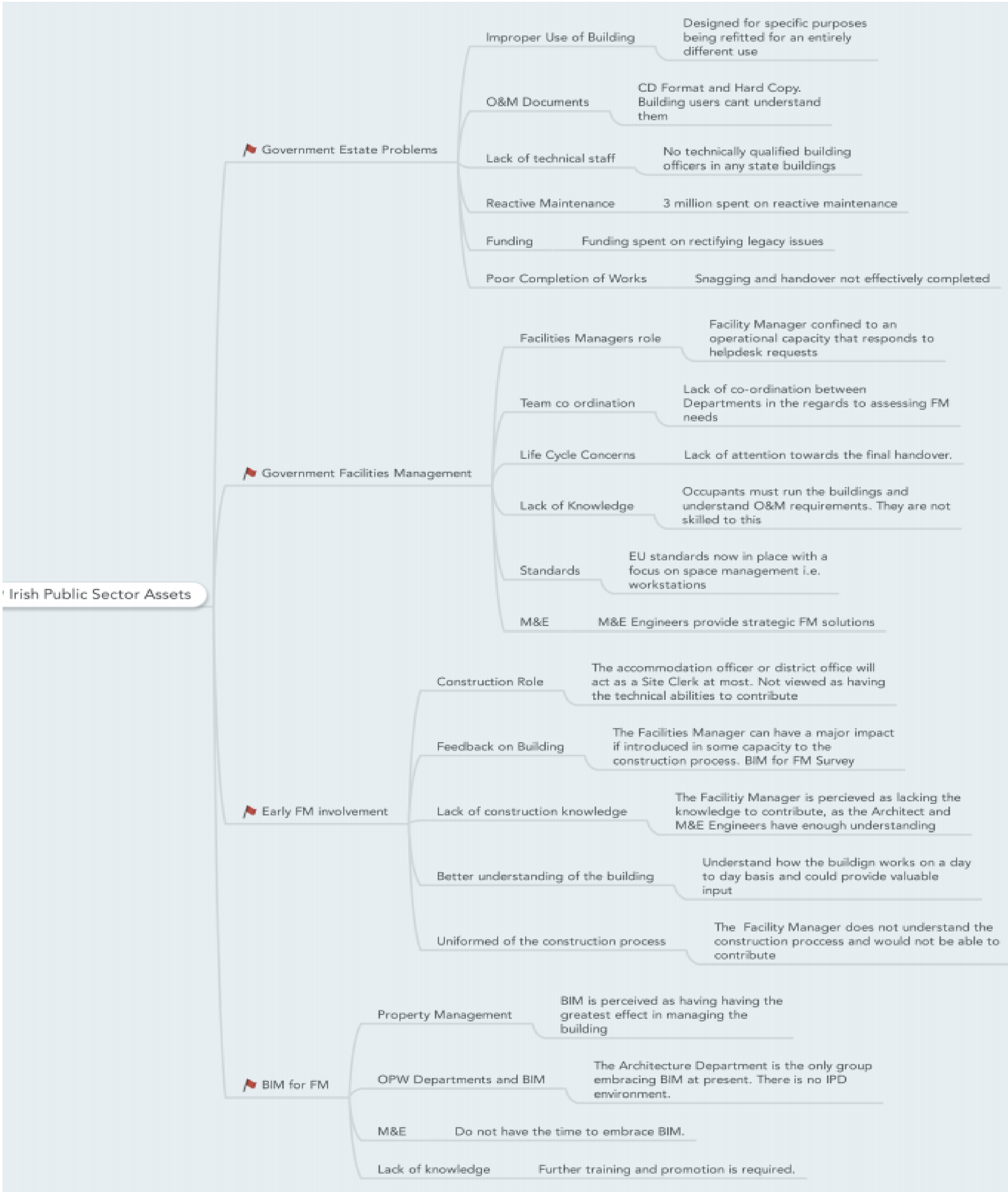

Fig 8.1: Theme One management of Irish public assets overview

8.4.2 Theme 2: Facility Manager Key Performance Tasks

The application of BIM alongside early Facility Manager involvement has been advocated as part of a solution that will more effectively address common public sector problems. The prevailing theme was that the Facility Manager can offer a more rewarding BIM process within a hybrid of roles that predominately focus on maintenance, plant / M&E, life cycle, space and energy related issues. The purpose of this section was to present a thematic analysis of the contribution of the Facility Manager within each of these areas and examine the perceived benefits. The results are detailed in table 8.9.

Theme 3: Key Performance Areas	**Sources Coded**	**Citations Coded**
Maintenance	11	136
M&E	6	74
Energy Management	5	49
Space Management	4	27
Occupant Behaviour	3	25
Costing	5	18
Data Control	6	9
Materials	3	7

Table 8.9: Breakdown of theme 2- Key Performance Areas

The analysis found that the early inclusion of the Facility Manager can assist in operational issues being addressed from the onset and can decrease the need for repairs and alterations in the lifecycle of the building. The findings also show that Facility Managers were seen to have a role to play in advancing the sustainability agenda, and their early involvement will help provide an understanding as to what data should be modelled. In addition, it was found that the BIM for FM modelling process offers the opportunity to visualise where M&E equipment will be located and the display of relevant data connected to this equipment. The results further acknowledge that the model offers the opportunity for the Facility Manager to visualise space more easily, therefore, improving their understanding of under-utilised spaces, as well as performing exercises in space management that were not permissible in traditional FM software packages. The area of cost management or 5D BIM provides the ability to drive costs for buildings and allows optional appraisals at the concept stage to be more accurately assessed. This was an area in which the research has indicated the Facility Manager can offer their skillset.

The thematic analysis suggests that the correct application of the model in tandem with early Facility Manger involvement could further impact on these target key areas to offer a potentially more beneficial design process.

8.4.2.1 Maintenance

Maintenance	Sources Coded	Citations Coded
Operational Efficiency Skillset	9	67
Reducing Functionality Risk	5	21
Replacement Costs	4	15
Accessibility	3	11
Asset Management	4	8
O&M Documentation	4	8
Safety	2	6

Table 8.10: Breakdown of sub-theme - Maintenance

Table 8.10 shows that within the **“**Maintenance” sub-theme the most prevalent theme was the use of his/her knowledge of “Operational Efficiency as a Skillset”. This would involve specifying equipment with minimal maintenance requirements that will reduce future operational costs.

“Early input means that they can plan earlier and optimise/ streamline the facility according to their needs not just for finances but for everything including occupant comfort and satisfaction” (Pilot Chair, CITA Technology Pilot, 2014).

The analysis shows that there was a common concern that too much focus was placed on the capital expenditure and not the operational expenditure. The Facility Manager was seen as a person who can help rectify this, as their hands-on experience can add value for maintenance and practical applications. As the Facility Manger will be the person responsible for maintaining and running the building on completion, it has been suggested that he/she should have an input into its design and specification of materials and services. The Facility Manager *“understands the logistical requirements for maintenance, who will operate the facility, and the cost of the most feasible product and what the supply chain requirements are” (BIM for FM Survey, 2012).*

The Facility Manager was not primarily interested in the capital costs of systems employed but was more concerned with the operating costs, functionality and maintainability. This could increase the upfront costs but in the long term the running costs will be lower.

The area of "Reducing Functionality Risk" was also rated highly because the Facility Manager's knowledge can provide an in-depth analysis, as to how the building will be required to function on a daily basis. The functionality risk can be described as the risk associated with the lack of functionality in a new facility arising from poor planning, design and construction of the facility. The Facility Manager can help in navigating this problem, as he/she will look to include flexibility and adaptability of the building, as he/she will have greater understanding of spatial needs, interaction of people and support services.

"The targets to achieve design value and productivity should not be made in the end after the design is done in the BIM model; instead targets should be known, based on a client business case. Knowledge of facility operations, such as scale and type of product, amount of people working should be incorporated in the design" (BIM for FM Survey, 2012).

Another prominent sub-theme was within the area of "Replacement Costs". The Facility Manager was seen to be able to work with the QS in specifying parts that were more maintenance reliant, which in turn can help provide a more cost effective life cycle outcome. The Facility Manager can ensure that the systems installed were not only functional but were easily maintained and spares easily sourced.

In regards to the sub-theme of "Accessibility", it was discovered that the Facility Manager can help the design to be more maintenance friendly from an accessibility point of view due to their knowledge of service lay-outs. The sub-theme of "Asset Management" addresses the application of the Facility Manager's knowledge of facility operations, such as scale and type of product which could be incorporated in the design. They can assist in helping the design team to ensure the most valuable assets were incorporated into the model. This could possibly help in identifying the assets that require detailed COBie information, therefore, eliminating the need to populate every asset with time consuming data. This, in turn, will help ensure that the most crucial "O&M Documentation" was accessible and readily available within the BIM model. The Facility Manager can further help the Architects to design for "Safety" in regards to maintenance.

"A lot of architects miss that essential item, how to maintain a building e.g. how safe it is to put a ladder beside a building to access the roof" (Pilot Architect, CITA Technology Pilot, 2014).

8.4.2.2 M&E

M&E	Sources Coded	Citations Coded
Operational Efficiency Skillset	6	31
Heating Systems	3	12
Maintenance Access	3	11
Lighting Systems	2	7
M&E Consultant	3	5
Replacement Costs	2	5
Power Consumption	1	3

Table 8.11: Breakdown of sub-theme M&E

The "M&E" node, as detailed in table 8.11, has proved similar in certain respects to the "Maintenance" node. The prevalent sub-theme once more was that the Facility Manager was perceived as having the greatest influence through early involvement in the BIM process in regards the M&E by applying their "Skillset to reduce Operational Costs". In the Technology pilot it was observed that the earlier systems were specified and integrated into the design the better the opportunity they have to impact on the financial outcome.

"Advance knowledge and FM systems choice means advance ways to simulate and optimise the systems to be installed" (Pilot Architect, CITA Technology Pilot, 2013).

The Facility Manager was viewed as the person who can offer such an enhanced input into the selection of systems. This was represented in the "Heating" and "Lighting Systems" sub-themes. They can ensure that the systems installed were easily maintained, therefore, avoiding plant down time and increasing productivity. The Facility Manager can assist in regards to specifying of heating systems, as he/she has an in-depth understanding of how the building will be used, so will be best placed to assist in design decisions e.g. introduction of heating zones within a building.

"It is vital that the FM has a major involvement in the installation of M&E in a facility. This is especially important in relation to the provision of power and heat, as the determining factors should prioritise life cycle costs as opposed to capital costs for the initial project" (BIM for FM Survey, 2012).

Other areas that evolved from the analysis included the Facility Manager contributing to the layout of the plant room in order to maximise space and ensure ease of "Access" for maintenance purposes. There were suggestions that the Facility Manager's involvement in the design period of the project might make better utilisation of the work space and more practical layout of the office from the services point of view. As with the accessibility sub-theme within the "Maintenance" node, the need for ease of access to machinery was a critical aspect which the Facility Manager can assist in working around impractical designs. "*By understanding the operation of the business that will be in the building and designing around it, maybe through the design and thereafter implementation of the BMS" (BIM for FM Survey, 2012).* There was also an understanding that he/she can work in conjunction with the "M&E Consultant" to provide a performance specification that can be more prescriptive.

Other sub-themes developed include the Facility Manager using his/her knowledge to ensure the specification of proprietary elements that were affordable to repair/maintain. This in turn will reduce the "Replacement Costs" associated with these elements. The Facility Manager can also drive down "Power Consumption" costs by including equipment with minimal maintenance requirements, long life expectancies and low energy consumption.

The selection of such equipment will enable the implementing and monitoring of more rewarding FM policies and financial plans, therefore, advancing the business's financial and sustainability strategies. This can also ensure better responses to reactive maintenance requests at an operational level and the strategic supervision of the facility.

8.4.2.3 Energy Management

Energy Management	Sources Coded	Citations Coded
Environmentally Friendly Systems	4	19
Energy Usage	3	19
Efficient Building Systems	3	11

Table 8.12: Breakdown of sub-theme - Energy Management

The most prevalent themes, as detailed in table 8.12, include that the Facility Manager can advise in the selection of "Environmentally Friendly Systems" and best practice for reducing "Energy Usage". As seen in the sub-themes for both **"**Maintenance" and "M&E", the Facility Manager can specify equipment that was functional but also energy conscious. They can *"focus the design team on control systems and monitoring data to ensure that the completed building measured performance matches the predicted building as designed." (BIM for FM Survey, 2012).*

The operational cost constitutes the majority of the life cycle cost of a building, therefore, the appointment of an FM consultant to advise on energy efficient design practice during the design stage was important. The Facility Manager could work alongside the energy consultant to give professional advice on optimising the energy performance of buildings, as they would have valuable experience on sustainability strategies from working with similar buildings.

"Early FM involvement is a must for the functionality of the project, bringing in new skills at an early stage can only be beneficial, for energy use/ building layout" (Land Surveyor, CITA Technology Pilot, 2013).

The Facility Manager can also assist in the selection of "Efficient Building Systems", through his/her understanding of the building and systems within it. This would allow the Client to use all of the buildings systems to their fullest capacity which will ensure value for money, value for occupants and value-added for the built environment.

8.4.2.4 Space Management

Space Management	Sources Coded	Citations Coded
Floor Layout	5	17
Workstations	1	5
Spatial Needs	2	5

Table 8.13: Breakdown of sub-theme -Space Management

The predominant sub-theme within table 8.13 was that early Facility Manager involvement can contribute his/her practical knowledge for the "Floor Layout" and coordination between departments. "*Having the Facility Manager involved in the construction period of the project might mean better utilization of the work space and more practical layout of the office from the services point of view. (BIM for FM Survey, 2012).*

The public sector were looking at the area of "Workstations" as a KPI in regards to implementing European FM standards. The better utilisation of space to accommodate more workstations was seen as a valid performance indicator. *"So the key performance indicators are again the primary to net floor area, the net floor area to total level area, and the gross floor area, all of these terms come from the FM standard "(Head of Information and Systems, Estate Portfolio Management, OPW).*

The Facility Manager as detailed in the **"**Floor Layout" sub-theme, if involved earlier in the design process, can help assist based on their existing knowledge of similar buildings so that spaces were better utilised. It would seem logical that they could assist in helping the OPW reach its KPIs for workstations in regards to spatial management.

The Facility Manager can assist with "Spatial Needs" by maximising space utilisation and allocate spaces for future expansion. The correct utilisation of space will enhance worker productivity.

8.4.2.5 Occupant Behaviour

Occupant Behaviour	Sources Coded	Citations Coded
Occupant Needs	3	8
Building Operations	3	8
Sustainable	2	5
Work Habits	1	4

Table 8.14: Breakdown of sub-theme - Occupant Behaviour

The Facility Manager was best placed to be able to offer a unique insight into understanding occupant behaviour with regards to their day-to-day interaction within a building. Table 8.14 shows that predominant sub-theme with this node was that the Facility Manager can contribute additional knowledge within the area of **"**Occupant Needs". The Facility Manager can plan for occupant comfort, as he/she were aware of the requirements of the occupants and if involved in the design and construction can ensure the building was tailored to the exact requirements of the occupant. There was a suggestion that the Facility Manager has a different understanding of the actual user needs than designers and so therefore, can offer an alternative perspective to the design.

The second largest recorded sub-theme was that of "Building Operations". As evident in the previous sub-themes the Facility Manager was seen to have a unique understanding of the building operations through working in similar structures. Through their knowledge of occupant behaviour he/she can provide an insight into how the building will be used and were well placed to assist in design decisions. The Facility Manager understands the working habits of people within the building and this information can be used to drive down the operational costs. They can communicate existing and previous end-user feedback to designers of similar facilities.

The final sub-theme of **"**Sustainable**"** was in reference to the Facility Manager assisting in providing information for sustainable output within the model by providing more accurate and realistic expectations of equipment. This will assist in ensuring that the theoretical BIM energy analysis during design was not significantly different to the reality post-construction. The

Facility Manager can also bring added value within the area of facility operations such as helping the design team understand the "working habits" of people within similar buildings.

8.4.2.6 Costing

Costing	Sources Coded	Citations Coded
Focus on OPEX	3	10
Objective Outlook	2	5
Workstations	1	2
Handover Documentation	1	1

Table 8.15: Breakdown of sub-theme - Costing

The most prevalent theme in table 8.15 was that the Facility Manager can provide a greater focus on the operational cost. The pilot 5D consultant stated that when he was focused on the technical aspects of the 5D process, he would have benefited from FM input at an early stage.

"The current focus is on CAPEX while FM brings focus onto OPEX. The QS should be able to use TOTEX when evaluating project options" (5D BIM Consultant, CITA Technology Pilot, 2013).

He adds that as QS's do not know what the implications were for choice of services, the Facility Manager can detail what works from a maintenance perspective and can feed the information back to the design team. He adds that spending an extra 10% at construction stage may reduce FM expenditure over the life by 20% or 30%.

As noted within other sub-themes the Facility Manager can offer an "Objective Outlook" compared to the traditional perspective, as they will be the people responsible for the O&M of the building they can offer an outlook that was practical and independent initially from costs and design, whereby this may be missed by the QS, Architect and Engineer due to the pressures of getting a project to tender/site. When it comes to the sub theme of "Workstations" within the "Space Management" node, there were synergies here in regards to the Facility Manager helping in reducing the financial costs per workstation by optimising the layout to include more workstations. This would normally be the role of Architect but the Facility Manager could offer their assistance in this area. The final sub theme of "Handover Documentation" was in relation to the Facility Manager making the QS aware of budget requirements for adequate handover of documentation.

8.4.2.7 Data Control

Data Control	Sources Coded	Citations Coded
Model Validation	4	5
COBie	3	4

Table 8.16: Breakdown of sub-theme - Data Control

The COBie process can require a large amount of information to be input into the model for each FM asset. There were suggestions, as indicated in table 8.16, within the sub-theme of "COBie" that the Facility Manager can streamline this process by specifying what assets require high and low levels of COBie data. This can reduce time spent on unnecessary data being added to the model parameters. Having the Facility Manager working in close proximity with the design team can assist in "validating" a more practical Asset Information Model (AIM), as this model will more strongly reflect the requirements needed at the O&M stage. They can further assist with the specifying of equipment within the AIR, which is an important part of PAS 1192- 3. This document will ultimately be used in translating the type and level of detail of an asset to be specified within the BIM model.

8.4.2.8 Materials

Materials	Sources Coded	Citations Coded
Material Selection	3	4
Quality of Finish	2	3

Table 8.17: Breakdown of sub-theme - Materials

The sub-theme of "Materials Selection" identified were the earlier involvement of the Facility Manager can dictate were the best selection of materials can better serve the long term O&M requirements of the Client. It was reported that the Facility Manager will be the person responsible for maintaining and running the building on completion, so therefore, they should have an input into its design and specification of materials and services. Their early involvement can also be of benefit in assisting how the selection of high "Quality Materials" may result in less replacement costs downstream in the O&M of the Facility.

8.4.1.9 Theme 2: Summary

The node of "Key Performance Tasks" aimed to further establish the prevalent themes with regards to what contribution of the Facility Manager in the early BIM process would be of most benefit. The most prevalent theme was that the Facility Manager can have the greatest influence with regards to maintenance related issues. They can use their knowledge of operational efficiency as a skillset in helping to reduce operational costs by specifying equipment with minimal maintenance requirements.

Other prominent themes include the Facility Manager's contribution from an M&E perspective, where, they can use their skillset to reduce operational costs. The Facility Manager can assist the M&E team, where possible to ensure that the systems installed were not only functional but were easily maintained, therefore, avoiding plant down time.

The Facility Manager can assist the design team in specifying equipment that was functional but also energy efficient. This was important as the operational costs can be as much as six times of the complete life cycle cost. The Facility Manager can provide professional advice on energy performance based on previous sustainability strategies from similar buildings.

Other sub-themes that developed included, contributing his/her practical knowledge on floor layouts in regards to the better utilisation of the work space and more practical layout of the offices from a services point of view. While this was primarily the role of the Architect the Facility Manager can assist by providing practical advice based on his/her own experience. The correct utilisation of space can increase worker productivity. The Facility Manger's practical knowledge of occupant behaviour can assist with communicating the needs of the end-user to the design team, therefore, ensuring the building can be tailored to the exact requirements of the occupant.

A further sub-theme that also arose was within the area of the Facility Manager assisting the QS in producing a more accurate life cycle cost by providing a greater focus on the operational cost. Other sub-themes include the Facility Manager validating the model from an FM perspective with regards to specifying the type of information and the level of detail in the model. There was also evidence that the Facility Manager may be able to assist in materials selection by advising how the selection of high-quality materials may result in lower replacement costs. Figure 8.2 to 8.4 illustrates the results from Theme Two.

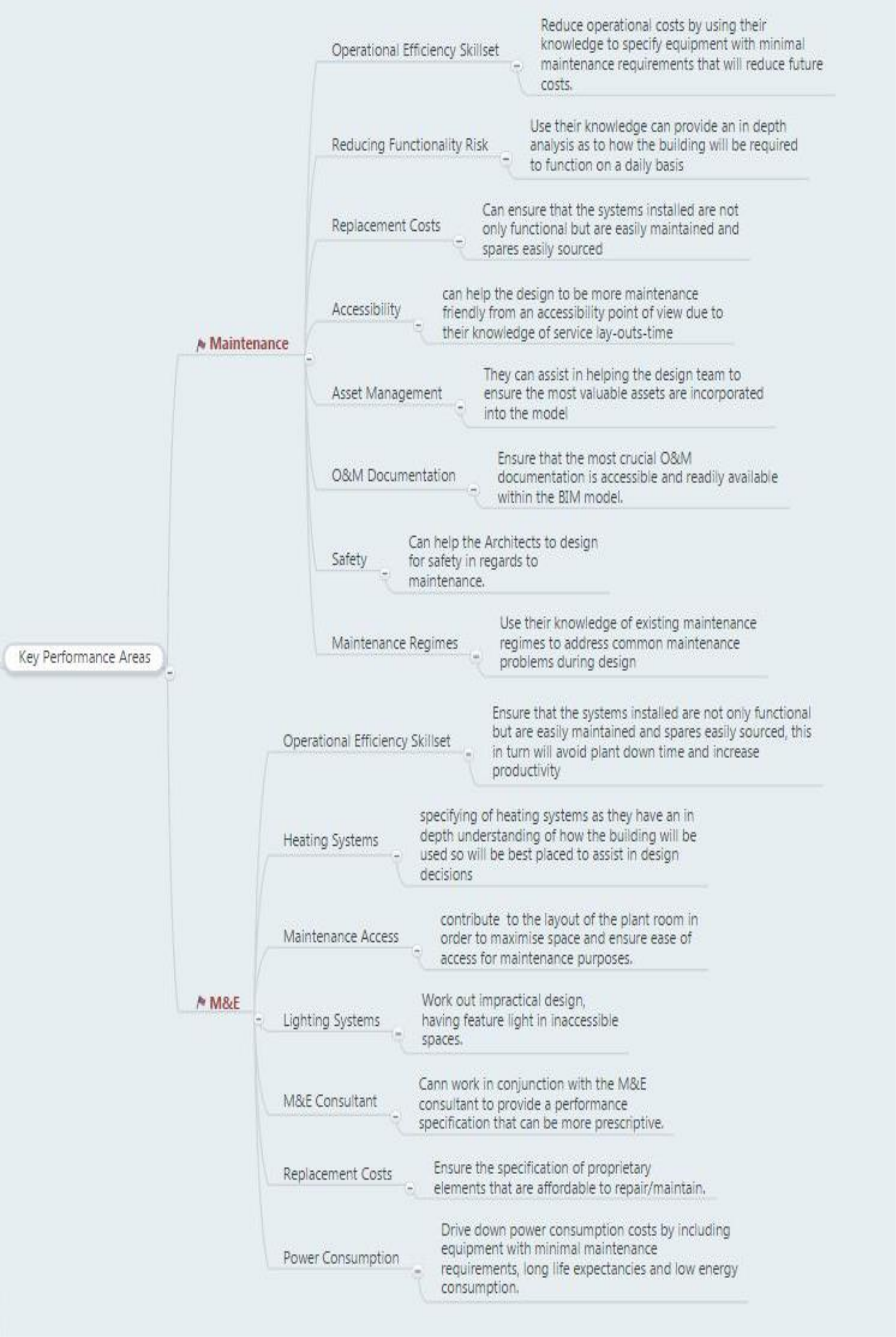

Fig 8.2: Theme Two key performance areas overview of sub themes 1-2

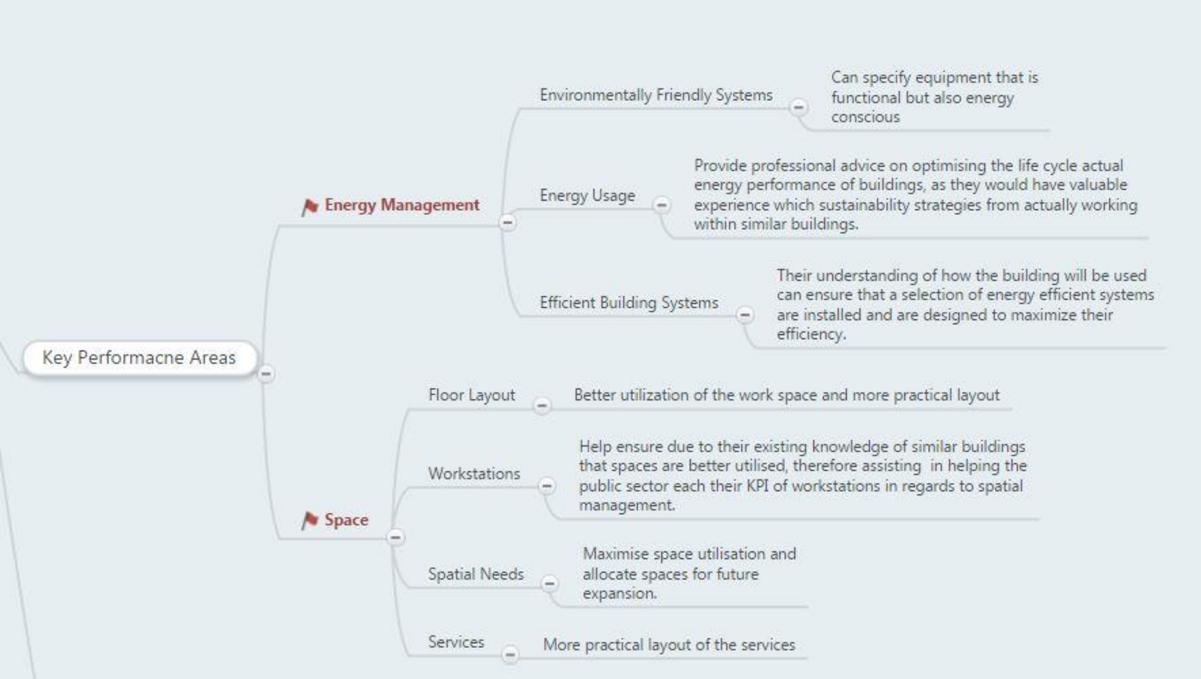

Fig 8.3: Theme Two key performance areas overview of sub themes 3-4

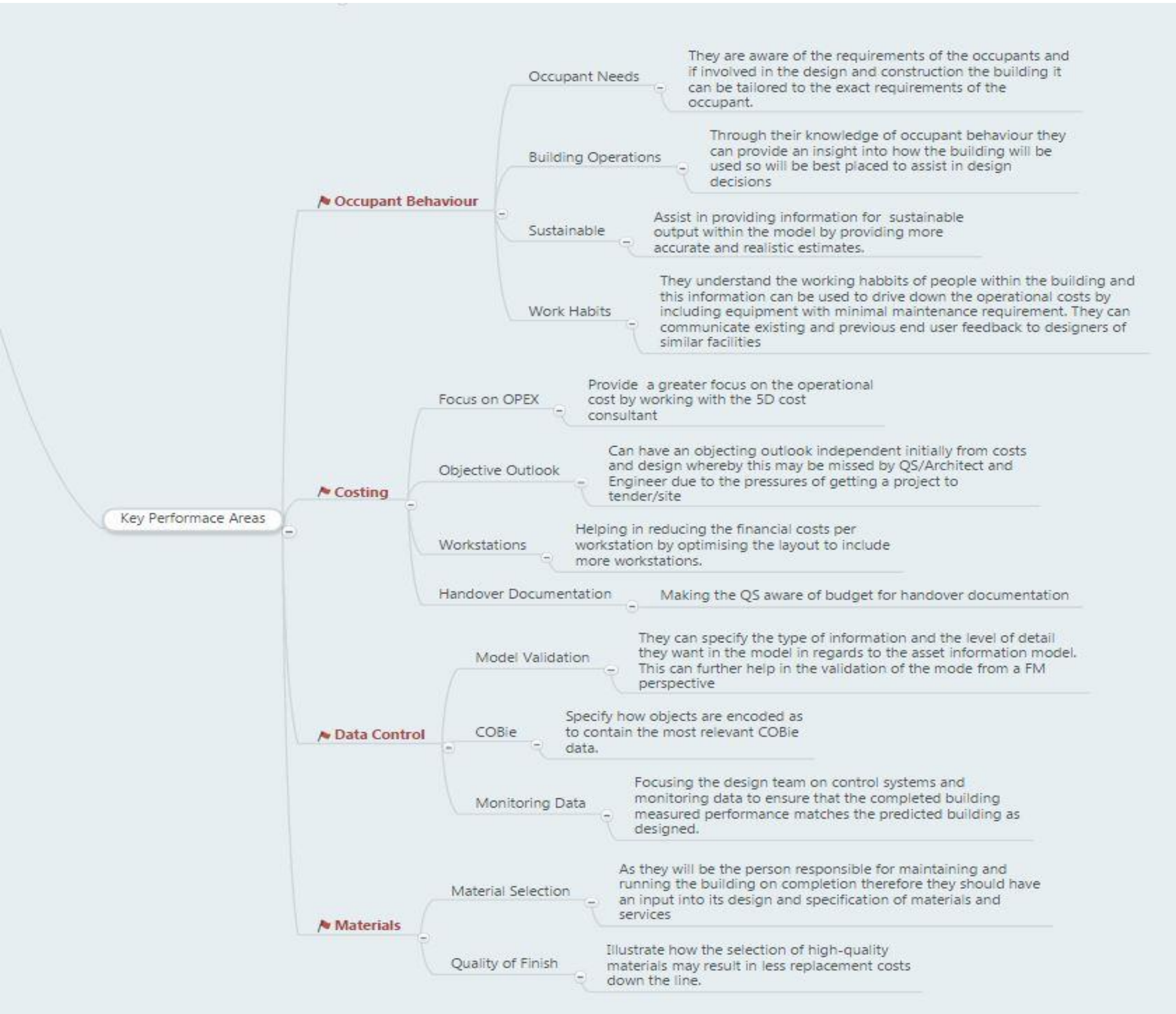

Fig 8.4: Theme Two key performance areas overview of sub themes 5-8

8.5 THEMATIC MODEL

Figure 8.5 illustrates the overall thematic model of this study which illustrates the key findings from the thematic analysis detailed through this phase of the research. This image shows the main concerns that were currently faced in the management of the Irish public sector. These include improper use of the building, poor O&M documentation, large sums spent on reactive maintenance, lack of focus on the O&M phase and no technical staff working within the buildings.

These concerns must be addressed by the Property Maintenance Department on a daily basis, who were confined to an operational capacity and were assumed not to possess the technical skills to contribute to the design process. Figure 8.5 details that the strategic FM decisions were made by the M&E and Architectural Departments, as the Property Maintenance Department were assumed to be uninformed of the construction process. BIM and its associated processes was being embraced as part of a solution to addressing the public sector concerns. Despite enhanced FM being the overall goal of adopting BIM technologies there was no input from the Property Maintenance Department into the design of the model. At present the Architectural Department appear to be the only profession contributing to the BIM process.

The solution proposed from the evidence collected within this research proposes that the Property Maintenance Department take a more strategic role in the BIM governed design process. This will mean that they can contribute their knowledge to important FM related criteria, which can result in a reduction of reactive maintenance responses during operation. The analysis has shown that the Facility Manager can offer practical advice in regards to a number of areas that include maintenance, M&E, life cycle costing, energy and space management, material selection and in validation of the model from an FM perspective.

Figure 8.5 further illustrates that the Facility Manager can achieve contributions in some of these areas through the proposed KPTs. The final thematic map is illustrated below.

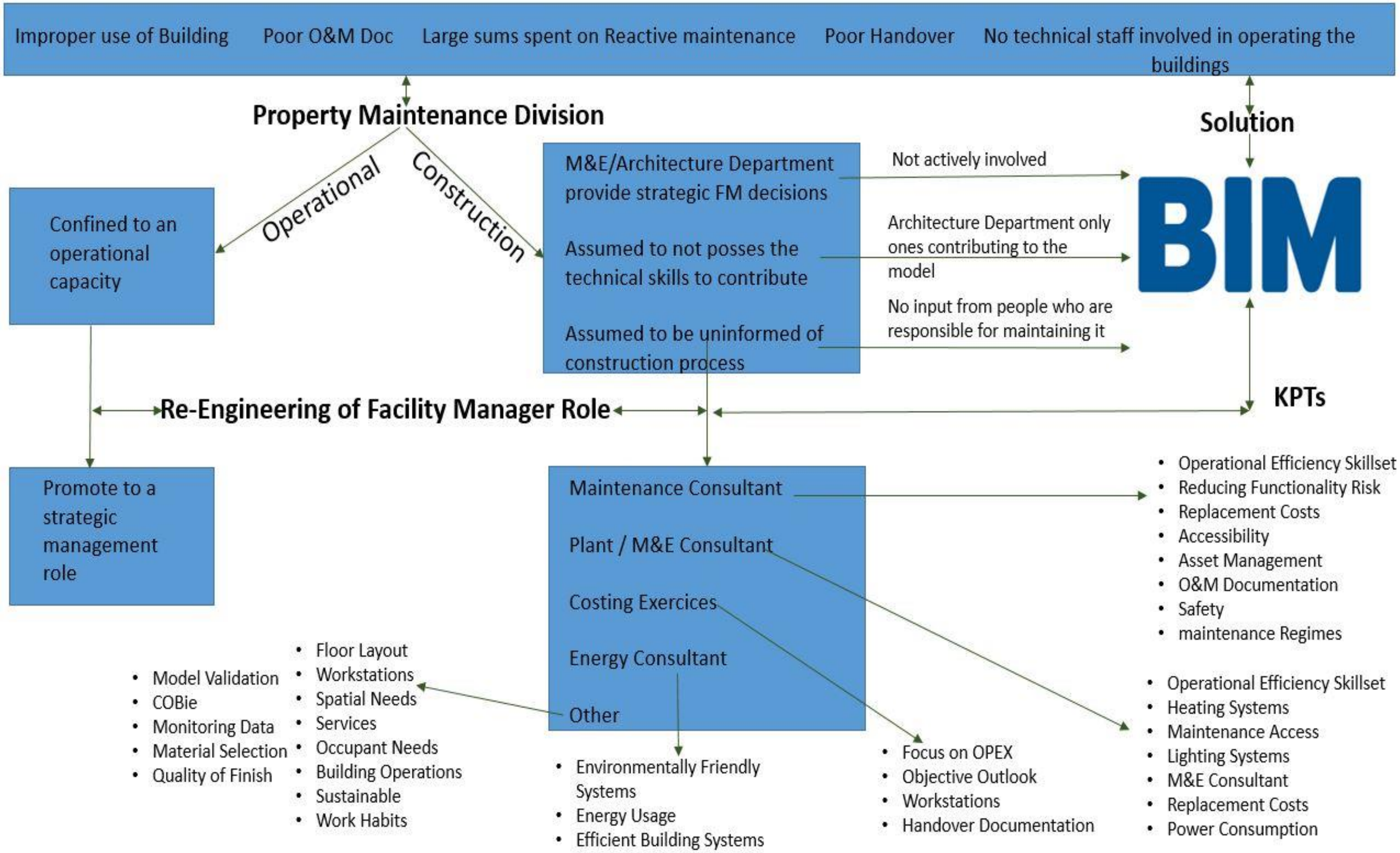

Fig 8.5 Thematic Model for this study

8.6 REFINED KPTS

The KPTs were refined to take into consideration the findings of the thematic analysis, so as to ensure they reflect the discussed areas of concerns. They were also refined to include any potential areas discovered within the thematic analysis that may have been initially overlooked in the first two phases of the research.

8.6.1 O&M KPTs

There was a strong reliance on reactive maintenance within the OPW. The maintenance KPT must take this into account. On investigation of the current suite of KPTs proposed within this area, it was evident to see that they sufficiently address the key areas were the Facility Manager can have the strongest impact in the design with regard to avoiding reactive maintenance in the operational phase. As poor O&M documentation was recorded as an area of concern within the management of public sector assets, this must be reflected in the refined suite of KPTs. The Facility Manager can assist in ensuring the O&M documentation / safety file has all the essential information by specfying and reviewing information associated with this process throughout the design. This will ensure that no important information was absent at the handover stage. While this was recorded in the earlier phases of research and reflected through a combination of KPTs, it was decided to provide a separate KPT to focus solely on this concern. A KPT for improvement of O&M documentation was added to ensure adequate focus was provided within this area

The O&M validation KPT (1D) has been moved to a different primary KPT, namely that of Data Control. This refinement will be justified in section 8.6.6. Figure 8.6 represents the refined O&M KPT, with changes made in red highlight.

8.6.2 M&E KPTs

The M&E Department within the OPW acts as the strategic FM branch of the State. It will be difficult for the Facility Manager to demonstrate a benefit from his/her inclusion within this area owing to a dedicated department already working on the design. Despite this, the research has highlighted that he/she can assist in a number of areas. On investigation of the current suite of KPTs proposed, within the area of M&E, it was evident to see that they sufficiently address the key areas were the Facility Manager can have the strongest impact in the design. The thematic analysis has discovered additional performance areas, such as the zoning of the building in which they could possibly assist. The Facility Manager can improve heating efficiency through the designating of more practical zoning in order to maximise operational efficiency. This was an area which though previously discussed within the research was not used within the KPT selection. The thematic analysis enabled areas such as these to be reanalysed which may have otherwise not figured predominately within the KPTs. A KPT for improving zoning of heating systems was the only refinement to the M&E KPT. Figure 8.7 represents the refined M&E KPT, with changes made in red highlight.

8.6.3 Energy Management KPTs

The Irish public sector was focused on implementing European Standards and with this there was a greater focus on the environment. The public sector has made promises to reduce carbon by 20%, which puts a strong emphasis on impacting these figures during the design. On investigation of the current suite of KPTs proposed within the KPT area of Energy Management it was evident to see that they already sufficiently address the key areas where the Facility Manager can have the strongest impact in the design with regards to reducing energy concerns. No further refinement was suggested for this area. Figure 7.15 in Chapter 7 represents the current KPT.

8.6.4 Space Management KPTs

At present the greatest opportunity in regards to space management from the OPW perspective was in maximising workstations with regards to net floor area per staff member. The space management KPT must take this into account. On refinement the KPT (4A) of "Enhancement of work space and practical layout" will be changed to "Enhancement of workstations per net floor area". Figure 8.8 represents the refined Space Management KPT, with changes made in red highlight.

8.6.5 Materials Selection KPTs

While the Facility Manager can have an impact on some of the current estate problems, other areas will need to be addressed from a staffing viewpoint. The early involvement of the Facility Manager can assist in a more efficient handover, therefore avoiding some of the issues associated with poor completion of works. The thematic analysis has shown that the performance area of Material Selection can be improved through earlier involvement of the Facility Manager in the BIM process on public works projects. This, in turn, can assist along with the other KPT's in reducing areas associated with poor completion of works. The core competency areas of "Leadership and Financial / Sustainability Strategy" and "O&M" can be improved through involving the Facility Manager in the BIM process with regards to material selection. The research has shown that the KPT of Material Selection can provide improvements by focusing on the following two areas:

1. **Internal Material Selection**
   - The Facility Manager will be the person responsible for O&M activities during the operational phase and therefore, should have an input into the specification of certain materials.
2. **External Material Selection**
   - The Facility Manager can apply their knowledge in assisting with the selection of external finishes that are associated with high replacement costs.

Figure 8.9 provides a summary of the Materials Management KPTs for early involvement of the Facility Manager in the BIM process.

8.6.6 Data Control KPTs

Irish public sector buildings designed for a set purpose were being further impacted on by not having the correct staff to operate them. It can be argued that early FM involvement and the production of a valid asset information model can better position the building to be operated by inexperienced staff. The thematic analysis has shown that the performance area of Data Control can assist in the production of a model that can be used by inexperienced staff if necessary. A streamlined model that has the most relevant FM information within it will assist in the operation phase. COBie was mandated as the Level 2 handover of information to the Client in the UK. The KPTs must take this into account, as there was a high possibility that if an Irish mandate happens, then COBie will be the preferred method of exchanging FM information at handover. The core competency areas of "O&M" and "Hard and Soft Project Management" can be improved through involving the Facility Manager in the BIM process with regard to data control. KPT *"Improve the practicality of the FM model for the operational phase"* (1D) which was originally based in the O&M KPT has been moved to this new KPT. The research has shown that the KPT of Data Control can provide improvements by focusing on the following two areas:

1. FM Model
   - The Facility Manager can specify the type and detail of FM information he/she wants in the model. The Facility Manager can ensure that the model was populated with the

most relevant O&M information, which can be practically used by the FM Team. They can further assist with the specification of equipment within the EIR and AIR, which will ultimately be used in translating the type and level of detail of an asset to be specified within the BIM model.

2. COBie
   - The Facility Manager can specify the level of detail required in regards to COBie data, thus in the process eliminating unnecessary time spent on this exercise.

Figure 8.10 provides a summary of the Data Control KPTs to demonstrate the benefits of early involvement of the Facility Manager in the BIM process.

8.7 SUMMARY

The purpose of this chapter was four fold with the first aim to establish the key areas of concern for Irish public sector assets. The thematic analysis established that public sector buildings were not being used for the purpose they were originally built and this was causing additional strain on the fabric of the building. Legacy issues were still prevalent, as a result of improper allocation of property management funds. Despite a change to how these funds were allocated there was still strong reactive maintenance procedures in place. This was coupled with a lack of focus on the operational phase during the design stage and poor O&M documentation control. There were also no technical staff working within the buildings. The second aim of the thematic analysis was to establish the key themes in regards to the role of the Facility Manager within the public sector design process. At present they were confined to an operational role with no input into the design. The research has shown that they can contribute to the early BIM process within a number of key areas, including O&M, M&E, energy and space management, materials selection and data control from a FM perspective.

The third aim was to ensure all data from previous findings had been included in the selection of the KPTs. It was ultimately found that opportunities such as the Facility Manager assisting with the designating of more practical zoning were missed within previous data analysis. As a result of the thematic analysis it enabled the exploration of existing data for missed analysis. The final aim of the thematic analysis was to refine the current suite of KPTs to demonstrate the contribution of early Facility Manager involvement in the BIM process based on the findings. All existing KPTs except for Energy Management recorded some form of refinement. Two new KPTs have been established, as a direct result of the findings of the thematic analysis. The current suite of KPTs detailed in table 8.18 were validated in the next chapter.

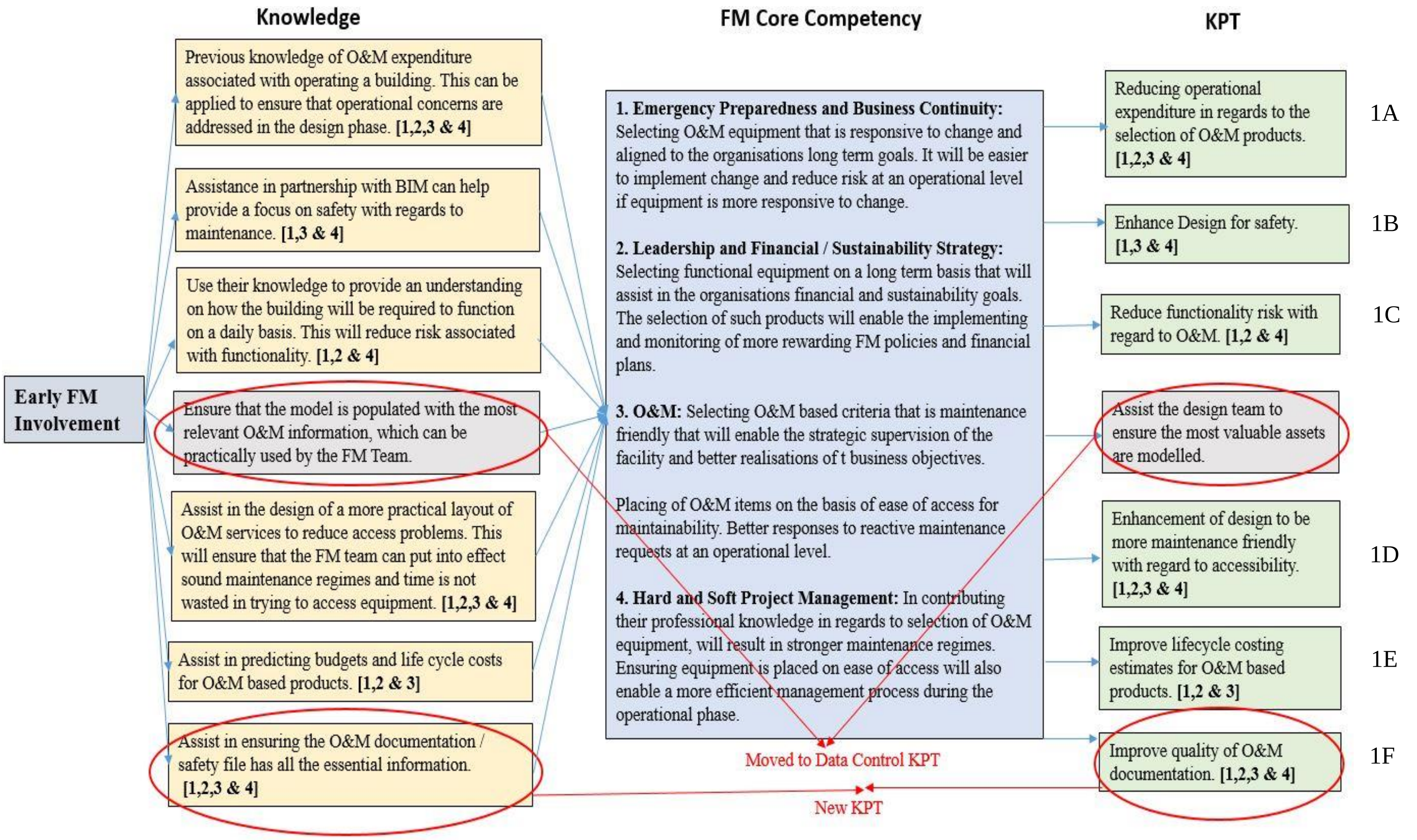

Fig 8.6: O&M KPTs for early involvement of the Facility Manager in the BIM process Revision 2

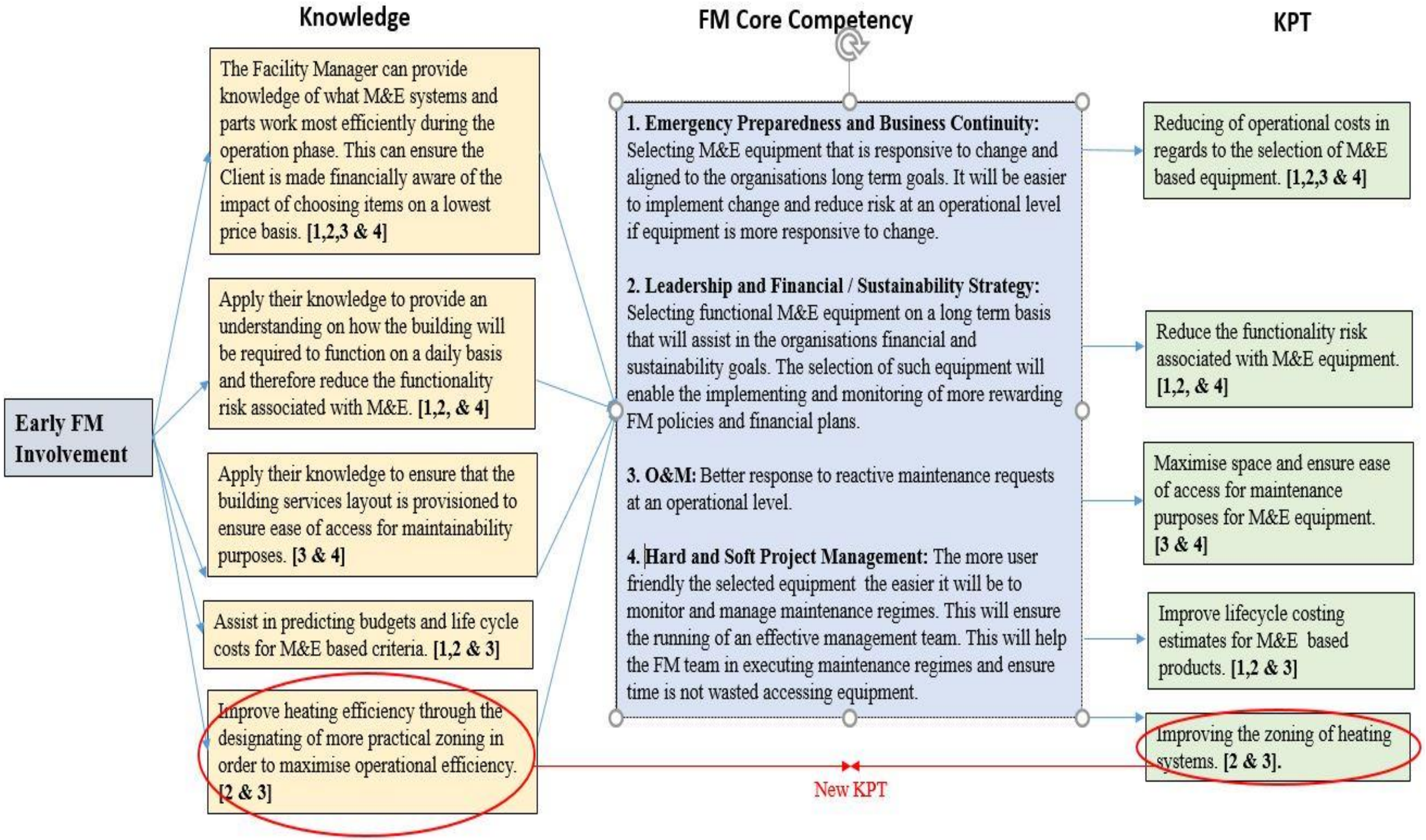

Fig 8.7: M&E KPTs for early involvement of the Facility Manager in the BIM process Revision 2

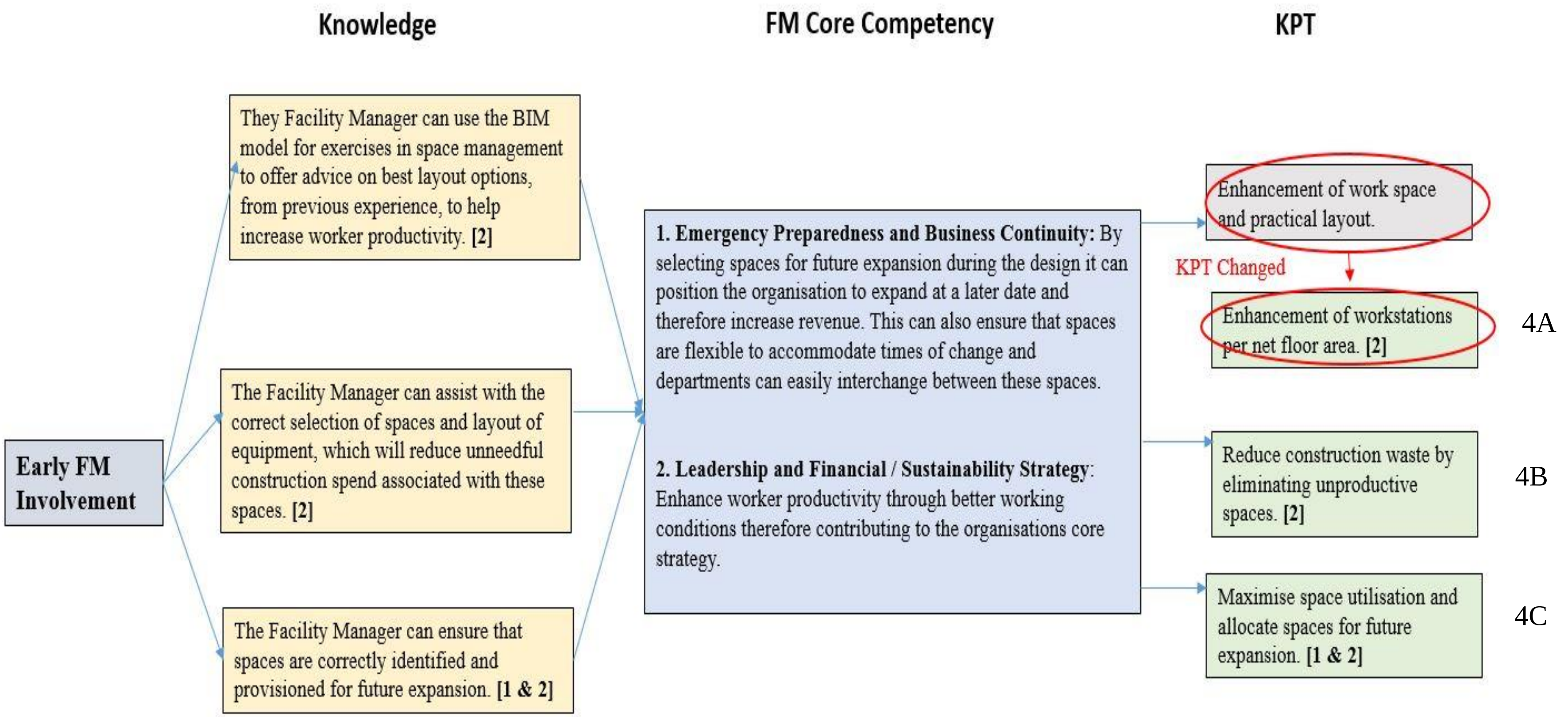

Fig 8.8: Space Management KPTs for early involvement of the Facility Manager in the BIM process Revision 2

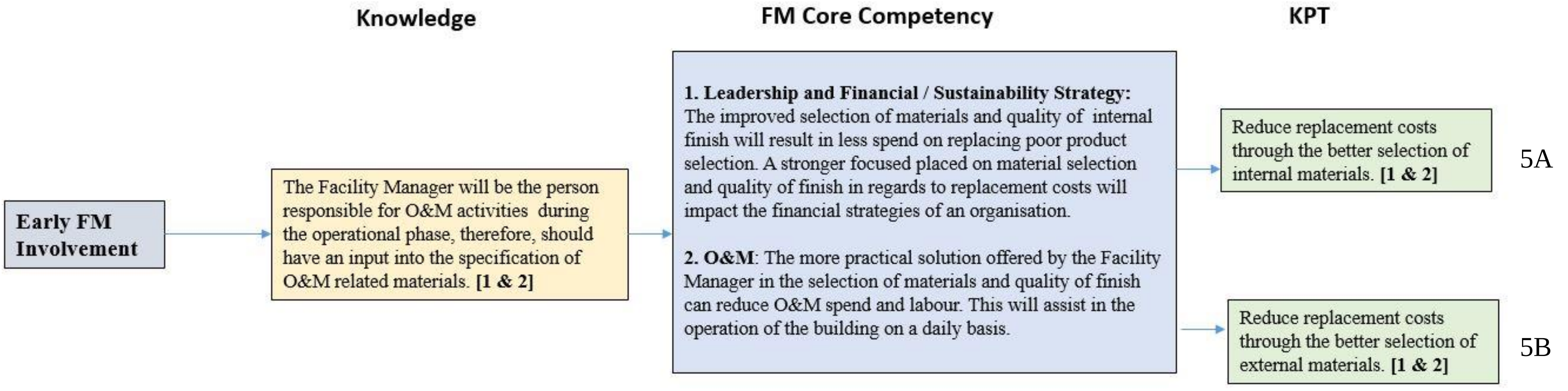

Fig 8.9: Materials Selection KPTs for early involvement of the Facility Manager in the BIM process Revision 1

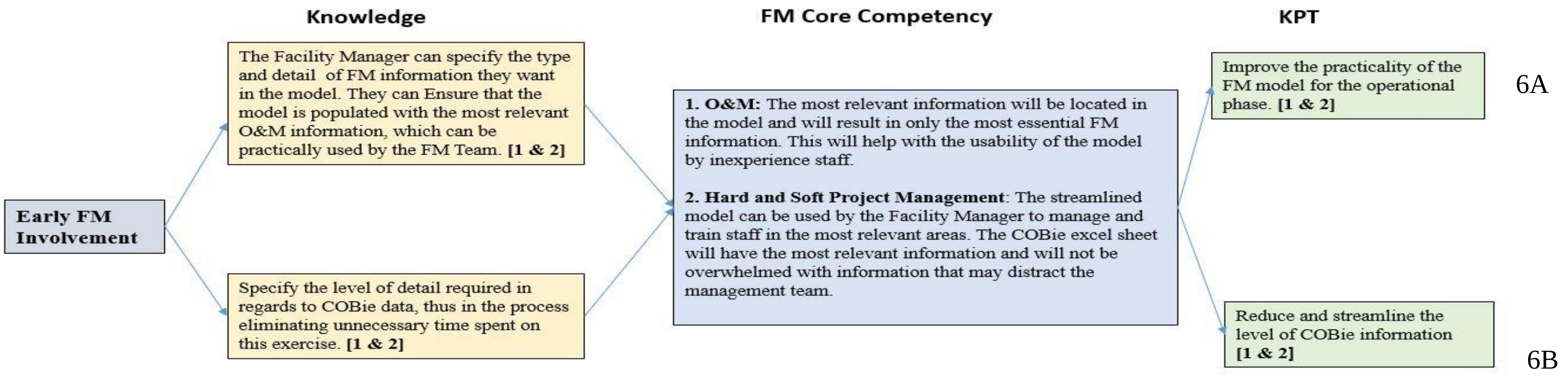

Fig 8.10: Data Control KPTs for early involvement of the Facility Manager in the BIM process Revision 1

Early Facility Manager Involvement in the BIM Process for Public Works Projects					
O&M	**M&E**	**Energy Management**	**Space Management**	**Materials Selection**	**Data Control**
1A. Reducing operational expenditure with regard to the selection of O&M products	**2A.** Reducing of operational costs in regards to the selection of M&E based equipment	**3A.** Reducing impact on external environment through the selection of environmentally friendly material / finish.	**4A.** Enhancement of workstations per net floor area.	**5A**. Reduce replacement costs through the better selection of internal materials.	**6A.** Improve the practicality of the FM model for the operational phase.
1B. Enhance Design for safety	**2B.** Reduce the functionality risk associated with M&E equipment	3**B.** Reducing energy costs through the selection of better energy efficient systems/materials:	**4B.** Reduce construction waste by eliminating unproductive spaces.	**5B.** Reduce replacement costs through the better selection of external material.	**6B**. Reduce and streamline the level of COBie information
1C. Reduce functionality risk with regard to O&M.	**2C.** Maximise space and ensure ease of access for maintenance		**4C**. Maximise space utilisation and allocate spaces for future expansion.		
1D. Enhancement of design to be more maintenance friendly with regard to accessibility.	**2.D**. Improve lifecycle costing estimates for M&E based products.				
1E. Improve lifecycle costing estimates for O&M based products.	**2E**. Improving the zoning of heating systems				
1F. Improve quality of O&M documentation.					

Table 8:18: Early Facility Manager involvement in the BIM process for Public work projects KPTs Revision 2

9 VALIDATION OF KEY PERFORMANCE TASKS

9.1 INTRODUCTION

This chapter concentrates on Phase 4 of the primary research plan. This involved expert analysis with two Facility Managers. The BIM model from Chapter Eight and a second BIM model of a special needs school commissioned by the DoES that has been granted planning permission, have been used as the main case studies within this phase of the research. The reason these models were chosen was that neither model had received any early FM input. The main aim of the research was to validate the KPTs detailed in table 9.17 by examining if the specified areas can be enhanced from applying the skillset of the Facility Manager at the design stage in the BIM process.

Data was collected throughout by capturing the expert analysis from the two Facility Managers whilst using two separate BIM models. The study confirms that the Facility Manager as result of the KPTs can positively contribute to the design of the two public sector BIM models.

9.2 PURPOSE OF STUDY

The purpose of this final phase of research was to validate and redefine, if necessary, the current set of KPTs. This demonstrated that the Facility Manager can contribute to the BIM governed design for public sectors projects. The refined KPTs from Chapter Eight served as the instrument to capture the contribution of the Facility Manager. The output from the two expert Facility Managers served as the validation of the proposed KPTs.

9.3 METHODOLOGY

The methodology involved carrying out an expert analysis through two experienced Facility Managers. The first Facility Manager had very little knowledge of BIM and had never used or viewed software associated with BIM. The Facility Manager was selected due to their previous participation in a case study detailed in the paper McAuley et al. (2012a), where they played an important role in contributing to a sports hospital's strategic goal by implementing a number of FM initiatives. The Facility Manager had over twenty years' experience in the FM field were he had worked on a number of private and public owned buildings. An initial site visit was arranged when the purpose of the study was outlined. It was organised over a period of two half days. The KPTs as detailed in Chapter Eight were emailed to the Facility Manager, to provide him with background knowledge, so an appreciation of the performance tasks could be gained. The models were not issued as he did not possess the knowledge or the software to access same.

The second Facility Manager had significant knowledge of BIM for FM and had been involved in developing an FM software product on a number of high profile projects. He had experience working as a Property Manager and also worked alongside a number of Facility Managers in establishing the key O&M needs. The files in IFC and DWG format were forwarded along with the KPTs for review before the analysis. The expert analysis took place over a half day period.

The rationale for choosing not to use a focus group approach with the two Facility Managers was due to the varying degrees of knowledge each participant had with regards to BIM. The purpose of the KPTs was to demonstrate the benefit of including the Facility Manager in the BIM governed design process no matter what their limited knowledge of BIM was. By having two Facility Managers at vastly different levels of skills and knowledge with regards to BIM permitted an insight into how appropriate the KPTs were to the wider FM profession, not those just BIM proficient. The expert analysis involved the author detailing the KPT in question to the Facility Managers and allowing them to explore the model to provide examples of where this was or was not relevant. This served as the basis for the validation of the KPTs. A sample transcript detailing the conversation between the author and one of the Facility Manager, from the walk through of one of the models can be located in Appendix 6.

9.4 BIM MODELS

St Patricks Special School Model

The special school model was received in a number of trade/discipline Revit files. This included Revit files for the architectural, mechanical, electrical, water closet (WC), rooms layout and kitchen equipment model. These files where combined into a federated model by use of Autodesk Navisworks.. This enabled a visual walk through of the complete building and mark-ups of specified areas within the model.

Greystones Coastguard Model

The Greystones coastguard model was received in an Autodesk Revit file format. This was a single file created by the Architect. Further information can be found on this model in Chapter 8. It was decided to use Autodesk Navisworks in tandem with this file, as it enabled a visual walk through of the building and mark-ups of specified areas within the model. This model was reviewed by the two expert Facility Managers, through the application of the KPTs, to ascertain were they could contribute their FM knowledge, so as to ensure the design addressed areas of concern that may be prevalent during the operational phase.

9.4.1 Interview with DoES Model Co-Ordinator

In order to provide further background on the special school's case study and model, a semi-structured interview was conducted with a member of the DoES who served as the model co-ordinator. This professional was selected as he had contact with all of the design team and was responsible for co-ordinating all of the trade/discipline models. The aim of the interview was to gain an understanding of the current status of the model and early FM input, if any, incorporated into the design. The interview would also serve to understand if there was a joint approach from the DoES and OPW in the design of the model. A full transcript of this interview can be located in Appendix 6.

The interviewee explained that the planning unit in the DoES identified a need for a new school to treat children with autism of varying scales. The Department then developed a brief and a number of sites were investigated. The interviewee explained their relationship with the OPW *"currently the only schools that the OPW were doing were through the devolved programme scheme, where external agencies through the Department may be given a number of schools to roll out over the year. So on that basis, that's how the OPW and the Department would interconnect with one another"*.

He explained that the DoES has a technical section with 36 people working in it, with a variety of qualifications i.e. architectural, engineering, mechanical and electrical, quantity surveying. In regards to an FM Department within the DoES he clarified that there *"would not be an FM specific department. The FM elements to the buildings were left to the design team to design. This must result in the design being robust and tried and tested"*. He adds items, such as *"mechanical and electrical equipment that need maintenance and an FM input were normally prepared by the specialist"*. He elaborated that during the design if specialised FM information was required then it would be sourced externally, as FM forms part of the brief. Figure 9.1 illustrates a rendered image of the school.

Fig 9.1: Rendered image of school taken from the DoES School model

In regards to the special school, he explained that the Board of Management were the people that were responsible for running the school. *"These could be lay people, members of the teaching staff, it could be anybody. They were not necessarily building experts. So that in itself creates issues with us, because in the handover from one Board of Management to another it may transpire that not all of the O&M manuals have been handed over. They could end up in somebody's garage or somebody's house at home"*. This has resulted in a request for manuals to be supplied in a digital format. He added that normally after the school was occupied there was a feedback process were any major issues will be considered for the next design process.

The interviewee stated *"in the operations side of things we don't get much feedback. Having somebody that knows how the building operates and knows what it costs to maintain was absolutely key"*. He acknowledged that *"some designers completely ignore the information given to them. But for schools and any civic buildings it's something that can no longer be ignored"*. He added that it was important that operational issues were addressed early, as the maintenance budget for these schools can become significantly reduced. *"The Department fund schools each year, it's what's called a capitation grant and this was based on the number of pupils that attend the school. While pupil size should indicate the size of the building this was not always the case. Sometimes the grant will not cover the costs of the building"*.

He explained that the special school's model has been used to generate the planning drawings, the Disabled Access Certificate (DAC) drawings and the fire certificate. *"All three have been procured and any statute obligations on the actual physical building were now being adopted* *into the model. This project would begin September 2016 providing all of the cost requirements were met. The next step was to prepare the project for tender."*

The model has received no early input from the Facility Manager. The FM input has come from the designer's knowledge of education buildings. *"Again we would have relied on the mechanical and electrical engineer in relation to the operational and maintenance costs associated with particular systems. The model was created by the DoES Architecture Department and the structural and M&E BIM services were outsourced"*. In regards to the M&E model he added that the *"M&E consultants were at a management level. So they would review a submission that would be sent in by an external consultant and they would ensure that that submission was in compliance with contract documentation"*.

He explained that the model at present would not have a sufficient level of detail in regards to FM. While some rooms have furniture within them, other rooms, such as standard classrooms did not have assets modelled. The model had no internal finishes detailed or electrical fixtures e.g. light switches. The model while offering a federated solution had a basic level of information and will need further detailing if used within a tender process. Further information on this case study can be located in Appendix 6.

This model, as similar to the Greystones model, had received no input from the Facility Manager. Despite the lack of FM detailing within the model, it was still used as one of the main vehicles along with the established KPTs, to validate if the Facility Manager could offer any contribution to be taken into the next stage of the design.

9.5 SPECIAL SCHOOLS MODEL

9.5.1 O&M KPTs

1A1: Reducing operational expenditure with regard to the selection of O&M products

Example 1: Doors

Facility Manager one explained that the door selection in most buildings was dictated by the fire certificate, which indicates where the fire corridors were that need to be protected. He requested to see the information attached to one of the classroom doors in the model. When selected very little information was visible on the door. There was no information on materials, ironmongery and the final finish. Figure 9.2 provides an illustration of the door details within the model.

Based on the lack of information the Facility Manager suggested that the final specification for the door should ensure "*from a hard-wearing point of view, it was a composite panel door, that will take a little bit of punishment from people moving in and out through them*". He added that he could not foresee a hardwood door being used and that it should be *"coated in PVC and have a metal framing which should result in zero maintenance"*. He further stressed the requirement for high quality ironmongery and to avoid the use of PVC gaskets, as in his experience they become worn out very quickly.

On inspection of the federated model in both Revit and Navisworks there was no visual evidence of doors having a kick plate. This according to the Facility Manager due to the nature of the building, should be rectified, as there will be a high level of activity of people transporting equipment in and out of rooms which leads to the possibility of the door becoming damaged. Figure 9.3 illustrates within the Navisworks model that there was no kick plate on any of the doors.

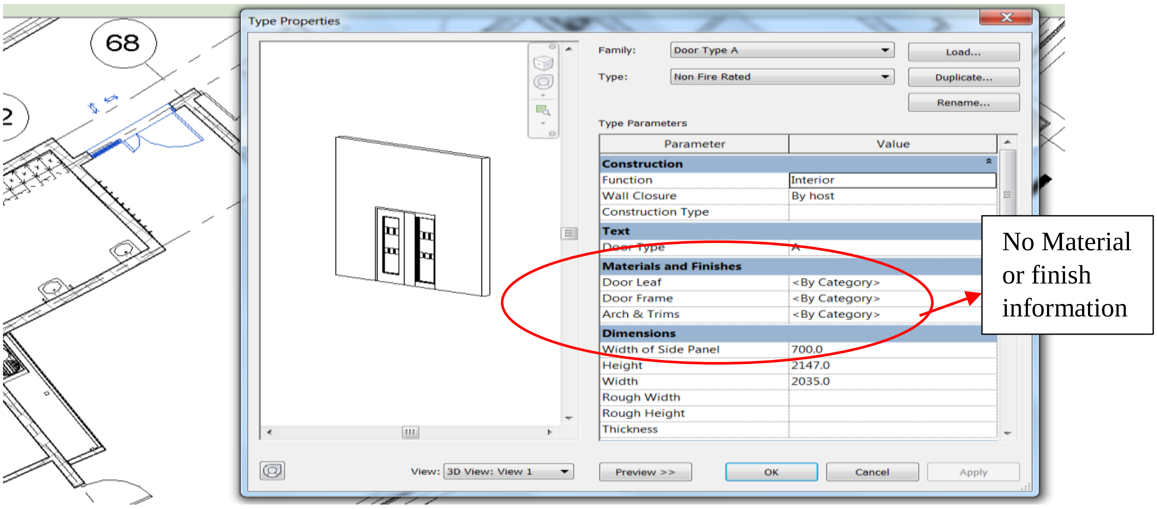

Fig 9.2: Illustration of current door properties within the DoES School model

Fig 9.3: Illustration of door selection in the DoES School model with no kick plates

Example 2: Room Furniture

The woodwork room was viewed in the model. Facility Manager one enquired if all the kitchen units were required. He asked why students would need a kitchen in a woodwork room. He further queried the materials used for the kitchen worktop. When interrogating the model, the counterwork top was specified as wood. He suggested an alternative to wood could be stone or standard Formica. This would last longer and would not require as much maintenance, as a wood worktop. Figure 9.4 details the breakdown of the worktop in the Revit model.

He further suggests that any fixed furniture using plastic wheels should be reconsidered, as they have no robustness and the ball bearing wear very easily.

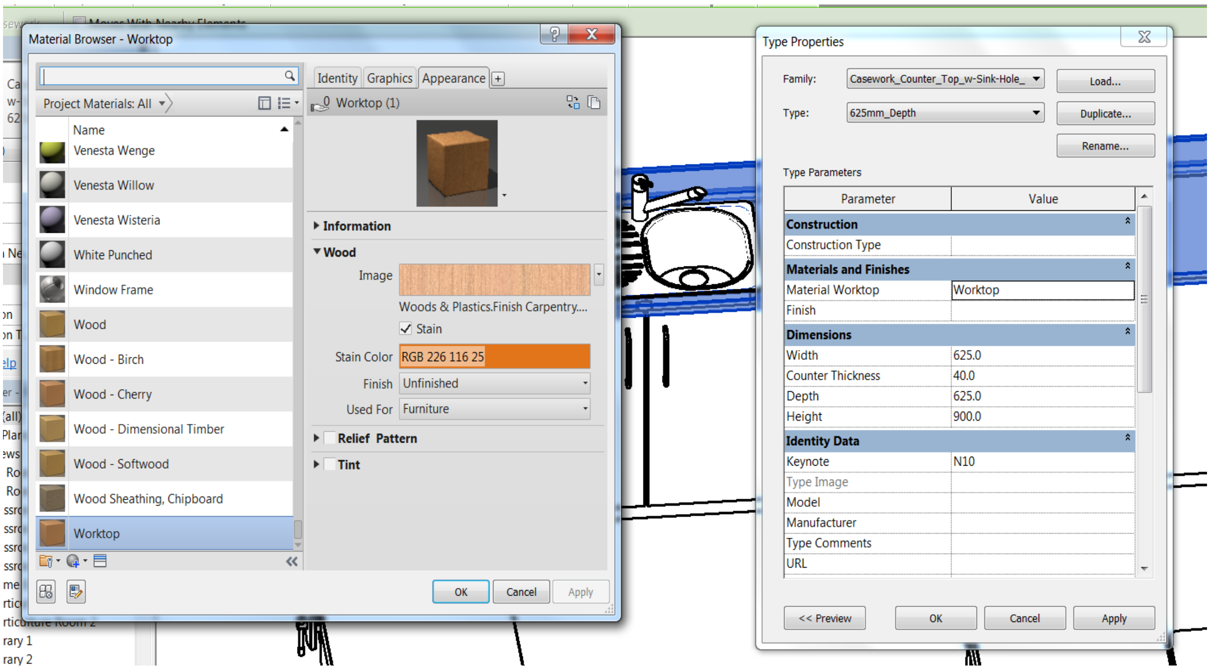

Fig 9.4: Illustration of current worktop properties from the DoES Revit Model

Example 3: Floor Finishes

Facility Manager one acknowledged that floors (except for the gymnasium) usually will be a polyflor or a marmoleum floor. He requested to see the information attached to one of the floors in the model. When selected it was evident that only the structural details were modelled. The floors were all 200mm RC Slabs. There was no finish specified for the concrete floors which will ultimately be the job of the Architect. Figure 9.5 provides an illustration of the floor details within the Revit model.

If consulted by the Architect, Facility Manager one would suggest the final floor should be marmoleum. He further added that it was imperative that when the floor, if marmoleum was selected, was initially installed, a wax or polish coat should be applied. He explains that from a maintenance perspective, if this was done on an annual basis, then the coat of polish / wax will absorb the daily operational impact instead of the floor. He stresses that "*it's very important that there's a maintenance regime put in place for the polishing of the floors once the school was ready for occupancy*".

He adds that if a lino or vinyl flooring was selected then one should make sure that was a homogeneous covering which consists of one single layer. He explains that some lino flooring will only have a thin layer of colouring which wears after a few years to reveal a faded underlay colour. If a homogeneous covering was selected it will mean that as natural wear and tear occurs the lino will remain the same colour. He also suggests using a ribbed matting system at the main entrance door which will remove loose debris from people's footwear. This should change in grade every few meters to ensure it removes most of the debris.

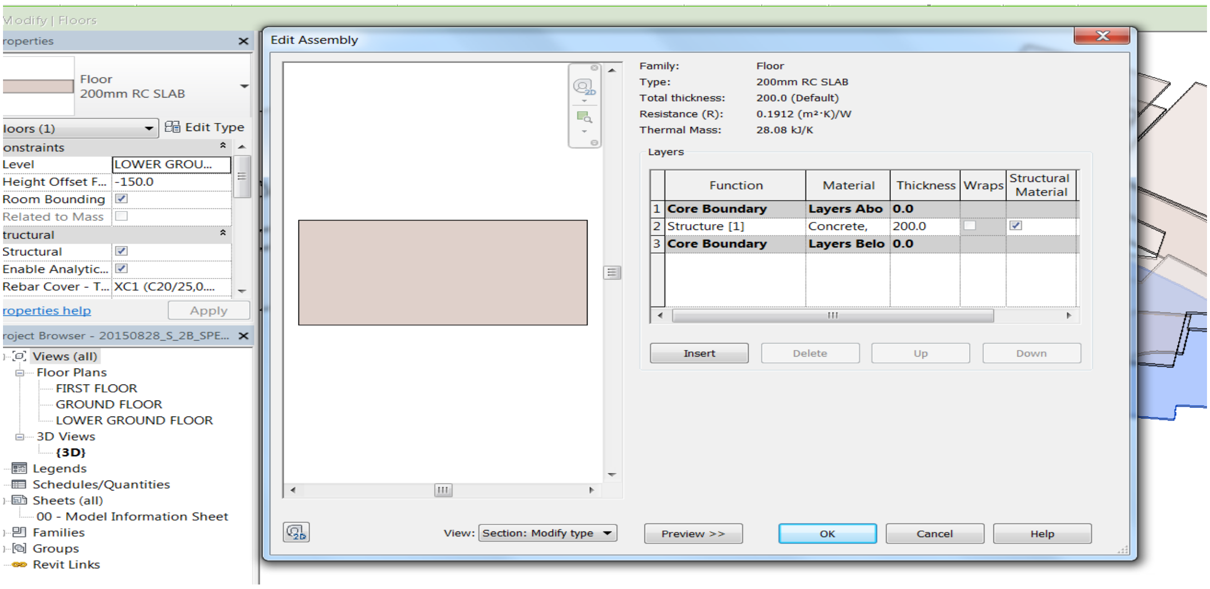

Fig 9.5: Illustration of current floor finish in the Does School model

1B: Enhance Design for safety

Example: Fall from heights

Based on the visual inspection of the model Facility Manager one noted that there was no fall arrest line around the roof which would impact on the safety concerns of members of the FM team working at heights. Facility Manager two also noticed a lack of visible edge protection within the model. Both Facility Managers believed that this will ultimately be installed during construction. Figure 9.6 illustrates that at present there was no visual fall arrest system on the roof.

Facility Manager one warns that a fall arrest system can result in high maintenance, as the harness must be certified yearly and this will become an ongoing maintenance costs. The use of specialised contractors should be considered, as it may not make financial sense to certify the harness unless the FM Team were required to perform ongoing maintenance on the roof.

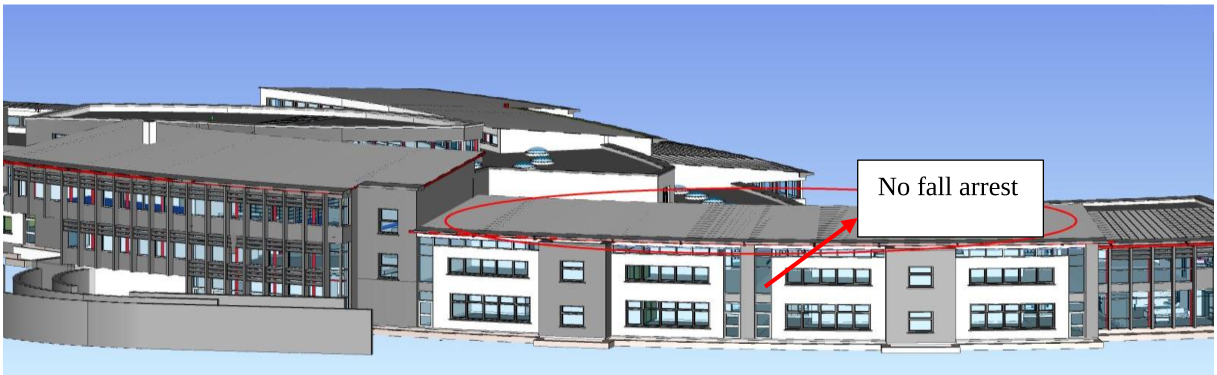

Fig 9.6: Illustration of no fall arrest system on the food in the DoES School model

<u>1C: Reduce the functionality risk in regards to O&M</u>

Example: Home Economics Room

On interrogation of the model it was found that there was a space allocated for a laundry room. This led Facility Manager one to ask why there was a requirement to have a washer / dryer in this room if similar services were offered in a designated laundry room on the same floor. He further recommends "*not putting the washing machine and the drier into an area where one was preparing food. It just does not make sense to me"* Figure 9.7 illustrates the current layout of the washer and dryer in the home economics room.

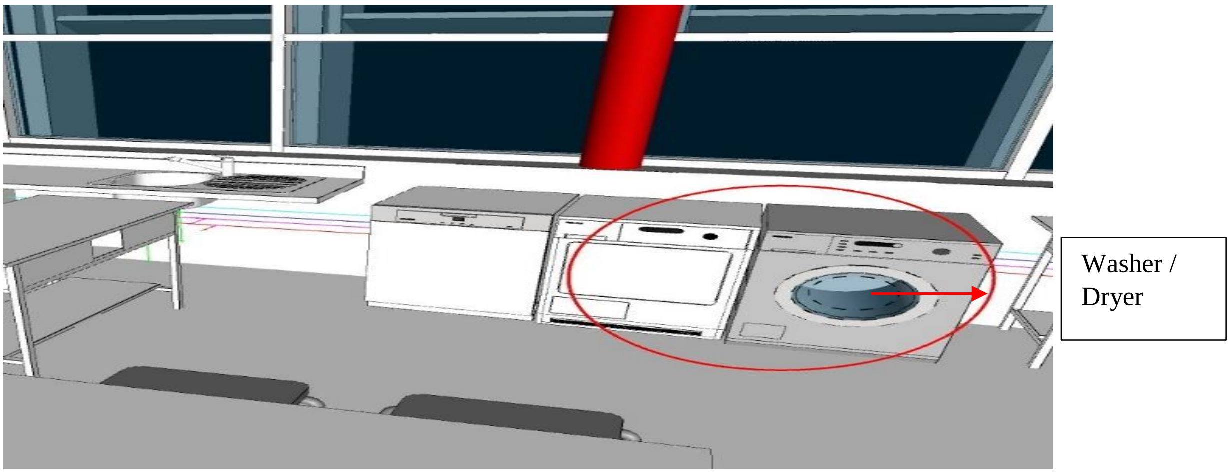

Fig 9.7: Illustration and washer and dryer layout in the DoES School model

1D: Enhancement of design to be more maintenance friendly in regards to accessibility

On inspection of validation of this KPT the Facility Manager suggested the same criteria as KPT 1B. Both Facility Managers did not see the requirement for this KPT as they believed they had already addressed concerns in regards to accessibility previously in KPT 1B. While the intention was to have a separate KPT for accessing O&M safety issues and accessibility concerns, it was found that this led to confusion, as the Facility Managers recognised that the same criteria could be specified for both KPTs.

1E: Improve lifecycle costing estimates for O&M based products

This KPT aimed to understand if the involvement of the Facility Manager in partnership with the QS and BIM could positively contribute towards a more accurate life cycle costing exercise with regards to the pricing of O&M products. This KPT could not be validated, as there was no opportunity for the Facility Manager and QS to work together.

When approached about the option of working with the QS, Facility Manager one saw the benefit of this approach. He believed that the more people involved in the pricing process the more realistic and accurate the final life cycle cost. He explained that with public sector buildings, in order to get a true cost with regards to O&M products, then utility bills and the staff costs necessary for functioning in the building should be taken into consideration. The final life cycle cost should include end of life items, statutory maintenance and routine maintenance costs over an agreed period of time. He believed that he could contribute in providing costs for these items through his years of practical experience.

Facility Manager two was in agreement with the benefits of working with the QS. He added that the QS was only looking at an install and purchase cost for a piece of equipment. "*The price was not just the buying price and install price, it's the 20-year lifecycle cost, which should be what's taken into account".*

While this KPT could not be validated there were strong suggestions that this KPT be retained.

1F: Improve quality of O&M documentation.

This KPT was added as a direct response to the current poor organisation of O&M documentation within public sector buildings. Facility Manager one believes that early Facility Manager involvement in partnership with BIM can ensure that the most relevant O&M documentation was recorded. He believed that he could provide a focus on what O&M

documentation would be most relevant and could work with other members of the design team to ensure that the correct documentation was supplied. He added that through BIM there was no requirement for a hard copy, as the model would contain links to the most valuable documents.

Facility Manager two believed that despite having O&M information easily accessible within the model *"you still need a hard copy, electronically or paper that can be easily accessed by people not familiar with navigating an asset information model".* He acknowledged that early Facility Manager involvement can ensure there was someone who can ensure that the correct and most relevant documentation was handed over.

While this KPT could not be validated due to the lack of maturity of the model, there were strong suggestions from the recorded responses that this was a performance area that could benefit from early Facility Manager involvement.

Summary

On reflection of the O&M KPTs there was evidence that the Facility Manager can assist in reducing operational expenditure with regard to the selection of O&M products. Through a visual inspection of the model the Facility Managers were able to suggest a more maintenance focused specification with regards to the door, floor and furniture. Suggestions were put forward to improve areas where safety could be a potential problem, such as the roof which may lead to additional maintenance costs. There were also opportunities to reduce the functionality risk in regards to O&M as seen through the home economics room. On inspection of the KPTs some were found to be similar in nature and served to confuse the Facility Managers. These KPTs will be combined into one. Other areas in which it was shown they could possibly contribute was through communicating with the QS in tandem with BIM to produce a more accurate life cycle cost with regards to O&M products. Also given that the public sector buildings were operated by non-technical people the early involvement of the Facility Manager will prove important in specifying the most important O&M documentation. Non-technical staff will be required to use these documents, so it will be important that they were not overly complicated and only have the key documentation.

Figure 9.8 provides a summary of the refined O&M KPTs after validation on the first BIM model for early involvement of the Facility Manager in the BIM process.

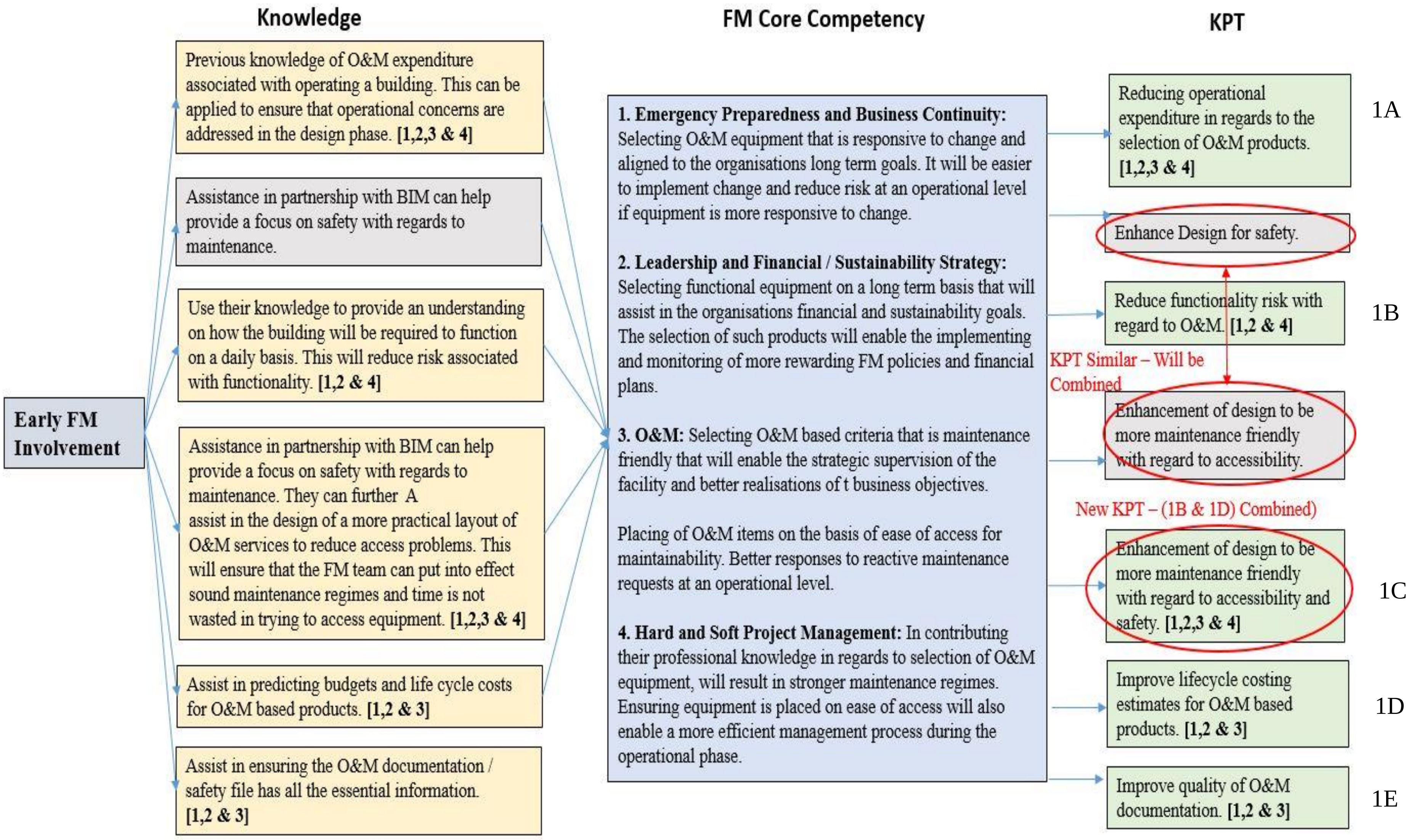

Fig 9.8: O&M KPTs for early involvement of the Facility Manager in the BIM process Revision 3

9.5.2 M&E KPTs

2A: Reducing of operational costs in regards to the selection of M&E based equipment

Example 1: Woodwork Room

After visual inspection of the model Facility Manager one identified some issues within the woodwork room. *"If you have a water source, especially in the classroom environment, should there not be a drinking fountain along with it at the sink. This would reduce the requirement to provide a drinking fountain out in the corridor".* While this could possibly be added during the detailed design he believed it to be an area that deserves further attention. Figure 9.9 illustrates a lack of drinkable water options beside the water source. This figure also shows the current specification details of the sink. The only retrievable details with regards to the sink was the materials used for the tap and sink.

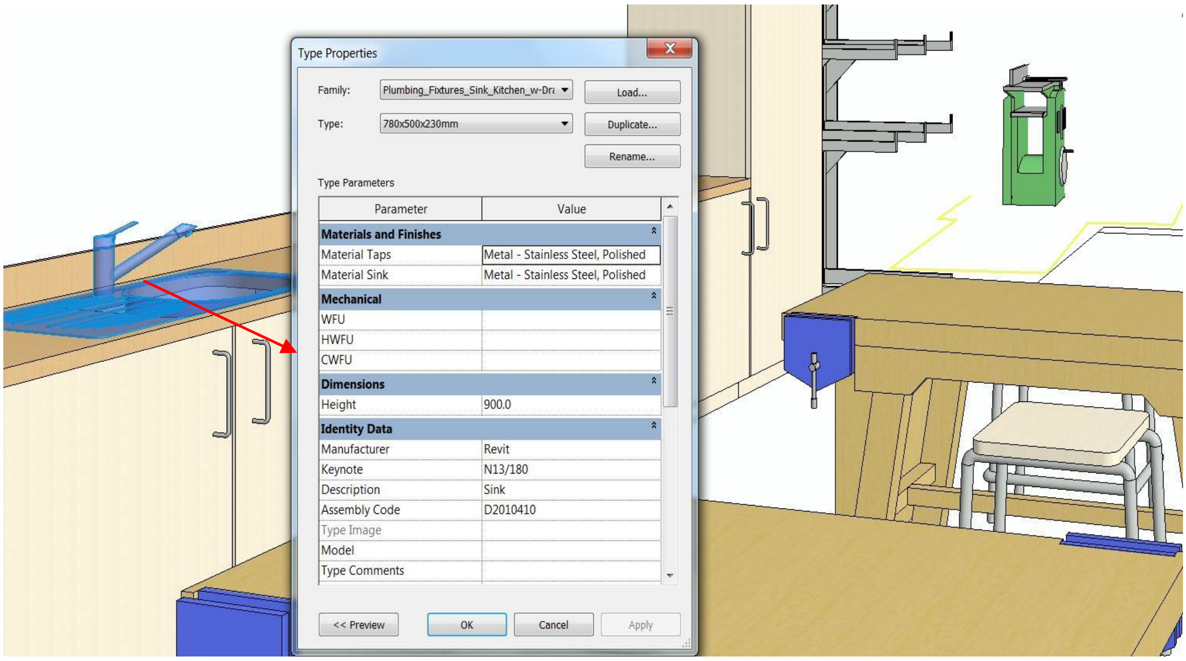

Fig 9.9: Illustration of no drinkable water source in the DoES School model

Example 2: Home Economics Room

Facility Manager one asked to view the information attached to the cookers. He explained that it was important cooking equipment installed in classrooms have a heat recovery ventilation system and equipment over each of the hobs to obviously take away the odours and gases. These systems can "*harness the warm energy, rather than just expelling it to the atmosphere".* Under normal circumstances this would be specified by the Architect or within the M&E Design, however Facility Manager one felt that he could assist the design team in this area. Figure 9.10 illustrates the current information attached to the cookers in the home economics room. The only retrievable details with regards to the cooker were its dimensions and material finish.

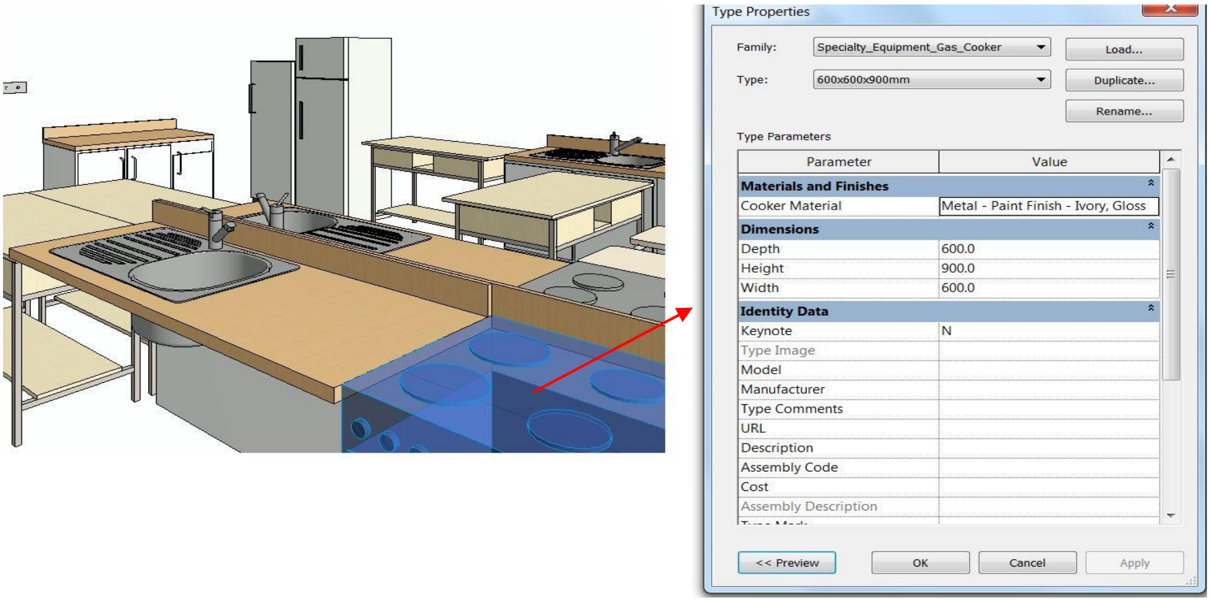

Fig 9.10: Illustration of cooker properties in the economics room within the DoES School model

Example 3: Local Control

Facility Manager one believed that Passive Infrared (PIR) sensors and occupancy sensors in the room were absolutely essential. He stressed that the local control for lights should be removed i.e. if somebody can switch on something, and if they have no responsibility to turn it off, it will be left on. *"Well if you take that responsibility away from them, then you won't have a problem. The same with heating. If you leave it as local control, there will be wasted energy"*. He believed while this will ultimately be the decision of the M&E designers, they must understand given that it was a school, that students may interfere or possibly vandalise items such as room temperature displays. Facility Manager two suggested that the option of a BMS should be strongly investigated, so as to enable the FM team the opportunity to track and regulate room requirements.

2B Reduce the functionality risk associated with M&E equipment

Example 1: Inaccessible Lighting

Facility Manager one provided an example of inaccessible lighting with regards to accessing feature lights in accessible spaces. He acknowledges that ultimately the design of such features was within the Architect's design scope but he could possibly offer some maintenance concerns in regards to the practicality of changing a light bulb or accessing a fitting to replace it. Facility Manager two states that maintenance in regards to these areas can be difficult and the possible reduction of such items will result in lesser need for specialist equipment.

On inspection of the model Facility Manager one highlights an area of concern within the building. The distance between the ceiling and the floor was eight metres making it difficult to change the lightbulbs. He states that if involved in the design team he could relay this concern to the Architect. The area in question is illustrated in figure 9.11.

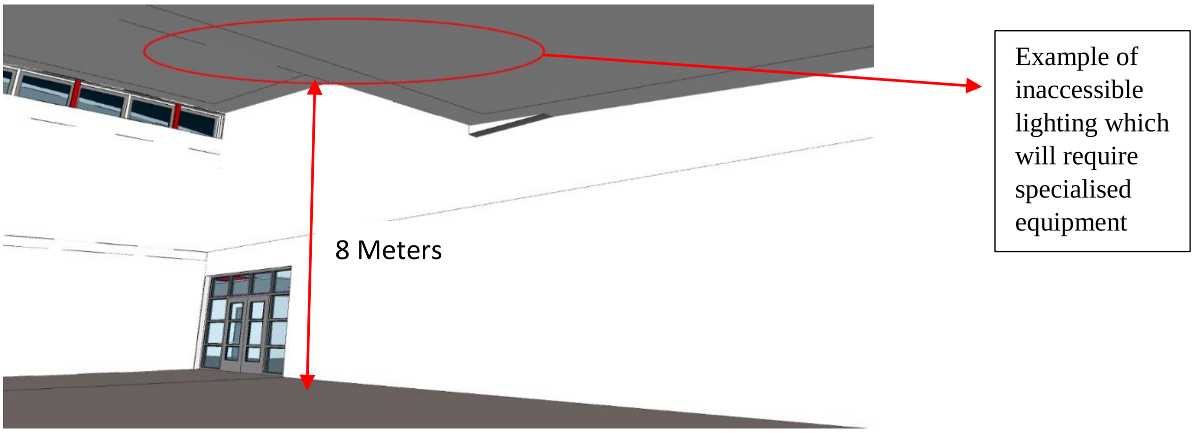

Fig 9.11: Illustration of inaccessible lighting in the DoES School model

Example 2: Placing of Radiators and Electrical Sockets.

Facility Manager two stated that as this school was to accommodate children with disabilities, special attention should be given to the placing of radiators. There would be concerns with the children burning themselves and a suggestion, if not already discussed by the M&E team, was to place the radiators at a higher level. Consideration should also be given to underfloor heating, as this will eliminate the possibility of the children burning themselves on low level radiators. On inspection of the model there were no radiators detailed. There should also be consideration given to the placing of electrical sockets, as the children may stick items into the sockets and could possibly electrocute themselves.

2C. Maximise space and ensure ease of access for maintenance

Example 1: Plant Room

Facility Manager one explained that a consideration which should be taken into account was access to major plant in the event of breakdowns or routine maintenance.

On the model he could not identify a door to access the plant room. He suggested that *"given the area was right beside the cold stores and a switch room, I would strongly recommend that* *the boiler room was bunded. Given that you have a lot of water sources in there. If any one of them burst, you would not want it going into the switch room and destroying all the switch gear, and having the whole facility without either heating or electricity for a period of time until the repair was done".* He also suggested further bunding for the food store and cold stores. Figure 9.12 illustrates the current location of the plant / boiler room in relation to the kitchen, chiller and switch room.

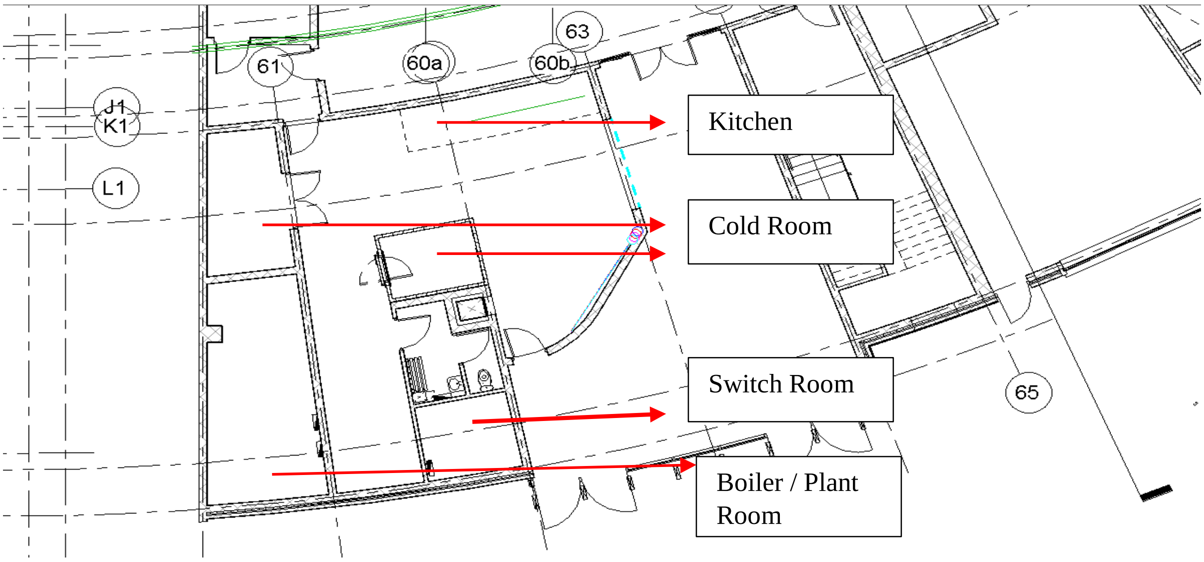

Fig 9.12: Illustration of location of plant room in the DoES School model

Example 2: Kitchen

Facility Manager one highlights that at present there was no external access provided for the boiler room in the model. On inspection of the model, if the design does not change, the only option to remove faulty plant was by bringing it through the kitchen and exiting through the main door. This route is illustrated in figure 9.13.

Facility Manager one states that if this was the planned route then consideration must be taken into the design when transporting or removing plant. "*One must assess transportation and risk appropriately and put a procedure in place for doing it and in doing so you won't have any issues in your kitchen*"

Facility Manager two stressed the importance of ease of access, not just for the plant room, but also for access to air conditioning units and air conditioning cassette units. This should be all shown in the model.

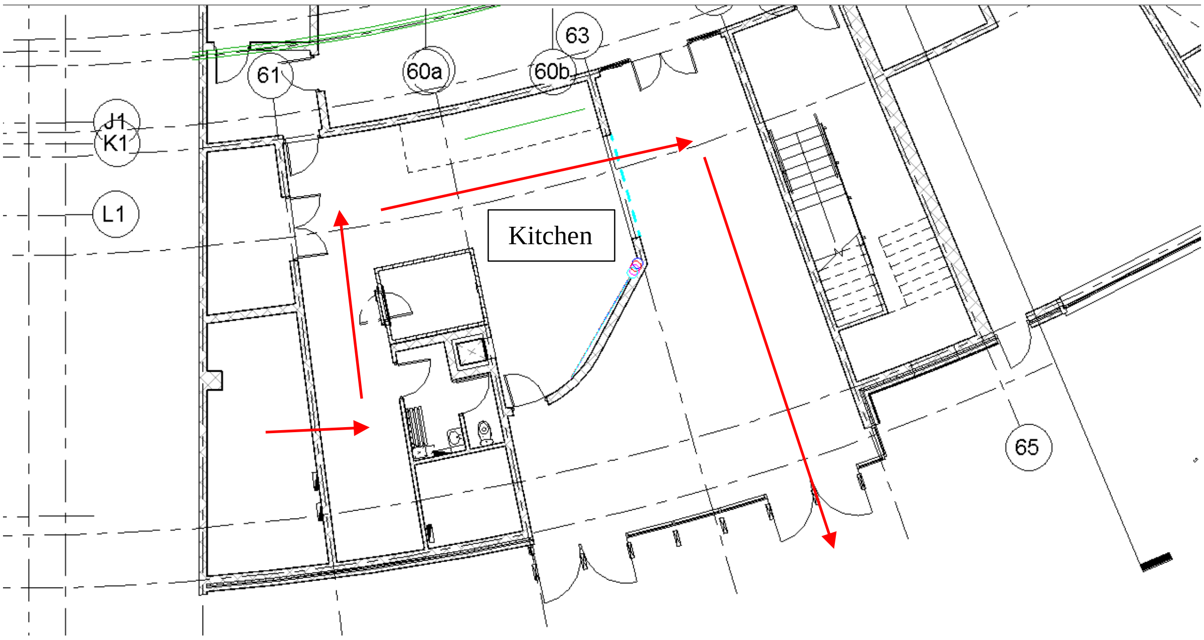

Fig 9.13: Illustration of plant breakdown access in the DoES School model

2D: Improve lifecycle costing estimates for M&E based products

This KPT aimed to understand if the involvement of the Facility Manager in partnership with the QS and BIM could positively contribute towards a more accurate life cycle costing exercise with regards to the pricing of M&E products. This KPT could not be validated, as there was no opportunity for the Facility Manager and QS to work together.

This KPT was examined with regard to O&M products earlier where it was found that both Facility Managers where in favour of working with the QS. Both Facility Managers did not see the requirement for an additional KPT with regard to working with the QS. As a M&E Department already exists within the OPW it would be hard to establish their contribution in specifying costs for M&E products, as the department should already have this information.

Given that the M&E Department was actively involved in the design phase of public works project, and strong similarities to KPT 1E, it was decided to eliminate this KPT.

2E: Improving the zoning of heating systems.

Facility Manager one did not believe that this was an area in which he could assist. As there was a dedicated M&E Department working on the design his contribution would be extremely limited. He added that from his perspective with regard to zoning "*if you put your money that it would cost to zone a building into the fabric and the standard of the windows, your zoning becomes less of a problem.*" Facility Manger two did not see how he could contribute here as this was the responsibility of the M&E engineer and was not an area that would benefit from his assistance. Despite the lack of contribution from both Facility Managers, it was decided that this KPT should remain, as it may prove beneficial for a different building.

Summary

On reflection of the M&E KPTs there was evidence that the Facility Manager can assist in reducing operational expenditure with regard to the selection of M&E equipment. Through a walkthrough of the model both Facility Managers were able to target areas of possible concern which included water sources, heat recovery and restricting local control of M&E items. Suggestions were put forward to reduce the functionality risk through targeting expensive maintenance costs associated with inaccessible lighting and areas that may be of danger to occupants within the school. Through the visual inspection of the model the Facility Managers highlighted the plant room as an area that will need further attention, as any breakdowns will result in possible contamination of kitchen surfaces through required access to the plant. On inspection of the KPTs some of them were found to be similar to the O&M KPTs.

Figure 9.14 provides a summary of the refined M&E KPT after validation on the first BIM model for early involvement of the Facility Manager in the BIM process.

9.5.3 Energy Management KPTs

3A: Reducing impact on external environment through selection of environmentally friendly material / finish

Example: Roof

Facility Manager one outlined that there were a number of products available for general and commercial construction that have a lesser impact on the environment. He requested to see the information attached to the roof. The roof in the model was specified as a generic 400mm metal aluminium pitch roof. He noted that roof specification was the responsibility of the Architect but considerations should be given to both the advantages and disadvantages of a zinc material or a grass roof.

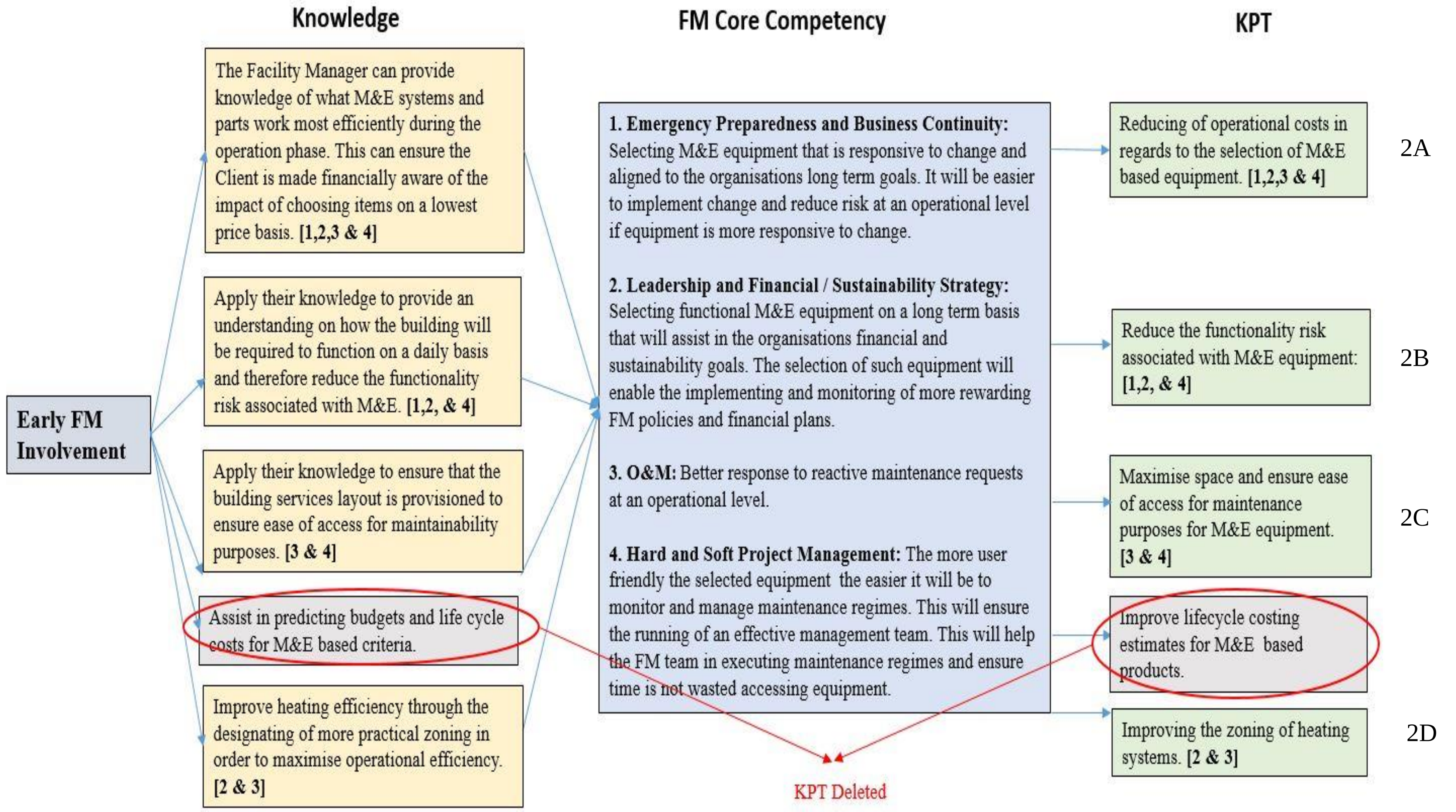

Fig 9.14: M&E KPTs for early involvement of the Facility Manager in the BIM process Revision 3

He could see no evidence of a rainwater harvesting systems detailed within the model. Such a system will enable the collection of rainfall which in turn can be treated and re-used for toilet flushing. This will *"negate you buying a lot of water off the mains supply"*. Figure 9.15 illustrates the current roof detail in the model.

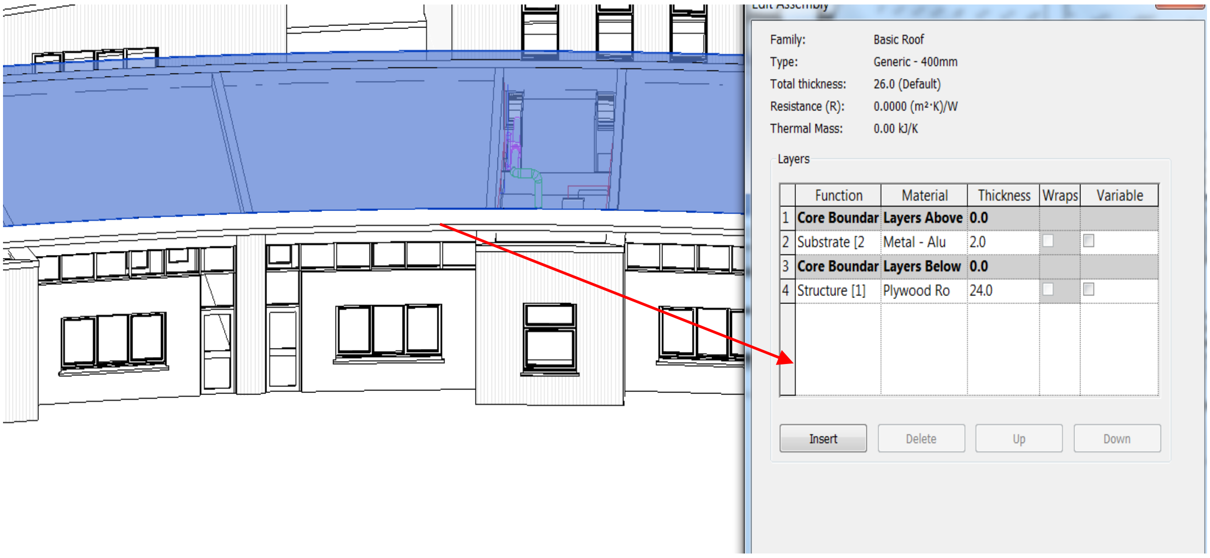

Fig 9.15: Illustration of roof selection in the DoES model.

3B: Reducing energy costs through the selection of energy efficient systems/materials

Facility Manager one explained that the biggest contributing factor to one's operational costs were energy costs. He explained that the two main sources of energy concerns were that of the heating and electrical use. He acknowledges that the selection of windows will be the Architects choice and they should have an extensive knowledge in this area. However, he added that if included in the design team he could *"contribute to the selection of the windows, which is probably the main source of heat loss in any building, the fabric of the building, and the insulation levels."* He adds that during the *"tender process there are alterations and changes made to the specification to meet the budget. The Facility Manager could have an opportunity to review the designed building and make any changes to it before the tender process comes into place.*

Facility Manager one added when it comes to reducing energy costs *"if there were occupancy sensors and LED lighting, that's a major reduction in overall energy usage in a particular school*". In regards to the heating he explains that the heating load was determined by how efficient the building fabric was: "*So again the specification of the window selection was critical to reduce the overall heating load".*

Example 1: Windows

While the selection of windows will be based on DoES standards, Facility Manager one still believes there were areas from which his earlier involvement can benefit in the selection process. He explained that a significant amount of money can be saved by having a good insulated fabric. "*Where you might save €100,000 on the construction cost of a building, this may well be spent on utility bills over the next couple of years as a result of those decisions. So I think every decision to alter the specification to meet the budget should be analysed with the impact it would have on operational costs".*

"Now if you can achieve a treble-glazed window, with a low e-coating, argon-filled, with an insulated frame, this will significantly reduce energy costs.". He also stated with regard to the windows that one must think about the security of the building as well. As this building was a school that's unoccupied outside of normal business hours it may be prone to robberies, as there was a lot of expensive equipment in the school.

Facility Manager two suggested avoiding placing sensors on the windows. These include sensors that measure the CO^2 levels which in turn automatically open the widows once this level reached a certain point. He warns that these sensors can lead to substantial maintenance costs which can become costly over the life cycle of the building.

Summary

On reflection of the Energy Management KPTs there was evidence that the Facility Manager can assist in reducing the impact on the external environment through the selection of a more environmentally friendly finish. On inspection of the model suggestions were made with regards to the roof material and possible integration of a rainwater harvest systems. The early involvement of the Facility Manager can assist with reducing energy costs through the selection of energy efficient systems/materials such as the windows. Due to the lack of detail in the model, it was difficult to specify more detailed outputs with regard to this KPT. A number of suggestions made by the Facility Manager were within the remit of the Architect. However, there was an opportunity to assist the Architect within this areas, so as to ensure they take into account possible maintenance considerations. No further refinement was suggested for this area.

9.5.4 Space Management KPTs

<u>4A: Enhancement of workstations per net floor area.</u>

One of the KPIs that the public sector was seeking to maximise was workstations in regards to net floor area per staff member. The special schools model did not offer this opportunity. This KPT could not be validated, as there was no opportunity for the Facility Manager to use the model as it was more suited to office buildings. When asked about this KPT both Facility Managers found it too specific, as it only offered the opportunity to assist within the area of space management in a limited way.

Example: Atrium

Facility Manager one believes that early involvement of the Facility Manager can assist in realising a more practical layout of the space. On inspection of the model he discussed the fact that double height atrium type spaces have a big volume and have a lot of air space that was required to be lit and heated. The double height spaces *"look well but the very fact that they were double height means that you were heating all of that volume of air, it probably isn't economically viable or energy conscious use of space*". While acknowledging that this will ultimately be an Architect based decision he believes that he can offer a more practical perspective with regards to spaces.

Facility Manager two discussed that in order for an accurate space management exercise to be performed one would need all furniture to be shown in the model. He advocates that through BIM the Facility Manager can assist the design through advising in occupant behaviour within these spaces. He can advise on how furniture was usually positioned by providing an insight into the occupant's day-to-day behaviour.

<u>4B: Reduce construction waste by eliminating unproductive spaces.</u>

On inspection of this KPT both Facility Managers believed that this was an area where they could not contribute. While they believed they could advise on a more practical use of the space during the design, the reducing of floor spaces was the Architect's responsibility. They acknowledged that by way of contributing to the previous KPT, this may offer the opportunity to reduce the gross floor area through better management of the space at the design stage.

4C: Maximise space utilisation and allocate spaces for future expansion.

On inspection of the model neither Facility Manager could suggest an area where they could contribute with regard to this KPT. Despite the lack of contribution from both Facility Managers, it was decided that this KPT should remain, as it may prove beneficial for a different building.

Summary

On reflection of the Space Management KPTs there was evidence that the Facility Manager can assist in offering a more practical perspective with regards to floor spaces. The Facility Manager can assist the design team by offering an insight into how these spaces will be utilised by the occupants. This can help ensure a more productive spaces for the workers. The original KPT of "Enhancement of workstations per net floor area" was found to be to narrow and restrictive and has been revised to "Enhancement of net floor area for more practical layout". This KPT can also be inclusive of workstations where necessary. The KPT of "Reduce construction waste by eliminating unproductive spaces" was found to be unrealistic. On further inspection of the KPTs some of them were found to be similar to the O&M and M&E KPTs.

Figure 9.16 provides a summary of the refined Space Management KPT after validation on the first BIM model for early involvement of the Facility Manager in the BIM process.

9.5.5 Material Selection KPTs

5A Reduce replacement costs through the better selection of internal finishes.

Facility Manager one believed this KPT to be very similar to KPT 1A (Reducing operational expenditure with regard to the selection of O&M products) where areas, such as the floor, doors and furniture were examined. However, additional areas were highlighted which were not selected earlier.

Example: Play suite rooms

On inspection of the model Facility Manager one asked to see the information attached to the internal finish. At present within the model the current wall finish was plaster. Based on this information he suggests a *"bio eggshell type paint which was hard wearing and washable. This means that you would not have to repaint the area with a standard emulsion every year, because there would be too much cost associated with that"*. Figure 9.18 illustrates the current wall finish in the model.

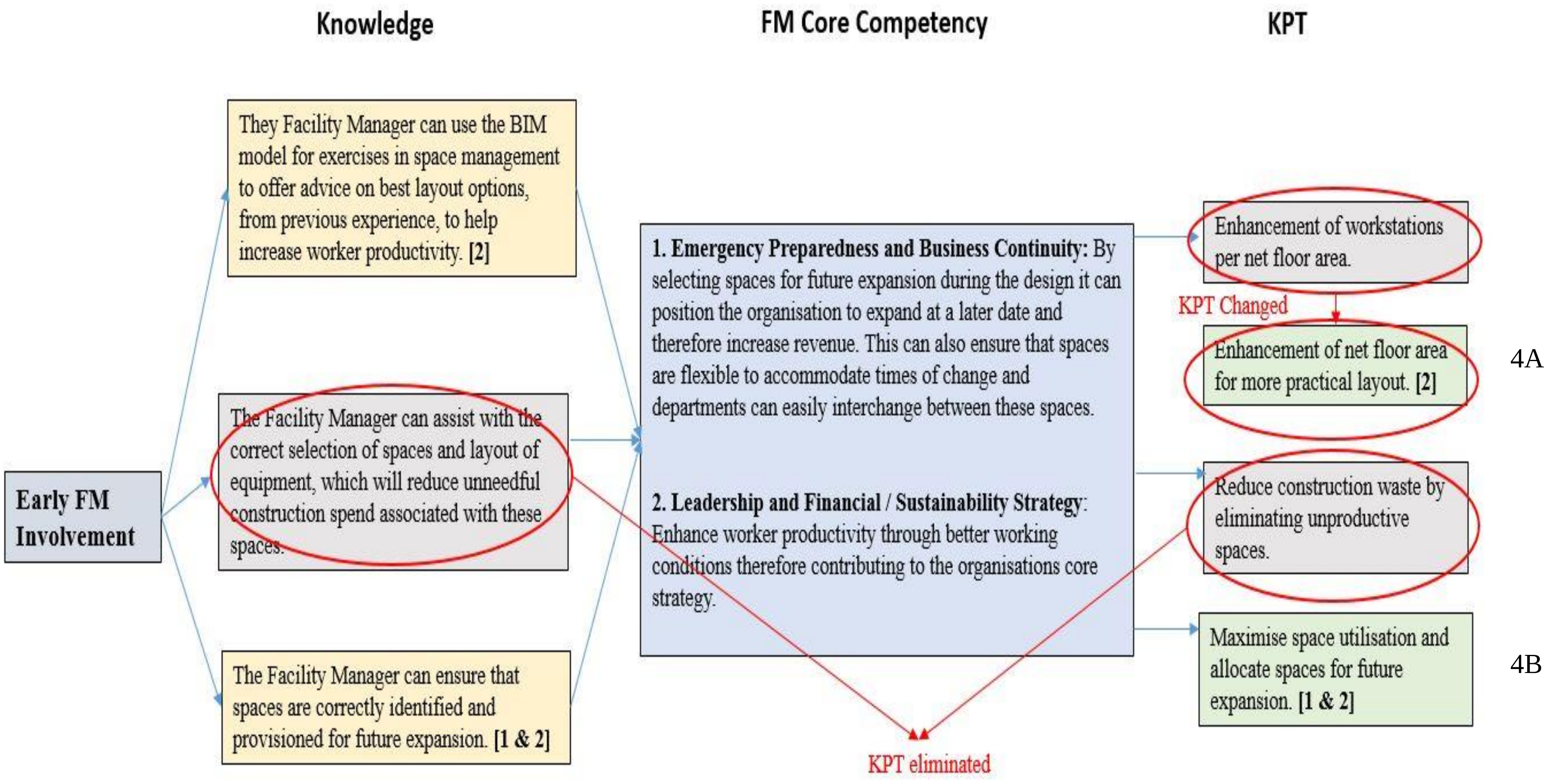

Fig 9.16: Space Management KPTs for early involvement of the Facility Manager in the BIM process Revision 3

5B Reduce replacement costs through the better selection of external finishes.

The Facility Managers once again found similarities with other KPTs, in this case the energy management KPT (Reducing impact on external environment through the selection of environmentally friendly material / finish). Facility Manager one suggested for this KPT that one should examine the landscaping requirements and work with the design team to ensure this was as manageable as possible given the site. As this information was not provided in the model, it was difficult for the Facility Manager to specify areas were they could contribute.

Summary

On reflection of the Materials Management KPTs there was evidence that the Facility Manager can assist in reducing replacement costs through the better selection of internal finishes, such as the wall finish. There was limited evidence that they could assist with external finishes with an opportunity in landscaping suggested. On inspection of the KPTs some of them were found to be similar to established KPTs already examined within the O&M and Energy Management areas. On this basis it was decided to change the title of the KPTs, so as to distinguish them from previously discussed KPTs. Figure 9.17 provides a summary of the refined Material Management KPTs after validation on the first BIM model for early involvement of the Facility Manager in the BIM process.

9.5.6 Data Control KPTs

6A Improve the practicality of the FM model for the operational phase.

This KPT aimed to understand if the involvement of the Facility Manager in partnership with BIM could help in the production of a simplified FM model that could easily be understood by non-technical people using the building.

Facility Manager two explained that if involved they could assist in working with the design team to produce a simplified model with only critical FM information. The model could primarily be used to access contact information on service providers and key information on systems, such as the fire alarm. He also suggested that data for energy / utilities costs should be easily retrievable, so as staff can monitor their usage.

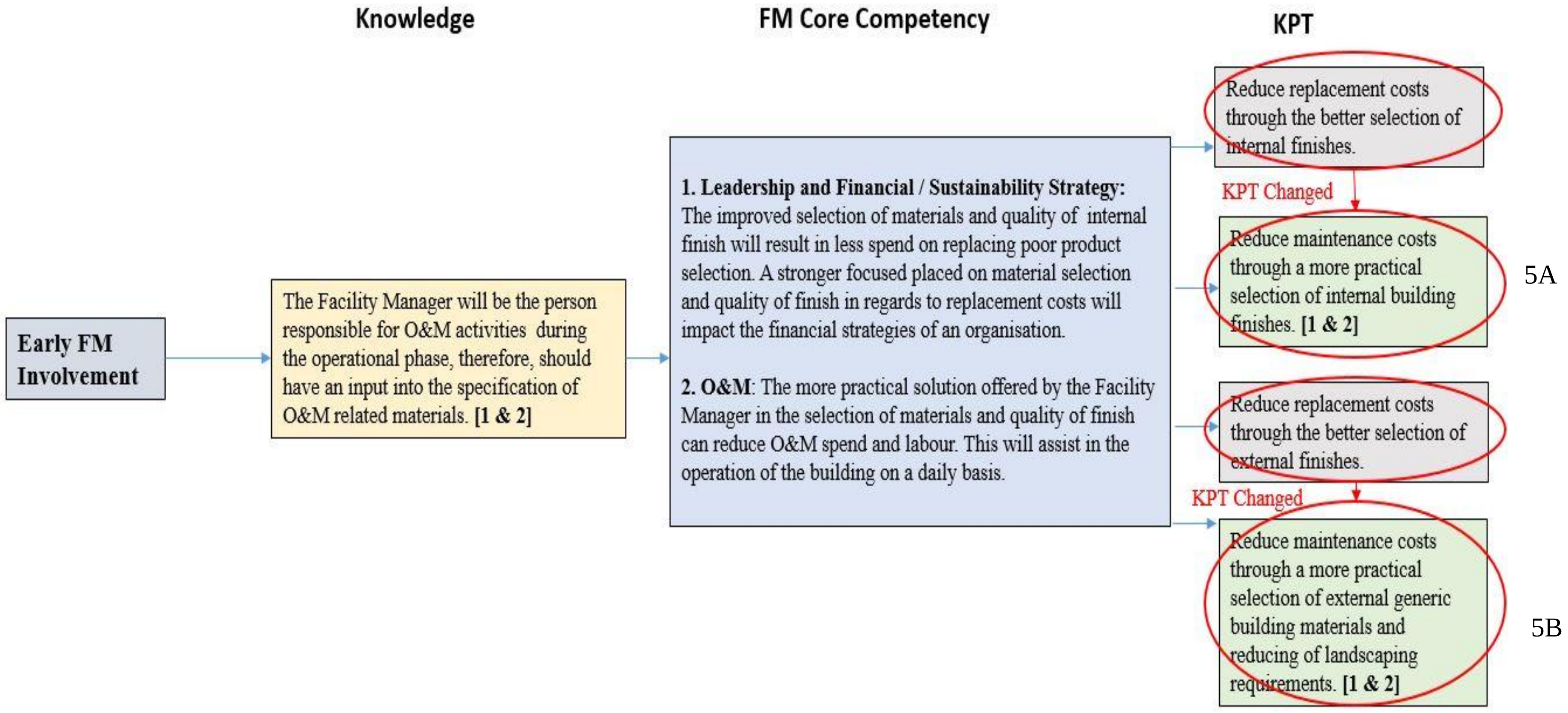

Fig 9.17: Materials Selection KPTs for early involvement of the Facility Manager in the BIM process Revision 2

6B Reduce and streamline the level of COBie information

This KPT was created in response to the UK Level 2 mandate which specifies that all FM information must be handed over in an Excel format at the end of the job. This KPT aimed to examine if the Facility Manager could assist the design team in selecting the assets that require either a high or low level of COBie information.

On inspection of the model there was no COBie information within any of the model parameters.

An explanation of COBie was provided and a sample of a COBie excel sheet was used to illustrate the information this process captures. Facility Manager one, who had no previous knowledge of COBie, states that there should be as much information on an asset provided as possible. He could not see himself assisting in this process, as from his brief understanding of it all the information provided in the COBie sheet was justified.

Facility Manager two was of the other opinion, based on his extensive knowledge of using COBie, that it can be excessive with regards to information. He sees COBie as being to detailed for some assets, which do not require such a high level of information. While this KPT could not be validated, there were suggestions from the recorded responses that this was a performance area that could benefit from the early Facility Manage involvement.

Summary

On reflection of the Data Management KPTs there was evidence that the Facility Manager can assist in the production of a simplified BIM FM model that can be used by non-technical staff that currently work in the Irish public sector. There were also suggestions that the Facility Manager could help in streamlining the COBie process by specifying which assets need a high and low level of information attached to them. The application of this KPT was extremely limited and there was no way of validating it. For this reason, it will remain as part of the final suite of KPTs, due to its potential to assist in early Facility Manager involvement in the BIM process. No further refinement was suggested for this area.

9.5.7 BIM Model 1 Summary

The model on initial inspection had very little FM detail within it. Despite this, the KPTs were still applied and it was found that the Facility Manager contributed in a number of areas. These included suggestions with regards to the wall and floor materials, plant room layout, concerns with the roof, door finishes, lighting fixtures and asset materials. A number of further areas were examined but could not be properly validated due to the lack of maturity of the model or access to resources. Some of the suggestions made by the Facility Manager, if not already incorporated into the initial specification, can significantly help reduce maintenance costs. The case study demonstrated that the Facility Manager can assist in a number of areas. Based on the finding of the case study table 9.1 details the key refinements made to the KPTs from Chapter Eight. These were applied on the second public sector BIM model. The KPTs with a red astrix beside them in table 9.1, could not be validated due to similar barriers encountered on the special schools BIM model.

Early Facility Manager Involvement in the BIM Process for Public Works Projects					
1A1. Reducing operational expenditure with regard to the selection of O&M products.	**2A.** Reducing of operational costs in regards to the selection of M&E based equipment.	**3A.** Reducing impact on external environment through the selection of environmentally friendly material / finish. .	**4A.** Enhancement of workstations per net floor area - **CHANGED TO** **4A**. Enhancement of net floor area for more practical layout.	**5A**. Reduce replacement costs through the better selection of internal finishes - **CHANGED TO** **5A.** Reduce maintenance costs through a more practical selection of internal building finishes.	**6A.** Improve the practicality of the FM model for the operational phase. **
1B. Reduce functionality risk with regard to O&M.	**2B.** Reduce the functionality risk associated with M&E equipment.	3**B.** Reducing energy costs through the selection of energy efficient systems/materials. .	**4B.** Reduce construction waste by eliminating unproductive spaces. – **DELETED.**	**5B.** Reduce replacement costs through the better selection of external finishes – **CHANGED TO** **5B**. Reduce maintenance costs through a more practical selection of external generic building materials and reduce landscaping requirements.	**6B**. Reduce and streamline the level of COBie information**.
1B. Enhance Design for safety and 1**C.** Enhancement of design to be more maintenance friendly with regard to accessibility – **COMBINED INTO.** **1.C** Enhancement of design to be more maintenance friendly with regard to accessibility and safety.	**2C.** Maximise space and ensure ease of access for maintenance.		**4C**. Maximise space utilisation and allocate spaces for future expansion. – **NOW 4B**		
1D. Improve lifecycle costing estimates for O&M based products. **	**2D**. Improve lifecycle costing estimates for M&E based products. – **DELETED.**				
1.E Improve quality of O&M documentation. **	**2E**. Improving the zoning of heating systems – **NOW 2D**				

Table 9.1: Early Facility Manager involvement in the BIM process for Public Work Projects KPTs Revision 3

9.6 BIM MODEL 2 – GREYSTONES COASTGUARD MODEL

On initial inspection of the model Facility Manager one observed that the model was not *"a building that would need the input of the Facility Manager"*. He stated that this was a relatively simple building and given that its transient users, will primarily be the Coastguard, there may be only one person who was a full-time employee. Facility Manager two stated that he can get a sufficient amount of detail from the BIM model. He observed that there was information missing, such as exterior wall finish, glass type, ironmongery and exterior steelwork not in the BIM model.

9.6.1 O&M KPTs

1A: Reducing operational expenditure with regard to the selection of O&M products

Example: Floors

In regards to the flooring, Facility Manager two observed that on both the lower and upper floors there will be excess moisture, as a result of boats entering and exiting the boat house. He suggested that "*more extract fans downstairs would be required".* Facility Manager two requested to see the information attached to the floor in the communications room. The information attached to the floor detailed that it was a 375mm thick concrete floor. No final finish for the floor had been specified.

The Facility Manager with regard to the final floor finish stated that the Coastguard should avoid the use of carpet in the office, so as not to have potential mold issues. He added "*you can't use the standard CIBSE guides for the extract ventilation for this type of building."*.

1B. Reduce functionality risk with regard to O&M

On inspection of the model both Facility Managers could not identify any significant concerns with regards to the functionality risk for O&M. Facility Manager one did observe that given the profession of the occupants they may be moving throughout the building wearing wet clothes, careful consideration will need to be given on placing anti slip mats throughout.

<u>1C. Enhancement of design to be more maintenance friendly with regard to accessibility and safety</u>

Example 1: Windows

Facility Manager two was concerned about the lack of access to clean the windows. He believed that this task required a scaffold, as a ladder may prove too difficult to use. *"Access to those second storey windows facing the sea, maybe they are tilt and turn and you can do it from the inside. But that's the kind of things I would be looking at".* He adds that if you can clean the outside of the windows from the inside that will save a significant amount of money.

Figure 9.18 illustrates the current difficulties in accessing the windows.

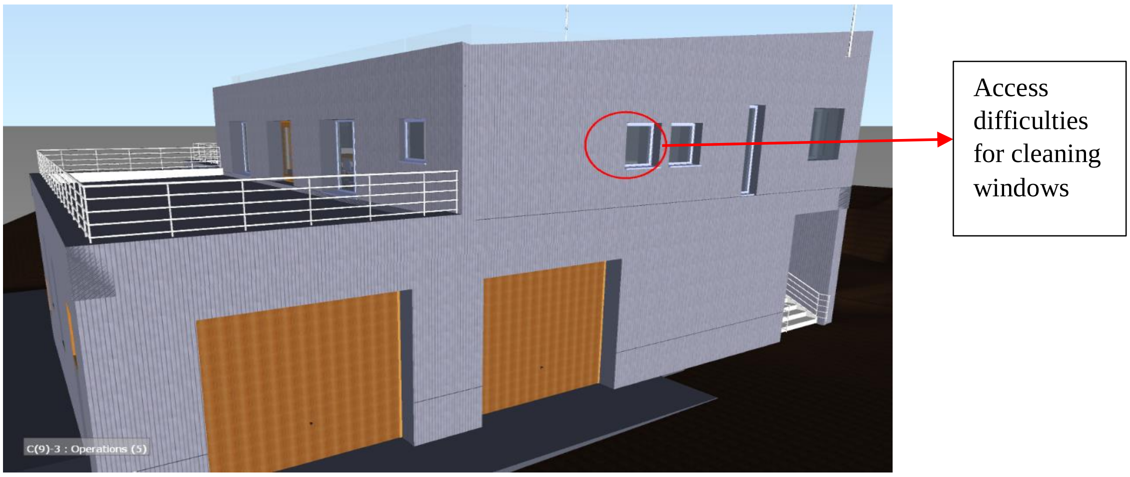

Fig 9.18: Illustration of current window position in the OPW Coastguard model

Example 2: Roof

Facility Manager states that there should be a guard rail around the flat roof at the top. *"Given its exposure, and I don't see anything on the BIM model to say that there was even a tie line or an access ladder up to it ".* He believed that there will be an antenna or some sort of a mast on the roof. With the *"maintenance associated with the antenna I would put a gantry ladder off that balcony at the back".* This would ensure ease of access as *"you never know the day nor the hour that you would have to get up to access those antennas, as they are crucial for communication with the craft when it's out to sea".* He did acknowledge, as the roof appears to be flat, there may be an access hatch which as of yet has not been modelled.

Facility Manager two did not see any detailed roof access or any signs of a fall arrest system modelled. He believed that access would be a primary concern given the location, as bad weather conditions may cause problems for the future. Figure 9.19 illustrates the current lack of fall arrest systems or safe access to the roof.

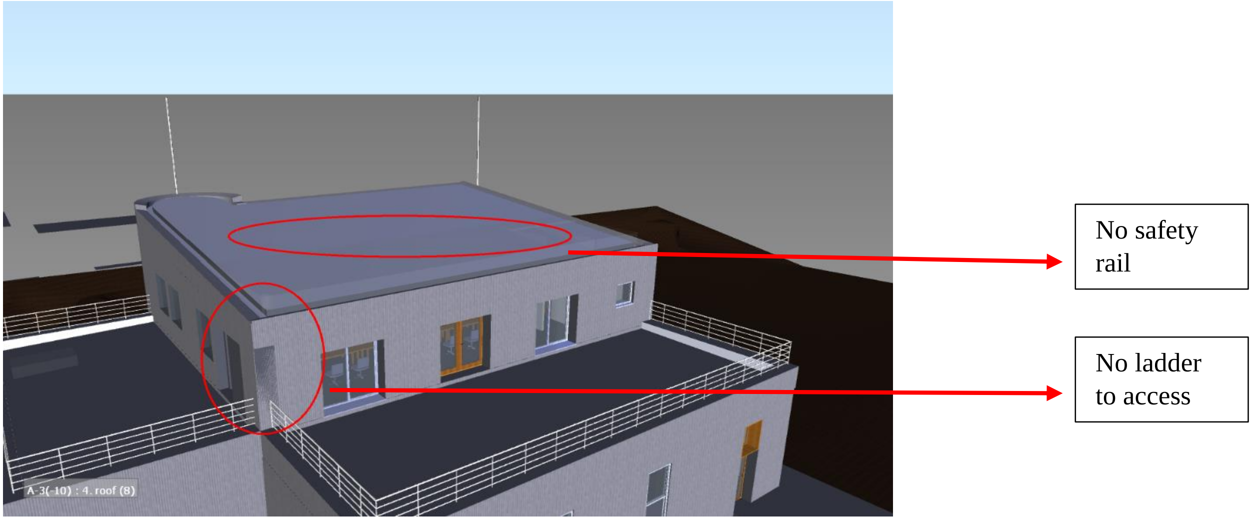

Fig 9.19: Illustration of lack of fall arrest or access to the rood in the OPW Coastguard model

<u>Summary</u>

On reflection of the O&M KPTs there was some evidence that the Facility Manager can assist in reducing operational expenditure. Given the low maintenance expected with this type of building there were not many examples provided by either Facility Manager, except for the flooring. Suggestions were put forward to improve areas where safety could be a potential problem, such as access to both the roof and for cleaning windows. A solution offered with respect to the windows was to have a tilt and turn type of window. There were not many opportunities to reduce the functionality risk, due to the nature of the building.

9.6.2 M&E KPTs

<u>2A: Reducing of operational costs in regards to the selection of M&E based equipment</u>

Facility Manager one observed with regards to the M&E that the focus should be on a *"good domestic installation that was simple to use, simple to turn on and off, and uncomplicated.* The reason for this was that the building will be used by volunteers, and transient users who will be passing through and may need fast access to utilities i.e. you flick a switch and the boiler comes on, and there was a cylinder of hot water there so they can all have a shower. *"I would not go for anything complicated as regards air handling units, or air conditioning, or anything like that".*

<u>2B: Reduce the functionality risk associated with M&E equipment</u>

In regards to the power Facility Manager one stated that this was the *"weakest point as regards the functionality of the building".* He asks the question *"if you were bringing in overhead* *cables into a Coastguard station, and it suddenly becomes a force 8 or 9 gale, and it blows your electricity out is there a standby generator in that instance?"* There was no evidence of a standby generator in the model. He adds that *"these were little things that you could question in the design"*.

2C: Maximise space and ensure ease of access for maintenance purposes for M&E equipment

Facility Manager two highlighted that lighting will be very important especially in the boathouse, as there will be a need to launch boats in the middle of winter. *"It's very important when you were returning to the station after your mission, that you can actually see were you are going. Thus lighting equipment was critical."*. Figure 9.20 illustrates the current ramp up to the boathouse. It will be critical that external lighting guiding the boats into the boat house was present. This lighting will more than likely be sensor operated and should be easy to access in case there was a problem. There will also need to be strong lighting within the boathouse, so that the Coastguard can see what they were doing during the evening.

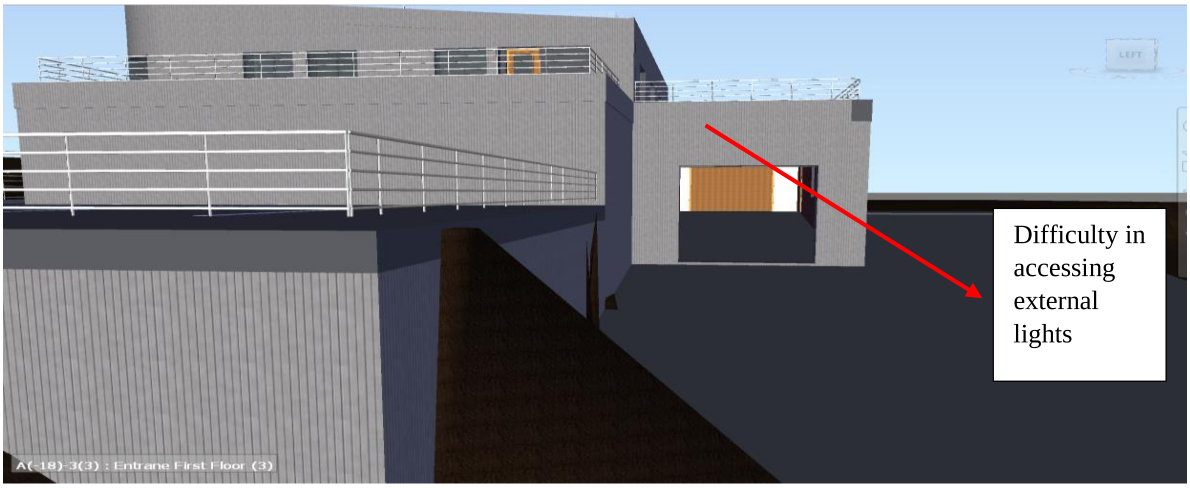

Fig 9.20: Illustration of current boat house entry for the OPW Coastguard model

2D: Improving the zoning of heating systems

Facility Manager two only sees the requirement for two separate zones i.e. the ground and first floor. *"The first floor will require more attention, as this was more in use on a day-to-day basis, while downstairs was probably only used on call outs or practice days"*. Facility Manager one did not see the rationale for zoning within a building so simple.

Summary

On reflection of the M&E KPTs there was some evidence that the Facility Manager can assist in reducing operational expenditure with regard to the selection of M&E equipment. Given the simplistic nature of the M&E layout, there were not many examples provided by the Facility Managers. Both Facility Managers would keep the M&E design simple ensuring that the Coastguard has access to instant hot water. Suggestions were put forward to reduce the functionality risk through further interrogation of the design with regard to the current position of the generator. Further suggestions were put forward to improve areas where safety could be a potential problem, such as access to external lights.

9.6.3 Energy Management KPTs

3A: Reducing impact on external environment through the selection of environmentally friendly material / finish

Facility Manager one explained that *"the most important aspect from a Facility Managers point of view was the exposure of the external cladding of the buildings to very aggressive elements".* He believed that the specification of the external cladding, the external rails, roofing material, and how it all works together, was very important. He would allocate a lot more time to the material selection and their application rather than the M&E. He would be concerned about the fabric maintenance moving forward. He could not tell from the model if the finish render would be painted.

Facility Manager two was also concerned about the exterior facade, as it will take a high degree of exposure. *So even the items such as the railings and access to those sea facing windows to clean them will need special attention".*

3B: Reducing energy costs through the selection of energy conscious systems/materials

Both Facility Managers found it difficult to make a substantial contribution within this area.

Summary

On reflection of the Energy Management KPTs there was some evidence with respect to this building which early Facility Manager involvement can assist in reducing the impact on the external environment through the selection of a more environmentally friendly finish. There was no evidence with regard to the Coastguard station that they could contribute towards reducing energy costs through the selection of energy conscious systems/materials. The specialist nature of the building made this KPT very difficult for either Facility Manager to contribute.

9.6.4 Space Management KPTs

4A: Enhancement of work space and practical layout ***Enhancement of workstations per net floor area or practical layout***

On inspection of the model Facility Manager one states *"everything was fit for purpose. Probably sized to meet with regulations and the resource numbers that would be occupying this facility. There was nothing over-elaborate about this area".* Both Facility Managers were satisfied that the building had utilised the space available to it.

4B: Maximise space utilisation and allocate spaces for future expansion

Both Facility Managers found it difficult to make a substantial contribution within this area.

Summary

On reflection of the Space Management KPTs there was no evidence that the Facility Manager can assist in offering a more practical perspective with regards to floor spaces. The building was fit for purpose and no opportunity presented itself for the Facility Manager to assist within this area.

9.6.5 Materials KPTs

5A Reduce maintenance costs through a more practical selection of internal building finishes

On inspection of the model Facility Manager one highlighted that the battery store which was used for charging the batteries from the various boats, should be a primary concern in regards to materials. He asked to view the information attached to the floor for this room. The information attached to the floor detailed that it was a 300mm thick concrete floor. No final finish for the floor had been specified. He observed that the lead acid batteries, if leaking, could damage the floor. "He adds that *"if you have batteries in this room and there was no call out for a couple of weeks, and they were leaking, it could have a detrimental impact on the building."*

5B Reduce maintenance costs through a more practical selection of external generic building materials and eliminating of landscaping requirements

Both Facility Managers found it difficult to make a substantial contribution within this area. Due to the location of the building there will be no requirement for landscaping. Also, as the building was designed to withstand harsh external exposure to high winds and the sea, there was little contribution the Facility Managers could make in reducing maintenance costs through a more practical selection of external generic building materials.

9.6.6 BIM Model 2 Summary

The model on initial inspection did not require a significant input from the Facility Manager due to the lack of maintenance associated with it, as a result of its specification to withstand harsh weather conditions. Despite this the KPTs were still applied and it was found that the Facility Manager contributed in a number of areas. These included suggestions with regards to the floor finish, safe access to the roof, cleaning of windows and external light concerns. Both Facility Managers agreed that the M&E specification should be kept relatively simple which reduced their input with regard to the M&E KPTs. Other KPTs, such as energy and space management had little recorded input. The case study has demonstrated that the Facility Manager can assist in some areas but was restricted due to the nature of the building. Despite this, some of the suggestions if taken on board by the design team could save on potential maintenance issues in the long term.

9.7 CONCLUSION

The purpose of this final phase of research was to validate and refine the current set of KPTs established in chapter Eight. The KPTs were applied on two public sector case studies. It was found that if involved earlier in the BIM process the Facility Manager can contribute within a number of areas. Their impact varied based on the type of project. The two case studies produced varying levels of success, with the Greystones Coastguard model demonstrating a limited contribution. This has demonstrated that the KPTs may not be suitable for all types of public sector projects.

Some of the KPTs applied on the first case study were found to be similar which served to confuse the Facility Managers. These were either eliminated or combined into a single KPT. Other notable refinements included the elimination of KPTs that were found to be unrealistic and KPTs which were not within the remit of the Facility Manager. A number of KPTs could not be applied due to the lack of maturity of the models or a lack of access to the construction team. However, there was enough evidence to suggest that if applied on a project with the required resources they could offer an area where the Facility Manager could contribute.

Table 9.2 presents the final set of KPTs that serve as the author’s contribution to knowledge.

Early Facility Manager Involvement in the BIM Process for Public Works Projects					
O&M	**M&E**	**Energy Management**	**Space Management**	**Materials Selection**	**Data Control**
1A. Reducing operational expenditure with regard to the selection of O&M products.	**2A.** Reducing of operational costs in regards to the selection of M&E based equipment.	**3A.** Reducing impact on external environment through the selection of environmentally friendly material / finish.	**4A.** Enhancement of net floor area for more practical layout.	**5A**. Reduce maintenance costs through a more practical selection of internal building finishes.	**6A.** Improve the practicality of the FM model for the operational phase.
1B. Reduce functionality risk with regard to O&M.	**2B.** Reduce the functionality risk associated with M&E equipment.	3**B.** Reducing energy costs through the selection of energy efficient systems/materials.	**4B.** Maximise space utilisation and allocate spaces for future expansion.	**5B.** Reduce maintenance costs through a more practical selection of external generic building materials and reduce landscaping requirements.	**6B**. Reduce and streamline the level of COBie information.
1C. Enhancement of design to be more maintenance friendly with regard to accessibility and safety.	**2C.** Maximise space and ensure ease of access for maintenance.				
1D. Improve lifecycle costing estimates for O&M based products.	**2D**. Improving the zoning of heating systems.				
1.E Improve quality of O&M documentation.					

Table 9.2: Final KPTS for early Facility Manager involvement in the BIM process for Public Work Projects

10 SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

10.1 SUMMARY

Coupled with the use of BIM in the design and construction phases, the earlier involvement of the Facility Manager can reap significant benefits to public works projects. In order to achieve more efficiently operating public sector buildings this early FM involvement must be a fundamental ingredient in the design of a building in the future. The early involvement of the Facility Manager can assist in creating a facility that will make it easier to manage the issues associated with both poor handover of documentation and completion of works. (McAuley et al. 2015b).

This approach has been restricted through a lack of understanding of where their involvement would be of benefit within the BIM design process. The delivery of Irish public sector projects has been focused on reducing capital costs with better focus on O&M. The thesis has demonstrated that, if deployed earlier, the Facility Manager can apply his/her operational efficiency skillset in helping to reduce operational costs and provide important information on the daily operation of the building, thus reducing the associated functionality risk. He/she can work with the design team to ensure a design for safe maintenance and accessibility. The Facility Manager can further assist in the layout and selection of M&E plant for both accessibility and efficiency related criteria. This knowledge of occupants and their working habits can be fed to the design team who can translate these concerns into the model. There is evidence that he/she can further assist in working with the QS to provide more realistic life cycle cost estimates. A number of KPTs have been suggested and validated within the course of the research that can offer a best practice guide for their inclusion (McAuley et al., 2013b&c and McAuley et al., 2015a&b).

While the Facility Manager can have an impact on some of the current public estate problems, other areas will need to be addressed from a staffing viewpoint. Buildings designed for a set purpose were being further impacted on by not having the correct staff to operate them. It can be argued that early FM involvement and the production of a valid asset information model will position the building better for emergency preparedness and thus continued business continuity (McAuley et al 2015a).

10.1.1 Review of Main Findings

Chapter 2 – Literature Review

The literature established that one of the most significant contributions to the FM process in recent times was ICT. The greatest potential within the ICT enhanced FM practice was BIM and its associated tools. BIM for FM can help shift project focus from design and construction to FM and operations (Volks et al., 2014, Gerber et al., 2011and Burcin et al., 2011). To achieve this the correct people must be involved from the outset of the BIM process to ensure that the most practical structure was commissioned for the Client. This was very important for the public sector, as the commissioned buildings, if poorly designed, will cost the tax payer additional monies to maintain (Olatunji and Akanmu, 2015, Di Silva, 2011, Mohammed and Hassanain, 2010, Kelly et al., 2005 and Enoma, 2005).

The 85% of life cycle costs due to O&M must be addressed during the design and construction of the public asset, as this was the optimum time to influence the operational costs (Aguilar and Ashcraft, 2013). As advocated throughout the Facility Manager can help in impacting these operational costs during construction, as his/her role was to assist the organisation to meet its strategic business goals and objectives (Lindquist, 2015, Wang et al., 2013, Liu and Issa, 2013 and Kelly et al., 2015)

This approach was not a new methodology and has been adapted in a number of projects. However, as evidenced from the literature review, there was still little research on this approach and there was strong evidence that the Facility Manger was still only viewed in an operational capacity (Kassem et al., 2015, Liu and Issa, 2013, Brewer et al., 2013 and De Silva, 2011). The literature justified the benefits and highlighted the barriers of this approach and in doing so highlighted a number of ongoing and new research gaps.

Some of the research gaps found within the literature include a lack of research on the end user of facilities, in particular the person who will be responsible for the final FM model and the role he/she play in the overall BIM process. The role that the Facility Manager occupies within the BIM process was still uncertain and there was little understanding of what performance areas he/she can assist within the BIM governed design process. The findings in the literature served as the basis for the establishment of the proposed contribution to knowledge.

Chapter 4, 5 and 6 – Phase One

The first stage of Phase 1 involved a qualitative-based case study. The selected case study involved observing a simulated design workshop of a generic designed primary school project. The objective of the case study was to investigate if BIM could assist the Irish Government in achieving a more cost certain construction methodology. It was discovered that BIM technologies could assist the public sector contracts in realising the goals of the CWMF. Despite the success of the pilot and workshop, Ireland was still a long way from embracing BIM on public works projects. Representatives of the OPW noted that despite the benefits that BIM would have on a number of Departments within the Government, it would still require "an act of faith" for the Irish Government to fully embrace it (McAuley et al., 2012b&c). Due to the lack of research and knowledge in the domain of BIM within Ireland at the time, it was important that this exploratory research was performed, so as to ensure there was an adequate cultural and technical platform available to establish and validate the KPTs. The pilot participants represented only a small cross section of the AEC sector who for all intent and purposes were already firmly in favour of BIM.

It was agreed that to further validate the findings the second stage of research would involve two separate but related cross-sectional type surveys. Survey one aimed to establish the current awareness of BIM and usage within the Irish AEC sector. A total of 100 organisations where selected randomly from a 143 CitA membership community to partake in a survey. A total of 90 responses were received. The survey concluded that in general there was a significant level of awareness of BIM in Ireland. The AEC/FM sector were still uncertain to as what BIM actually meant and further education was needed to address this. The survey showed a strong belief within the Irish AEC sector that they should follow the UK's move towards the mandating of BIM. There was a number of concerns raised with this process, including alienating SMEs and creating a monopoly in the public sector where only large enterprises can compete. There needs to be smarter cost effective ways to enable all companies to adopt BIM and that awarding of multiple contracts to any one firm was limited over a given period of time to prevent cronyism (McAuley et al., 2012d). The results from this survey enforced the findings of the workshop findings which ensured that there was an adequate cultural and technical platform available to establish and validate the KPTs.

The workshop and survey helped answer the first two research aims of the thesis, as it identified that the current awareness of BIM within Ireland was high, with levels similar to the UK. BIM was seen as been able to assist in achieving the objectives of the CWMF and that it could be of specific benefit in regards to the management of the public sector estate. Irish support for a mandate as similar to the UK was seen as a strong solution to promoting its use. In order for this to be realised then existing cultural barriers and fear of costs would have to be addressed.

The second survey focused on the Irish FM sector and aimed to establish the role of the Facility Manager in the design process and to establish if he/she can make a valid contribution. It also sought to establish the current awareness of BIM and general ICT usage. The survey was issued in partnership with the IPFMA and generated a total of 38 company responses from a total sample size of 80 businesses. The results demonstrated that there was little involvement of the Facility Manager during the early stages of construction, despite a strong claim, as to the significant benefits that he/she would bring to the construction team. There had been little movement towards cutting edge technologies from the Irish FM sector, in order to streamline maintenance and further enhance lifecycle management. Encouragingly there was a significant understanding of how ICT can improve the overall FM process, which includes the use of an integrated BIM package to minimise deficiencies and aid cost reduction during the running of a building. (McAuley et al., 2013a., Hore et al., 2013 and West et al., 2013). This final stage of phase 1 of the research assisted with establishing the research aim of where the Facility Manager can have the greatest impact in the design process. A number of early design target areas were established which included include M&E, O&M, energy and space management, and occupant behaviour. These early design target areas which the Facility Manager can impact, if incorporated earlier in the design, played a key role in establishing the KPTs within Phase 2 of the research.

Chapter 7

The potential areas established in Phase 1, in which the Facility Manager could impact the design through his/her earlier involvement were validated through a transformative design approach within a pilot case study. This involved establishing a set of KPTs through a three stage process, which involved the triangulation of both the core competencies and early design target areas associated with the role of the Facility Manager, with existing BIM KPIs. The triangulating of these three performance areas resulted in the establishment of common criteria which served as the basis of the KPTs.

These findings from the CitA Technology pilot established that the Facility Manager can play a significant role in ensuring the most functional and practical structure can be realised. The

Facility Manager can help ensure that the most relevant data was embedded into the model, that will be of most benefit when it comes to the operation of the building (McAuley et al.,2013b&c). The FM team believe that it could help streamline the needs of the Client to focus on the total costs over the lifecycle of the building and not just on the construction budget (McAuley et al.,2015a). The KPTs included areas compromising of maintenance, M&E, energy and space management.

Phase 2 of the research helped answer the research aim, of demonstrating by use of a pilot project how the shifting of project focus from design to FM can be enhanced through inclusion of the Facility Manager in the BIM process. This was achieved through the CitA Technology Pilot which demonstrated how early involvement of the Facility Manager can play a significant role in the BIM design process. This phase of research was also responsible for establishing the first suite of KPTs which would be further refined on Phase 3 before final validation.

Chapter 8 – Phase Three

It was important that any validation of the KPTs in the field represented a solution which was directly relevant to the public sector. This involved action research where the author spent three months working on a public sector project and collecting data to form part of the refinement analysis. The project was a Coastguard station in which the author worked in partnership with the design team in the detailing of the model. It was ultimately found that BIM was in its infancy and there was still considerable work to be performed in order for it to reach its potential. The Property Maintenance Department was confined to an operational capacity and was not seen as part of the design process. If strategic consultation in regards to FM was required, this was usually provided by the Architect or M&E Department. Data was collected through interviews which enabled the KPTs to reflect a more balanced public sector solution.

In order for the KPTs to reflect the findings of the action research a thematic analysis of the data collated was undertaken. This ensured that the proposed KPTs for early Facility Manager involvement addressed the key concerns now faced by the Irish public sector estate. The data collected during the action research was also integrated with previous data collected during the first two phases of research. This would ensure that all collated data to date would receive a high level of cross reference and analytical rigor ensuring any previous data not analysed was incorporated into the refined KPTs.

It was ultimately found that the most prevailing themes in regards to public sector estate problems involved improper use of the building, lack of documentation and staff concerns with regards to the operation of the building. The analysis also showed that the Facility Manager and his/her team were confined to an operational role that respond through a helpdesk system to reactive maintenance requests.

The dominant theme included the operational efficiency skillset of Facility Managers in helping to reduce operational costs and provide important information on the daily function of the building, therefore reducing the associated functionality risk. Facility Managers can work with the design team to ensure a design for safe maintenance and accessibility. He / She can further assist in the layout and selection of M&E plant for both accessibility and efficiency related criteria. Their knowledge of occupants and their working habits can be fed to the design team who can translate these concerns into the model. The Facility Manager can further assist in working with the QS to provide more realistic life cycle cost estimates. FM involvement, as seen through the analysis, was a fundamental ingredient in the design of a building with regard to reducing the operational spend. The analysis further showed that the Facility Manager could have an important role in the BIM process during the design (McAuley et al., 2015b). The KPTs where refined to match the findings of the thematic analysis. These areas included O&M, M&E, energy and space management, data control and materials selection.

Phase 3 of the research helped answer a number of research aims outlined in Chapter One, which included the identification of current inefficiencies that exist in the management of Irish public sector assets and the strategic position of the Facility Manager within the public sector model. This penultimate phase of research was also responsible for refining the KPTs to ensure they reflected a solution that was relevant within the public sector and that no potential criteria concerning the current proposed set of KPTs was missed through previous undertaken analysis. These KPTs served as the basis for validation in the final phase of the research.

Chapter 9 - Phase Four

The final phase of research involved validating the KPTs on the Coastguard BIM model from Chapter Eight and a special school's BIM model procured by the DoES. Neither model had any early FM input. Two expert Facility Managers were used to validate the KPTs. One Facility Manager had no knowledge of BIM while the other had an extensive knowledge. It was ultimately found that the Facility Manager could address a number of design issues as a result of the guidance provided from the KPTs. The KPTs were further refined to match the final findings from the expert analysis.

This phase of the research served in validating the authors proposed contribution to knowledge, which was a set of KPTs based around the core competency areas associated with the role of the Facility Manager. It was ultimately found that O&M, M&E, energy and space management, material selection and data control, were the main criteria that can be used to demonstrate early Facility Manager involvement in the BIM process.

10.2 CONTRIBUTION TO KNOWLEDGE

The author has provided a contribution of knowledge in both the academic and industry practice fields.

10.2.1 Contribution to Knowledge: Industry

The KPTs can be facilitated within the industry to help achieve a more robust FM process for the public sector, facilitated by the use of a suite of unique KPTs. The research has put forward the business case for the adoption of BIM and, in particular, the adoption of particular KPTs by Facility Managers leading to a more robust FM practice for the Irish public sector. The output of the KPTs were based on influencing the core competency areas uniquely associated with the role of the Facility Manager. It has been shown that these areas can be enhanced as a result of their inclusion in the BIM governed design process therefore leading to a more functional and rewarding operational stage. These KPTs can provide guidance of where their inclusion will be of greatest impact and how their assistance within these areas will enhance a number of key competencies.

10.2.2 Contribution to Knowledge: Academic

The KPTs have furthered the argument with regards to FM in large, specifically in the domain of its strategic position (Madritsch and Ebinger, 2011, Saleh et al., 2011, Jay and Ooi, 2001, Mobley and Khuncumchoo, 2006, Price, 2001 and Grimshaw, 2007). The KPTs have demonstrated that when promoted to a strategic positon the Facility Manager can make a strong contribution. This can further the academic stance that FM has now become a key discipline, with a need to break away from current thought patterns and adopt a new way of thinking.

Academic literature has shown that the Facility Manager was only involved in the design process in a very limited way, at the discretion of the client (Brewer et al., 2013, De Silva, 2011, Liu and Issa and Kassem et al., 2015). This was despite academics such as Hodges

(2005), Enoma (2005), Mohammed and Hassanain (2010) and De Silva (2011) promoting their inclusion through highlighting that the failure to address FM problems right from the design stage can result in the maintainability issues further down the line. The Facility Manager has found themselves facing the same problems within the BIM process despite the repeated call for their inclusion (Kassem et al., 2015, Wang et al., 2013, Kelly et al.,2013 and Liu and Issa, 2013). The KPTs have provided tangible evidence and a contribution to knowledge by demonstrating that the Facility Manager can impact the BIM process within a number of areas and therefore have furthered the academic literature and research available in advocating this approach. The KPTs and subsequent results have provided a tool that can be used to demonstrate the contribution which they can bring.

10.2.3 Contribution to Knowledge: Industry and Academic

The author has also provided a contribution to knowledge with respect to BIM and FM within Ireland. Through conference and journal papers published and disseminated to the Irish AEC Sector has helped advance the academic and industry understanding of BIM and FM with regards to the Irish public sector. (McAuley, 2015a,b&c, Moore, 2015a&b, Kane et al., 2015, O'Loingsigh et al., 2014., Deeney et al., 2014, McAuley et al., 2013a,b&c, Hore et al., 2013, West et al., 2013, Deeney et al., 2013, McAuley et al., 2012a,b,c&d, Kehily et al., 2012a&b, McCormack et al., 2012).

10.3 ACHIEVEMENT OF THESIS OBJECTIVES.

The main target of this thesis was to create a number of KPTs that could be used to justify the inclusion of the Facility Manager in the BIM governed design process. Table 10.1 summarise the achievement of the thesis objectives.

Thesis Objectives	**Authors Findings**
Identify the current awareness of BIM within Ireland and provide viable solutions to promote this construction methodology.	BIM awareness was high with levels similar to the UK. There was a fear of cost and cultural barriers in place preventing further adoption. There was support for a mandate as similar to the UK, which was seen as a strong solution to promoting its use.
Review the appropriateness of implementing BIM as a solution in procuring and managing Irish public sector assets.	BIM was seen as been able to assist in achieving the objectives of the CWMF. The output from the RIAI Workshop and BIM for Ireland survey established that it can be of specific benefit in regards to the management of the Irish estate.
Identify the inefficiencies that currently exist in the management of Irish public sector assets.	The most prevailing inefficiencies with regards to public sector estate problems involved the improper use of the building, lack of documentation and staffing concerns due to a lack of knowledge in the operating of the building
Examine the current role of the Facility Manager within the Irish public sector and their perceived role within the construction process.	The Facility Manager and their team were confined to an operational role that respond through a helpdesk system to reactive maintenance requests. The Architecture and M&E Department act as the strategic FM arm of the state.
Establish where the Facility Manager can have the greatest impact in the design process.	As a result of the BIM for FM survey a number of key areas where established where the Facility Manager can impact the design. These include M&E, O&M, energy and space management, and occupant behaviour
Demonstrate by use of a pilot project how the shifting of project focus from design to FM can be enhanced through inclusion of the Facility Manager in the BIM process	The CitA Technology Pilot demonstrated through the early involvement of the Facility Manager that they can play a significant role throughout the BIM process.
Establish and validate a set of KPT's that can support the business case for the inclusion of the Facility Manager in the early BIM process within the public sector.	A set of KPTs were established based around the core competency areas associated with the role of the Facility Manager and the cross referencing of these established areas where their early involvement can impact the BIM governed design process. These KPTs were piloted, validated and refined a number of times. It was ultimately found that O&M, M&E, energy and space management, material selection and data control, were the main criteria that can be used to demonstrate early Facility Manager involvement in the BIM process.

Table 10.1: Achievement of Thesis objectives

10.4 LIMITATIONS

The author faced a number of limitations throughout his research which mainly included a lack of BIM maturity within the public sector. A lack of understanding of BIM within the industry on initial start of his research meant that a significant amount of time had to spent on exploratory research to establish if BIM was a viable solution for the public sector. This coupled with the lack of ICT advancement in the FM industry resulted in making his research aims and objectives extremely difficult. A further limitation was encountered in the final phase of research with respect to the maturity of the models used to validate the KPTs. As no FM information or documentation, such as PAS 1192 -3 was used in the specification of the required asset information or in promoting standardised processes, the contribution of the Facility Manager was made more difficult. If more information was incorporated into the model it would have offered the opportunity for the Facility Managers to contribute more to the KPTs.

10.5 FURTHER STUDY

There was a growing awareness of BIM within the Irish public sector which is now experiencing a return to economic growth. BIM has seen an incremental jump in usage within the AEC sector from 2012 to 2016 and is now seen as a valid methodology moving forward. The Irish Government is now recognising, as evidenced through its medium term strategy that BIM is a powerful risk management tool that can help assist the GCCC forms of contract. Recently there have been encouraging signs of BIM being used on elements of large public works projects. These include the Grangegorman Development Project and the proposed new Children's Hospital, which is to be primarily located on the city centre site of the existing St James Hospital (McAuley et al., 2015c). Further research will need to show how BIM can be applied throughout the complete lifecycle of a public works projects. This can offer the opportunity for the OPW to move towards a more FM focused BIM approach.

The KPTs in Chapter Nine can be applied on such a project. A fully integrated BIM project will offer the opportunity for the integration of all the different departments in the OPW. At present only sections of the Architecture Department are skilled in BIM technologies with a move now required for other departments to follow suit. This will provide the opportunity to test the KPTs. Applying the KPTs will offer the opportunity for the Property Maintenance

Department to supply its input into the design. Further research could demonstrate that the Property Maintenance Department can have a strategic role in the procurement and management of future assets. This in turn will provide further evidence of the business case to include them in the design process. Further research in refining these KPTs must be driven by the OPW in partnership with the Property Maintenance Department.

Each of the KPTs offer a potential avenue for further research. As the KPTs demonstrate an area where the Facility Manager can contribute, the subsequent testing could result in the production of a measurement criteria to quantify this contribution. By establishing a tool to measure the specific contribution within each KPT can advance the current knowledge pool with regards to BIM and performance measurement. This in effect will give further weighting to the inclusion of the Facility Manager in the BIM governed design process.

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APPENDIX 1 - DETAILS ON RIAI BIM WORKSHOP

Venue: RIAI, 8 Merrion Square, Dublin 2, Ireland.

Time of Event: 1st – 4th November 2011 (all day 9:30am – 5:30pm)

9th November 2011 – Presentation to Government and Industry at RIAI

BIM Workshop – Project Team

• Client	DoES
• Project Manager	Keogh Consultancy
• Architects	Coady Partnership Architects
• Structural / Civil Engineers	Punch Consulting Engineers
• Service Engineers	Ethos Engineering
• Quantity Surveyors	Kerrigan Sheanon Newman
• BIM QS Consultants	IT Construct
• BIM Specialist / Support	ArcDox
• Technical Supports	Diatec
• FM Documentation Handover	Moore DFM
• Official Observers	OPW
• Hosts / Sponsors	RIAI / CitA

Pilot Activities

The design team was provided with a digital brief with the overall goal to design a BIM model of a standard generic DoES school. A suggested workflow was established in direct opposition to the current traditional work stages. These work stages aimed to differentiate from traditional processes through adopting BIM technologies. The proposed work stages are detailed in figure 1A. A potential BIM workflow was adopted to match the new work stages. Figure 1B illustrates this process where it shows deliverables expected at client briefing, design stage and FM stage. The model was exploded down to its core components and then given to the design team to work on specific components. The process involved in achieving this is illustrated in figure 1C. This figure shows a breakdown within Revit of a door, window and floor and the properties associated with them. The various professionals involved all worked on their own model, which was synchronized with a central server, allowing all participants of the workshop to monitor each other's work and, therefore, promoting collaboration. An image captured from the workshop illustrating this environment is detailed in figure 1D.

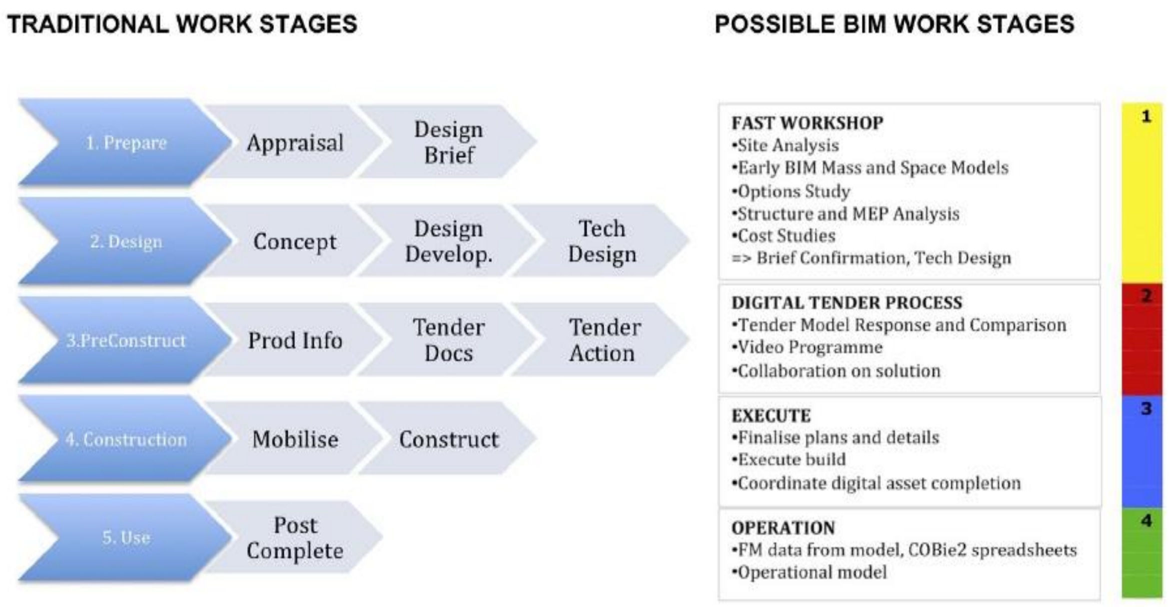


Figure 1A: RIAI BIM Workshop Work Stages

Figure 1B: RIAI BIM Workshop Workflow

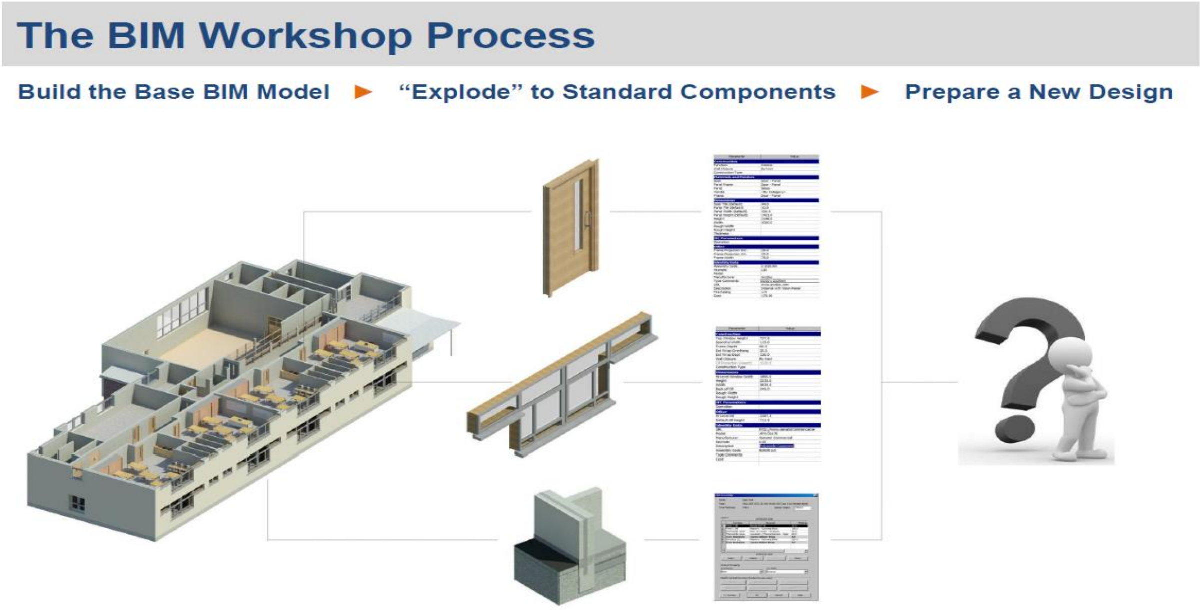


Figure 1C: RIAI BIM Workshop Process

Figure 1D: Illustration of RIAI BIM Workshop environment

Through the collaborative process of everyone working on the same model, the design team was able to see what the other disciplines where doing and this fostered a greater team ethic throughout the design process. This resulted in a strong group dynamic, which in turned enabled the design team to identify areas of possible clash detection, as there was no legal restrictions or copyright concerns within the pilot. Each profession produced their own model that in turn could be merged together into a federated model. An image of this process is illustrated in figure 1E. This further resulted in each profession learning from each other and addressing possible collaboration problems and concerns, which may present themselves in future live projects between the concerned professions.

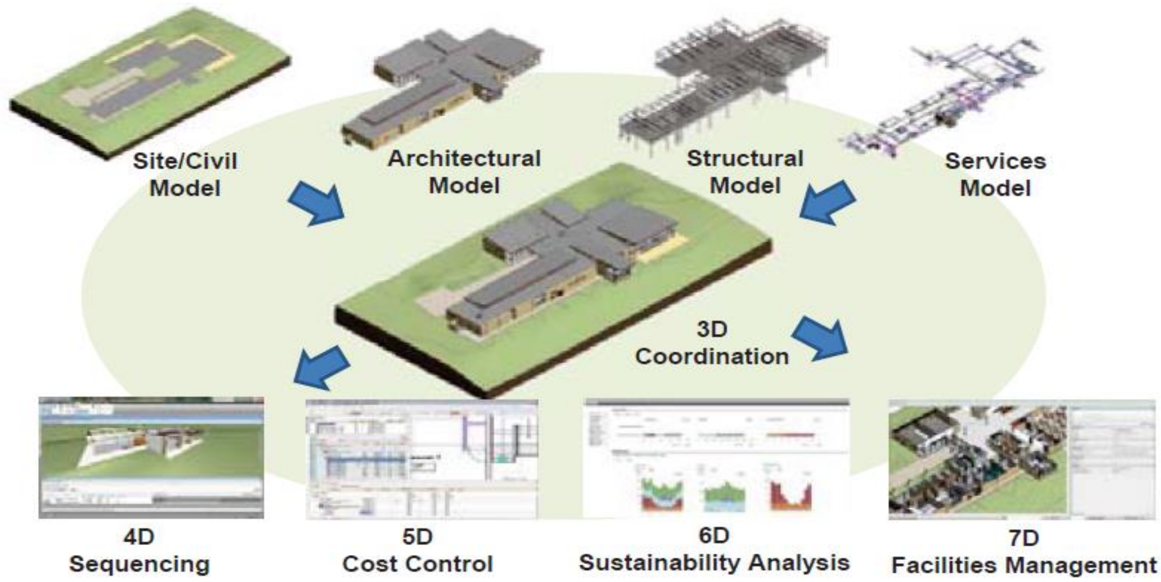


Figure 1E: Merging of trade discipline models into a federated model.

The BIM process permitted a different and more sustainable method of construction to be undertaken which helped designers concentrate on energy efficiency and improved carbon construction. The BIM workshop allowed the designers to create four mass models at different orientations and to perform exercises in concept energy analysis, so as to choose the most economical and sustainable building possible. The energy model was inputted with weather predictions to aid in orientation data, internal floor areas, the number of people who will use the structure, cost of electricity and fuel, average lighting power, exterior wall area, window area, etc. to enable an accurate analysis to be performed. The energy analysis armed with this data was used to calculate the energy usage for the year and so, therefore, assuming discounts rates, a life-cycle energy usage / cost could be generated. The analysis also provided the user with the predicted renewable energy potential that could be harnessed from the roof PV potential (solar electric) and the wind turbine potential for the mass model, based on its climate and geometry. These figures were subsequently used to generate the net annual CO2 emissions, which is basically the CO2 emissions from electricity and fuel consumption for the analysed model, minus the renewable energy potential. This in turn permitted the BIM energy specialist to provide the architect with the information to suggest the most carbon-friendly building to the client. The results from this energy analysis are illustrated in figure 1F.

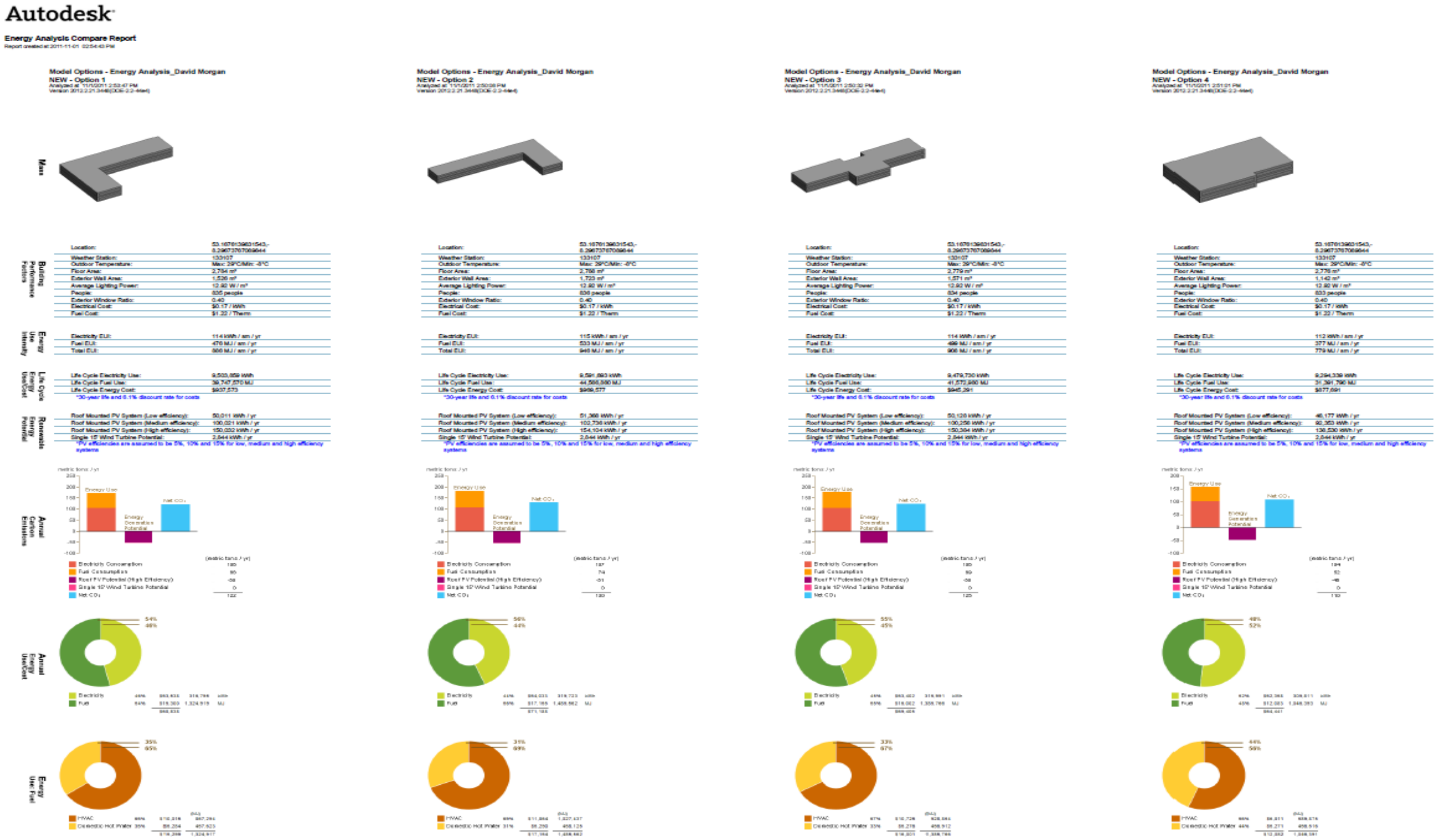


Figure 1F: Mass Model used for CO2 Analysis

APPENDIX 1 – INTERVIEW TRANSCRIPT FROM THE RIAI BIM WORKSHOP

Interview with BIM Consultant (BC)

Barry *How can BIM be of benefit to the new GCCC forms of contract if it was adopted?*

BC You are able to involve the design team in a lot earlier in the project and the QS can also provide a cost analysis. The mass models will enable air flow ratios and a cost can be added against this. Traditionally the architect would design his model and send this to the structural engineer, who in turn, will send back his drawings. Usually only then will the QS come aboard and price the job. BIM can facilitate this and allows a very simple collection of data and quantities that everyone can use.

Barry *Can you use the model to plan for eventualities to help better price the tender?*

BC That's another part of it, and it's probably more orientated towards the contractor's side but there is definitely a cost saving in clash detection. Basically you can build the whole building virtually before you have to build, therefore, you can see clashes before they happen on site. If you change these clashes at the early stage before it gets to site, its costs very little and saves time.

Barry *Is there much of an initial investment required by the client at the start?*

BC The client does not care how you get there, as long as you get there on budget, and on time. The contractor wants to ensure he manages the client's budget. The real savings for the contractor is in clash detection and the coordination of the design team's information and BIM facilities this. Contractors and Clients are going to lean towards BIM, as you have better certainty in cost and time and in theory have a better thought out and planned building.

Barry *Have you used BIM any public works projects yet?*

BC No, but when you talk about public works you are talking about the biggest clients in the country, which is the Government and from a Facility Management point alone that is huge. I don't know their budget but I imagine they have a lot of facilities around the country. BIM can help them manage their buildings effectively.

Barry *Why hasn't Ireland embraced BIM compared to the UK?*

BC In fairness, it has taken off and I don't think they are that far ahead. The Government need to be a bit more forward thinking. I've been in contact with people over in the

UK and attended conferences and there is no doubt they are ahead of us, but they are not leaving us behind. We are improving in Ireland because people are tired of the traditional system and the recession did not help. We were too busy and big to notice what everyone else was doing.

Barry *Should the Irish Government start working towards the mandating of BIM?*

BC The UK Government and the Irish Government are not going to be a hundred miles behind each other. Ireland have been progressing in a number of areas and I do not see why we can't be world leaders in this. We have been at the forefront of the smoking ban and we have progressed in other ways. The biggest drivers will be contractors, as it will be those guys who will save time.

Barry *Are the contractors not the people most in danger within these contracts?*

BC Contractors need to be more cost certain. From the Client's point of view, they are using the new contracts to control cost within a traditional design team. If the contractor is going to make a profit out of these contracts, then they need to be assured of the quality of the drawings. They can use clash detection achieve this.

APPENDIX 2 – TARGETED ORGANISATIONS FOR THE BIM IN IRELAND SURVEY

The BIM in Ireland survey detailed in chapter five utilised the CitA member database, which consisted of 141 members, which catered for a broad cross-section of stakeholders within the Irish AEC/FM and training sector. A sample size of 113 organisations were selected from this database. Table 2A details the companies selected for the survey. Authorities or professional bodies were not contacted.

Nr	CITA Active Database	Contacted	
		Yes	No
1	ArcDox		
2	Arthur Gibney & Partners		
3	ARUP		
4	Athlone Institute of Technology		
5	Austin Reddy & Company		
6	Autodesk		
7	BAM Construction Ltd.		
8	Bank of Ireland		
9	Baseline CS Ltd		
10	BENTLEY SYSTEMS		
11	BER Directory.ie		
12	Blanchardstown Institute of Technology		
13	Bruce Shaw		
14	BSS Software Services		
15	Burdens		
16	Carlow IT		
17	CEMAR		
18	Chevron Training		
19	CIBSE		
20	CIF		
21	CIOB		
22	Coady Partnership Architects		
23	Concept 2 Achievement		
24	Construction Industry Council		
25	Construction Information Services		
26	Construction IT Alliance		
27	Cork Institute of Technology		
28	Cosgrave Developments		
29	Creative Tension		
30	Cronin & Sutton Consulting		
31	Cummins & Voortman Architects		
32	DATECH Ireland		
33	David Flynn Ltd.		

Nr	CITA Active Database	Contacted	
34	David McLoughlin & Associates		
35	Davis Langdon		
36	DCS+P		
37	Dedicated CAD Systems Ltd		
38	Delap & Waller		
39	Devereaux Architecture (PM Group)		
40	DG Group		
41	Diatec Graphic Products Ltd		
42	DPS Engineering Ltd		
43	Dublin City Council		
44	Dublin Institute of Technology		
45	Dundalk Institue of Technology		
46	ECI M2		
47	Eden Training		
48	Egan & Associates		
49	EIDA Solutions Ltd		
50	Engineers Ireland		
51	Enterprise Europe Network		
52	Enterprise Ireland		
53	Equator Architects		
54	E-Tenders Solutions Ltd		
55	Ethos Engineering Ltd		
56	Exchequer Software (Ireland) Ltd		
57	Fingal County Council		
58	Fumbally Exchange		
59	G and T Crampton		
60	GMIT		
61	Graphisoft UK Ltd		
62	Gypsum Industries Ltd.		
63	Hackett Reprographics		
64	Hanley Pepper		
65	Homan O'Brien		
66	Intel		
67	IRDG		
68	Irish Exporters Association		
69	Irish Passive House Academy		
70	Irish Software Innovation Network		
71	ISAC CRH Computer Services		
72	IStructE		
73	John Paul Construction		
74	John Sisk and Sons Ltd.		
75	Jones Engineering		
76	Kerrigan Sheanon Newman		
77	Kingspan Limited		

Nr	CITA Active Database	Contacted	
78	Konectall		
79	Korec Group		
80	Letterkenny Institute of Technology		
81	LGCSB		
82	Limerick Institute of Technology		
83	Linham Construction Limited		
84	Masonry Fixings		
85	McDonald Surveys		
86	McGahon Surveyors		
87	MDY Construction		
88	Mercury Engineering		
89	Mulcahy McDonagh and Partners		
90	Murphy McGerr Architecture		
91	Murphy Surveys		
92	National Development Finance Agency		
93	National Digital Research Centre		
94	Nicholas O’Dwyer Ltd		
95	NJ OGorman		
96	Nugent Manufacturing		
97	O Sheas Builders		
98	O"Connor Sutton Cronin Consulting		
99	Office of Public Works		
100	Outsource ATS Ltd		
101	P J Hegarty and Sons		
102	P J Walls Ltd.		
103	PM Group		
104	PMO Ltd		
105	Programme Project Management Ltd		
106	PUNCH Consulting Engineers		
107	Quigg Golden Limited		
108	Railway Procurement Agency		
109	Reddy Architecture		
110	Roankabin		
111	Rothborn FM		
112	Roughan & O'Donovan		
113	RPS Consulting Engineers		
114	Ryan Architectural Solutions Ltd.		
115	SCEG		
116	Scott Tallon Walker		
117	SIAC Construction Ltd		
118	Sierra Communications		
119	SIG Ireland		
120	Siteserv Access & Formwork Ltd		
121	Sketchrender		

Appendix 2 – Targeted Organisations for the BIM in Ireland Survey

Nr	CITA Active Database	Contacted	
122	Skillnets		
123	Smartbuilder Software Ltd		
124	SMP		
125	Society of Chartered Surveyors		
126	Sweeney Sheet Metal Ltd		
127	Synchro Ltd		
128	Talbot and Associates		
129	Tekla		
130	The RIAI		
131	Thermodial		
132	Thomas Garland & Partners		
133	Tralee Institute of Technology		
134	Trevor Wood Consulting Engineers		
135	Trinity College Dublin		
136	Tualatin		
137	University College Cork		
138	University College Dublin		
139	Varmings		
140	Waterford Institute of Technology		
141	Winthrop Engineering & Contracting		

Table 2A: CitA Membership Databased utilised for the BIM in Ireland Survey 2012

APPENDIX 2 – PILOT OF BIM FOR IRELAND SURVEY

An online pilot survey of the BIM in Ireland survey was initially distributed to a small number of knowledgeable BIM persons in Ireland. Two members from the RIAI Workshop (detailed in chapter four) and two senior academics were selected to complete a pilot survey. The questions asked within the pilot survey are detailed in the next four sections.

SECTION 1 - RESPONDENT DETAILS (SECTION 1/4)

1. **Please indicate in which of the following sectors you/your organisation primarily operate:**
    - Architecture
    - Quantity Surveying
    - Contractors
    - Engineering
    - Consulting
    - Suppliers
    - Facility Managers

2. **Please indicate what is your profession**
    - Architect
    - Architectural Technologist
    - Quantity Surveyor
    - Structural Engineer
    - Mechanical Engineer
    - Electrical Engineer
    - Civil Engineer
    - Contractor
    - Software Engineer
    - Software Vendor
    - Building Services Engineer
    - Landscaper

- Interior Designer
- Manufacturer Facility Manager
- Property Developer
- Project Manager
- Law
- Other (please specify)

3. **Please indicate in what geographical region you work in? (Multiple answers permitted)?**
    - Leinster
    - Munster
    - Connacht
    - Ulster

4. **How much of your work is done internationally?**

1) None 2) 0-10% 3)10-20% 4)20 -30% 5)30-40% 6)40-49% 7) over 50%

5. **What is your current awareness and use of BIM?**
    - Just beginning to take notice of BIM.
    - Aware and currently using BIM.
    - I have never heard or participated in BIM.

SECTION 2 USE OF CAD AND BIM

Building Information Modelling (BIM) is a process of generating and managing, reliable & coordinated building design and construction documentation, within a data-rich virtual 3D model, which can be used throughout a project's life cycle. The revolution of BIM across the global construction world continues to grow with various countries including the USA, Finland, Norway, Denmark, UK, Germany, Singapore and Korea, who are all currently in the process of developing BIM guidelines.

Please indicate your level of support towards the following

6. **What is your organisation's use of CAD (Multiple Answers Permitted)?**
    - No CAD

- 2D only
- 2D and 3D CAD
- 3D only
- 3D with intelligent data

7. **When producing CAD drawings which of the following tools do you mainly use?**

- Autodesk AutoCAD.
- Autodesk AutoCAD LT.
- Autodesk Revit.
- Nemetschek Vectorworks.
- Graphisoft ArchiCAD.
- Google Sketchup.
- Bentley Microstation.
- Bentley Building Suite.
- Nemetscheck Allplan.
- Other (please specify).

8. **Please indicate your level of support for the following statements?**

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- BIM requires changes in our workflow and practices.
- BIM improves visualisation of the project.
- BIM increases co- ordination of construction documents.
- Clients will increasingly insist on us adopting BIM.
- BIM brings cost efficiencies.
- BIM increases speed of delivery.
- Adopting BIM increases our profitability.
- The government will make people use BIM for the public sector.
- The industry is not clear enough on what BIM is yet.
- We will need BIM so we can design sustainable buildings.
- BIM is all about software.
- BIM does not facilitate bespoke design or construction.

- BIM is just a synonym for 3D CAD drawings.

9. How much do you agree with the following suggestions in trying to improve the value of BIM within the Irish AEC / FM Sector?

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- Improved interoperability between software applications.
- More 3D building product manufacturer specific content.
- Improved functionality of BIM software.
- More clients asking for BIM.
- More clearly defined BIM deliverables between parties.
- More external firms with BIM skills.
- More internal staff with BIM skills.
- Reduced cost of BIM software.
- More use of contracts to support BIM and collaboration.
- Willingness of Authorities to accept models.
- More incoming entry level staff with BIM skills.
- More hard data demonstrating the business value of BIM.
- More readily available training in BIM.
- Have you any further further recommendations in improving the value of BIM within Ireland (Optional).

10. What do you believe your projected use of BIM will be in 5 years?

- We currently use BIM.
- In one year we will use BIM.
- In three years we will use BIM.
- In five years we will use BIM.

11. What do you believe the Importance of BIM will be in in five years?

- No importance.
- Low importance.

- Moderate importance.
- High importance.
- Very High importance.
- Where do you see BIM in 5 years from no (Optional)?

SECTION 3 - USE OF BIM ON PUBLIC SECTOR (SECTION 3/4)

The CWMF is a series of documents which collectively describe the operating environment, procedures and processes to be followed for the delivery of capital works projects. The aim of the CWMF is to ensure that there is an integrated methodology and a consistent approach to the planning, management and delivery of public capital works projects, with the objectives of greater cost certainty, better value for money and more efficient project delivery.

The next questions will aim gather your opinion and recommendations in regards to the adoption of BIM within this framework

12. Do you have any experience in working within the CWMF and the GCCC forms of contract?

- Yes
- No

13. If you answered yes to Question 12 then please answer question 13 and 14. If you answered no to question 12 please move on to Question 15

Under what GCCC contract have you tendered / worked? (Multiple answers permitted)

- Building Works Designed by the Employer.
- Building Works Designed by the Contractor.
- Civil Engineering Works Designed by the Employer.
- Civil Engineering Works Designed by the Contractor.
- Civil Engineering and Building Works Designed by the Employer.

14. Have these contracts based on your experience provided

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- Greater cost certainty.
- Rebalance of risk.
- Value for Money.
- Efficient delivery of projects.
- Any Further Comments (Optional).

15. **There is a plan for a phased five-year development within the UK that public works projects will be required to use BIM techniques from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government client would have an estate that was smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions.**

Based on your extensive or brief knowledge of BIM do you believe that the Irish Government should follow in the footsteps of the UK?

- Yes.
- Neither Yes or No.
- No.
- Please indicate the reason for your answer (Optional).

16. **The overreaching aim of the CWMF is:**
    1. **Move towards greater cost certainty at contract award stage and ensure, as far as practicable, that the accepted tender prices and the final cost are the same.**
    2. **Award contracts on the basis of a lump-sum fixed-price to the greatest extent possible.**
    3. **Rebalance risk, so that there is optimal allocation of risk.**
    4. **Achieve value for money.**
    5. **Achieve more efficient delivery of the project**

Using your extensive or brief knowledge of BIM please indicate your level of support for the following suggestions in the use of BIM in meeting these objectives.

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- BIM can provide a greater cost certainty as the mass model studies allow design teams to design to a cost, rather than cost to design.
- The BIM model provides exercises in design, programming, cost, value management and concept energy analysis allowing a more accurate financial assessment for a contract with a fixed price.
- The risk factor can be better predicted through having a virtual model which enables clash detection and avoidance of a number of eventualities.
- Value for Money – BIM enables a whole life cycle approach, through its unique access to a combination of energy analysis tools that complement the BIM process. This approach offers a much greater value for money to the client as it addresses their needs over the structures life.
- Efficient delivery of the projects – BIM enables testing of design solutions to provide a more responsive building design to the client brief, and, better coordination of all project information.
- Have you any further comments in regards to adopting BIM within the CWMF (optional).

17. This question is optional

If the Irish Government decided to follow the UK standards to implement a level 2 BIM (File Based Collaboration and Library Management) requirement by 2016 what in your opinion do you perceive to be the biggest advantage / barrier and how best should they go around ensuring its success?

SECTION 4 - THE GOVERMENT ESTATE AND BIM (SECTION 4/4)

The final section of the Survey will address BIM in regards to managing the Government's estate

18. By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. There are at present robust tools existing within BIM to

help in reducing significant carbon emissions through performing analyses on energy performance, lighting and HVAC systems.

Taking into consideration your knowledge of BIM do you believe that BIM can ensure a smarter and carbon free estate for the Irish Government?

- BIM is the answer to a carbon free future.
- BIM can play a significant role in ensuring we meet 2018 targets.
- I am undecided to its use as a tool to reduce carbon.
- BIM can play a minor role in ensuring we meet 2018 targets.
- BIM has no role to play in low carbon management.
- Have you any further comments in regards to the role BIM can play in ensuring a low carbon future (Optional).

19. **Ireland also faces significant problems in the near future through the "retro-fitting" of its existing building stock to meet carbon targets. The McGraw–Hill Green BIM Report (2010) states that Green BIM practitioners find BIM to be particularly useful when it comes to green retro– fitting with over 25% of the survey participants view BIM as highly applicable for use in green retrofits.**

Taking into your consideration your knowledge of BIM do you believe that BIM can ensure that the retro fitting of existing stock can meet carbon targets?

- BIM is the answer to ensuring that the retro fitting of existing stock meets carbon targets.
- BIM can play a significant role in ensuring we meet retro fitting existing stock carbon targets.
- I am undecided to its use as a tool to reduce carbon on the retro fitting of existing building stock.
- BIM can play a minor role in ensuring the retro fitting of existing stock meets carbon targets.
- BIM has no role to play in ensuring the retro fitting of existing stock meets carbon targets.
- Have you any further comments in regards to the role BIM can play in ensuring a low carbon future for the retro fitting of existing stock

- (Optional).

20. The BIM model used during the initial design and construction stage can be used effectively in the Facilities Management (FM) and the deconstruction stage, ultimately resulting in a whole life cycle BIM model. In regards to FM it is noted that the BIM model can ensure amongst other things Improved space management, efficient use of energy's, streamlined preventive maintenance, etc

What is your views in regards to the usefulness of BIM in been used a FM tool to manage a Public Works Project?

- BIM can be a crucial FM tool in managing the Government's estate.
- BIM can be a significant FM tool in managing the Government's estate.
- I am undecided to the use of BIM as a FM tool.
- BIM can play a minor role as a FM tool in managing the Government's estate.
- BIM has no role to play in the FM process.
- Have you any further comments on the use of BIM as a FM tool?

APPENDIX 2 –BIM FOR IRELAND SURVEY QUESTIONNAIRE

As detailed previously a total of 113 organisations were selected from the CitA membership community to partake in a survey. A date was fixed for completion of the survey which the author extended by ten days in order to generate more responses.

The author chose that questions would predominantly be asked within, a closed ended format, as it was felt given the unfamiliarity from some of the sample in regards to BIM, that an open ended format could prove to be too demanding. As this survey was intended to feed into a more detailed FM focused survey, it was decided that close ended questioning would make the analysis less challenging. However, one open ended question was included to ensure those who had used or were aware of BIM had an opportunity to provide some qualitative feedback. The closed nature of the questions was purposefully varied, ranging from closed-ended with ordered choices and partially closed-end questions. Some of the questions were designed on a contingency basis, so that they were only applicable to a certain section of the respondents who met the set credentials. The questionnaire is detailed in the next four sections.

SECTION 1 - RESPONDENT DETAILS

1. **Please indicate in which of the following sectors you/your organisation primarily operate:**
    - Architecture
    - Quantity Surveying
    - Contractors
    - Engineering
    - Consulting
    - Suppliers
    - Facility Managers
    - Training and Education
    - IT Vendors
    - Business Services

2. **Please indicate what is your profession**

- Architect
- Architectural Technologist
- Quantity Surveyor
- Structural Engineer
- Mechanical Engineer
- Electrical Engineer
- Civil Engineer
- Contractor
- Software Engineer
- Software Vendor
- Building Services Engineer
- Landscaper
- Interior Designer
- Manufacturer Facility Manager
- Property Developer
- Project Manager
- Law
- Other (please specify)

3. How much of your work is done internationally?

1) None 2) 0-10% 3)10-20% 4)20 -30% 5)30-40% 6)40-49% 7) over 50%

4. What is your current awareness and use of BIM?

- Just beginning to take notice of BIM.
- Aware and currently using BIM.
- I have never heard or participated in BIM.

SECTION 2 - USE OF CAD AND BIM

Building Information Modelling (BIM) is a process of generating and managing, reliable & coordinated building design and construction documentation, within a data-rich virtual 3D model, which can be used throughout a project's life cycle. The revolution of BIM across the global construction world continues to grow with various countries including the USA, Finland, Norway, Denmark, UK, Germany, Singapore and Korea, who are all currently in the process of developing BIM guidelines.

Please indicate your level of support towards the following

5. What is your organisation's use of CAD (Multiple Answers Permitted)?

- No CAD
- 2D only
- 2D and 3D CAD
- 3D only
- 3D with intelligent data
- Other (Please Specify)

6. When producing CAD drawings which of the following tools do you mainly use?

- Autodesk AutoCAD.
- Autodesk AutoCAD LT.
- Autodesk Revit.
- Nemetschek Vectorworks.
- Graphisoft ArchiCAD.
- Google Sketchup.
- Bentley Microstation.
- Bentley Building Suite.
- Nemetscheck Allplan.
- Other (please specify).

7. Please indicate your level of support for the following statements?

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- BIM requires changes in our workflow and practices.
- BIM improves visualisation of the project.
- BIM increases co- ordination of construction documents.
- Clients will increasingly insist on us adopting BIM.
- BIM brings cost efficiencies.

- BIM increases speed of delivery.
- Adopting BIM increases our profitability.
- The government will make people use BIM for the public sector.
- The industry is not clear enough on what BIM is yet.
- We will need BIM so we can design sustainable buildings.
- BIM is all about software.
- BIM does not facilitate bespoke design or construction.
- BIM is just a synonym for 3D CAD drawings.

8. How much do you agree with the following suggestions in trying to improve the value of BIM within the Irish AEC / FM Sector?

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- Improved interoperability between software applications.
- More 3D building product manufacturer specific content.
- Improved functionality of BIM software.
- More clients asking for BIM.
- More clearly defined BIM deliverables between parties.
- More external firms with BIM skills.
- More internal staff with BIM skills.
- Reduced cost of BIM software.
- More use of contracts to support BIM and collaboration.
- Willingness of Authorities to accept models.
- More incoming entry level staff with BIM skills.
- More hard data demonstrating the business value of BIM.
- More readily available training in BIM.
- Have you any further recommendations in improving the value of BIM within Ireland (Optional).

9. What do you believe your projected use of BIM will be in 5 years?

- We currently use BIM.
- In one year we will use BIM.

- In three years we will use BIM.
- In five years we will use BIM.

10. What do you believe the Importance of BIM will be in in five years?

- No importance.
- Low importance.
- Moderate importance.
- High importance.
- Very High importance.
- Where do you see BIM in 5 years from no (Optional)?

SECTION 3 - USE OF BIM ON PUBLIC SECTOR (SECTION 3/4)

The CWMF is a series of documents which collectively describe the operating environment, procedures and processes to be followed for the delivery of capital works projects. The aim of the CWMF is to ensure that there is an integrated methodology and a consistent approach to the planning, management and delivery of public capital works projects, with the objectives of greater cost certainty, better value for money and more efficient project delivery.

The next questions will aim gather your opinion and recommendations in regards to the adoption of BIM within this framework

11. Do you have any experience in working within the CWMF and the GCCC forms of contract?

- Yes
- No

12. If you answered yes to Question 12 then please answer Question 13 and 14. If you answered no to Question 12 please move on to Question 15

Under what GCCC contract have you tendered / worked? (Multiple answers permitted)

- Building Works Designed by the Employer.
- Building Works Designed by the Contractor.
- Civil Engineering Works Designed by the Employer.

- Civil Engineering Works Designed by the Contractor.
- Civil Engineering and Building Works Designed by the Employer.

13. Have these contracts based on your experience provided

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- Greater cost certainty.
- Rebalance of risk.
- Value for Money.
- Efficient delivery of projects.
- Any Further Comments (Optional).

14. There is a plan for a phased five-year development within the UK that public works projects will be required to use BIM techniques from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government client would have an estate that was smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions.

Based on your extensive or brief knowledge of BIM do you believe that the Irish Government should follow in the footsteps of the UK?

- Yes.
- Neither Yes or No.
- No.
- Please indicate the reason for your answer (Optional).

15. The overreaching aim of the CWMF is:

1. **Move towards greater cost certainty at contract award stage and ensure, as far as practicable, that the accepted tender prices and the final cost are the same.**
2. **Award contracts on the basis of a lump-sum fixed-price to the greatest extent possible.**
3. **Rebalance risk, so that there is optimal allocation of risk.**
4. **Achieve value for money.**
5. **Achieve more efficient delivery of the project**

Using your extensive or brief knowledge of BIM please indicate your level of support for the following suggestions in the use of BIM in meeting these objectives.

Options: 1) Strongly Agree 2) Agree 3) Neither Agree or Disagree 4) Disagree 5) Strongly Disagree

- BIM can provide a greater cost certainty as the mass model studies allow design teams to design to a cost, rather than cost to design.
- The BIM model provides exercises in design, programming, cost, value management and concept energy analysis allowing a more accurate financial assessment for a contract with a fixed price.
- The risk factor can be better predicted through having a virtual model which enables clash detection and avoidance of a number of eventualities.
- Value for Money – BIM enables a whole life cycle approach, through its unique access to a combination of energy analysis tools that complement the BIM process. This approach offers a much greater value for money to the client as it addresses their needs over the structures life.
- Efficient delivery of the projects – BIM enables testing of design solutions to provide a more responsive building design to the client brief, and, better coordination of all project information.
- Have you any further comments in regards to adopting BIM within the CWMF (optional).

16. This question is optional

If the Irish government decided to follow the UK standards to implement a level 2 BIM (File Based Collaboration and Library Management) requirement by 2016 what in your opinion do you perceive to be the biggest advantage / barrier and how best should they go around ensuring its success?

SECTION 4 - THE GOVERMENT ESTATE AND BIM (SECTION 4/4)

The final section of the Survey will address BIM in regards to managing the Government's estate

17. By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. There are at present robust tools existing within BIM to help in reducing significant carbon emissions through performing analyses on energy performance, lighting and HVAC systems.

Taking into consideration your knowledge of BIM do you believe that BIM can ensure a smarter and carbon free estate for the Irish Government?

- BIM is the answer to a carbon free future.
- BIM can play a significant role in ensuring we meet 2018 targets.
- I am undecided to its use as a tool to reduce carbon.
- BIM can play a minor role in ensuring we meet 2018 targets.
- BIM has no role to play in low carbon management.
- Have you any further comments in regards to the role BIM can play in ensuring a low carbon future (Optional).

18. Ireland also faces significant problems in the near future through the "retro-fitting" of its existing building stock to meet carbon targets. The McGraw–Hill Green BIM Report (2010) states that Green BIM practitioners find BIM to be particularly useful when it comes to green retro– fitting with over 25% of the survey participants view BIM as highly applicable for use in green retrofits.

Taking into your consideration your knowledge of BIM do you believe that BIM can ensure that the retro fitting of existing stock can meet carbon targets?

- BIM is the answer to ensuring that the retro fitting of existing stock meets carbon targets.
- BIM can play a significant role in ensuring we meet retro fitting existing stock carbon targets.
- I am undecided to its use as a tool to reduce carbon on the retro fitting of existing building stock.
- BIM can play a minor role in ensuring the retro fitting of existing stock meets carbon targets.

- BIM has no role to play in ensuring the retro fitting of existing stock meets carbon targets.
- Have you any further comments in regards to the role BIM can play in ensuring a low carbon future for the retro fitting of existing stock
- (Optional).

19. **The BIM model used during the initial design and construction stage can be used effectively in the Facilities Management (FM) and the deconstruction stage, ultimately resulting in a whole life cycle BIM model. In regards to FM it is noted that the BIM model can ensure amongst other things Improved space management, efficient use of energy's, streamlined preventive maintenance, etc.**

What is your views in regards to the usefulness of BIM in been used a FM tool to manage a Public Works Project?

- BIM can be a crucial FM tool in managing the Government's estate.
- BIM can be a significant FM tool in managing the Government's estate.
- I am undecided to the use of BIM as a FM tool.
- BIM can play a minor role as a FM tool in managing the Government's estate.
- BIM has no role to play in the FM process.
- Have you any further comments on the use of BIM as a FM tool?

20. **At present there are a number of events taking place within Ireland to help promote the process of BIM. The purpose of the last two sections of this survey was to gather your views on the possibility of mandating a BIM process on public works projects in Ireland. Please indicate any further recommendations below, if some areas that you believe are of further concern that have not been adequately addressed in this survey.**

APPENDIX 2 - SPSS PROCESS

Method of Results

The author used the programme IBM SPSS Statistics 21 to analyse his results for the BIM in Ireland survey. The first step was to input the results of the actual survey into this programme. There are two windows in the programme the variable and data view. An image of the screenshot is shown illustrated in the figure 2A.

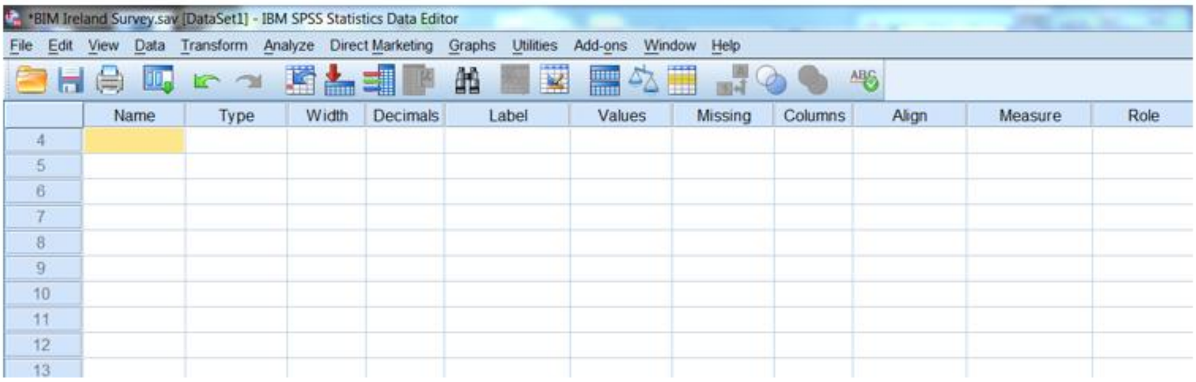


Figure 2A: SPSS Variable View (Source IBM SPSS Statistics 21)

Within the variable view there are a number of columns that required populating, as detailed below

- Name: This is the name of the variable and must be unique. This name will also correspond to a similar cell in the data view. For Q1 “Please indicate in which of the following sectors you /your organisation primarily operate” the variable was called “Sector”. This was repeated for each question.
- Type: There are two types of variables that must be selected here, either a numeric value that must be aligned to a numeric value or string value that may have letters or numbers. All the values are numeric based for this analysis.
- Width: The width of a variable is the number of characters SPSS will allow to be entered for the variable.
- Decimals: This columns represents the number of decimal places that can be displayed.
- Label: The label section is where the actual question that was asked in the survey is imported.

- Values: This is where you assign your ranking system for each question. Each question will require value labels, so as SPSS can correspond their values to data entered in the data view. For Q3 "What is your current awareness of BIM" the following values where entered into the values column for that question
  1. = Just beginning to take notice of BIM
  2. = Aware and currently using BIM
  3. = I have never heard or participated in BIM

A screenshot of the screenshot is shown illustrated in the figure 2B.

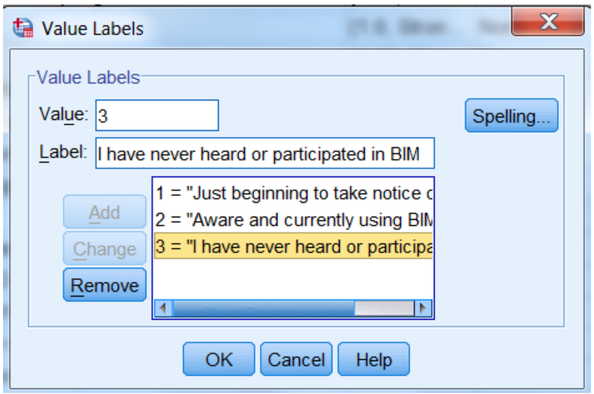


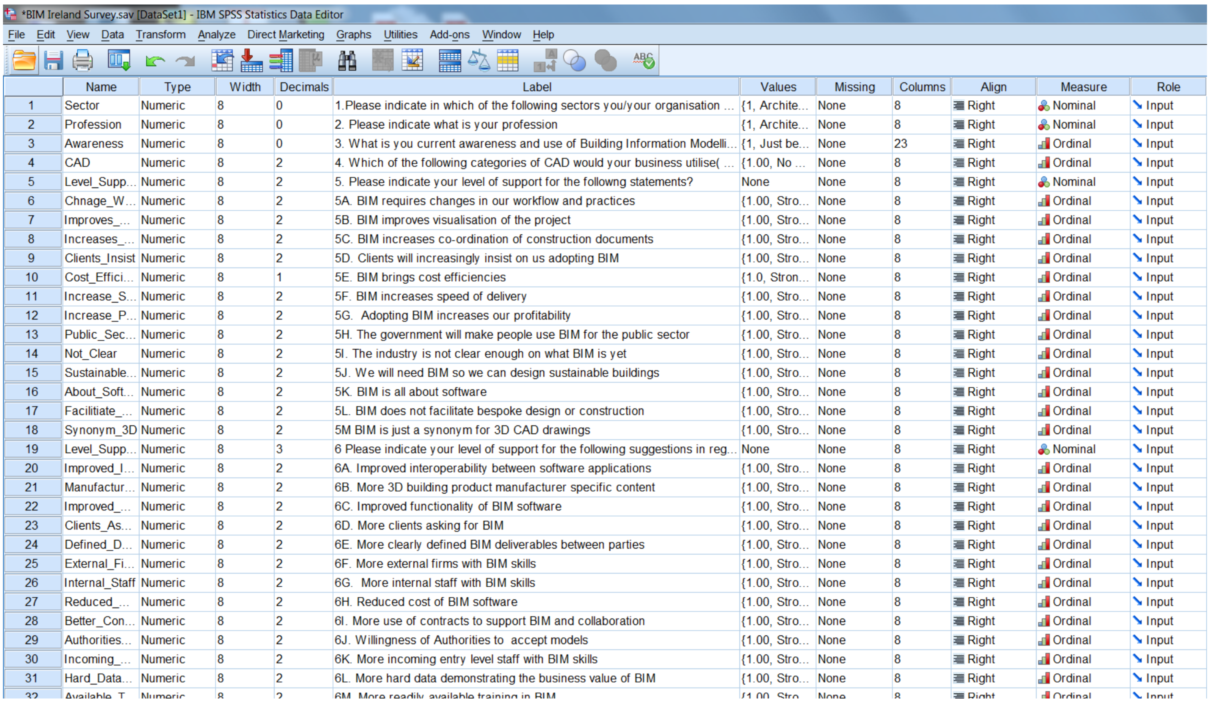
Figure 2B: SPSS Value Labels (Source IBM SPSS Statistics 21)

- Missing: This will signal to SPSS that data should be treated as missing, even though there is some other numerical code recorded instead of the data.
- Columns: This tells SPSS how much space is allocated rather than the degree to which it is filled.
- Align: This columns is for aligning the text to whatever side is chosen i.e. left, right, justified, etc.
- Measure: This columns informs the programme between nominal, ordinal and scale. The difference between the three are as follows
  1. A nominal scale is one with no order or rank i.e. what is your profession.
  2. Ordinal Scale: There is an order to the selection but the difference between each choice is not set i.e. very aware, aware, not aware, etc.
  3. Rank: This is an agreed ranking system between each option that can be easily measured i.e. salary rank, percentage of international work, etc.

The majority of questions where measured on an ordinal basis, as the answers provided where in the form of a Likert scale. For Q 8 "What do you believe your projected use of BIM will be in 5 years" there was five answers provided ranging from very important to no important. The five answers where given a ranking scale of 1-5. However despite the difference between very important (Rank 1) and low importance (Rank 4) been computed as 3 (1 – 4 =3), there is still no accurate measurement of what exactly this value means. While in a scale system for salary in where the choices range from 10,000 to 5000, an accurate numeric value can be calculated to determine the difference of pay between employees.

- Role: The role that a variable will play in your analyses.

Figure 2C details the completed sheet for the inputted data.

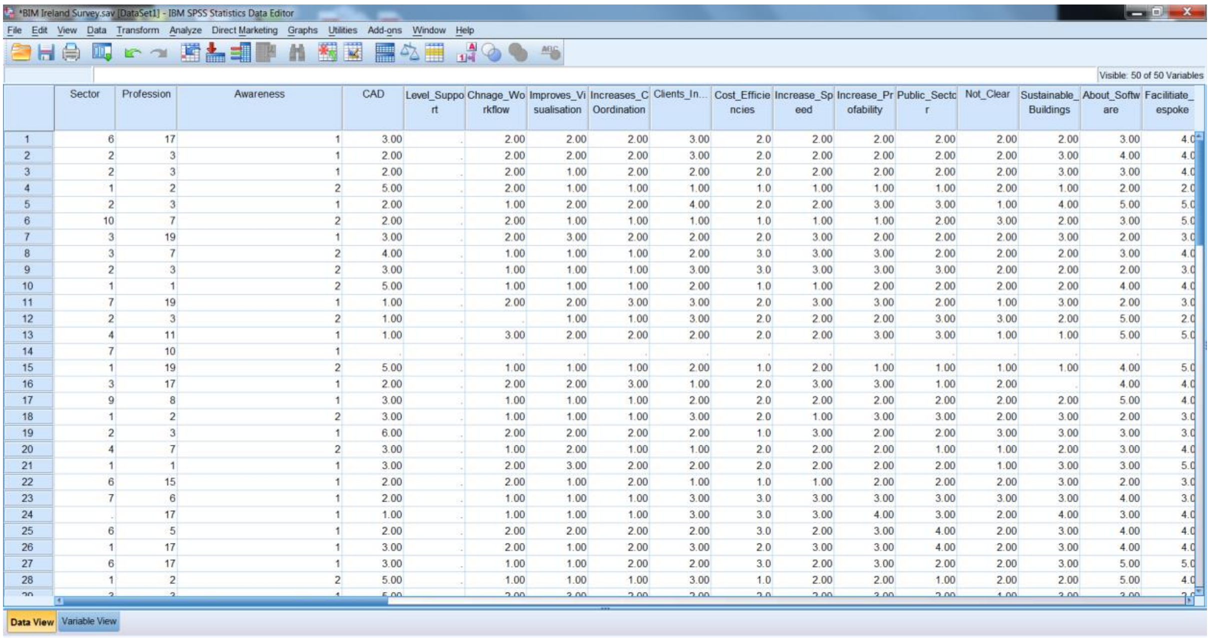

*BIM Ireland Survey.sav [DataSet1] - IBM SPSS Statistics Data Editor

File Edit View Data Transform Analyze Direct Marketing Graphs Utilities Add-ons Window Help

	Name	Type	Width	Decimals	Label	Values	Missing	Columns	Align	Measure	Role
1	Sector	Numeric	8	0	1.Please indicate in which of the following sectors you/your organisation ...	{1, Archite...	None	8	Right	Nominal	Input
2	Profession	Numeric	8	0	2. Please indicate what is your profession	{1, Archite...	None	8	Right	Nominal	Input
3	Awareness	Numeric	8	0	3. What is you current awareness and use of Building Information Modelli...	{1, Just be...	None	23	Right	Ordinal	Input
4	CAD	Numeric	8	2	4. Which of the following categories of CAD would your business utilise(...	{1.00, No ...	None	8	Right	Ordinal	Input
5	Level_Supp...	Numeric	8	2	5. Please indicate your level of support for the followng statements?	None	None	8	Right	Nominal	Input
6	Chnage_W...	Numeric	8	2	5A. BIM requires changes in our workflow and practices	{1.00, Stro...	None	8	Right	Ordinal	Input
7	Improves_...	Numeric	8	2	5B. BIM improves visualisation of the project	{1.00, Stro...	None	8	Right	Ordinal	Input
8	Increases_...	Numeric	8	2	5C. BIM increases co-ordination of construction documents	{1.00, Stro...	None	8	Right	Ordinal	Input
9	Clients_Insist	Numeric	8	2	5D. Clients will increasingly insist on us adopting BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
10	Cost_Effici...	Numeric	8	1	5E. BIM brings cost efficiencies	{1.0, Stron...	None	8	Right	Ordinal	Input
11	Increase_S...	Numeric	8	2	5F. BIM increases speed of delivery	{1.00, Stro...	None	8	Right	Ordinal	Input
12	Increase_P...	Numeric	8	2	5G. Adopting BIM increases our profitability	{1.00, Stro...	None	8	Right	Ordinal	Input
13	Public_Sec...	Numeric	8	2	5H. The government will make people use BIM for the public sector	{1.00, Stro...	None	8	Right	Ordinal	Input
14	Not_Clear	Numeric	8	2	5I. The industry is not clear enough on what BIM is yet	{1.00, Stro...	None	8	Right	Ordinal	Input
15	Sustainable...	Numeric	8	2	5J. We will need BIM so we can design sustainable buildings	{1.00, Stro...	None	8	Right	Ordinal	Input
16	About_Soft...	Numeric	8	2	5K. BIM is all about software	{1.00, Stro...	None	8	Right	Ordinal	Input
17	Facilitiate_...	Numeric	8	2	5L. BIM does not facilitate bespoke design or construction	{1.00, Stro...	None	8	Right	Ordinal	Input
18	Synonym_3D	Numeric	8	2	5M BIM is just a synonym for 3D CAD drawings	{1.00, Stro...	None	8	Right	Ordinal	Input
19	Level_Supp...	Numeric	8	3	6 Please indicate your level of support for the following suggestions in reg...	None	None	8	Right	Nominal	Input
20	Improved_I...	Numeric	8	2	6A. Improved interoperability between software applications	{1.00, Stro...	None	8	Right	Ordinal	Input
21	Manufactur...	Numeric	8	2	6B. More 3D building product manufacturer specific content	{1.00, Stro...	None	8	Right	Ordinal	Input
22	Improved_...	Numeric	8	2	6C. Improved functionality of BIM software	{1.00, Stro...	None	8	Right	Ordinal	Input
23	Clients_As...	Numeric	8	2	6D. More clients asking for BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
24	Defined_D...	Numeric	8	2	6E. More clearly defined BIM deliverables between parties	{1.00, Stro...	None	8	Right	Ordinal	Input
25	External_Fi...	Numeric	8	2	6F. More external firms with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
26	Internal_Staff	Numeric	8	2	6G. More internal staff with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
27	Reduced_...	Numeric	8	2	6H. Reduced cost of BIM software	{1.00, Stro...	None	8	Right	Ordinal	Input
28	Better_Con...	Numeric	8	2	6I. More use of contracts to support BIM and collaboration	{1.00, Stro...	None	8	Right	Ordinal	Input
29	Authorities...	Numeric	8	2	6J. Willingness of Authorities to accept models	{1.00, Stro...	None	8	Right	Ordinal	Input
30	Incoming_...	Numeric	8	2	6K. More incoming entry level staff with BIM skills	{1.00, Stro...	None	8	Right	Ordinal	Input
31	Hard_Data...	Numeric	8	2	6L. More hard data demonstrating the business value of BIM	{1.00, Stro...	None	8	Right	Ordinal	Input
32	Available_T...	Numeric	8	2	6M. More readily available training in BIM	{1.00, Stro...	None	8	Right	Ordinal	Input

Figure 2C: SPSS complete variable view (Source IBM SPSS Statistics 21)

The data view section sheet represents the responses from the survey. However, each response must be converted to the value assigned in the variable value, as per the column "Values". As explained each question is ranked on an ordinal value scale. These responses from the survey must be converted to these values i.e. when imputing one of the respondents answers, all their responses must be converted to the set value. Using the example above of "What is your current awareness of BIM" in where the respondent selected "I have never heard or participated in BIM", this would be represented in the data view as "2" in which corresponds to the assigned ranking value. A picture of the completed data view is shown in the figure 2D.



	Sector	Profession	Awareness	CAD	Level_Support	Chnage_Workflow	Improves_Visualisation	Increases_COordination	Clients_In...	Cost_Efficiencies	Increase_Speed	Increase_Profability	Public_Sector	Not_Clear	Sustainable_Buildings	About_Software	Facilitiate_Bespoke
1	6	17	1	3.00	.	2.00	2.00	2.00	3.00	2.0	2.00	2.00	2.00	2.00	2.00	3.00	4.0
2	2	3	1	2.00	.	2.00	2.00	2.00	3.00	2.0	2.00	2.00	2.00	2.00	3.00	4.00	4.0
3	2	3	1	2.00	.	2.00	1.00	2.00	2.00	2.0	2.00	2.00	2.00	2.00	3.00	3.00	4.0
4	1	2	2	5.00	.	2.00	1.00	1.00	1.00	1.0	1.00	1.00	1.00	2.00	1.00	2.00	2.0
5	2	3	1	2.00	.	1.00	2.00	2.00	4.00	2.0	2.00	3.00	3.00	1.00	4.00	5.00	5.0
6	10	7	2	2.00	.	2.00	1.00	1.00	1.00	1.0	1.00	1.00	2.00	3.00	2.00	3.00	5.0
7	3	19	1	3.00	.	2.00	3.00	2.00	2.00	2.0	3.00	2.00	2.00	2.00	3.00	2.00	3.0
8	3	7	2	4.00	.	1.00	1.00	1.00	2.00	3.0	3.00	3.00	2.00	2.00	2.00	3.00	4.0
9	2	3	2	3.00	.	1.00	1.00	1.00	3.00	3.0	3.00	3.00	3.00	2.00	2.00	2.00	3.0
10	1	1	2	5.00	.	1.00	1.00	1.00	2.00	1.0	1.00	2.00	2.00	2.00	2.00	4.00	4.0
11	7	19	1	1.00	.	2.00	2.00	3.00	3.00	2.0	3.00	3.00	2.00	1.00	3.00	2.00	3.0
12	2	3	2	1.00	.	.	1.00	1.00	3.00	2.0	2.00	2.00	3.00	3.00	2.00	5.00	2.0
13	4	11	1	1.00	.	3.00	2.00	2.00	2.00	2.0	2.00	3.00	3.00	1.00	1.00	5.00	5.0
14	7	10	1	.	.	.	.	.	.	.	.	.	.	.	.	.	
15	1	19	2	5.00	.	1.00	1.00	1.00	2.00	1.0	2.00	1.00	1.00	1.00	1.00	4.00	5.0
16	3	17	1	2.00	.	2.00	2.00	3.00	1.00	2.0	3.00	3.00	1.00	2.00	.	4.00	4.0
17	9	8	1	3.00	.	1.00	1.00	1.00	2.00	2.0	2.00	2.00	2.00	2.00	2.00	5.00	4.0
18	1	2	2	3.00	.	1.00	1.00	1.00	3.00	2.0	1.00	3.00	3.00	2.00	3.00	2.00	3.0
19	2	3	1	6.00	.	2.00	2.00	2.00	2.00	1.0	3.00	2.00	2.00	3.00	3.00	3.00	3.0
20	4	7	2	3.00	.	1.00	2.00	1.00	1.00	2.0	2.00	2.00	1.00	1.00	2.00	3.00	4.0
21	1	1	1	3.00	.	2.00	3.00	2.00	2.00	2.0	2.00	2.00	2.00	1.00	3.00	3.00	5.0
22	6	15	1	2.00	.	2.00	1.00	2.00	1.00	1.0	1.00	2.00	2.00	2.00	3.00	2.00	3.0
23	7	6	1	2.00	.	1.00	1.00	1.00	3.00	3.0	3.00	3.00	3.00	3.00	3.00	4.00	3.0
24	.	17	1	1.00	.	1.00	1.00	1.00	3.00	3.0	3.00	4.00	3.00	2.00	4.00	3.00	4.0
25	6	5	1	2.00	.	2.00	2.00	2.00	2.00	3.0	2.00	3.00	4.00	2.00	3.00	4.00	4.0
26	1	17	1	3.00	.	2.00	1.00	2.00	3.00	2.0	3.00	3.00	4.00	2.00	3.00	4.00	4.0
27	6	17	1	3.00	.	1.00	1.00	2.00	2.00	3.0	2.00	3.00	2.00	2.00	3.00	5.00	5.0
28	1	2	2	5.00	.	1.00	1.00	1.00	3.00	1.0	2.00	2.00	1.00	2.00	2.00	5.00	4.0

Figure 2D: SPSS Data view (Source IBM SPSS Statistics 21)

APPENDIX 3 - PILOT OF BIM FOR FM SURVEY

An online pilot survey was initially distributed to the IPFMA for comment. The feedback included that the survey needed reconstructing and that the survey was too detailed. There was a particular concern that respondents would not be aware of BIM and that they would not have sufficient knowledge to complete the survey.

The feedback received required a fundamental redesign of the survey. The questionnaire is detailed in the next three sections.

SECTION 1 – THE CASE FOR EARLY INVOLVEMENT

It is widely regarded that the maintenance and operating costs of buildings can be five times the capital costs, with the business operating costs reaching up to two hundred times the capital costs over the life of the building. Furthermore, a total of 3.8 % of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility. It is suggested that the Facility Manager is in a position to address some of these improvements and help increase productivity, as they have a unique position to view the entire project lifecycle.

The purpose of this survey is to ascertain your opinion with respect to the early involvement of the Facility Manager in the design and construction process.

1. **Please indicate in which of the following sectors you/your organisation primarily operate**
    - Property Management
    - Facilities Management
    - Other. Please Specify

2. **Which type of facilities / property management is your organization primarily involved. Please tick as many of the appropriate options that apply.**

Options: 1) Major 2) Minor 3) None

- Retail
- Education Pharmaceutical
- Health

- Industrial
- Sport and Leisure
- Residential Offices
- Other. Please Specify

3. **In your experience are Facility Managers involved in the design and/or construction phases of a project. Please indicate below to what level the Facility Manager is involved in either of these two phases.**
    - 0 – 9% (Little involvement)
    - 10 – 39% (Somewhat involvement)
    - 39 – 69% (Regularly involved)
    - 70 – 100% (Routinely involved)

4. **In your opinion should the Facility Manager have a role in the design and construction phases of a project?**
    - No
    - Minor
    - Major
    - No opinion

5. **In what way can the Facility Managers make a major or minor contribution to the design and construction phases? Please indicate what impact the Facility Manager can make in the following areas.**

Options: 1) Major 2) Minor 3) None

- Space management
- Strategic planning in aligning real estate and facilities plans
- Asset Management
- Documentation control
- Preventive maintenance scheduling
- Reducing carbon emissions
- Better energy management
- Driving sustainability

- Ensuring enhanced construction potential
- Improved functionality of the building
- Reducing life cycle costing
- Improved security
- Improved emergency evacuation and fire simulation

6. What are the main arguments in favour for the Facility Manager being strongly involved in the early stages of the construction process?

7. What are the main barriers for the Facility Manager being strongly involved in the early stages of the construction process?

SECTION TWO - FM and ICT Working Together

Operating and maintaining high performance buildings requires a sophisticated organization with careful preparation and planning. This has ultimately seen rapid advancement of information and communication technologies in the FM process, particularly Internet and Web-based technologies during the past 15 years. This has now resulted in the partnership of FM and BIM, where it is advocated that BIM can offer a new level of functionality for the management of buildings and the physical assets within them, as BIM provides a unified digital repository of all building components

The purpose of this section is to ascertain your current position in regard to the importance of ICT and in particular, the current relevance of BIM, as a future tool to support FM services throughout the entire project lifecycle,

8. What IT software do you use to support your FM processes?

9. Where do you think inefficiencies exist in the Facility Management process? Please indicate below if these inefficiencies can be found in the following areas

Options: 1) Major 2) Minor 3) None

- Insufficient access to O&M Manuals
- Poor preventative maintenance

- Lack of understanding of current ICT systems
- Resource allocation
- Asset Management
- Poor design of equipment layout
- Lack of adequate space for mechanical room
- Excessive amount of equipment
- Legacy issues from construction
- Communication with other departments
- Lack of recognition by other departments
- Carbon Management
- Poor energy management
- Lack of sustainability initiatives
- Waste reduction
- Other. Please Specify

10. How can ICT be successfully deployed to address these inefficiencies?

11. Are you aware of any particular innovative use of ICT to improve the overall Facility Management process? If so please give details.

12. How aware are you of the current interest and debate in respect to Building Information Modelling (BIM)? Please tick one

- Very aware
- Somewhat aware
- Not aware

13. It has been reported that Building Information Modelling (BIM) promises accurate, timely, design and construction information that is centralised, giving everyone access to the same data and greatly improving communication and collaboration for the project team. To what level can it in your opinion support the Facility Manager throughout the building's lifecycle?

- 0 – 9% (Little support)
- 10 – 39% (Somewhat supportive)

- 39 – 69% (Potential to be regularly supportive)
- 70 – 100% (Potential to be routinely supportive)

14. Have you any experience in using a BIM model for Facility Operation and Maintenance (O&M)?

- Yes
- No

If Yes, then please provide details

15. In what format is O&M information usually required by your organization? Please select all that apply:

- Paper based
- A digital copy on a CD or DVD
- WebFM O&M system
- Other, Please Clarify

16. Have you ever received O&M information in a BIM file format?

- Yes
- No

17. COBie - is an information exchange specification for the capture and delivery of information needed by facility managers. COBie can be viewed in design, construction, and maintenance software as well as in simple spreadsheets. The COBie approach is to enter the data as it is created during design, construction, and commissioning. Are you aware of COBie and its application in the FM Industry

- Yes
- No

18. Would you agree that COBie has the potential to improve the overall FM process?

- Yes
- No
- No Opinion

Please give the reasoning for your choice.

19. What do you believe will be your projected use of BIM over the next 5 years

- We currently use BIM on some of our projects
- In one year we will using BIM on some of our projects
- In three years we will use BIM on some of our projects
- In five years we will use BIM on some of our projects
- We do not intend to invest in BIM software in the next 5 years

20. Do you believe that BIM will be in routine use in the FM sector within the next 5 years?

- Yes
- No
- No Opinion

SECTION 3 - BIM AS A FM TOOL IN MANAGING THE GOVERNMENT'S STATE FACILITIES

There is a plan for a phased five-year development within the UK whereby public works projects will be required to use BIM from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government as a client would have a public sector that was smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions. This strategy will effectively mean that all companies that wish to tender for public works projects in the UK by 2016 must use a BIM model throughout the whole construction process, in order to be considered as a project participant.

The purpose of this section is to explore current views in respect to the use of a BIM tool to better manage both newly and existing public sector facilities and structures.

21. Do you believe that the Irish Government should take a similar stance to the UK and mandate the use of BIM?

- Yes
- No
- No Opinion

Please give the reasoning for your choice.

22. **Do you have any experience in working within the Public Works Sector in regards to Facilities or Property Management of existing Government assets?**
    - Yes
    - No

If you answered Yes then please answer the following question if you answered NO then please move to question Q24

23. **Please comment on what inefficiencies you believe currently exist in regards to Facilities or Property Management within the Irish public sector facilities?**

APPENDIX 3 - BIM FOR FM QUESTIONNAIRE

A total of 80 organisations where selected randomly from the IPFMA membership community to partake in a survey, which resulted in a total of 38 responses received.

It was decided that questions would be a mixture of open and closed questions, as it was felt that most of the respondents would like to add their own insight into a number of questions. The inclusion of open ended questions generated both qualitative and quantitative data that could be analysed to help establish some key criteria that were explored in the second phase of the research. The questionnaire is detailed in the next three. sections.

SECTION 1 –EARLY INVOLVEMENT

It is widely regarded that the maintenance and operating costs of buildings can be five times the capital costs, with the business operating costs reaching up to two hundred times the capital costs over the life of the building. Furthermore, a total of 3.8 % of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility. It is suggested that the Facility Manager is in a position to address some of these improvements and help increase productivity, as they have a unique position to view the entire project lifecycle.

The purpose of this part of the survey is to ascertain your opinion with respect to the early involvement of the Facility Manager in the design and construction process.

1. **Which type of facilities / sector is your organization primarily involved. Please tick as many of the appropriate options that apply.**
    - Retail Education Pharmaceutical Health
    - Industrial
    - Sport and Leisure
    - Residential
    - Offices
    - Other (please specify)

2. **In your experience are Facility Managers involved in the design and/or construction phases of a project. Please indicate below to what level the Facility Manager is involved in either of these two phases.**

- 0 – 9% (Little involvement)
- 10 – 39% (Somewhat involvement)
- 39 – 69% (Regularly involved)
- 70 – 100% (Routinely involved)

3. **It has been suggested that if the Facility Manager was integrated early into the construction process, it could help maximise sustainable construction potential, as well as providing a new cost focus for building. In your opinion based on this quote and your knowledge should the Facility Manager have a role in the design and construction phases of a project?**
    - No
    - Minor
    - Major
    - No opinion

Please explain your answer

4. **It is accepted that almost 4 % of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility. It is suggested that the Facility Manager is in a position to address some of these improvements and help increase productivity. In what way can the Facility Managers make a major or minor contribution to the design and construction phases to increase productivity?**

5. **What are the main arguments for and against for the Facility Manager being strongly involved in the early stages of the construction process?**

SECTION 2 - FM AND INFORMATION COMMUNICATION TECHNOLOGY (ICT) WORKING TOGETHER

Operating and maintaining high performance buildings requires a sophisticated organisation with careful preparation and planning. This has ultimately seen rapid advancement of Information and Communication Technologies (ICT) in the FM process, particularly Internet and Web-based technologies during the past 15 years. It is suggested that if the Facility Manager has the proper financial and ICT planning tools can create long-lasting value to the organisation by developing, implementing and maintaining sustainable facility practices.

The purpose of this section is to ascertain your current position in regard to the importance of ICT and in particular, as a future tool to support FM services not just at the handover stage but throughout the entire project lifecycle,

6. **What IT software do you use to support your FM processes e.g. Computerized Maintenance Management Systems (CMMS), Computer Aided Facilities Management, etc.**

7. **There a number of inefficiencies that exists in the construction process (legacy problems) that the**

8. **Facility Manager must try and rectify after handover of the building. How in your opinion can ICT be successfully deployed to address these inefficiencies?**

9. **Are you aware of any particular innovative use of ICT to improve the overall Facility Management process? If so please give details.**

10. **It is now widely recognized that Operation & Maintenance (O&M) represents the greatest expense in owning and operating a facility over its life cycle. In what format is O&M information usually provided / required by your organization? Please select all that apply:**
    - Paper based
    - A digital copy on a CD or DVD
    - WebFM O&M system
    - Other, Please Clarify

11. **How aware are you of the current interest and debate in respect to Building Information Modelling(BIM)? Please tick one**
    - Very aware
    - Somewhat aware
    - Not aware

12. **1If you answered yes to Q10 above then please indicate if you have any experience** in using a BIM model for Facility Operation and Maintenance.
   - Yes
   - No
   - If Yes, then please provide details

SECTION 3 – ICT AS A FM TOOL IN MANAGING THE GOVERNMENT'S STATE FACILITIES

The Irish construction sector has seen a sharp decline in output since 2007, with initial forecasts of recovery not expected to happen until 2014. Despite this the Irish Government has announced a number of large capital expenditure investments to be initiated over the next few years, including the awarding of State contracts worth up to €16 billion a year for environmentally-friendly policies

in 2010, and, a €1.5 billion programme in 2012 to provide new schools and extend existing schools across the country. The Irish Government are now rewarding construction firms for applying environmentally friendly methods, so as, to promote sustainability and drive down carbon. The UK are applying a more radical approach by implementing a plan for a phased five-year development whereby public works projects will be required to use BIM from 2016.

The purpose of this section is to explore current views in respect to the Facility Manager and ICT / BIM can help to better manage both newly and existing public sector facilities and structures.

13. **There are at present initiatives in Ireland, so as to reduce greenhouse gas emissions by up to 20% by the year 2020.By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. How much of an impact can the Facility Manager play in ensuring these targets are achieved if introduced in a consultant role at the beginning of the project?**
   - None
   - Minor
   - Major
   - No opinion

   Please explain your answer

14. There is a plan for a phased five-year development within the UK whereby public works projects will be required to use BIM from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government as a client would have a public sector that was smarter and better equipped to face a low carbon economy. Do you believe that the Irish Government should take a similar stance to the UK and mandate the use of BIM?

- Yes
- No
- No Opinion

Please give the reasoning for your choice.

15. Do you have any experience in working within the Public Works Sector in regards to Facilities or Property Management of existing Government assets?

- Yes
- No

If you answered yes then please comment on what inefficiencies you believe currently exist in regards to Facilities or Property Management within the Irish public sector facilities?.

SECTION 4 – OPTIONAL FEEDBACK AND CONTACT INFORMATION

The purpose of this section is to ascertain if you, the respondent, would be willing to be involved in further dialogue with the author in regards to creating interactive facility management capabilities through BIM.

APPENDIX 3 - OPEN ENDED RESPONSES FROM BIM FOR FM IN IRELAND SURVEY

This part of the appendix will list the responses from the open ended questions within the BIM for FM in Ireland Survey. Table 3A details the response from question three of chapter six *"It has been suggested that if the Facility Manager was integrated early into the construction process, it could help maximise sustainable construction potential, as well as providing a new cost focus for building. In your opinion based on this quote and your knowledge should the Facility Manager have a role in the design and construction phases of a project?"*

Role	Involv-ment	Early FM impact on design / construction
Major	0-9%	The Main problems for a FM point of view is where AHU & AC units are located. Units can be poorly placed for maintenance.
Major	0-9%	By getting insight from the Facility Manager in the early construction / design stages could highlight areas that could be changed to improve the running costs of the building. It also makes sense to have the opinion of the person who will be operating and maintaining the building.
Minor	0-9%	Too much focus on cost alone at the design stage can result in poor architecture. This is evident all over the country where insufficient resources are devoted to design and all the focus is on minimum cost. If the Facility Manager is also the Architect, there is perhaps potential for improvement.
Minor	0-9%	May be appointed at design stage as a consultant to aid with design decision in areas which will impact on future FM for the building.
Minor	0-9%	The FM needs enough involvement to ensure the facility best meets the future needs.
Major	0-9%	To ensure that maintenance can be more readily accessible, correct location of facility, correct type of facility.
Minor	0-9%	Operational and maintenance factors are very important at the design stage and this is being recognised by Bream and Leed. The Facility Manager is generally part of the client body rather than a specialist consultant on the design team.
Minor	0-9%	I would imagine that a Facility Manager could inform design decisions. Once the building is on site there would be less room for meaningful input as the project has already been designed with costs agreed etc. I chose 'minor' because in the overall scope of designing and constructing a building there is a full design team comprising of many professionals all of whose input is important.
Minor	0-9%	Certainly should have a role/input into the design. Particularly important in relation to more complex M&E systems, where one would expect FM issues to be considered by

		the designer. However, this is not often given any consideration and therefore there is scope for improvement.
Major	0-9%	The Facility Manager will understand the "Operational Requirements" of the building. If (s) he is the ultimate FM on that site, they will want to ensure that systems and procedures are in place that will make their life easier during building occupation.
Major	0-9%	Facility Manager should have input in design of common areas in residential developments and may also have relevant knowledge of the type of machinery that is most cost efficient. For example, Motors on gates and lifts or the design of refuse areas or entrance hallways.
Mino r	10-39%	Particularly in large developments with complex infrastructure, it is critical to involve the FM not only to understand the operation of the facility but to know the background to a particular design approach.
Major	10-39%	A FM could work alongside Energy Consultants to give professional advice on optimising the life cycle actual energy performance of buildings. They would have valuable experience which sustainability strategies that actually work in practice in
Major	10-39%	Due to the in depth knowledge of the FM in running of the clients business it makes perfect sense to utilise their expertise in the design and construction
Major	10-39%	Hands on experience can add value for maintenance and practical applications.
Major	10-39%	Facility managers have a broader understanding of the synergy of services that are likely to be deployed on site after the construction period. Having the Facility Manager involved in the construction period of the project might mean better utilization of the work space and more practical layout of the office from the services point of view.
Major	10-39%	The practical experience integrated at an early stage would be invaluable and would assist in completion of a plant that "worked".
Major	10-39%	It is vital that the FM has a major involvement in the installation of M&E in a facility as they are the ones who will have to live with consequences. This is especially important in relation to the provision of power and heat as the determining factors should prioritise life cycle costs
Major	39-59%	In my experience of building houses, the client is effectively the FM and is involved from start to finish. In building offices, the clients FM is involved regarding signing off floor layouts / furniture / finishes / lighting etc. from start to finish.

Table 3A – Response from Q3

Table 3B details the response from question four in chapter six *"It is accepted that almost 4% of improvements in productivity of the facilities of a building would be equal to the total cost of design, construction and operation of the facility. It is suggested that the Facility Manager is in a position to address some of these improvements and help increase productivity. In* *what way can the Facility Managers make a major or minor contribution to the design and construction phases to increase productivity? ".*

Involvement	**Suggested areas in were early Facility Manager involvement can contribute to the design and construction phases**
0 – 9%	Adding another perspective to the design process.
0 – 9%	FM manager could request provision for Data Loggers at construction stage, input into type/efficiency of heating system, input into zoning of heating systems, input into type/efficiency of Lighting system.
0 – 9%	Give an in-depth analysis as to how the building will be required to function on a daily basis.
0 – 9%	They have an in depth understanding of how the building will be used so will be best placed to assist in design decisions i.e. Heating zones within a building.
0 – 9%	The targets to achieve design value and productivity should not be made in the end after design is done in the BIM model; instead targets should be known based on client business case. Knowledge of facility such as scale and type of product, amount of people working should be incorporated in the design.
0 – 9%	Objective outlook, that is independent initially from costs and design whereby this may be missed by QS/Architect and Engineer due to the pressures of getting a project to tender/site. Potentially better versed in new techniques etc. missed by traditional design team.
0 – 9%	Lifecycle costs and suitability of finishes etc.
0 – 9%	The FM Manager understands the logistical requirements for maintenance, who will operate the facility, and the cost of the most feasible product and what the supply chain requirements are.
0 – 9%	Highlighting areas of concern that other professions may not have knowledge of.
0 – 9%	Focusing the design team on control systems and monitoring data to ensure that the completed building measured performance matches the predicted building as designed, this way it avoids the Low energy building Paradox.
0 – 9%	By supplying alternatives to issues that may arise from the project.
0 – 9%	During Construction, Facility Mangers may have relevant knowledge of an area and equipment that will reduce future costs. For example, we manage an apartment complex in a flood plain. All gate motors and lift motors were installed at ground level - these could have been easily installed above flood levels thereby reducing expensive repair and replacement costs.
0 – 9%	Specify operations and maintenance regimes. Advise on User behaviour and requirements Specify information requirements
10 – 39%	Ensuring the specification of proprietary elements that are affordable to repair/maintain.
10 – 39%	Streamlining the design briefing process and providing early detailed client requirements to minimise costly design changes later on.

10 – 39%	Can give the designer a true feeling of how user groups will use the building & it's facilities
10 – 39%	FM could contribute their practical knowledge for the floor layout and coordination between departments to minimise the duplication of tasks.
10 – 39%	The Facility Manager is aware of the requirements of the occupants and also what they do not require.
10 – 39	By applying their knowledge of the facility operations from previous sites and discussions with other senior executives.
10 – 39%	Maintainability: If the FM is consulted on which systems are to be used they can ensure that the systems installed are not only functional but are easily maintained and spares easily sourced. This would avoid plant down time and increase productivity
10 – 39	By having an input into the following elements of M & E design; the layout of the heating system into zones, the appropriate BMS, the electrical system.
10 – 39%	Work out impractical design, having feature light in inaccessible spaces. By understanding the operation of the business that will be in the building and designing in around it, it maybe through the design and thereafter implementation of the BMS.
39 – 69	FM's have a better understanding of actual user needs than designers. Experience with what works and what doesn't also contributes to productivity.
39 – 69%	Layouts Business Flows Servicing needs / access to equipment

Table 3B – Response from Q4

Table 3C details the response from question five in chapter six *"What are the main arguments for and against for the Facility Manager being strongly involved in the early stages of the construction process"*.

Involvement	**Arguments for and against for the Facility Manager's inclusion in the design**
0 – 9%	Arguments against would be that they are taking some of the overseeing role away from the project architect.
0 – 9%	Locating units. Zoning areas. Access points for servicing units.
0 – 9%	For: building can be designed to be proactive to daily requirements to being reactive / Against: may slow down the design process, but is worth it
0 – 9%	Delay project with obscure suggestions
0 – 9%	They have an in depth understanding of how the building will be used so will be best placed to assist in design decisions.
0 – 9%	If the Facility Manager is also the Architect there is a strong argument for the inclusion of their skills. However, if the FM's focus is entirely on cost or sustainability etc., to the detriment of the overall whole.
0 – 9%	For: arly intervention hence less potential disruption / Against: Additional Fee and further partEy added to the team.

0 – 9%	Against: they may not understand the cost of installation / For: early collaboration ensures all possibilities and requirements are covered.
0 – 9%	Against: FM fees for consultation / For: added insight and knowledge.
0 – 9%	For: continuity between design intent and operational efficiency / Against: another voice in design, becomes a bit 'design by committee'.
0 – 9%	I would say that their input may be needed in the design process firstly. I would need convincing on what role they would play in a professional capacity however. What is their qualification? Do they hold PI insurance? Whom are they employed by? Etc.
10 – 39%	If a building is leased when it has been designed & built there is generally a costly & somewhat compromised retro/refit. However, if a building is identified at design stage & the occupants involved in the design & construction the building can be tailored to the exact requirements of the occupant.
10 – 39%	For: provide feedback / Against: Already too many bodies involved.
10 – 39%	Con: not enough experience-too much interference / Pro; first-hand knowledge of service lay outs.
10 – 39%	For: streamline and re-iterate historical design process and information download / Against: additional stakeholder in design sign-off process.
10 – 39%	For: feedback on how the building will be used / Against: can lack the technical & materials costs skills.
10 – 39%	For: detailed knowledge of the clients business and operations / Against: none
10 – 39%	For: contributing to optimise a building layout to increase performance. / Against: relying too heavily on their contribution
10 – 39%	The FM could slow down the design process. Also have a personal opinion that they wish to force on the Design Team. An experienced FM will also bring the practicalities of operating the facility to the table.
10 – 39%	Unless the FM can delegate a significant part of his/line responsibility for the duration of the early stages, it results in a significant additional workload.
10 – 39%	If the FM has no construction experience, they may hinder the process.
10 – 39%	Senior management isn't used to having FM participating on the decision process. FM can actively contribute to the effective design of the site.
10 – 39%	The FM is not primarily interested in the capital costs of systems employed. They are far more interested in the operating costs, functionality and maintainability. This could increase the upfront costs but in the long term the running costs will be lower.
39 – 69%	For - they make sure the client gets what they want/ Against - they can sometimes have alternative agendas.
39 – 69%	Knowledge of maintenance requirements. Knowledge of user needs. Knowledge of running costs. Knowledge of regulatory requirements.

Table 3C– Response from Q5

Table 3D details the response from question six in chapter six *"There are at present initiatives in Ireland, so as to reduce greenhouse gas emissions by up to 20% by the year 2020.By the end of 2018 the public sector must own or rent only buildings with high energy-saving standards and promote the conversion of existing buildings to "nearly zero" standards. How much of an impact can the Facility Manager play in ensuring these targets are achieved if introduced in a consultant role at the beginning of the project?"*.

Role	Contribution of the Facility Manager in reducing carbon
0 – 9%	Again it's another professional who can bring their knowledge and experience to the design team.
0 – 9%	By ensuring energy efficient systems are installed and are designed to maximize their efficiency through their understanding of how the building will be used.
0 – 9%	The FM is in a good position to understand and influence the outcome of the efficiency of the design.
0 – 9%	I would imagine a Facility Manager works with what he/she has in front of them. I would consider the design of a building to be of primary importance. Good facilities management should then follow with suitably qualified individuals to oversee same. If a Facility Manager is engaged during the design process they could have more of an impact. I would however question why a professional design team comprising architects / engineers / services consultants / quantity surveyors / energy consultants / etc. cannot make appropriate decisions during the design stage. It does however make sense that the end-user is engaged during the design process.
0 – 9%	Many buildings have sophisticated systems that do not realize their potential as they are not operated correctly.
0 – 9%	He will have greater energy consumption awareness and can look to drive this down.
0 – 9%	Specify operations and maintenance regimes Advise on User behaviour and requirements Specify information requirements
0 – 9%	The Facility Manager may have relevant experience in the selection of energy efficient machinery and plant for the development.
10 – 39%	The FM can drive a programme to reduce energy savings.
10 – 39%	They can have a role as an advisor but too much influence may affect delivery of the construction project.
10 – 39%	BIM should streamline the design/construction and future expansion planning by putting everything on a central platform.
10 – 39%	The expertise of the FM, if brought in at early design stage, and involved in the process will allow him/her take ownership of the targets etc.
10 – 39%	Real practical advice about energy saving strategies that work/don't work in similar buildings of this type.

10 – 39%	The M&E consultant provides a performance specification in most cases which is then developed by the M&E contractor into the detailed design. The FM as a consultant can be more prescriptive in developing the performance specification and be involved in the approval process.
10 – 39%	As plant operators the FM is ideally placed to instigate EM&T solutions and strategies on site.
10 – 39%	Identifying the buildings with optimum heating and power sources such as CHP.
10 – 39%	It not just about the buildings and the service within, it's about the occupiers actions and to a great extent, FM's can influence these actions to be more sustainable.
39 – 69%	Selection of equipment that meets user needs, whilst meeting energy saving standards.
39 – 69%	Client cost decisions limit input, client's not forward thinking.
70 – 100%	Use of consultants still necessary but basic understanding from FM always required.

Table 3D– Response from Q6

Table 3E details the response from question eight in chapter six "*There are a number of inefficiencies that exists in the construction process (legacy problems) that the Facility Manager must try and rectify after handover of the building. How in your opinion can ICT be successfully deployed to address these inefficiencies?"*

Role	Contribution of the Facility Manager in reducing carbon
0 – 9%	Use BIM
0 – 9%	A good BIM model
0 – 9%	Client gets a lot more benefit out of it, However, clients are having problem as to how to manage all that information after they have it what they have asked for.
0 – 9%	If Revit/other BIM software (and those who use it) delivers all it promises it has potential to minimise inefficienes through the proper design stage. Furthermore, the co-ordination of drawings, both for construction and for as-built use after handover for manuals, maintenance etc., can only help to minimise deficiencies and aid cost reduction during the running of a building.
0 – 9%	The BIM process, if properly implemented during the design development and construction of a project, offers a vastly improved means of communicating and co-ordinating project designs to relevant stakeholders. Through improved communication we afford ourselves an opportunity to improve design outcomes.
0 – 9%	Not relevant to projects I have been involved in.
0 – 9%	Utilising integrated solutions across the plan build operate lifecycle.
0 – 9%	Training the user and better o &m manuals
0 – 9%	Leed and BREEAM O+M addresses these deficiencies adequately. Simplified BMS and operational manuals, hosted on the cloud allow for the FM manager to churn problems.

0 – 9%	Through use of a more integrated BIM system throughout design, construction and maintenance of building.
0 – 9%	Do the job right the first time. Don't find out later that they forgot to install gaskets in the plumbing after the job is finished.
0 – 9%	Provide all handover documents in digital , accessible format to building owners as part of safety file.
0 – 9%	Many larger sites and / or corporations tend to have a helpdesk service whereby the occupants can log a call out service.
0 – 9%	Getting digital information that can immediately be "consumed" into FM systems, without requiring information to be manually recreated.
10 – 39%	By early identification of problems.
10 – 39%	Get it right at design and construction phase.
10 – 39%	Ensure all materials & equipment is fully tested & commissioned.
10 – 39%	By using an integrated package from the start should show up possible inefficiencies which can be addressed at an early stage in the design process.
10 – 39%	Managing huge amounts of data efficiently.
10 – 39%	Safety / Maintenance file can be digital as a minimum or have a BMS in place linked to a BIM of the facility.
10 – 39%	Careful planning and execution with CAFM assistance.
10 – 39%	Get involved at the design stage to minimise the possibility but if you are not then an in depth review in consultation with the IT Manager to identify specific requirements would be essential.
10 – 39%	From what I see of BIM, I think that it is the way to go. Do the design and modelling before the build starts.
39 – 69%	Understanding CAD, practical application.

Table 3E– Response from Q8

Table 3F details the response from question twelve in chapter six *"There is a plan for a phased five-year development within the UK whereby public works projects will be required to use BIM from 2016. This plan was devised around a hypothesis which defined a scenario in which the Government as a client would have a public sector that was smarter and better equipped to face a low carbon economy. Do you believe that the Irish government should take a similar stance to the UK and mandate the use of BIM?"*

Position	Follow the UK stance and implement BIM
For	BIM is the way to move in order to integrate a more fully complete building process, rather than having individual disciplines working alongside but not in a fully integrated manner.

For	It comes down to the 70% of building costs during the lifecycle being in the FM stage. It's obvious that by investing in the design stage, where changes are least costly to make, would vastly improve the ROI for Government through buildings which are cheaper to run.
For	The Irish Government should provide support, grants, additional quality marks in tender submission etc. This will generate an uptake in the adoption of BIM. The Irish Construction industry are easily adaptable to change. BIM needs to be driven by both industry and the government.
For	If the UK have laid the groundwork, then it makes sense to analyse the work carried out to date and adapt for our own use.
For	Currently maintenance of the public buildings is largely ignored.
Against	The UK has been building up to this situation. Ireland would only be reacting in a knee jerk way. I think there is a common consensus that it is the way the production drawings and documentation is going and it'll get there without pressure from the government.
Against	It will take a long time to fully integrate BIM as the industry is slow to adapt to change.
Against	Currently the cost of implementing BIM technology to small practices is prohibitive.
Against	BIM is merely a tool and can be a vague tool. A T square and calculator could technically be called BIM. BIM has been around for almost twenty years and still doesn't integrate well with other platforms. It is not suited to bespoke Architectural work and leads to a design by excel type approach.
Against	I believe they are taking on too much too soon and to force the public sector to accept this would lead to many pickets and angry people. Should be a ten year plan not a 3 year plan.

Table 3F– Response from Q12

APPENDIX 4 – FURTHER DETAILS ON THE CITA TECHNOLOGY PILOT

This part of the appendix contains further details of the CitA technology pilot. The team consisted of the following members

- Paul Sexton, Civil/ Structural Engineer SCEG LTD (Chair)
- Bernard Voortman, Architect/Urban Designer Cummins and Voortman Ltd
- Trevor Woods, Quantity Surveyor, Construct IT
- Enda Grimes, Contractor, John Paul Construction ltd
- Dr Alan V. Hore, Director, CITA LTD
- Barry McAuley, CITA/DIT Researcher
- Pearse Mc Mahon, Nugent Manufacturing Ltd
- Bobby Gallagher, Facilities Manager, Moore DFM
- Philip Geoghegan, Urban Design, iCON Architecture & Urban Design
- Enda Nolan, Civil Engineer/Land Surveyor Coastway Ltd.
- Ross Cahill O'Brien, Architect Cahill-O'Brien Associates Ltd
- Colin Reid, Mechanical & Electrical Consultants Johnston Reid & Associates
- Gearoid McGuire, 4D Analysis, PPM
- Cathy Molly, Quantity Surveyor, Austin Reddy Associates
- Kieran O Connor, Contractor, Stewart Construction
- Client, Fingal County Council

The Pilot Project timeframe was commissioned from January to November to run in tandem with the CITA Technology Series. The author's role within the Pilot was to act as the chief researcher and to ensure a measurement tool was in place to map the progress of the Pilot Team. The original framework for the Pilot Project resulted in a development map that produced a number of interesting areas in which the topographical areas were complicated, resulting in it being too difficult to design on a 2D campus. Figure 4A illustrates the village framework. This resulted in an enhanced brief being suggested to the Client for the creation of a virtual model for the whole area which could be further used to analyse and investigate best design options. This virtual interactive model could also be utilised by the planning department to analyse planning applications. This model further presented an interesting building in the form of Rowlestown community centre. The community centre was in need of some form of refurbishment and offered the chance for the CITA Pilot Team to create a sustainable and functional building. Figure 4B provides an image taken from the virtual model while figure 4C is a picture of the existing community centre.

Fig 4A: Garristown Urban Design Framework

Fig 4B: Virtual Model

Fig 4C: Community Centre

Survey data was provided for the project through three combined methods that consisted of firstly setting up a Global Positioning System (GPS) grid of the area, and then secondly, as there were no drawings of the area or detailed surveys, an UAV was flown over the area capturing digital information. The UAV was pre-programmed using Google earth and GPS, and was flown over the area to create a digital model over a four-hour period. Thirdly this data was combined with the laser scan of the building. Digital data was also required so as to investigate if a Sustainable Drainage Systems (SuDS) programme was required of the earth. The model was geo-referenced to the Irish national grid enabling accurate contours of the land for cross sections. This data was then combined with the laser scan of the building. Using a cloud based solution provided by Team Platform a full colour point cloud was produced. The software platform of Photosynth was also used to upload the photos for the UAV. An elevated view of the site helped with health and safety issues. An image of one of the elevations taken from Photosynth is illustrated in figure 4D.

Fig 4D: – Elevation through Photosynth

Before commencement of the scheme design began there where a number of different standards investigated. The AEC (UK) BIM Standards where strongly consulted before modelling began. It was agreed to use these standards for file naming purposes. The Pilot Project represented the opportunity to demonstrate how these standards would be implemented from the very beginning.

The 3D terrain model received from survey data was then imported into Archicad. This was then imported into further Google Sketchup. Cloud data was also received. The point data was imported into Google Sketchup. The team received a complete model of the building which was 30GB in size. The survey information originally imported into the platform of Archicad took up to 8 hours to import. A simplified model (300 Mb) was used with 20-million-point cloud setting filter distance, which took only an hour and half to import, thus creating a simplified 3D model picture. Through combined point cloud data and orthorectified imagery, a building model was constructed. As textures where applied to the model, it became more realistic and provided a platform to make decisions, which plans, sections and elevations could be easily generated. Data was also imported into Rhino 3D, which is a tool associated with creating shapes and forms. An image of the combined point cloud data and orthorectified imagery is presented in figure 4E.

Fig 4E: Combined point cloud data and orthorectified imagery

This model was then exported from Archicad back into a Point Cloud sketch up file and was then further overlaid to the full point data. An image of this is shown in figure 4F.

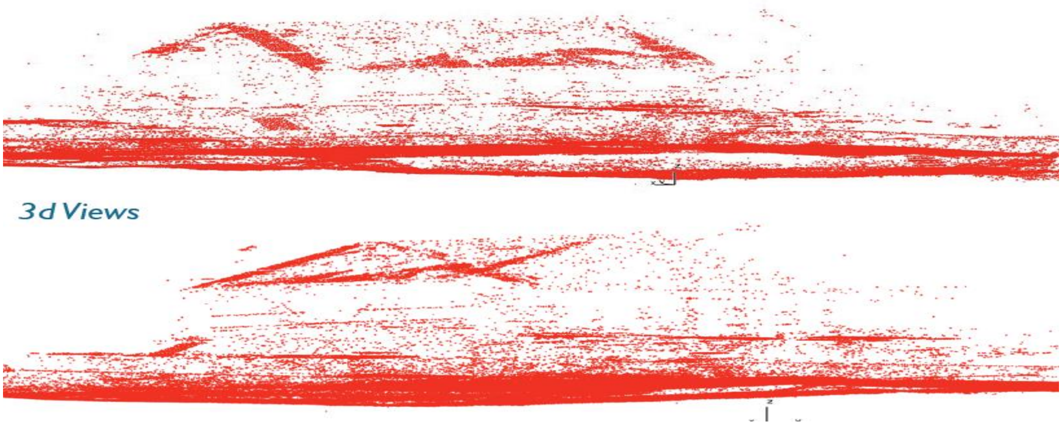


Fig 4F: Point Cloud in Archicad

The model was shared through model validation platforms, such as Tekla BIMsight and Solibri. This represented the opportunity to verify the integrity of the model through two different platforms. Some issues that were raised between Tekla and Solari included a 5-10% difference in quantities.

A further meeting also took place with Fingal County Council in which a brief was established. This brief involved two phases of the project with phase one ultimately aiming to revaluate the current structure and produce a solution for a more functional building. This was based on the Client’s request for better thermal comfort, enhanced artificial lighting, improved acoustics, and upgrade to the crèche, as well as, the addition of a shop.

Through the use of Skype and Dropbox amongst other methods the building began to be designed while interacting online. Layers were created in Photoshop and once an outline design was created it could be modelled and checked in Ecotect wind model. It was found the new suggested extensions to the building would deflect the wind. Figure 4G shows an illustration taken from the model of the original building, while figure 4H illustrate an image of the model in Ecotect.

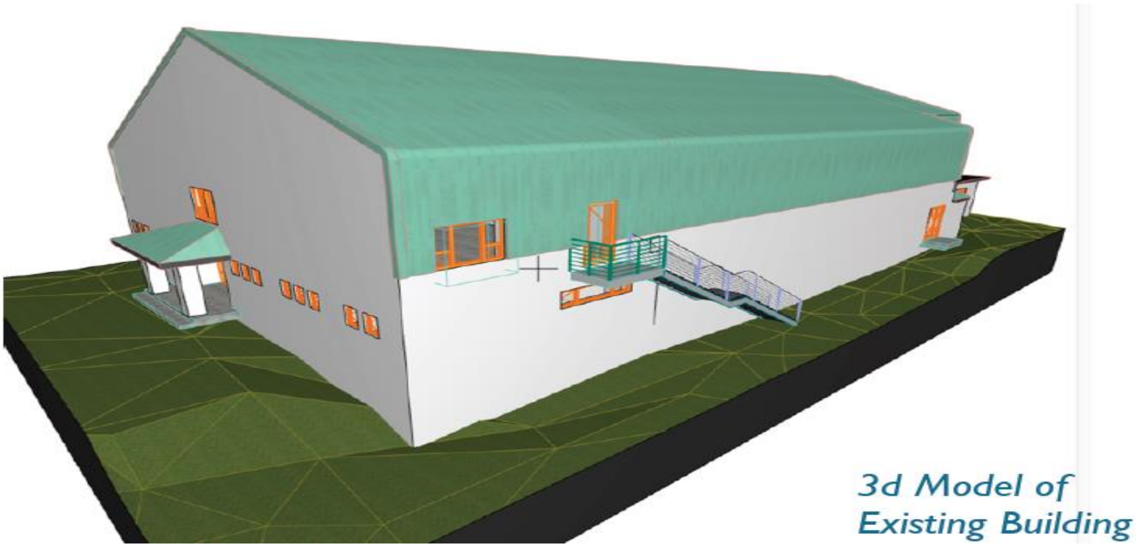


Fig 4G: 3D model of existing building

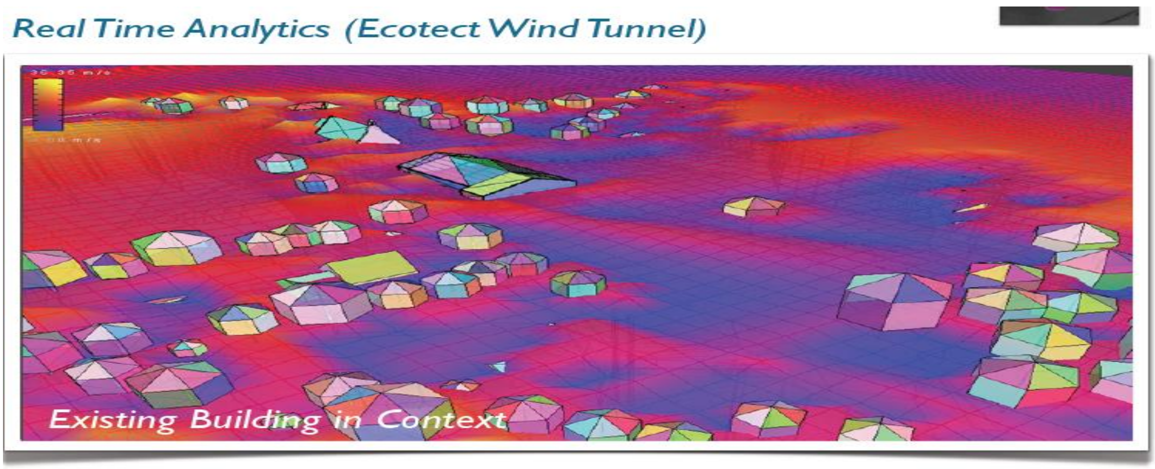


Fig 4H: Ecotect wind tunnel

The FM Team exported the IFC file into a software tool that develops a documentation index. The FM team initially used COBie but found it extensive i.e. a single item could have ten pieces of information leading to a massive Spreadsheet. The model was revised to incorporate all the requested information to be included from the FM Team.

A weekly site meeting was set up online to help exchange information. An illustration of this online meeting platform is shown in 4I. A platform called GoToMeeting was used throughout the course of the pilot.

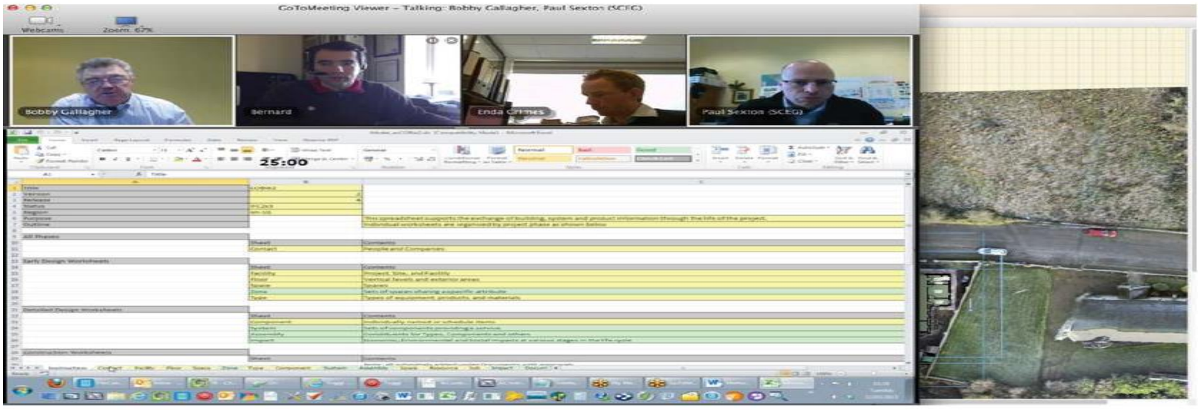


Fig 4I: Online Meeting Platform

The QS imported a Trimble model into CostX, which proved to be visually strong but poor functionally. The IFC model was then imported into Exactal CostX. A number of concerns were raised from the QS, including structures under the ground in which roads were modelled leading to 165,106 m^3 of additional concrete. Figure 4J shows an illustration of this error.

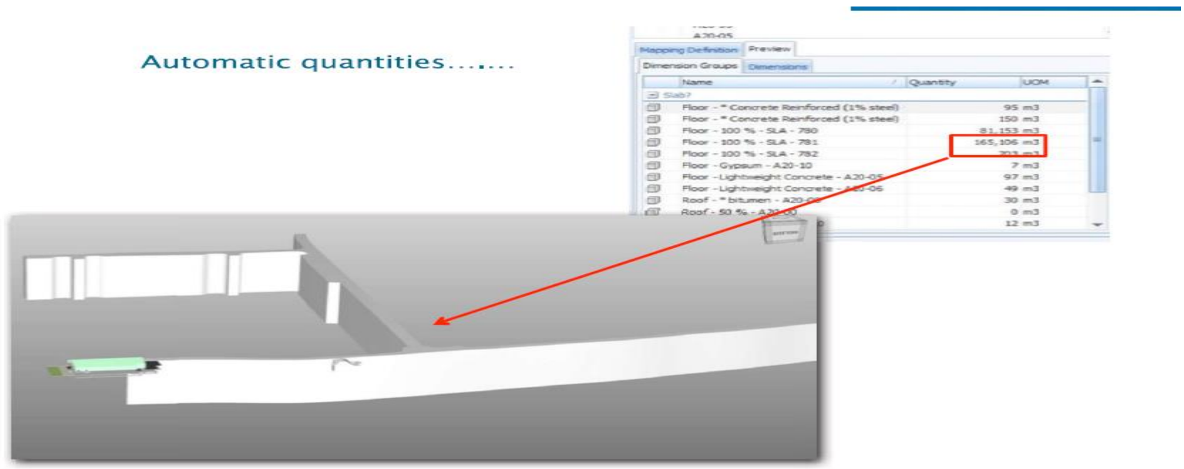


Fig 4J: Errors found by QS

Synchro was used for site logistics. The survey data showed a large drop, resulting in the only place to position the onsite compound was beside this. This permitted the contractor from the offset to see where a number of possible problem areas may occur. A number of construction methodologies could be explored. Figure 4K shows a picture of the proposed site layout.

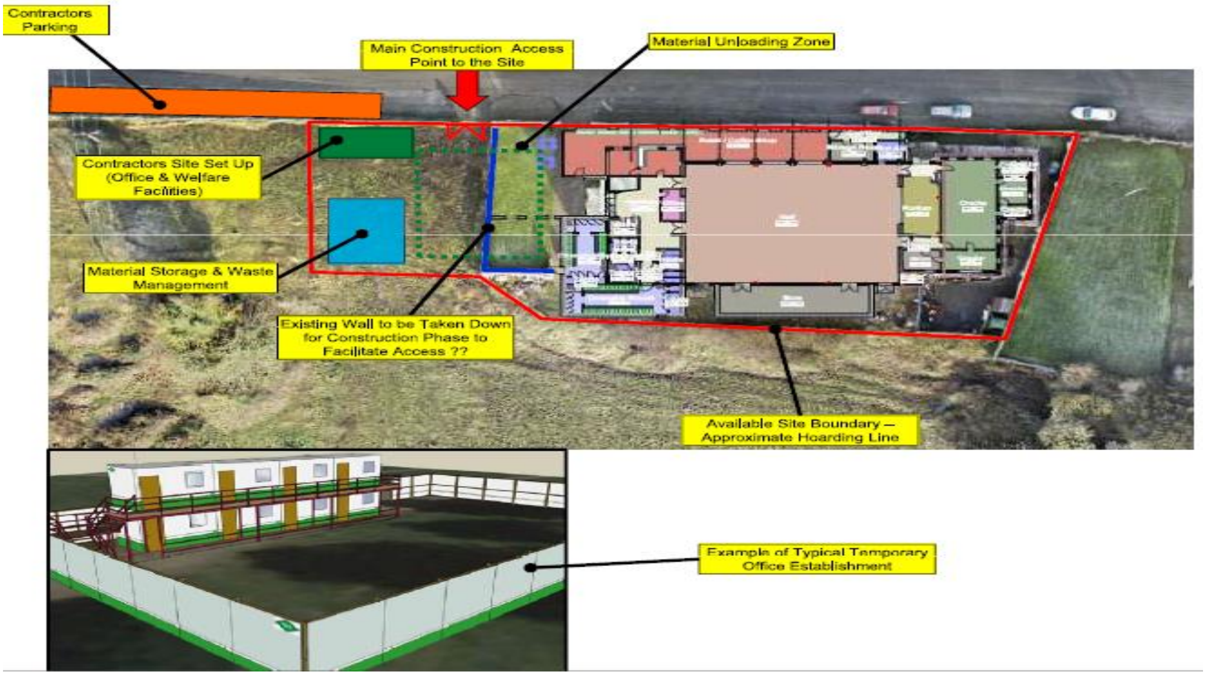


Fig 4K: Site logistics

The building's interior was modelled, so as an informed design could be undertaken. The Client and planning authorities were able to easily understand the design intent. Figure 4L and 4M shows an illustration of the proposed developed design at the time. Figure 4N provides an illustration of the actual hall to how it looked in the 3D model

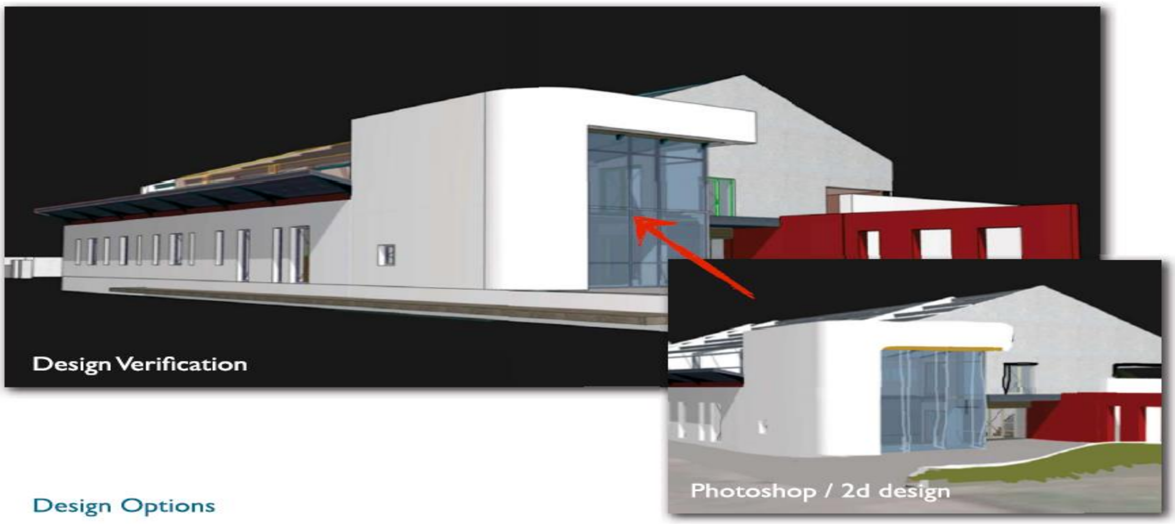


Fig 4L: Developed Design of CitA technology pilot

Fig 4M: Design Refined CitA technology pilot

Fig 4N: Exiting and 3D model of hall

The M&E Pilot Team member described the existing building as a metal clad tassel wall building not in great condition. The pilot team along with the M&E designer sat around the table and discussed the vision in regards to plant. The space was dived into the four different areas of retail, office and general use areas, meeting rooms, general purpose hall and crèche. The M&E pilot consultants conducted heat analysis and cooling loads on internal elements. In terms of ventilation and heating there wasn't a passive solution that lent itself to the structure in regards to the hall. It was agreed to reuse the original floor ducts and put a package unit at ground floor for ease of maintenance. This would improve the ventilation through the space by providing heating and cooling, so it could modulate to match the occupancy levels. A plant space was created in a hidden area behind the roof by the architect. Fan coil units were placed in the meeting room's areas, as these areas would fluctuate quite differently each day depending on occupancy levels. Figure 4O shows an illustration from the model of the Fan Coil Units (FCU) situated in the false ceiling

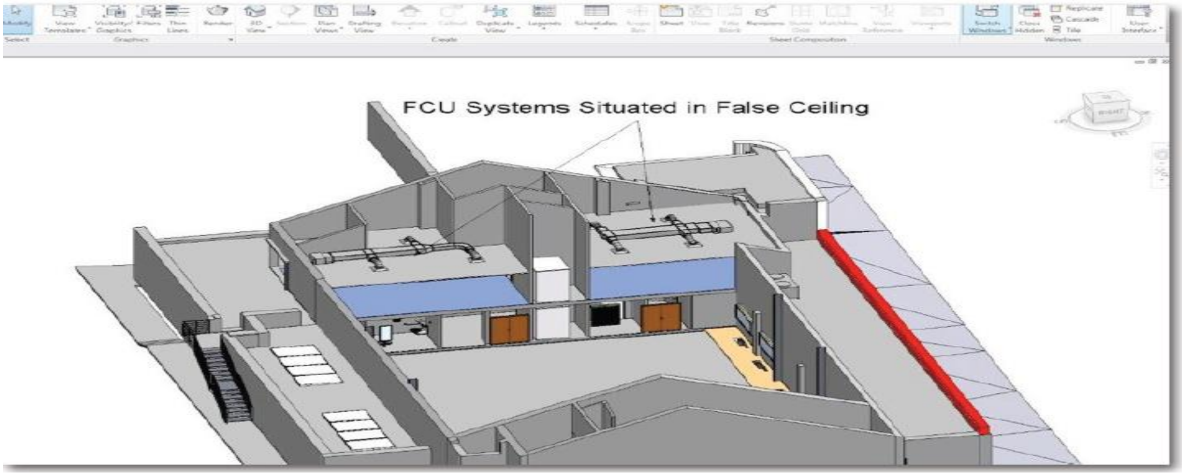
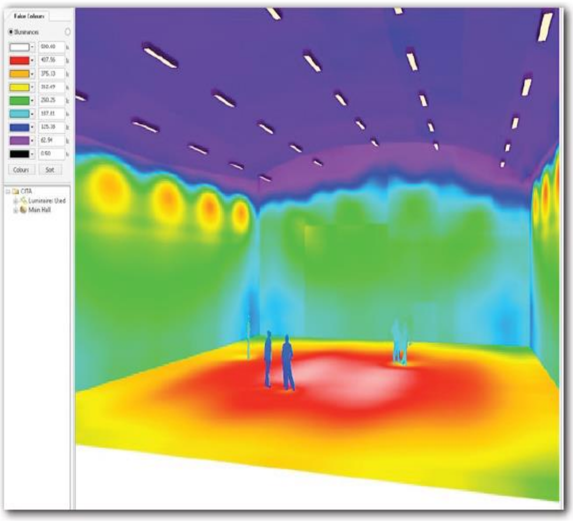


Fig 4O: Retail and Office Area and Circulation

The crèche was treated as an independent area, as so it could be metered separately with the idea to put a small heat pump for underground heating to avoid high surface temperature for the children. This ensures that there would be heat ventilation circulation to make sure the place could be heated without having to open all the windows

The retail unit had a lighting simulation performed. An illustration of this is provided in figure 4P. The Acoustics' were also investigated where it was found that the curve elements below the metal deck roof helped in creating a sense of space. Figure 4Q provides an illustration of this finding.



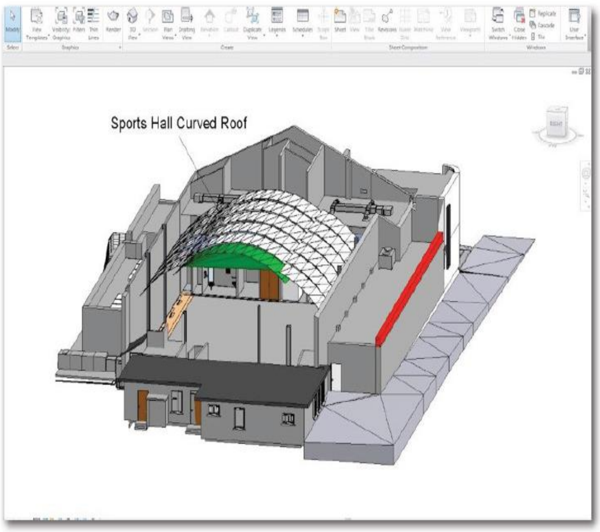


Fig 4P: Lighting Analysis

Fig 4Q: Acoustics

The areas of FM and whole life cycle costing were strongly taken on board. There was a deck area and below it directly was the plant room. The AHU Package unit was placed there and the heat pump located within a room beside it. This was also designed with the view of ease of access to ensure that all future maintenance could easily take place. A BMS was also considered so as to enable the building to become more user-friendly and prevent a lack of information causing further problems. This would allow the option to control running costs and a web alert or sms alert to be sent to designated people to inform them if the building needs attention.

The model had incorporated all the structural and M&E information. Some outline specification had been drafted for the purpose of the QS, with all elements been classified in accordance with Uniclass 2. There was a design option for the floor that was investigated where a touch button would change the layout of the court. This design option was not feasible for the community centre. An illustration of this is show in figure 4R.

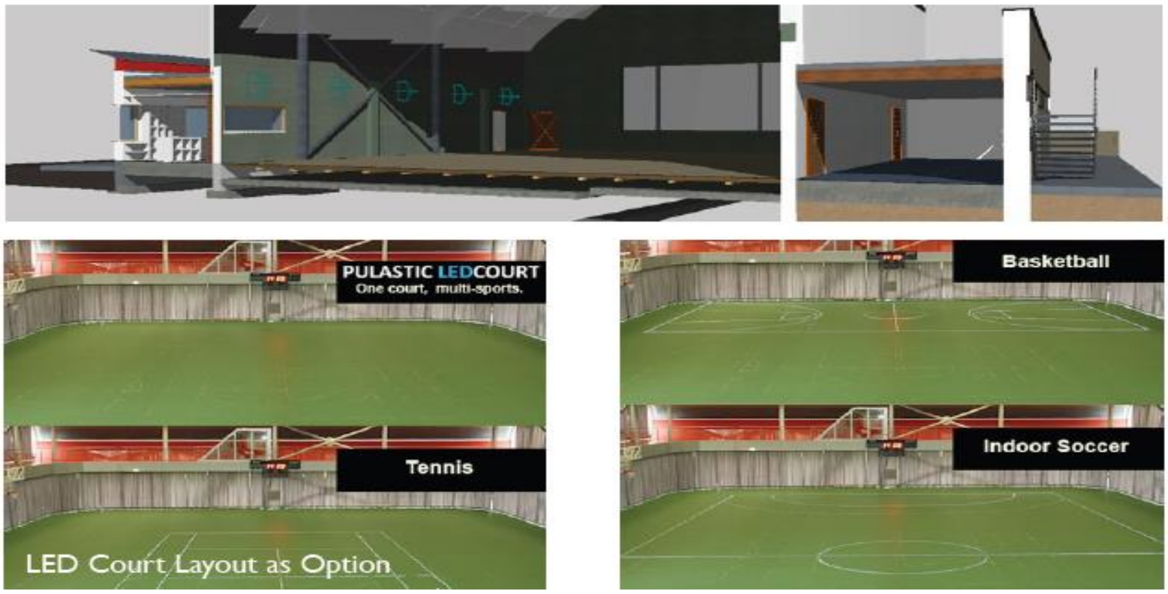


Fig 6.R: Court options.

The objective of the pilot QS Team was to produce a cost plan, which was done in both 2D and 3D. The IFC file was imported into CostX which produces a transparent model. The QS found the model to be information rich but not a lot of this was relevant i.e. 703 cells of information were provided while only 7 are required.

A model map was created mapping information from the model to dimension groups. The preliminary cost plan was calculated in both 2D and 3D. A budget of 2 million was reported, with most of the budget going on M&E. Table 4A details the difference found between using 2D and 3D platforms.

Cost in 2D	Cost in 3D
Time - 1.5 to 2 Days - More work with design team	Time - Initially 1-2 days mapping issues / get across in a format to work with - 1 day to create model maps and cost plan - Benefits will be reaped in Options and changes – any changes to the model can be filtered quiet easily
Ease - Traditional measure with scale rule and hard copy drawings - Make assumptions, ask questions	Ease - Mapping issue are frustrating - Tedious
Accuracy - Composite descriptions / rates – standard cost plan - Accurate for level of detail at cost plan stage	Accuracy - Validation of model. This could be validated from the 2D quantities - How do we know?

Table 4A: Comparison of 2D and 3D

The contractor changed mid-way from John Paul to Stewart. Stewart Construction entered the Pilot with the goal of investigating 4D Technologies in regards to possibly advancing current practices, This included assessing the scope of works, building / structure type, site constraints, budget / duration, prelims, construction sequence, site set up, outline construction programme and procurement. There over reaching aim was to investigate how BIM can make the company more competitive and commercially viable.

The model was used by the contractor for a number of preliminary items that included the calculation of onsite staff, off site staff, welfare facilities, site security, scaffolding, plant and equipment. The model was used for initial site inspection i.e. the model helped establish that the building was close to the road, overhead power lines were an issue, adjacent buildings in the area, etc. This initial assessment provided a quick understanding of what resources would be required for traffic management. Figure 6S and 6T shows an illustration from the model of some of the site constraints.

Fig 6S: Site Constraints example 1

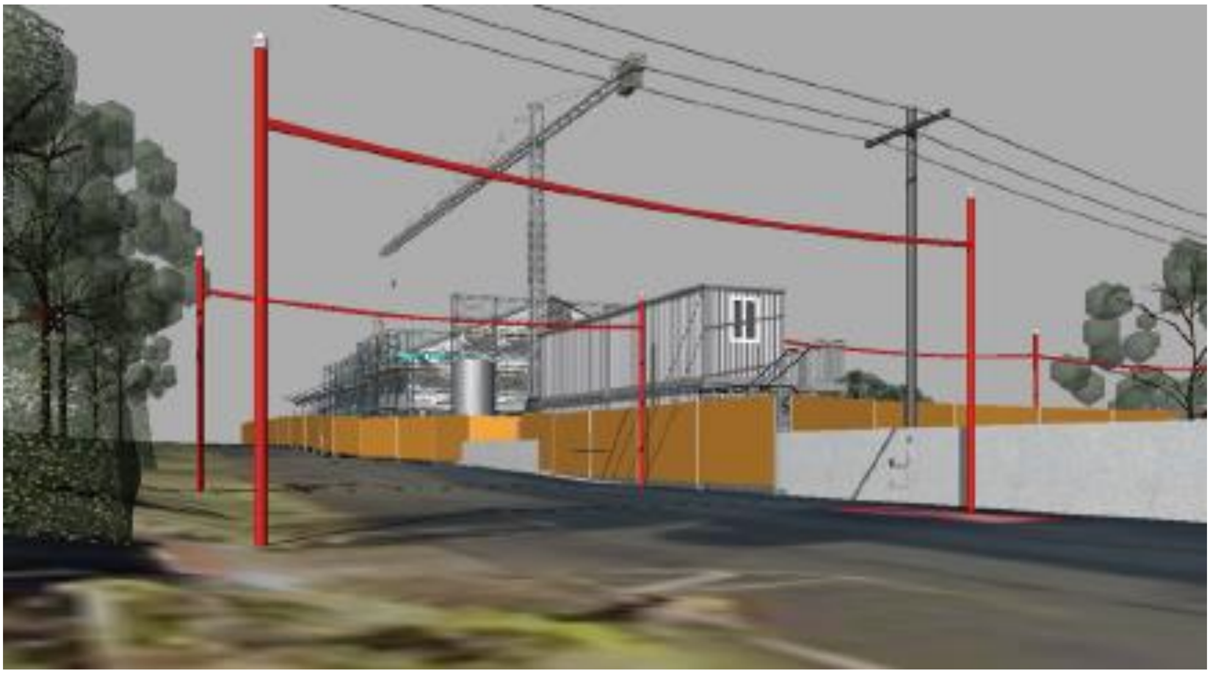


Fig 6T: Site Constraints example 2

Clash detection was performed throughout this process. Clashes included an AHU in front of an exit door, ducts clashing within the ceiling spaces, etc.

Tekla BIMsight was utilised to share the federated model, as it permitted a number of notes to be attached before been issued to the pre-fabricated contractor. The Architect initially investigated how the concrete elements and the subdivisions of the panels could be broken into pre-fabricated slabs. An image of this process is shown in figure 4U.

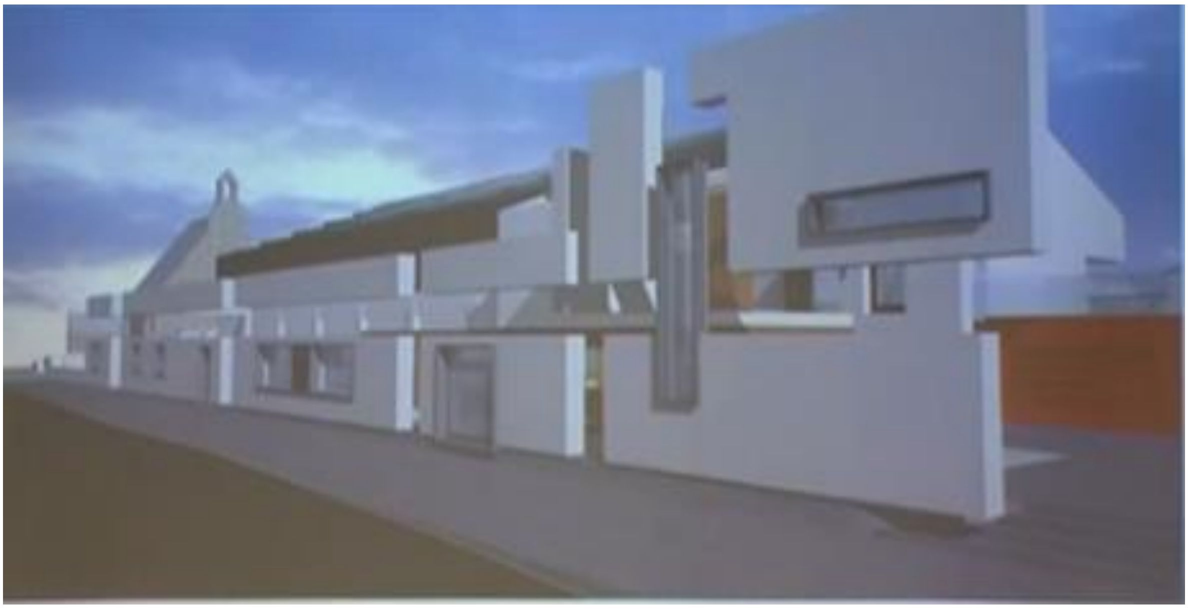


Fig 4U: Possible pre-fabricated breakdown of the building

A full manufacturing schedule of parts, as well as drawings of items, such as stairs in which weights were calculated was produced. The model produced files for the CNC machines, which is a process used in the manufacturing sector that involves the use of computers to control machine tools. These were exported to a German standard known as DSTV. This is a simple format that machine handlers could easily use. A manufacturing team who specialise in pre-fabricated BIM structures were introduced into the Pilot team, so to allow for a number of pre-fabricated elements to be modelled. The IFC file was imported into Tekla Structures in which obstructive and irrelevant surfaces where filtered out, so as to identify what products could be used for the building .

Kingspan where introduced into the Pilot Team. The IFC file was imported into Tekla Structures in which obstructive and irrelevant surfaces were filtered out, so as to identify what Kingspan products could be used for the building. The next step was the setting out of the Kingspan roof and wall sheeting planes.

After this was done the application of Kingspan roof system including roof panels, roof lights, fillers and gutters using Kingspan bespoke toolset / macros were loaded into the model.

APPENDIX 4 – PILOT KPIS

The KPIs detailed below were established to measure both the pilot and FM team's contribution. The KPIs detailed in chapter seven are numbered differently below. Table 4A details the difference in the KPI numbering.

Chapter 7	Appendix 4
KPI 1	KPI 3
KPI 2	KPI 4
KPI 3	KPI 5
KPI 4	KPI 6
KPI 5	KPI 7
KPI 6	KPI 8
KPI 7	KPI 9

Table 4A: Difference in KPI numbering

Taking all the pilot aims, attributes for establishing KPI's and pilot KPI suggestions, the following KPI's were implemented on the CitA technology pilot.

Pilot Teams Skills and Knowledge Development (KPI 1)

- This measured the pilot team's reaction and acceptance, their cultural attitudes, their skill and knowledge level and related software. This sought to measure where the value for each member of the team lies.

Trust (KPI 2)

- This measured the high levels of trust and respect within the pilot team, effective communications, pilot team satisfaction and cultural alignment between client and pilot team. This sought to quantify the benefits of team integration and close collaboration.

4D Planning and Scheduling: Time, Safety and Budget (KPI 3, 4, 5)

- **Time:** This measured the benefits of using a 4D scheduling and planning approach and the possible reduction in the pilot programme that comes with this process. This measured the team's time and expenses associated with the pilot, as well as, preparation for Building Regulations Submission.

- **Safety:** Health, safety and environmental considerations for both the client and stakeholders.
- **Budget:** This measured the savings in regards to how the adoption of current technologies can result in savings for the project.

Early FM Involvement: Environmental, Financial Management, Functionality and Effectiveness, and, FM and Construction Team Engagement (KPI 6, 7, 8, 9)

- **Environmental:** The measured energy usage pre and post occupancy.
- **Financial Management:** The measurement of operational expenditure.
- **Functionality & Effectiveness:** This measured construction and quality assurance.
- **FM and Construction Team Engagement:** This measured the value and barriers associated with the involvement of the Facilities Manager with the design and construction team from the start of the BIM process.

Client Satisfaction (KPI 10)

This measured if the client's awareness has become more sophisticated and their financial budgeting moves towards a more holistic process to incorporate wider environmental considerations. This sought to measure the effective management of the client's requirements and where the value lies for the client.

Waste (KPI 11)

This measured the part that technology can play in the reduction of waste and, therefore, CO2 emissions through the fostering of better off- site fabrication techniques and better practices both.

Figure 4V illustrates the KPIs adopted for the CITA Technology Pilot.

Appendix 4 – Pilot KPIs

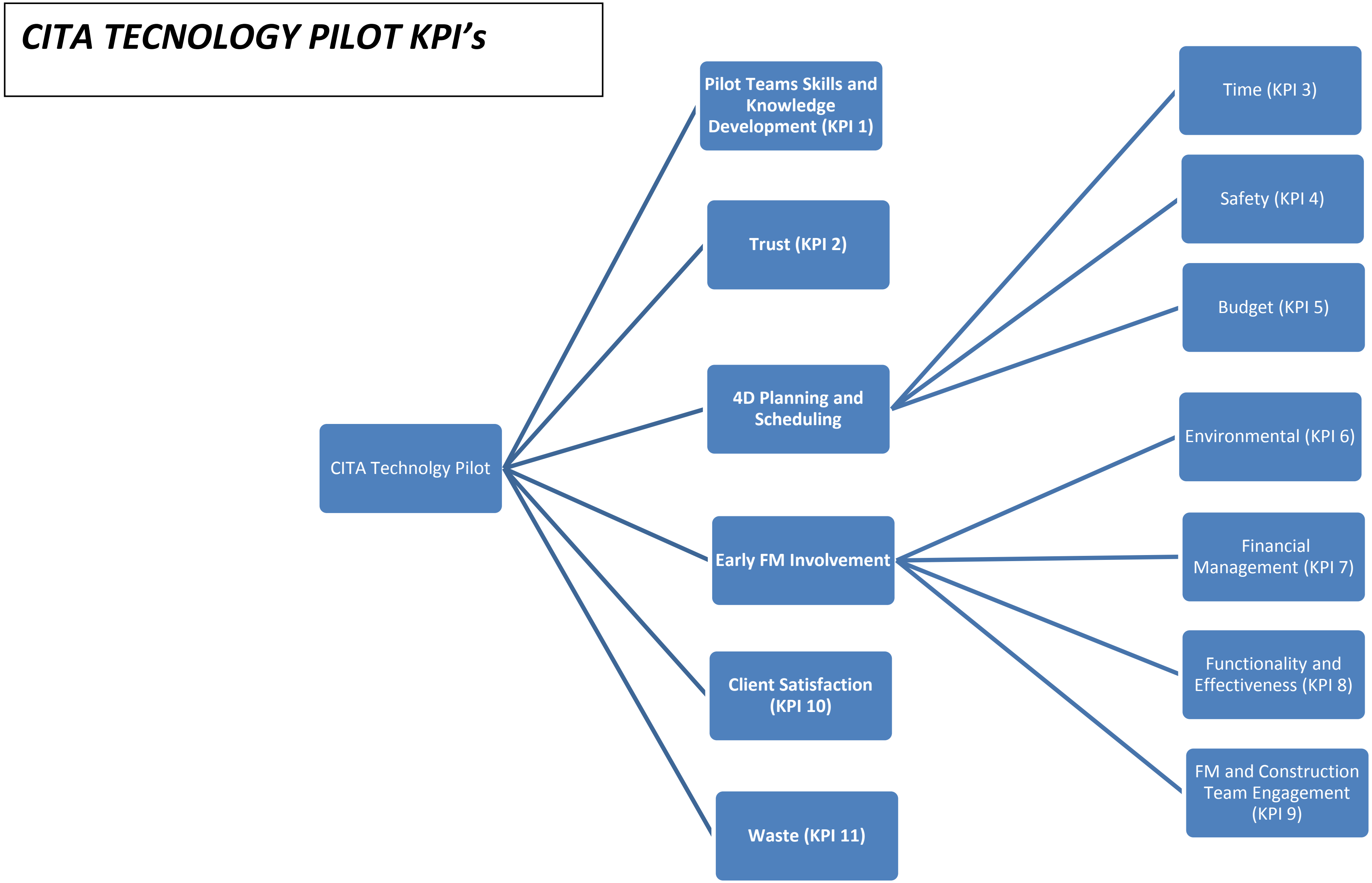


Figure 4V: Pilot KPIs

APPENDIX 4 – CITA TECHNOLOGY PILOT SURVEY

A total of 15 organisations were involved in the pilot. Each organisations were asked to complete a survey at the mid-way point and at the end of the pilot. A total of 10 organisations responded to the final survey. The survey is detailed below in the

SECTION 1 –KPI 1 & 2

This section will measure the pilot's team's skills and knowledge development. This section will also aim to measure the pilot team's trust and where the value for each member of the team lies.

1. This question aims to measure the Pilot Teams Skills and Knowledge Development since undertaking the pilot project. Please indicate the degree to which you have experienced a change in skill and development in the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Knowledge
- Communication and collaboration skills
- Software skills
- Attitude

Please add any further positive or negative comments in regards to any further team skills and knowledge development encountered throughout the pilot to date

2. This question aims to measure the high levels of trust and respect within the pilot team. Please indicate the level in which your trust has changed in regards to the outlined areas below:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Trust and respect for other disciplines within the pilot team
- Trust in regards to effective
- communications
- amongst other pilot team members

- Trust and cultural alignment between client and pilot team

Please specify any other areas in which you found where the levels of trust within the pilot team where enhanced or restricted

SECTION 2 –KPI 3, 4 & 5

This section will aim to measure the three KPIs that are valued the highest when it comes to 4D & 5D Technologies.

3. **This question aims to measure the benefits of using 4D scheduling and planning in regards to reducing the project schedule (time) for the pilot project. Please indicate the level in which 4D scheduling and planning has been an advantage or disadvantage in the following areas:**

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Reduction in the pilot programme by using 4D technologies compared to other traditional construction project you have worked on.
- Time and expense in which you have encountered by working within the pilot.
- Reduction in time in regards to Building Regulations Submission

Please indicate where you believe that 4D Technologies can have the most benefit to your profession. Also please provide an estimated figure if possible for the amount of time and expense in which you have encountered within the pilot to date.

4. **This question aims to measure the benefits of using 4D technologies within the pilot in regards to safety. Please indicate the level in which 4D technologies can be an advantage in regards to safety within the following areas for both client and stakeholders:**

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Health and safety on site
- Environmental considerations

Please comments on any particular areas that were enhanced when it came to safety by using 4D technologies.

5. This question aims to measure the benefits of using 5D technologies in regards to controlling the budget within the pilot project. Please indicate the level in which 5D technologies have been an advantage or disadvantage in the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Cost reductions in the budget by using 5D technologies compared to other traditional construction projects you have worked on.
- Accuracy of predicting budgets
- Time spent in producing budgets

Please indicate where you believe the use of 5D Technologies can have the greatest savings.

SECTION 3 –KPI 6, 7, 8 & 9

This section will measure early Facilities Management Involvement in regards to Environmental, Financial Management, Functionality and Effectiveness, and, FM and Construction Team Engagement. This will aid in establishing the key measures / areas from the early stage of design into post occupancy, as they pass through the whole BIM process.

6. This question aims to measure the benefits of early Facilities Management involvement in regards to better environmental practice. Please indicate the level in which early Facilities Management Involvement in regards to better environmental practice has been an advantage or disadvantage in the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- The measurement of energy usage pre and post occupancy.
- Evaluating sustainability options

Please specify how early FM involvement can enhance environmental consideration and practices.

7. This question aims to measure the benefits of early Facilities Management Involvement in regards to improving financial management. Please indicate the level in which early Facilities Management Involvement can impact financial management within the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Operational Expenditure

Please specify how early FM involvement can improve financial management for the building

8. This question aims to measure the benefits of early Facilities Management Involvement in regards to increasing the Functionality & Effectiveness within the pilot project. Please indicate the level in which early Facilities Management Involvement can impact the Functionality & Effectiveness of the plot project in the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Maximising construction potential
- Maximising sustainability potential
- Enhancing quality assurance for the client

Please specify how early FM involvement can increase the functionality and effectivenss of the project

9. This question aims to measure the value and barriers associated with the involvement of the Facilities Manager with the design and construction team from the start of the BIM process in regards to the pilot. Please indicate the value in which the early involvement of the Facilities Manager can help impact / change the BIM process.

SECTION 4 – KPI 10 & 11

This will section measure the client's satisfaction and the part that technology can play in the reduction of waste within the pilot

10. This question aims to measure the client's awareness within the pilot. Please indicate the level in which the client's awareness has changed below:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Client's awareness has become more sophisticated
- Financial budgeting has moved towards a more holistic process to incorporate wider environmental considerations.
- Effective management of the client's requirement

Please specify where you believe the value lies for the client

11. This question aims to measure the part that technology can play in the reduction of waste through better off- site fabrication techniques and better practices both financially and environmentally in regards to the pilot. Please indicate the level in which technology can play in the reduction of waste in the following areas:

Options – 1) No Change 2) Little Change 3) Some Change 4) Significant Change 5) Much Change

- Construction waste
- CO2 emissions.

Please specify how technology can be used to reduce waste through better practices both environmentally and financially

12. Have you any further comments or suggestions that you would like to address in regards to the CITA Technology Pilot?

APPENDIX 4 - TRANSCRIPT OF INTERVIEWS FROM THE CITA TECHNOLOGY PILOT

This part of Appendix four details an interview with the 5D consultant (5DC) from the CitA technology pilot.

INTERVIEW TRANSCRIPTION

Barry	*In your experience do you find there has been a disconnect between the client's needs and what they receive at handover?*
5DC	Yes, I think that there's a big disconnect as clients focus solely on the capital expense and are not really thinking about the operation of the building. The focus is always on the capex rather than opex. They can find themselves becoming lost in the construction process.
Barry	*Do you find that BIM has helped better realise the client's needs?*
5DC	BIM can make the construction process more transparent and lets the client visualise what they are getting. It can be difficult for non-construction people to interpret traditional 2D documents or convert a 2D document to a 3D visualisation in their mind.
Barry	*In regards to the BIM process do you feel that you contributed at the right times or the QS should be involved earlier.*
5DC	I have been away from the formal QS role for a number of years, however, the traditional arrangement was that the QS would be involved from the start. Traditionally the QS would be appointed and shortly after the Architect was appointed. They would start preparing early stage estimates and order of magnitude costings. I think QS engagement with BIM has to start earlier, the QS has to start working at mass model stage and not just when it's a fully developed model.
Barry	*A high level of trust was experienced in the pilot through transparency. In a real-life scenario could you imagine this type of trust being shown in a real-life project?*
5DC	I think so but it depends on the side of the table you are at, whether you are part of the design team or whether you are the contractor. If it's a traditional arrangement where it's design, bid and build there's always that reluctance to share and be transparent with the contractor. But generally with design teams there would be a certain amount of openness and transparency.

Barry *You mentioned in one of your KPI that model quality issues are a big constraint at present. Would you be able to elaborate on this for me?*

5DC Yes, there's a disconnect between the designers or model authors who are not aware of how models will be consumed downstream. Something that looks good in 3D, when you peel back the layers, there's gaps or there's issues with information. In the pilot project model there are some ceiling tiles or acoustic baffles on the roof of the sports area. They are modelled using a floor tiling tool. So when it comes across into the quantification software these items appear in the roof as being floor tiling.

There are issues there with translations. When the objects were taken out into another platform and actually quantified, a lot of the information wasn't transferring across. So you were getting very generic descriptions.

Barry *What experience within the pilot, if any, did you have in helping to shift project focus from design and construction to FM and operations?*

5DC I didn't see anything that was feeding through to the costings from a facilities management or an operational perspective i.e. putting in CHP plant as opposed to a regular electrical connection. We did not do lifecycle costing or whole lifecycle costing or look at the operation side of things, which was probably a failing on our part.

Barry *Is it a lack of knowledge within the industry of exactly where early FM involvement can be of benefit.?*

5DC Yes, I think it's down to there being a disconnect that the Facility Manager does not get involved in projects until handover stage.

Barry *Is this still the same with regard to the BIM process?*

5DC Yes. The UK are looking for a 20% reduction in capital costs and 27% reduction in carbon costs. They realise that over the life of a building the capital cost is insignificant. A recent study showed that the capital cost was only 6% of the cost of the building over its life. So, as an industry the QS only controls 6% of the capital cost of a project. Whereas, if we could spend an extra 2%-3% on capital costs may reduce the operational costs. The industry needs to look at outcomes of building projects rather than outputs. We are all focused on handover and getting to practical completion, and then getting to the end of the defects liability period, and that's it. We don't as an industry think about, well how is this building going to operate for the next 30 years.

Barry *Within your KPI survey you mentioned there's too much focus on the technical aspects of the 5D process. How do you believe the involvement of the Facility Manager as a profession can impact or change the BIM process?*

5DC As a QSs I don't know what components are good or bad over the life of a building. A lot of FM companies should have a pool of information, such as, if a valve fails every four years as opposed to every ten years i.e. using a George Fisher as opposed to a Pegler Newton type of valve. This information should be given to the design team. Nobody thinks about how the building will be maintained. Maybe, by spending an extra 10% at construction stage, could reduce FM expenditure over the life by 20%. It is the FM guys in theory that should have that information. Whether they actually have it or whether there is a lack of databases there, or whether they just don't analyse their stuff that way I cannot tell. There's a gap there for someone provide this type of information.

Barry *.Could you suggest any key criteria to help measure the involvement of the Facility Manager?*

5DC To assess the impact of their involvement it's going to be difficult. In terms of KPIs it could be design options that happen once the Facility Managers gets involved. The only other option is to examine what would the planned capital costs have been without FM involvement versus with FM involved? Then you would need to look at operational savings as well.

Barry *From your experience in the pilot and your experience in general, do you believe that Client awareness has become changed through the use of BIM?*

5DC No. I think there's still a lack of client knowledge as to what BIM can deliver. There are a lot of Irish clients mandating level 2 BIM on projects but they don't know what it means. They are asking for level 2 BIM and are not thinking about the data they need. The decisions they make normally there's no formal data coming back to base those decisions on. Having formal gateways and COBie data drops, as well as being able to assess design team performance and have information at key decision points is novel. And a lot of Irish Clients don't seem to know what an employer's information requirement documents is.

APPENDIX 5 – NVIVO PROCESS

Method of Results

The first part of this process involved familiarising yourself with your data, this involved in putting all of the data detailed from table 8.1 into Nvivo. After cleansing of the data to eliminate incomplete or unrelated answers, each one of the primary research outputs where imported into the software. A snapshot of this can is detailed in the figure titled "Initial input of primary research".

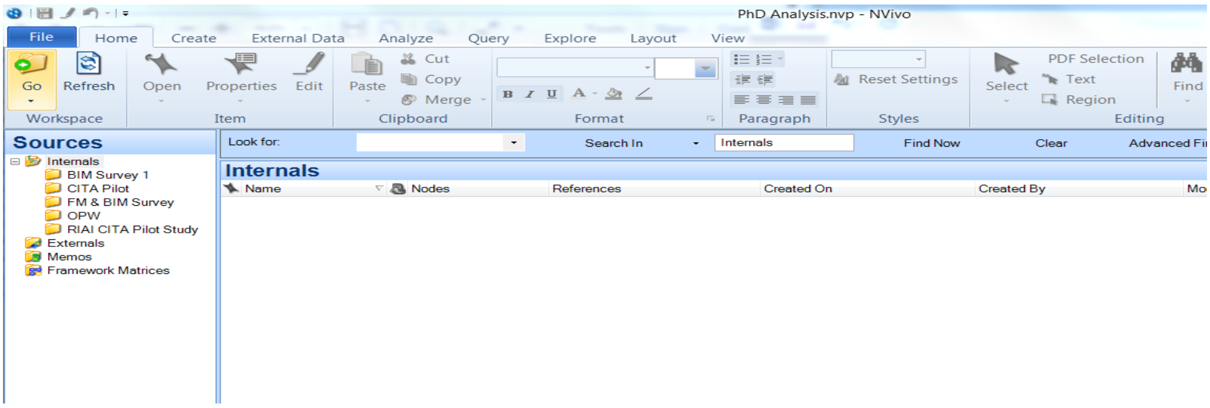


Fig 6A: Initial input of primary research.

The first phase involved interrogating the research and generating nodes within each piece of primary research. This involved manually scrolling through all the data and systemically coding lines of text to the relevant nodes. This part was extremely time consuming owing to the high amounts of collected research. This created an initial 60 nodes in which can be located in the coding book in the appendix 6B. A snapshot of this process is titled "open coding" The Snapshot titled "coding process" details the process involved in the coding of one single line of text within an interview transcript.

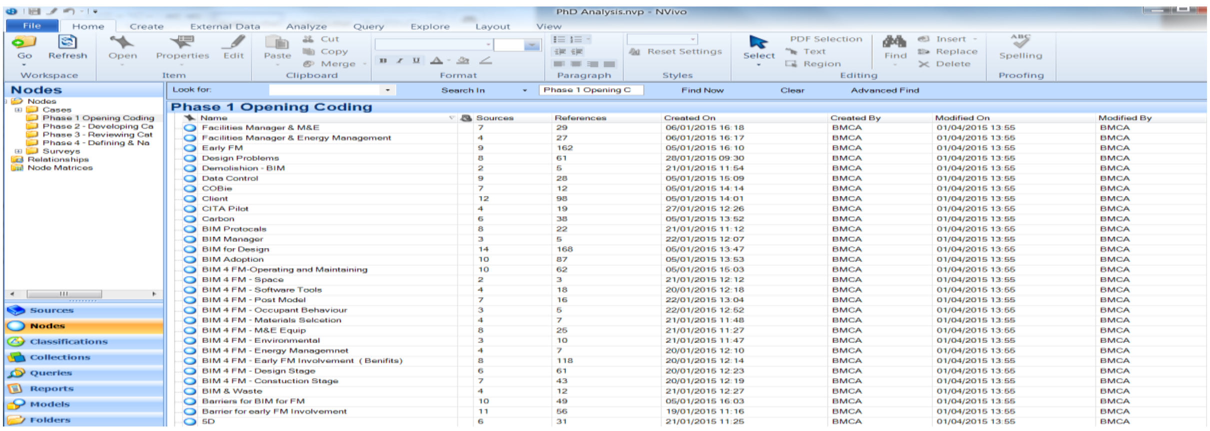


Fig 6B: Open Coding

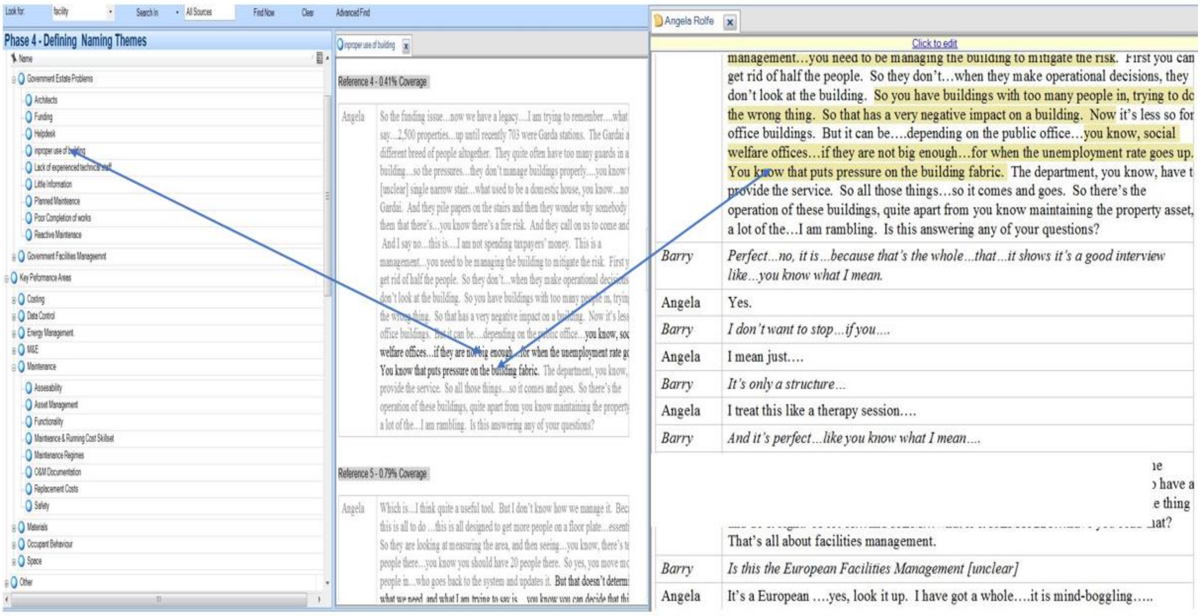


Fig 6C: Coding Process

The second phase involved developing categories in which consisted in the collating of codes into themes. This involved going through each of the nodes and then organising them into categories. This ultimately involved breaking the nodes down into more descriptive nodes and assigning them to the most relevant categories. This produced 11 categories in which consisted of 58 nodes. The breakdown of phase two of the coding can be located in the coding book in the Appendix 6B. A snapshot of this process is detailed in the figure titled "developing categories".

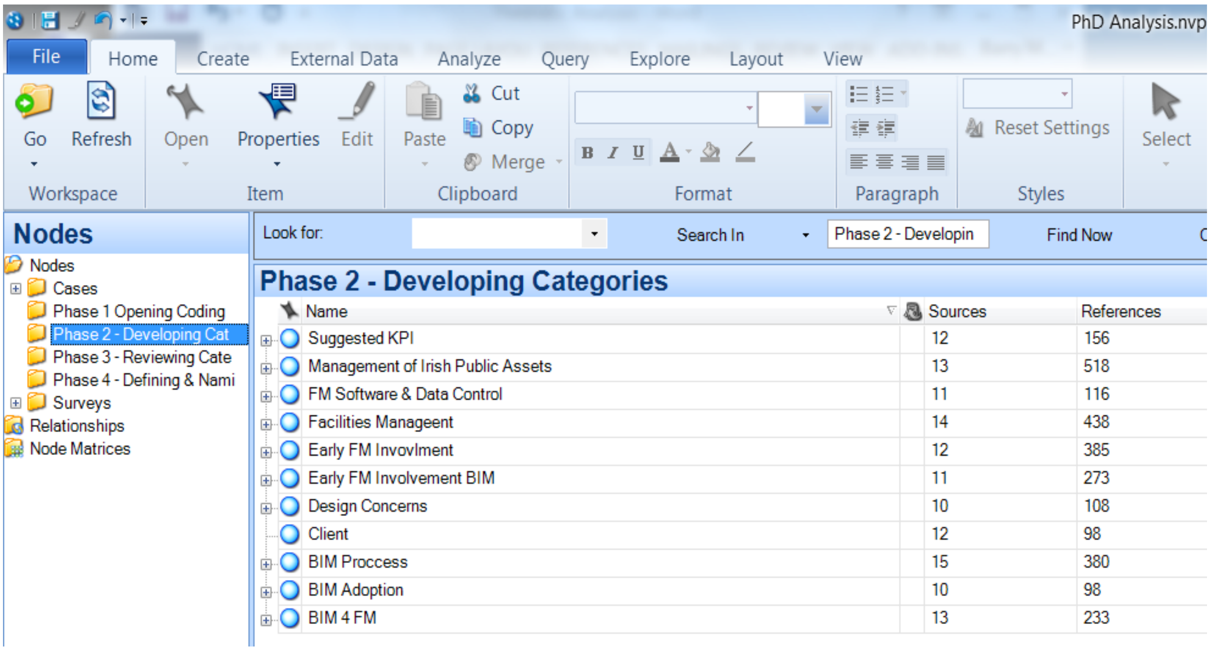


Fig 6D: Developing Categories

The third phase involved reviewing the categories to ensure the coded themes work in relation to the extracts. This involved reviewing the categories and breaking down the now restructured categories into sub-categories to offer a more in depth understanding. This produced a further 14 nodes. The breakdown of phase three of the coding can be located in the coding book in the Appendix 6B. A snapshot of this process is detailed in the figure titled “reviewing categories”.

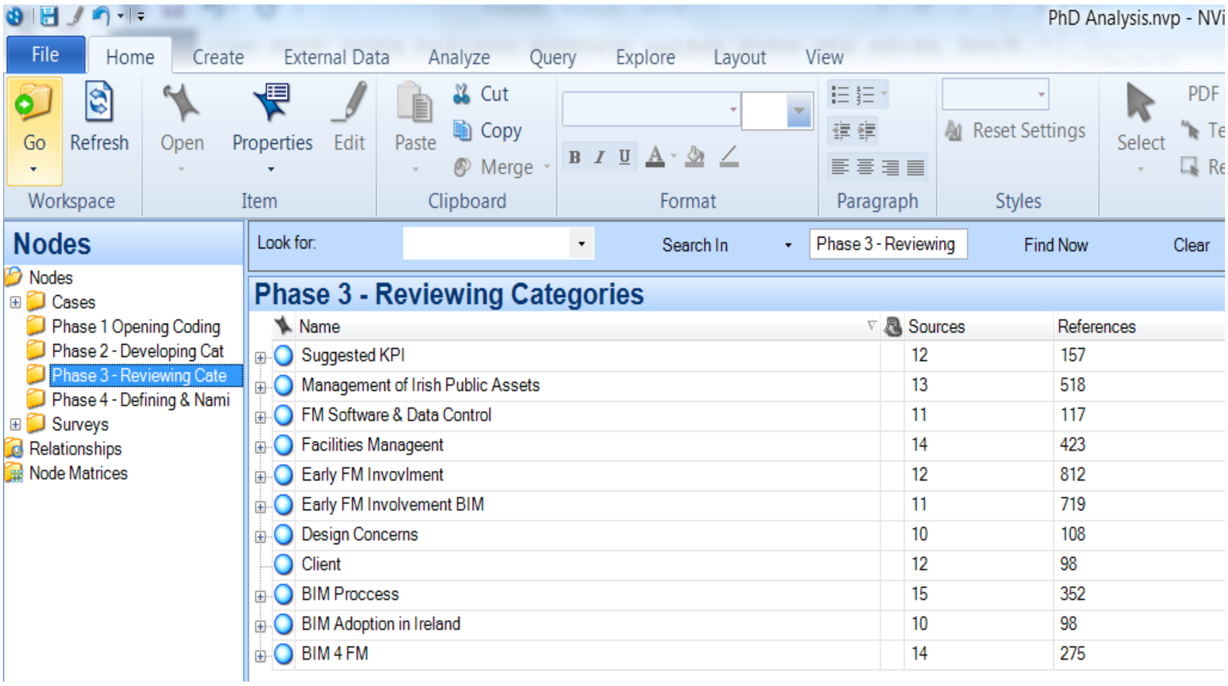


Fig 6E: Reviewing categories.

The next phase of the thematic analysis involved defining and naming themes and the reduction of data. This produced 3 key themes that had a total of 69 nodes. Memos where further linked to the analysis as this enabled one to record the ideas, insights, interpretations or growing understanding of the material in the project. A snapshot of this process is illustrated in the figure titled “linking memos”. Important aspects of the interview or data where recorded through annotations. This permits the recording of comments, reminders or observations about specific content in a source or node. A snapshot of this process is illustrated in the figure titled “Annotations”.

Appendix 5 – Nvivo Process

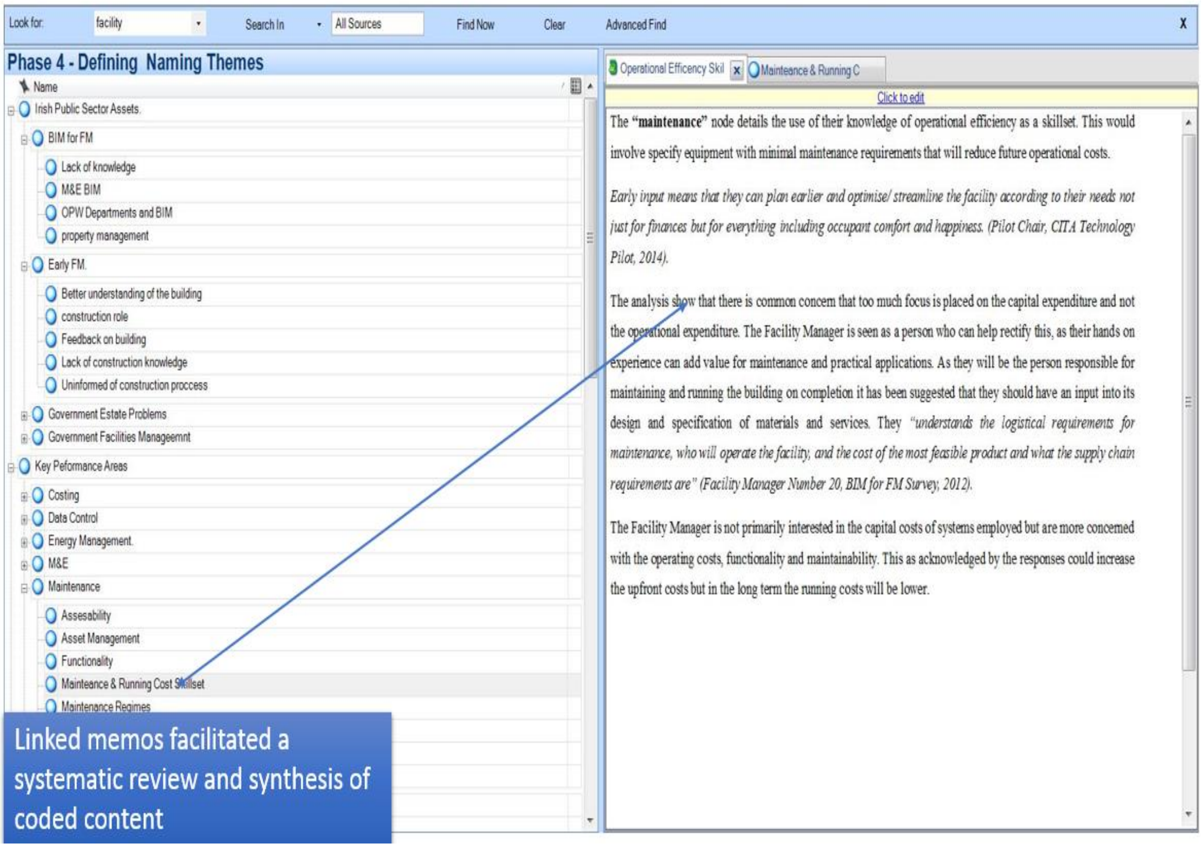


Fig 6F: Linking Memos

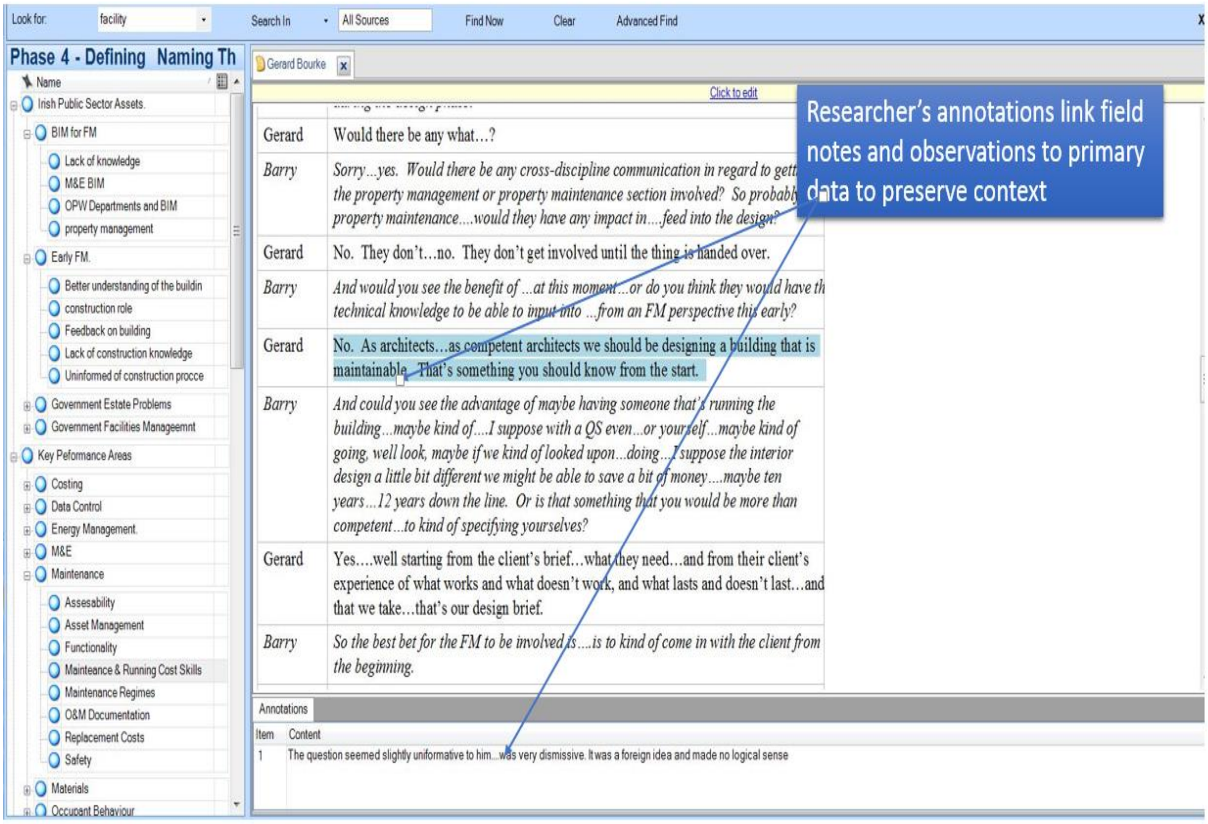


Fig 6G: Annotations

APPENDIX 5- TRANSCRIPT OF INTERVIEWS FROM THE OPW

This part of Appendix six details an interview with the Head of Property Maintenance (HPM) within the OPW

INTERVIEW TRANSCRIPTION

Barry	*What is your current knowledge of BIM*
HPA	The reality is there are about 2,500 existing buildings that we are responsible for and most we have very little information on. The new builds, which there are very few at the moment, would be wonderful to have a model on. But that's going to make such a little difference on the day to day operational issues. We have had no recruitment within the OPW for many years and for BIM to be a reality we need some enthusiastic people who will want to use it.
Barry	*What assets or buildings do your look after on a daily basis?*
HPA	There are about 320 properties in each of my eight regions and within those I would have a regional architect, two technicians and three district inspectors who effectively do reactive and planned maintenance and minor capital works, on all those properties. These properties range from one man Garda stations, little bungalows to whole complexes of large government offices which would have multi-occupancy, most of which were built in the 80s and 90s. They are coming to the end of their useful life. We also have some decentralised offices that were built by developers who now don't exist and are falling apart. They do not have safety files because there was a dispute and the paperwork never came through. That's the reality.
Barry	*How do you maintain these buildings from day to day?*
HPA	We have people on the ground who can respond to an incident, such as if a kid throws a brick through a window of a Garda station or if after a storm the roof is leaking. We perform condition reports on key buildings and decide if we are going to resurface or replace the windows in that building. That's the sort of basic level we are at. In parallel our M&E colleagues would have maintenance contracts in place for all the statutory lifesaving systems. So there's that day to day work going on keeping all those properties maintained

HPA So they are reasonably fit for purpose and if we are lucky the property asset value isn't diminishing. There's a whole funding issue in relation to all of this but I won't complicate the funding part, because obviously we broke the budget again this year, because we weren't given enough. But you have to react and there are some things that are not negotiable.

Barry Is there O&M documentation / safety files for these buildings?

HPA I mean it is very rare where a new building has been built and handed over in the last ten years with a proper set of as built drawings and a proper safety file. There is a practical completion in where the project team becomes dispersed. The snagging and the final retentions become something that's squeezed in.

Barry Have you seen on many occasions where the Facility Manager may be involved in the Design phase?

HPA Oh very rarely. I think the coastguard stations has asked for the assistance of one of my District Inspectors to act as clerk of works, or actually resident engineer. They take on this role in order to keep their skills in terms of working on building sites, rather than just fixing things. And I facilitated that. In one instance in Killybegs the District Inspector / Civil Engineer sent a photo of the foundations to the Architect in Dublin.

Barry Did the Architect act on this information?

HPA Yes, she condemned it without having to drive all the way to Donegal.

HPA More often than not the design team would do their own thing and we are lucky if we know what's happening.

Barry Would you see a benefit of having one of your staff sit work with the Design Team

HPA Absolutely. Well certainly at the very least at practical completion or as the building is being complete.

HPA They could attend the site meetings and understand how the building was put together. There is a danger from my point of view that they will be sucked into the process, and they could spend all their time supervising the site, and not doing their own job. There are politics within the public sector at the moment, where there's not enough people to do everything. So there is has to be a bit of give and take.

Barry At present what is the greatest maintenance costs?

HPA In Dublin we have a measure term maintenance contract, which means there is a help desk and a call out and everything is well documented. I think in Dublin north and south, we probably have about 400 properties that are large and complex. We spend about €3m on providing a reactive and planned maintenance service for those buildings i.e. door handle falls off and they call it in to the help desk. Effectively in terms of expenditure we spend €3m in Dublin and €3m across the rest of the country doing reactive maintenance.

Barry *How can you reduce this spend in the future?*

HPA We want to reduce reactive and increase planned. There are logistical issues. Because for planned we probably need to put together tender documents, so you need somebody to do drawings. So it's a different sort of person doing that.

HPA The whole funding issue has changed recently. There was a Department of Finance circular in 1994 where effectively each department funded their maintenance. So they prefunded OPW and we carried out the maintenance. But they decided if the roof was leaking they would only pay to patch it, they were not going to pay to do the whole roof. And if they were in Government buildings it was only the department who was immediately under that part of the roof that was leaking. So now the funding since January 2013, there's a new circular, and that money comes to us, which gives us in theory a move from reactive to planned. The difficulty is we have legacy problems because buildings weren't properly maintained.

HPA Take for example, we have a total of 703 were Garda stations. The Gardaí are unique. They quite often have too many guards in a building and do not manage buildings properly. They pile papers on the stairs which results in a fire risk. This is a management problem and you need to manage the building to mitigate the risk. Essentially you have buildings with too many people in, trying to do the wrong thing. So that has a very negative impact on a building. Also with social welfare offices if they are not big enough for when the unemployment rate goes up can put pressure on the building fabric.

HPA I am grappling with all these things at the moment and I am looking at how other places do it. I am trying to have a maintenance management framework and we are looking at the European Standards at the moment. We are focusing on section 6 which is space management. It is tough work to understand them.

HPA It is all designed to get more people on the floor. So they are looking at measuring the area and how they fit more people on it. But that doesn't determine what we need and for example if the roof has failed the staff numbers should reflect this. This is primarily about office buildings. A lot of our properties aren't office buildings. Historic properties, visitor centres for national monuments, cultural institutions. So there's a wide range and a lot of them are small domestic buildings out in rural situations. The ISO standards systems are effectively designed for large companies and corporations with a strong portfolio of office buildings. We don't have that sort of portfolio.

Barry *How do the OPW intend to manage the information with regard to these buildings.*

HPA At the moment they are looking for records on buildings and at present we don't have proper records. Buildings are messy, difficult things and they fall down and they break. It is difficult to have an accountancy view of a building on paper. If you are a company with a portfolio and can decide on the standard of facilities management, there is no problem in achieving this. We own a variety of buildings and lease a lot of buildings that are occupied by other entities that we have no control over. How the Revenue Commissioners use a building is quite different to how Social Protection uses a building, which is quite different from how the Gardaí use a building. It is not our business to tell them how to operate these buildings.

HPA There is one thins the OPW has always done very well particularly since 1922 is convert, alter existing buildings for new uses. Take for example the Customs House which is now an office building. The Four Courts has been completely reconfigured inside. Leinster House was not purpose-built as a Parliament building. That was the Duke of Leinster's townhouse and then it was taken over by the RDS. I don't think OPW as an organisation has themselves designed and procured and constructed an office building. In the decentralised programme, we were instructed by Charlie McGreevy to use the design build on PPP.

Barry *From your knowledge is there a good level of BIM awareness in the OPW*

HPA Yes, we haven't engaged our engineering or QS colleagues to do a full BIM. There has been Revit training which has been used for a lot for presentations. We have got to invest in the people and we need a new generation of people effectively to take the lead. What we do not have at present a generation of technologists or architectural technologists that are skilled in BIM.

Barry *BIM could possibly be a great help in regards to the better management of O&M activities .*

HPA The thing that you should realise about state buildings is that there are no building officers i.e. technically qualified building officers in any state buildings. In other words, we design, procure and construct a building and then we hand over to unqualified people and then wait to get the call when something goes wrong. The only public buildings that I am aware of in Ireland that have building managers are third level institutions, colleges, universities and ITs.

Barry *Who are responsible for the management of the other public sector buildings?*

HPA There is a sort of attitude that anybody can manage a building.

HPA A Government Department would have what is known as an accommodation officer. It could be a general service person, who will look after things like the cleaning or the catering or broken furniture.

HPA If something is broken they are not technically qualified to understand the safety file. As this job is of the general service grade, if anybody takes to it, or gets into it, chances are they will be promoted somewhere else in the organisation. So it is not seen as a specialist area with any specialist knowledge.

HPA I think something like 12 district inspectors retired in the last 6 six years. These were of the older generation and had a strong understand of the buildings needs. One gentleman could tell from how hard the wind was blowing if there would be a leak in the roof.

HPA It is difficult operating in the public sector. With a corporate organisation who has ten office buildings in a number of cities, making serious FM decisions about how they maintain the assets, how they retain the staff is my understanding of FM working at a high level. If the OPW reduced its office buildings to a select number, you could probably do that. The public sector cannot knock down all the interior walls and make it open plan and decide to install sash windows. These type of issues are not efficient in what FM assumes in terms of what the building looks like. In the public sector you can either sell the building if it’s not performing, or they can invest and upgrade the whole thing. They can borrow the money and do what’s needed. We cannot do this because it’s taxpayers’ money. We are not property speculators and essentially are stuck with what we have.

HPA The OPW looks after all the building, fabric and services, because we are the only people with the expertise to make sure that it is compliant. What used to happen is that Clients got in their own builders and they knocked holes through walls and ducts, etc. The fire stopping was all destroyed. There was nobody managing these works and we have now discovered that there is fire stopping issues, damage to the roof, etc.

HPA We are still too much reactive and that's to do with the legacy of things. It is also to do with buildings standard i.e. when they are built back in the 80s and 90s, which isn't the standard now.

Barry *Do any of the buildings have computer management maintenance systems?*

HPA We have been fighting for a maintenance management system for the last five years. There is something on e-tenders at the moment actually.

HPA We have a help desk and because we have building codes, you can press a button and see all the works that were done on a building. We cannot do this for buildings down the country, because we just don't have that system. What we want is a central help desk with a proper system, not only, tracking the works and the payment, but the customer feedback, etc. We can use this information to intervene instead of been dependent on somebody picking it up

Barry *How is O&M information requested at present?*

HPA Nowadays it tends to be a CD.

HPA But with a hard copy in the building. That's what I think we are currently asking for. We do have boxes full of hard copy documents, which never got to where it should be. At least the CD can go on the file. It can be easily copied or you arrive and there should be a hard copy on site, depending on the building. Most of the buildings were built long before safety files were required. You may have part of a safety file but you would not have it for the whole building, unless you were doing a full refurbishment.

HPA It's fairly primitive I am afraid.

APPENDIX 6 - TRANSCRIPT OF INTERVIEW WITH THE MODEL CO-ORDINATOR FOR THE SPECIAL SCHOOL

This part of Appendix seven details an interview with the Model Co – ordinator (MCo) from the DoES.

INTERVIEW TRANSCRIPTION

Barry	*Can you please provide a quick background on the model.*
MCo	Well our forward planning unit would have identified a need for a new school to treat children with autism of varying scales. An area was identified where a large number of kids were already attending other primary schools with facilities for kids with special needs. The Department's forward planning unit would have identified this to the DoES. The Department would have then developed the brief for a new school based on a population of about 80 children that will be attending the school. Sites were investigated and reviewed within the available area, and the most available site was selected. This site has its own challenges with regards to access, given that Wexford is a sloped area of the country.
Barry	*What is the connection between the OPW and DoES?*
MCo	Well effectively the OPW would do work for the DoES on a contractual basis. Currently the only schools that the OPW are doing are through the devolved programme scheme, where external agencies through the Department are given a number of schools to roll out over the year. Currently the OPW have 11 schools for this year. On this basis, that's how the OPW and the Department would interconnect with one another.
Barry	*So the OPW would procure a site and then you would build it?*
MCo	Yes. They would look after everything from site procurement right through to final construction, appointment of contractors, etc.
Barry	*Where does the DoES fit with regards to this partnership?*
MCo	We do the same, our technical section has 36 people working in it, all varying qualifications, architectural, engineering, mechanical and electrical, quantity surveying, architects and technicians or technologists. Basically considering the number of schools we do in a year, the department would not be able to handle the

volume of work. This is why we use the support of the other agencies that may not be so busy.

Barry *Did the OPW have any input into this school?*

MCo No. Absolutely none at all. This is totally done by the in-house design team in the Department because we have the specialist knowledge with regards to kids that have disabilities. This has all been incorporated into this specific design. This would be outside the normal scope of design parameters that the Department would set through their guidelines due to the nature of the kids who are going to be attending the school.

Barry *Has there been any FM input into this model? Do you have a specific FM department that has worked in partnership with the DoES on the model?*

MCo No. There would not be a specific FM department. The FM element to the buildings are left to the design team to design. The fundamental approach to designing schools from a FM point of view is to reduce any ongoing or maintenance costs for the school. Therefore, the design must be very robust and tried and tested. This does not get away from standard criteria, such as mechanical and electrical equipment that needs maintenance and requires an FM input. This is normally done by a FM specialist. If it is our mechanical and electrical design team, then they will have to come up with a schedule of maintenance services which are handed over to the board of management of the school.

Barry *So the M&E Department in effect would offer the strategic FM input for the department?*

MCo Yes. They would do lifecycle costs on pumps and equipment and anything that has to be maintained from a mechanical and electrical point of view, and likewise if the architects select something on the façade or whatever that requires annual or regular maintenance, this has to be defined within the project brief. That's part of their brief. This would be done on all traditionally procured projects. On projects like PPPs the FM people are brought in at the design stage. So when you would appoint contractors, whoever the winning contractors bid is, their FM people would actually be brought in at that stage.

Barry *So who would the FM specialist typically be?*

MCo They would be a mixture of a lot of different professionals. Depending on the type of building that you are doing, you could even have people that are brought in for landscaping depending on the requirements of the development plans. Again, the brief for the project defines what is going to happen within the physical infrastructure and it will determine what FM specialists are required.

Barry *With regards to running of the school, is this left to the Board of Management?*

MCo Yes. The Board of Management in all primary and secondary schools will be the people that are responsible for running the actual school. This is a voluntary board and is voted in every three years by the school. They have an election every three years. This could be lay people, members of the teaching staff, it could be anybody. They are not necessarily building experts. So, that in itself does create issues with us, because with the handover from one Board of Management to another it may not transpire that all the O&M manuals have been handed over. They could end up in somebody's garage or somebody's house. Once again that creates a big issue for us. We have tried to get around that is by asking for the manuals to be supplied in a digital format, which can be stored on a computer in the school or stored in the DoES for further use. This means that if the building is ever going to be developed we have a copy of the as-built drawings and certain information about the building that we would believe to be critical for an extension.

Barry *Is there any use of advanced FM systems such as CAFM?*

MCo No. They would all be paper-based or pdf copies of the files on a CD.

Barry *With regard to the specialist FM consultant, is this an in-house consultancy offered by the Property Maintenance Department?*

MCo These would be services that traditionally are not engaged by the Department internally. So if you don't have the expertise internally we buy in those services. So we would look to tender an FM consultant to produce any documents that need to be produced for the tender.

Barry *What stage is the model at currently?*

MCo The model was used to generate the planning drawings, the DAC drawings and the fire cert. So all three have been procured and any statute obligations on the actual physical building are now being adapted into the model. There were a couple of issues with the DAC and gradients on the site, given the site has some severe slopes on it.

MCo The project we are hoping will start in September this year, provided all of the cost requirements are met. It's not a traditional form of building. It's going to be expensive but stage 2b approval has been given. So we are now on stage 3 of the PwC project stages. The next step now is to prepare the project for tender.

Barry *Would you be happy to go to tender with the current model?*

MCo No, I would say the model is about 90% complete. We have through the collaboration process that we are using, found anomalies and those issues are now being fixed to make sure that everybody's models are compliant and succinct with one another.

Barry *Would the specialist Facility Manager ever be employed as part of the design team?*

MCo This would come down to the designer's knowledge of education buildings. We know what works in buildings and we know what does not work in buildings. The danger is that when we start to introduce new products or new systems. Take for example the access system that for the building which are very high tech. We would rely on the mechanical and electrical engineer to have their homework done in relation to the operational costs associated with that particular system. They would need to produce documentation showing this. It is a requirement at stage 2b that all those elements are done. This is something we are starting to look more and more at, because it is becoming more prevalent in the industry that people are looking at how long the building is going to be in use as opposed to just building a building and occupying it. This is now gaining a higher status within the design remit

Barry *The DoES seem a little more open to involving the Facility Manager in the design process than the OPW?*

MCo The OPW would have to follow the same guidelines that we do in relation to public procurement. They traditionally would have had maintenance personnel that would have looked after buildings, which would have been the old caretaker system. But buildings have become more technologically advanced and because of that, your standard caretaker now would not understand the different electrical control panels and pumping systems that are in a school. They were more there to fix broken locks on doors, and that type of stuff, as where the technology now has extended beyond their realm of knowledge. We now have to look at how we are going to address that new technology that we are putting in buildings.

Barry *It would not be a single FM Person it would be a series of FM specialists?*

MCo It all depends on the complexity of the specialism. Two or three years ago I did a job in Tyrrellstown and the local authority came back and were specifying over €200,000 worth of landscaping. This resulted in an argument with the council, because schools just cannot afford to maintain landscape of that volume. We actually had to end up getting in a specialist in order to get the planning permission. There is now a specialist contract in place for the maintenance of the landscape in that area. If it's not there the landscape is going to die and we are going to be in breach of our planning permit.

Barry *How did the FM specialists influence the design?*

MCo Well the difficulty there was, the design was done and sent in to the council. The council came back to us with a design of their own and unfortunately that had adverse impacts on the delivery of the contract, because there were additional costs. We tend to keep things simple that have been tried and tested and low maintenance. What they came back with in regards to their landscaping resulted a yearly bill of about €50,000 to maintain that entire campus. Unfortunately, the Department now have to suffer that element of it.

Barry *Is there an opportunity were the Facility Manager could sit with the design team and help influence them with regards to the model?*

MCo Absolutely, if one of the FM issues within the building is picked up and going to generate further problems for us down the line, it's certainly something that the Department will go back to the designer with.

Barry *At present, it would be down to the Architect or M&E people to pick these issues up?*

MCo At the moment it's down to the architects and the engineers. If it is a specialist area we will seek advice in that specialist area, for example the DoES don not fit air conditioning systems in schools. One of the problems that we have ran into is our building performance is that we are now achieving air tightness rates of less than 3cu.m. per hour, which in itself is a contradiction in terms, because if we have to passive ventilate the building we have got to cut a hole in the wall to let fresh air in. The problem with that is, we don't have a mechanical extraction system to allow for the heat losses. We are now at a point where we now need expertise in an area of mechanical ventilation to look at what the potential implications are for newly designed buildings.

Barry *Would these design issues be brought forward into the next design??*

MCo Yes, we have a feedback process. That happens normally a year after the school is occupied. Over that year any issues that have been coming up continually within the school will be taken on board for the next design process. The handover stage involves training the staff how to use the building. We always advocate that any of the caretaking staff and the cleaning staff are present at these meetings. We would try get the people who installed the products to explain what maintenance the floor requires and how regular it has to happen. This will also be documented in a schedule. We found that the verbal conversation between two people works better than asking somebody to sit down and go through boxes of documents to try and pick up on what they need to do with different elements of the building. Unfortunately, the way schools are currently designed, that's the methodology that we use.

Barry *Is there an opportunity to promote the inclusion of the Facility Manager in the design team?*

MCo Part of our job is to supply a school of a particular standard, so that no child in the country is reaping the benefits of being in a better building than somebody else. It has to be transparent and across the board. I think with modern technology in order to achieve that there certainly are roles that need to be picked up on.

Barry *What was your role in the design of the model?*

MCo I was the co-ordinator. I was co-ordinating the models and helping the architectural staff to understand how to produce co-ordinated models. I also conducted some of the clash detection, so as to show them the difference between models that are federated and are not federated. One of the things we discovered when we ran this process was that we had different sets of consultants all doing the same thing. There was a duplication of work with an example being the rising walls and the foundations, everybody seemed to have them in under floor plans. But when we actually lined them up they were all slightly different. So the co-ordination of the information was probably my biggest role.

MCo All the architectural work was done in-house. The structural and mechanical and electrical was outsourced.

Barry *Would your M&E department not have the required skills to input directly into the model?*

MCo No. The M&E consultants we have are at a management level. They would review a submission that would be sent in by an external consultant and they would ensure that that submission is in compliance with our contract documentation.

Barry *So you are still some way away from an IPD approach?*

MCo Well this has been done through a collaboration process. I don't think there's any Government Department that would have a full resource of an entire design team that would be capable of producing that. The majority of them will have specialists in one area or another.

MCo That would be the same with the OPW, the DoES, the Department of Defence, etc. The co-ordination of the information is absolutely key. In any project I have done in the DoES, the results are in the quality of the project that's produced, this varies depending on the personnel that are involved and the commitment of the people involved in doing it.

Barry *Do you believe the Property Maintenance Department if involved in the design team could reduce the operational costs?*

MCo Having somebody that knows how buildings operates and what it costs to maintain a building is absolutely key. Now, having said that, some designers completely ignore that information that's given to them. That's a personal choice. But for schools and any civic buildings that are done it is something that can no longer be ignored. It certainly would benefit the whole process by knowing that the design is as cost effective as possible or is actually maintainable within the budgets that the schools are given. The Department fund school's money each year, it's what's called a capitation grant. The capitation grant that they get is based on the number of pupils that attend the school. The lower the number of pupils the lesser money they get to maintain the building, i.e. it should indicate that the building is smaller and would require less maintenance. But it's not always the case that that capitation grant is going to cover the running costs of the building.

APPENDIX 6 - TRANSCRIPT OF INTERVIEW WITH INTERVIEWEE ONE FROM THE EXPERT INTERVIEWS.

This part of Appendix seven details an interview with Interviewee one (FM1) from the expert interviews with regards the DoES special school's model. Before the interview commenced FM1 was provided with a walk through of the model and explained the purpose of each room. This was done in partnership with Revit, as so a floor plan could be viewed and a more detailed description of the information attached to the assets could be interrogated.

INTERVIEW TRANSCRIPTION

Barry *If you were brought on earlier within this project and examining the model, as it, is there any particular areas on initial inspection that you could target by reducing operational expenditure with regard to the selection of O&M products?*

FM1 The biggest contribution factor to your operational costs are your energy costs. If you wanted to have a look first, from an energy point of view, your two main sources of energy are heating and electrical use, primarily lighting. They are the two biggest contributions to your energy bill on an annual basis. If you were looking at the heating in isolation, what factors could I as the end user and operator of the building bring to the design process here to assist in having a building that's easier to heat and it retains your heat? I can contribute to the selection of the windows, which is probably the main source of heat loss in any building, the fabric of the building, and the insulation levels. There are rules and regulations around the construction of buildings nowadays, as regards the insulation quality of them. But, more often than not, in a tender process, all of the best design work might get fractured or pared back through value engineering. In the cut and thrust of a tender process to get it built there are alterations and changes made to the specification to meet the budget that's available. I would say that the facility manager would have an opportunity to review the designed building and make any changes to it before the tender process comes into place. It is very hard to implement changes after that. That design review does not have to be huge. I think it could be something depending on the size of the building that could be done in conjunction with the architect and the mechanical and electrical services engineer, probably over two or three good detailed sessions. I as a facility manager would see this as the optimum time for the facility manager to come to the table. I could assist with a review of all the specified equipment's and sign off on the specifications of both the M&E and the fabric for the windows, insulation standards, etc. When the package is tendered, and the tender responses come in, I would strongly recommend that the FM would be sitting at the table for the tender review process. There lies the biggest challenge for the building, as during the cut and thrust of the tender negotiations things get changed or altered. This may have a detrimental impact to the operation of the building.

Barry *Take for example the woodwork room which we are currently walking through in the model. Can you highlight any possible concerns with regards to O&M/.*

FM1 Does the BIM tell you what this room is specifically used for?

Barry *Yes. I can generate this information by clicking on the properties tab or returning to the Revit model.*

FM1 There is a bit of a kitchen area there and whatever that's used for I don't know. It looks fairly excessive for two work benches. Do you need all that kitchen units?

Barry *If we look at the kitchen unit properties here we can see that it is specified as wood?*

FM1 The first question I would ask, looking at that is, what is the kitchen for? In a woodworking room, why would you need that? Let's assume it's needed. I would suggest using stone or formica instead of wood, as in my experience it will last longer. The tap looks like it's a standard mixer, kitchen tap, with a sink drainer. There's nothing there that's going to make a lot of difference to the operation of the building. The only thing is, when you would have a water source like that there, especially in the classroom environment, should there not be a drinking fountain along with it there at the sink? If you had one there you would not have to provide a drinking fountain out in the corridor or whatever.

FM1 I would say the lux levels in that area, where you are using hand tools would have to be checked as well, to make sure that there's adequate light for using hand tools in a woodworking environment.

Barry *We ae currently in one of the classrooms. Have you any suggestions based with regards to O&M for this classroom.*

FM1 In these areas you would probably use an eggshell paint which is hard wearing and washable. You would not want to have to repaint the area with a standard emulsion every year, because there would be too much cost associated with that. It could be a bio eggshell type paint. I would also avoid using any fixed furniture that has plastic wheels, as the ball bearings wear very easily.

Barry *At the moment we are in one of the toilets. Have you any suggestions for this area?*

FM1 The cubicle rails look good. I would use tried and tested products from Armitage, or Venesta.

Barry *We are navigating through the corridors at the moments. Can you suggest any O&M concerns here, such as the doors?*

FM1 Well door selection in most of these places is dictated by the fire cert, which will indicate where the fire corridors are that need to be protected. From a hard-wearing point of view, they are probably a composite panel door, that will take a little bit of punishment from people moving in and out through them. I would not say they would be a hardwood door. I would say they would be a composite panel with zero maintenance and PVC coated. I would suggest a metal framing and standard ironmongery on them, you know. I would avoid using PVC gaskets, as they tend to wear out very quickly.

The doors will have a general mistreatment by the various users. A consideration to using a PVC shield should be taking on board. These can comply with the colour scheme of the school. I would also avoid the use of automatic doors, as if they fail, there might not be anyone on the grounds who have the expertise to fix them.

Barry *Are there any areas with regard to safety that may concern you at present within the model.*

FM1 Well one thing is that there seems to be a basement in this school. There is a two storey at one end and one storey at the other end. There will be a requirement for a number of ramps to access the two storey and all of the associated ramps. With regards from an external point of view, it does not look to be too difficult. I do not know what the specification for the external finishes are, but from a window cleaning point of view, and all of that sort of thing, it looks pretty OK.

FM1 There is also no fall arrest line all around the roof, so that if anyone is up there doing maintenance, they would not be able to secure themselves. But in general it looks, from an accessibility point of view, a nice architectural structure.

It could be cheaper to hire people to perform work on the roof if there is not a large requirement for ongoing maintenance. A harness could cost 1000 euro a year to certify and if it is not used extensively, this could be an unneedful cost on the school.

Barry *Can you see any potential issues with regards to accessibility*

FM1 No, I assume that as it is a government building it has followed the correct building regulations.

Barry *Can you seen any opportunities in possibly reducing the Reduce functionality risk with regard to O&M.*

FM1 Well again not knowing what the full suite of services are in the school, it would be very hard for me to comment on that. I would need to know the daily functions that are taking place in the school. However, one thing that should be considered during the design process is, given that it is a special needs school, that a lot of the equipment and materials that are specified should be done a standard that would accommodate the requirements of the special needs pupils, i.e. that you don't leave any balconies open. Some of the students may be prone to self-harm.

FM1 In a general secondary school, I suppose that would not come into the thought process. But if it's accommodating pupils with special needs, again, you can only assume that at some stage that a student might come along that would be prone to self-harm

Barry *Unfortunately, none of the M&E details are present such as the electrical sockets. Would you have any potential concerns with regards to items such as that?*

FM1 From a socket and a lighting point of view, if everything is installed as per the current regulations, the RECI regulations, soon to be ISO standards, if everything is installed to them regulations you will not have a problem with electrical. Because all of the devices and outlets are protected you know.

Barry *At the moment we are in the laundry room, I have selected this room as there is a substantial amount of assets details. Can you suggest any concerns, with regards the functionality risk here?*

FM1 It's not feasible in a school environment to actually do your own laundry. I would not put the washing machines and the drier into an area where you are preparing food. It just does not make sense to me. There's a dishwasher, that's fine. But there's a washer/drier there for doing what I would assume is probably dish and table cloths. If there's a laundry room and you insist on washing those items yourselves, it should not be in that room.

FM1 Looking at the hobs I would assume there is something to take away the odours. I would be looking within the M&E service to see if there is some sort of heat recovery put on those. This could harness the warm energy, rather than just expelling it to the atmosphere.

Barry *This is where the boiler room and cold stores are to be positioned. Would you be satisfied with their position?*

FM1 It looks fine. A consideration which should be taken into account is that if any of the major pieces of plant actually, for whatever, reason developed a defect and necessitated their changing out, how easy or how accessible is it to remove a main boiler from that room and replace it? There is no point in discovering when the building is a live environment that you can't get the boiler out to replace it.

Barry *Have you any comments on the switch room?*

FM1 It looks very small.

Barry *Based on the walk through of the model could you suggest any areas of in where you could help Reduce the operational costs in regards to the selection of M&E based equipment?*

FM1 I can notice there is no door in the plant room. However, that's just a little miss on the BIM. But given that the area is right beside cold stores and a switch room, I would strongly recommend that the boiler room is bunded, as you have a lot of water sources in there. If any one of them burst their banks, you do not want it going into the switch room and destroying all the switch gear, and having the whole facility without either heating or electricity for a period of time until the repair is done. We spoke about the access for major pieces of plant. Also, bunding, your food store and your cold stores right beside it. All of which would be very susceptible to flooding. It causes an awful lot of damage and your insurance company actually might have a major problem with that.

FM1 With regards the selection of equipment there is a wide variety of equipment out there for heating, lighting and all your major energy uses. Lighting is probably the main area, and there's been huge advances in LED technology and occupancy sensors for all of these areas. In the review of the design, prior to tender, I would have picked up whether all of that criteria were in or not. If you have occupancy sensors and LED lighting, that's a major reduction in overall energy usage. The second thing is, your heating. The heating load is determined by how efficient your building fabric is. Again the specification if the building fabric and the windows should be as high a specification as is affordable under the budget. Careful consideration needs to be given to the efficiency, the maintenance intervals and boilers.

Barry *Can you suggest any other areas with regards to O&M concerns*

FM1 The floors are always an area of concern. The floors in the school probably outside of the gym area will always be a polyfloor, like a marmoleum. Once they are installed, if there's a wax or a polish coat applied to them, leaves it very easy to maintain them. So effectively you are only polishing the polish. This from a maintenance point of view on an annual basis requires a new fresh coat of polish put down onto them. You are never actually wearing the floor; you are just wearing the polish.

If a lino is selected it will need to be homogeneous, as if not, when it wares will look very poor. If a homogeneous lino is selected it will last for years and will always look in a good condition. The further use of a ribbed matting system, will extend the life of the flooring as it will remove dirt as people enter the building. This should change in grade every few meters.

Barry *What would happen of tis polish was not applied?*

FM1 If you did not do this initially, then when you are cleaning the floor you are actually cleaning the product that you lay. Eventually if you cleaned it often enough you will wear into it. It is very important that there's a maintenance regime put in place for the polishing of the floors once the school is ready for occupancy.

Barry *Could your earlier involvement assist in the better zoning of heating systems?*

FM1 To be honest with you the only thing you can do depends on the type of heating. If it's radiators or if it's underfloor heating, if it's either or you can put a local wall stat with a three port valve going into the room to feed whatever the heating circuit is. I find if you put your money that it would cost to zone a building into the fabric and the standard of the windows, your zoning becomes less of a problem. To zone out a building can be costly. Where people focus on the zoning of the heating. It can cost a lot of money to invest in a BMS to manage the zone valves. I don't know whether this is a facility that would necessitate a subject matter expert to look after it. Normally in schools you have a caretaker looking after the place who goes around and fixes the door that are broken, etc. They also turn on the heat when it's needed. If you can remove a lot of mundane calls from his schedule and take the control away from him, i.e. just make the building as energy efficient as possible, with very little human interference, it always leads for a more efficient solution.

Barry *In regards to reduce functionality risk for M&E can you suggest any areas.*

FM1 Sometime an Architect can add a feature lights in accessible spaces. From the point of view of functionality normally these features aren't very functional. They are usually tall areas in the atrium. I would look at the practicality of changing a light bulb or getting up to a fitting to replace it.

Barry *Can you suggest any other areas?*

FM1 I can see there a lot of skylights which are no problem once they are of an adequate ventilation and insulation. They are there to provide natural light, but there's no point in having that natural light unless that natural light is linked to a lux meter and it dims the internal lighting, so that your lux level is maintained in the area at all times. There's no point in having one or the other or both on at the same time. So if you have sky lights, and if they are letting in any good amount of light, but it's not sufficient for the area, you need a lux meter in that area. Unless you put the lux meter in with the sky light you will find that the lights are on the whole time and the sky light renders itself useless.

Barry *Can you suggest any areas in the model where you may have concerns when it comes to accessing M&E items for Maximise for maintenance.*

FM1 This is important and consideration must be given to items such as air handling units, refrigerant units, switchboards, etc. Access should be a primary concern for ease of replacement and maintenance, so that you are not endangering the maintenance personnel in conducting routine maintenance reviews.

Barry *We are in the boiler room at present. As there are no items within the room it is difficult to pick up any further access issues. Despite this, have you any concerns with this space?*

Barry *And what about the boiler room and switch room that we are looking at here?*

FM1 I would not see anything wrong at the moment. The switch room looks small but it might not be the main switch room. That could be external in the building near the ESB transformer. So that switch room would be more than adequate for the basement.

FM1 I also notice that you will have to come through the kitchen to replace the plant.

FM1 You have to ask the question how often would you have to bring a major piece of equipment through to the boiler room? Not very often. How often would you have to bring some inhibitor chemicals? Maybe annually. Once you have your transportation and risk assessed appropriately and you put a procedure in place, you will not have any issues in your kitchen. Once it's done out of hours when there's no food prep available, and the area is cleaned afterwards.

FM1 Um.

Barry *Can you suggest any ways in reducing any impact on the external environment through the selection of environmentally friendly material or finish.*

FM1 There are all sorts of products out there available for general and commercial construction that have lesser impact on the environment. You could instead of using concrete, go for a timber-framed building. Another example is that instead of having a roof with zinc, you could have a grass roof. Externally it's wide open for a grass roof. Rainwater harvesting, there's all sorts of tools and products available out there. of rainwater harvesting off that. With rainwater harvesting, you can treat that water and re-use it then for toilet flushing. All of your toilets within the buildings could be serviced off that. This will negate you buying a lot of water off the mains supply.

Barry *How about reducing energy costs through the selection of energy conscious systems/materials*

FM1 Windows, I cannot say it often enough. There is a lot of money to be saved in having a good insulated fabric. The importance of this can get lost in translation and can become value engineered out of the final design. Where you might save €100,000 on the construction cost of a building, you will give it back to one of your energy suppliers in probably two to three years, because of those decisions. I think every decision to alter the specification to meet the budget should be analysed with the impact it would have on operational costs.

Barry *Could you assist with the window selection?*

FM1 There is no particular window I could tell you to go and buy. I would suggest you purchase aim best possible product available for the budget. If you can achieve a treble-glazed window, with a low e-coating, argon-filled, with an insulated frame, it will be a significant benefit. When it comes to the windows you need to think about the security of the building as well. This is a building that's is unoccupied outside of normal business hours and could be prone robberies, because there's a lot of expensive equipment in the school. The window would have to be a secure.

FM1 I would also remove the local control from these things, i.e. if somebody can switch on something, and if they have no responsibility to turn it off, it will be left on. If you take that responsibility away from them, then you won't have a problem. The same with heating. If you leave it as local control, you are going to have it turned up very high and never be turned down.

Barry *The OPW are have a KPI based on maximising workstations per net floor area. This is mainly for office buildings. In general, taking this into consideration, is there any areas were you could offer advice on space management based on the walkthrough of the model.*

FM1 You are limiting yourself to certain type of buildings with that KPI, it does not leave an opportunity open for the Facility Manager to assist. I would try to avoid double height atrium type spaces as you will have a big volume of area there. It will result in a lot of air space that still has to be lit and heated. However, I do recognise that the spaces are required. As regards any of the other areas, I would not have a lot of input into, because I have not studied the requirements for the school.

Barry *Can you suggest any other areas where you may can assist with space management?*

FM1 I noticed earlier that the principal's office was small It doesn't look over large. I assume the Principal will be meeting with other parents, school board members, politicians, etc. The principle is a key person and a lot revolves around them here. So maybe they need a little bit more space with a second desk that she can sit down around it with other people.

Barry *Can you see any opportunities were you could specify spaces that be used for future expansion?*

FM1 There are two schools of thought on that and at the time it seems like a very good idea, to put in all of that space. However, in actual fact it can be very unaffordable to the client and may put the business in jeopardy. This overcame that through enormous cost, i.e. bank repayments, for an area that is generating no revenue out of. If I was at the decision table I would recommended that all of the available infrastructure was put in, i.e. that the lifts were brought up to that level.

Barry *OK, yeah, perfect. Yeah, so many rooms here….*

FM1 Alright, Barry, no panic. I have the tea. [break]

Barry *A KPT that has come out of the research is that the facilities manager's practical knowledge of O&M and M&E systems can be used in partnership with the Quantity Surveyor with BIM technology to establish a more accurate financially rewarding building plan. Do you think that's realistic? That you could actually work with the QS to produce a more accurate lifecycle kind of assessment?*

FM1 I that's fair. You see in today's environment, especially in Ireland, it's a lot more popular to have school building programmes and road building programmes as a public private partnership. So how that works is, the public side of things, i.e. the government or the state or the OPW or whatever agent of the state requires a building for a particular function right. They go to the market and they seek responses to this need. The state will provide the land, and then the contractor will provide the consortium to provide the building. Once it is all done the contractor will then look after that building for a period of 25 years and will be paid a rate over the term per month that will encompass the cost of the building and the cost of operation of the building. Let's take for example that this was 30-year partnership and it was a €30m project right.

FM1 So in theory the cost per month to the state would be €1m. But then the financing of that cost has to be paid for, plus the operation of the building and any routine and upgrades and maintenance that's required. It is very important in a model like that, that you have the lifecycle costs of the building over the 10 years, 20 years and 30 years. The facility manager would get involved in that process with the QS or the accountants or whoever is putting the package together. The final life cycle figure will include bank interest, utility bills, the staff necessary for functioning in the building. It would also include all your end of life items, statutory maintenance routine maintenance over the period of time.

Barry *Based on your brief exposure to BIM do you still view the need for a separate digital or paper based copy of O&M documents?*

FM1 No, the BIM is a live tool that's used during the course of construction, there's absolutely no need to have hard copy of the O&M documents. There still needs to a series of checks and balances in place to make sure that all of the information is in the model..

Barry *With regards to materials, if involved in the design process could you help reduce the replacement costs through the better selection of internal and external finishes.*

FM1 I covered a lot of areas were this was discussed earlier. I think that the end users shouldn't be involved the detailed design process and the design should nearly be practically complete before the end user gets involved. There should be a period of time were the end user can suggest make alterations before it goes to tender.

Barry *Yeah.*

FM1 So as regards infrastructural items in a place, you know, you will buy…if there's a lift car required we will say, you will certainly go and buy a very decent manufactured lift for the building, because you don't want it to constantly be giving you trouble. So in areas like key infrastructure, like a lift, like a fire alarm, a fire alarm is very important. Like if you put in a good fire alarm, albeit the statutory maintenance is still every three months, but at least the equipment will last longer, you know.

Barry *Have you any further suggestions based on the what you seen from the model today?*

FM1 It is a very important tool for safety in the building and could be a significant help with regards to fire training,

Barry *Do you think you could improve the practicality of the FM model for the operational phase by helping in the section of the most relevant assets?*

FM1 In the advent that I would be involved in the building, I would specify as much of the equipment as possible. I would give the contractor very little scope for amending or blending your design when he's tendering it. For example, if you put in for a Schindler lift in your building, everybody has to go to Schindler to get the price of that. So if you see a variance in the tender, you would know one of them, either didn't bother going to Schindler or just put a random figure to this requirement.

Barry *The whole way that we capture information from the FM perspective is through construction operation build information exchange. This is essentially an excel sheet. I will show you an example of a COBie spreadsheet. (COBie is explained in detail to the interviewee)*

Barry *As you can see a significant amount of information is required on every asset. Now this is a massive amount of information. If involved in the design could you help to reduce and streamline the level of COBie information*

FM1 I don't see why this information should be reduced as all the information specified can be used as some stage. If there is a change of Facility Manager it would be very helpful to have a single source to go to, to find out who manufactured for example a that table, where can I get a replacement, how much were they originally, etc. How helpful would that be? It would be hugely beneficial.

FM1 The more information for every single aspect of the building the better. Because it's a lifelong tool then for the maintenance and operation of that building.

APPENDIX 6 - DETAILS ON DOES CASE STUDY

Location: St Patricks School, Drumgold, Enniscorthy, Co. Wexford

Design Team

- Architect — DoES
- Civil & Structural Engineers — Thomas Garland & Partners
- M&E Engineers — Semple & McKillop Consulting Engineers
- Quantity Surveyors — MJ Turley and Associates
- PSDP — Stephen Diamond Landscape Architects

DoES Special School Details

The site is located 1.2km east of Enniscorthy town centre and is bordered to the south by Drumgold road and to the west by Temple Shannon Road. The surrounding area is largely rural in nature. The overall site is 4.2 Hectares with the site for St Patricks school representing 2.6 Hectares. The topography of the site is steeply sloping. An aerial view of the site is illustrated in figure 7A. Figure 7B provides an illustration of the proposed final building.

Figure 7A: Aerial view of DoES school site

Figure 7B: Illustration of the complete School

The lower ground floor is to connect naturally with the lower level on the southern site. The lower level ground floor area is to be approximately 1074m^2 with a septate zone created for more independent pupils up to 18 years of ages. Figure 7C provides an illustration of the lower ground floor plan.

The ground floor is approximately 3661m^2. The main entrance is to be easily accessible from set down areas. External play areas are to be directly accessible from all junior class rooms with the soft play area located adjacent to senior severe / profound classrooms and behavioural suite. A total of 16 class rooms are to be on the ground floor with therapy rooms centrally located. The admin, dining and public areas are to be located close to the main entrance and central in the plan. Figure 7D provides an illustration of the ground floor plan.

The first floor area is 825m$^{2.}$ This floor is to contain staff areas, principal's office and clinician's office located on the upper floor area. This floor will also contain specialist teaching areas that include music, art, computer room and the library. Figure 7E provides an illustration of the first floor plan.

Special attention will be required with regards to storage and circulation spaces, which need to provide not only for a variety of mobility devices, but also provide sufficient space for the passage of supporting staff whilst attending students. The adequate provision of storage space especially for mobility devices and specific teaching apparatus will also be important. Special details will be required for hygiene facilities. Every aspect, from tap heads, hand dryers and dispenser units to ironmongery, toilets and room configurations need to be assessed from the perspective of how well it prepares students for independent living. Significant proportions of the rooms need to be left empty to allow for ease of movement and manoeuvrability both by students and special need assistants. Figure 7F provides a rendered image of the final building.

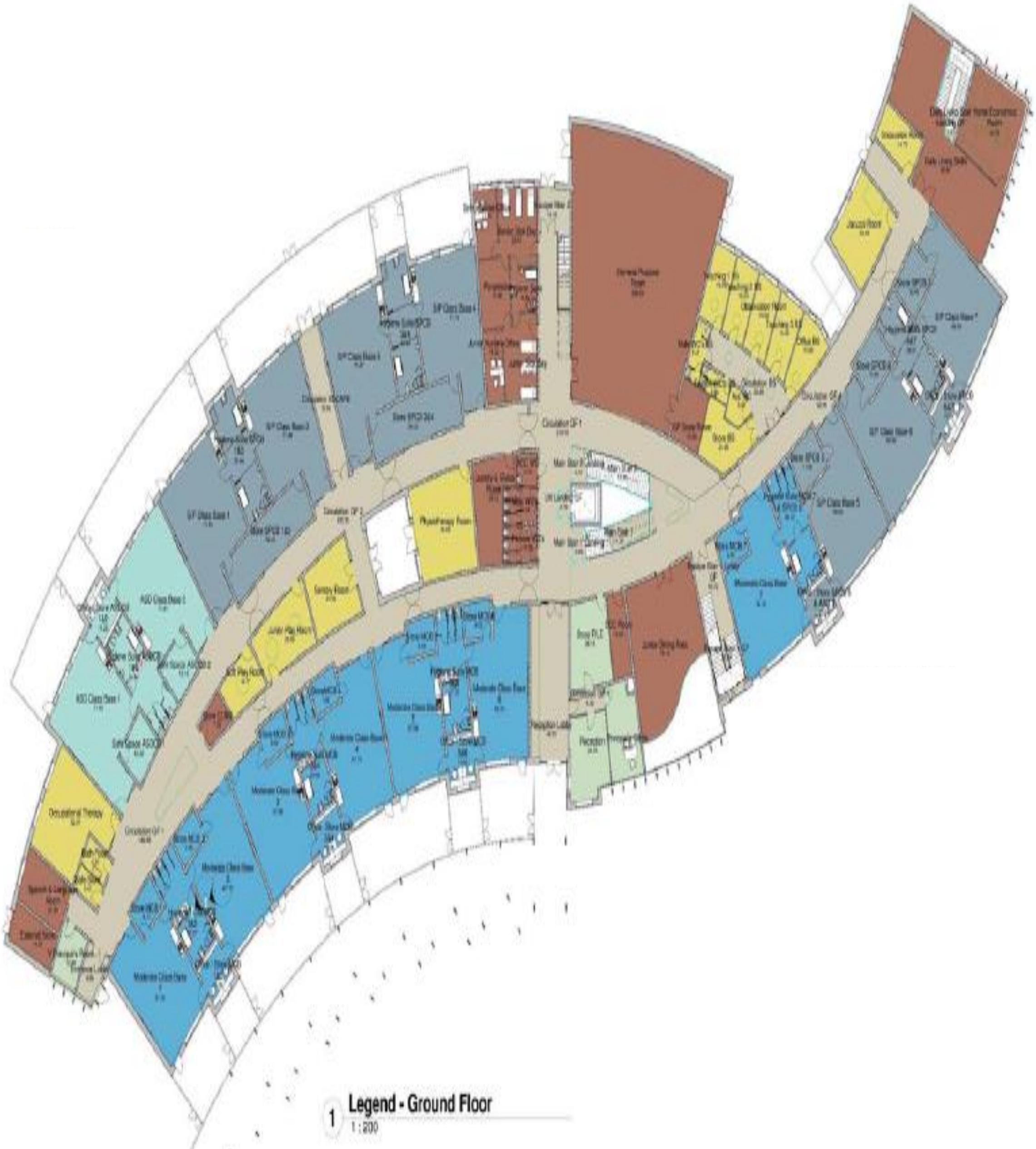


Figure 7D: Ground floor plan

Appendix 6 - Details on DoES case study

Figure 7C: Lower ground floor.

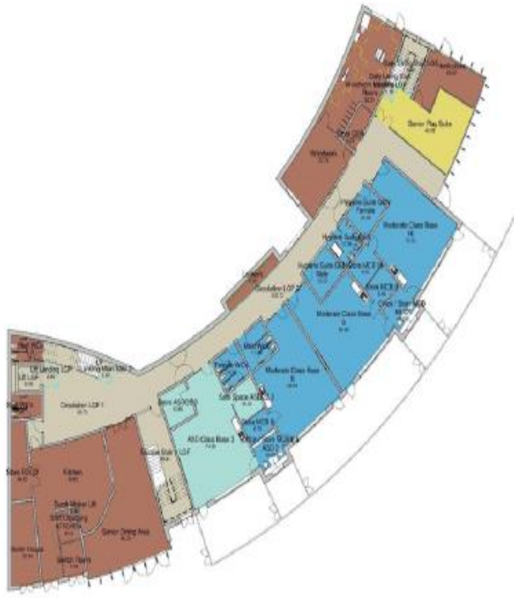


Figure 7E: First floor

Figure 7F: Images of the final rendered school