UTILISATION OF BUILDING INFORMATION MODELLING IN FACILITIES MANAGEMENT: A SOUTH AFRICAN CASE STUDY

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Contents

DECLARATION

I declare that this research report is my own original work. It is being submitted for the Degree of Master of Science in Building to the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.

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ABSTRACT

Facilities management is longest phase in the life cycle of a facility. To effectively manage a facilities' electronic information is needed. An integrated information management system such as Building Information Modelling (BIM) can be utilised to support data at any given phase of a building life cycle. Literature review shows that there are benefits to using BIM in Facilities Management. However, there is insufficient research regarding the use of BIM in facilities management in South Africa.

The purpose of this research was to investigate the extent to which BIM is utilised in the South African Facilities Management sector and identifies the challenges faced by Facilities Management personnel while using BIM. Data was obtained through interviews and an online survey. The interviews were used to gather information from a small sample, while the survey was used to understand a larger sample. Both qualitative and quantitative data analysis techniques were used to analyse the data. The research was limited to international BIM standards, as BIM is a new concept in South Africa and there is scarcity of relevant literature in the context of South Africa. The findings reveal that majority of Facilities Management practitioners are not utilising BIM, due to factors relating to cost and week support organisations. Those who use BIM believe that the model does not have enough information to carry out all Facilities Management activities.

Keywords: *Facilities Management (FM), Building Information Modelling (BIM) utilisation, determinants, UTAUT, South Africa*

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Acronyms

AEC	Architecture, Engineering and Construction
ATT	Attitude
BI	Behavioural Intention
BIM	Building Information Modelling
CAD	Computer-Aided Design
CAFM	Computer-Aided Facility Management
CMMS	Computerised Maintenance Management System
COBIE	Construction Operation Building Information Exchange
DOI	Diffusion of Innovations
DWF	Design Web Format
EAM	Enterprise Asset Management
EE	Effort Expectancy
FM	Facilities Management
FMM	Facility Maintenance Management
FS	Facilitating Conditions
IT	Information Technology
IWMS	Integrated Workplace Management Systems
K-BIM	knowledge-based BIM
MEP	Mechanical, Electrical and Plumbing
NBIMS	National BIM Standards
PE	Performance Expectancy
RCM	Reliability Centred maintenance
RFID	Radio Frequency Identification
SAFMA	South African Facilities Management Association
SI	Social Influence
SEM	Structural equation modelling
TAM	Technology Adoption Model
TOE	Technology Organization and Environment Framework
TPB	Theory of Planned Behaviour
UB	Use Behaviour
UK	United Kingdom
US	United States
UTAUT	Unified Theory of Acceptance and Use of Technology

1. INTRODUCTION

Facilities Management (FM) encompasses multiple roles for the purpose of ensuring functionality of the built environment, through integration of people, places, processes and technology (International Facility Management Association, IFMA, 2015). The main focus and function of Facilities Management (FM) is to manage changes that occur in the relationship between organisations, their employees and their facilities (Chotipanich, 2004). According to Nutt (2004), the relationship involves an extremely broad range of activities including but not limited to the;

a. Physical use of built space, use of technology, provision of services, ensuring maintenance as well as modification and adaptation where necessary;
b. Human and business component of facility purpose, its use and function, provision of security, ensuring safety, comfort, and environmental health; and
c. Financial issues of property investment, asset value, and the costs and benefits of occupancy.

From the foregoing, it is important to note that FM can be a challenging and difficult process (Lin and Su, 2013). One important challenge that can be experienced in FM is information collection, storage and sharing (Eastman, Teicholz, Sacks and Liston, 2011). According to Mendez (2006) the main reason that hampers information management is that most of the FM information is documentation in paper formats, which are not easy to locate and maintain.

The use of information in FM is no longer limited to the maintenance records for routine, reactive or compliance purposes but rather it involves operational and strategic elements where data and information are captured, processed, shared, applied and reported (Achoru, 2015). With technological advancements in the digital age, facility management teams are encouraged to transfer and store building information in digital formats that are readily available (Teicholz, 2013). Therefore, effective FM, requires an integrated information management system that provides practitioners with adequate information to control maintenance functions to support day-to-day operations and decision making (Graddy, 2010; Chen and Wang, 2009).

Information management systems such as Computerised Maintenance Management System (CMMS), Computer-Aided Facility Management (CAFM), Integrated Workplace Management Systems (IWMS), Enterprise Asset Management (EAM) and Building Information Modelling (BIM) can be used for storing and sharing FM information. BIM involves several components beyond building geometric relations.

Eastman (2009) posited that BIM involves "spatial relationships, light analysis, geographic information, and quantities and properties of building components. Current BIM software is therefore used by individuals, businesses and government agencies in infrastructure planning, design, construction and FM (Azhar, 2011; Bryde et al. 2012; Riddell, 2009). BIM is therefore an emerging technological information management process and product that tackles interoperability and information integration issues (Motamedi, 2013).

The use of BIM in Facilities Management can have numerous benefits including but not limited to faster and more effective information sharing and cost control (Arayici, Onyenobi and Egbu, 2012). With the advancement of BIM, developed countries such as the United Kingdom (UK) and the United States America (USA) have expressed great interest and acceptance towards BIM adoption and its use in Architecture, Engineering and Construction (AEC) (Succar, Sher and Williams, 2012). Unfortunately, it is generally reported that the use of BIM in Facilities Management is lagging behind its' use in AEC (Sabol, 2008). Despite the potential and significant benefits, BIM in FM is still in its infancy (Korpela and Miettinen 2013: Lui and Issa, 2013), the latter has been expressed globally as well as in South Africa (Kotze, 2013).

1.1 Problem articulation

Facilities Management is a component of a building life-cycle which contributes the most to the total cost of a project, compared to the cost of design and construction (Dettbarn and Gillday, 2004). According to Jordani (2010) the cost of FM activities accounts for 85% in the life cycle cost of a building. Hence, the information management tools used during FM should reduce costs and improve efficiency.

BIM in FM has been motioned as a tool for improving cost efficiency and the generation and management of FM related information (Parn, Edwards and Sing, 2016). The introduction of BIM in FM gives the opportunity to integrate information throughout the life cycle of a building (Mohanta and Das, 2016).

There is strong evidence from existing research of successful implementation of BIM in various developed countries such as US (Liu and Issa, 2015; Becerik-Gerber, ASCE, Jazizadeh, Li and Gulben, 2012), UK (Kiviniemi and Codinhoto, 2014; Arayici, Onyenobi & Egbu, 2012) and Canada (Asen, Motamedi and Hammad, 2012) in both public and private sector. This up-take by developed countries is an indication of the benefits of BIM in FM. However, according to Bui, Mershbrock and Munkvold, (2016) the implementation of BIM in developing countries is rare. Furthermore, the state of BIM research in developing countries remain undocumented (Arif and Sawhne, 2013). Even though the implementation of BIM in developing countries is still in the infancy stage, there were publications exploring BIM in AEC from developing countries such as China (Zhang, long, Lv and Xiang, 2016), India, (Sarkar, Raghavendra, and Ruparelia, 2015) and Malaysia (Bui et al., 2016).

In the case of South Africa, available literature shows evidence of architects and construction firms that have started using BIM in various projects (Kiprotich, 2014; Kotze, 2013; Venkatachalam et al, 2014; Kekana et al, 2014, Akintola et al, 2016, and Pinfold and Fapohunda, 2016). However, there is scarcity of literature exploring the use of BIM in Facilities Management within developing countries and South Africa. Thus, indicating a research gap regarding the use of BIM in Facilities Management in South Africa. This study therefore aimed to build and understand the extent of BIM utilisation in the South African Facilities Management landscape.

The research problem can be stated as:

There is limited research on the adoption of BIM in the Facilities Management sector in South Africa, leading to poor foundational knowledge, undocumented lessons, and an inaccurate picture of the current BIM adoption status of the local Facilities Management sector and the attendant challenges.

1.2 Research Question

Main Question:

What is the nature and occurrence of BIM utilisation in Facilities Management practice among Facilities Management practitioners in South Africa?

Sub-Questions:

a) What is the nature of utilisation of BIM in Facilities Management practice among Facilities Management practitioners in South Africa?
b) What challenges, if any, are faced by Facilities Management practitioners in utilising BIM for practice in South Africa?
c) What are the determinants of BIM adoption?

1.3 Aim

The aim of this research is to explore the nature and occurrence in terms of the extent of BIM utilisation in Facilities Management in South Africa, the challenges and the determinants of BIM adoption.

1.4 Objectives

The objectives are:

1. To determine the levels and extent of BIM utilisation in Facilities Management practice among Facilities Management practitioners in South Africa.
2. To identify the challenges faced by Facilities Management practitioners in utilising BIM for practise in South Africa.
3. To find out and evaluate the determinants for the adoption of BIM for Facilities Management practise in South Africa.

1.5 Scope of the work

This research will focus on Facilities Management practitioners across South Africa, making special reference to the Facilities Management companies that are registered with the South African Facilities Managers' Association (SAFMA).

1.6 Limitations

Limitations are:

- Finding relevant literature about the utilisation of BIM in Facilities Management in developing countries and South African context.

- The adoption of BIM in South Africa started in 2004 (Kotze, 2013). Meaning that BIM in South Africa is relatively young. Therefore, documented cases of the use of BIM in South Africa are scarce. In reviewing the literature, international BIM practices were therefore applied.

1.7 Statements of Assumption

An assumption is made that BIM has not yet been widely incorporated by professionals and companies in the South African construction industry. This is based on the paucity of information available on BIM in South Africa.

1.8 Summary of Methodology

Since the utilisation of BIM in FM is still in its infinite stages, there is scarcity of empirical data. To gather the data, this research used two data collection methods namely; semi structured interviews and an online questionnaire. Firstly, the interviews were conducted to gather information on FM functions, information management and the use of BIM in FM. Secondly, the questionnaire was designed based on the interview results. Purposive sampling was used to allow the researcher to select a sample of participants who would give the most accurate information. Data collected was analysed using thematic and correlation analysis.

1.9 Outline of the report

The final thesis will be arranged as follows: Chapter 2 presents the literature review. It provides an in-depth understanding of previously documented literature on BIM in FM. Chapter 3 provides detailed discussion on the research design and methodology employed in this study to determine the levels and extent of BIM utilisation, challenges as well as explore the determinants of adoption in South Africa. The tools and data analytical methods used as well as ethical considerations are also discussed in this chapter. Chapter 4 outlines the findings and results obtained from the research undertaken and lastly, Chapter 5 provides the discussion and conclusion as well as further research which could be undertaken to further develop the findings of this work.

2. LITERATURE REVIEW

The purpose of this chapter is to conduct a literature review on the level of BIM utilisation and its adoption globally and South Africa in particular. This will include providing a summary of relevant academic literature related to Facilities Management (FM). Furthermore, exploring all aspects and functions of a Facilities Management unit, with a focus on literature related to the utilisation of technology in Facilities Management.

The discussion on technology in FM elaborates on programs that are used for storing, sharing and managing information in all aspects of FM. The concept of BIM is then introduced, together with its applications and tools, after which the chapter reviews BIM as a tool in Facility Management and the use of BIM in South Africa, with a focus on the level of BIM use and the determinant associated with the adoption of BIM.

To shed new insight to the understanding of BIM adoption in FM in South Africa, the application of the Unified Theory of Acceptance and Use of Technology (UATAT) framework is reviewed. The framework was used to further explain the use of BIM in FM and factors that influence the intension to use BIM in FM.

2.1 Facilities Management

FM has gradually gained a position as a discipline and profession within the property and construction industry. This importance is highlighted by the establishment of professional FM institutions globally such as IFMA in the USA, JFMA in Japan, BIFM in the UK, FMA in Australia, and SAFMA in South Africa (Tay and Ooi, 2001).

FM as a growing profession in the built environment has evolved over time owing to different views and definitions. Becker, (1990), states that "*FM is the coordination of all efforts related to planning, designing and managing buildings and their systems, equipment and furniture to enhance the organisation's ability to compete successfully in a rapidly changing world".*

FM is the process needed to support and enhance an organisation's core business by making sure that its buildings, systems and services provide a quality, cost-effective environment for people and processes (Chotipanich, 2004).

It is an integrated approach to operating, maintaining, improving and adapting the buildings and infrastructure of an organisation in order to create an environment that strongly supports the primary objectives of that organisation (Rondeau et al., 2012). On the other hand, the South African FM Association ascertains that FM enables sustainable enterprise performance through the whole life management of productive workplaces and effective business support services (Atkin and Brooks, 2015).

In addition, FM can be seen as the application of the total quality techniques used for improving quality, adding value and reducing the risk associated with building occupation and support services delivery (Alexandra, 2001), with the primary function of the process being resource management at strategic and operational levels of support (Liu and Su, 2013).

This study adopts the definition of FM based on the work of (Figgis, 2007, pp 1), which states that:

> *"FM' is a simple and an accurate label for the work done to ensure that a building or building complex works efficiently and effectively, that it meets the needs of the people active inside it").*

In the past, organisations such as universities, colleges, hospitals and government departments focused mainly on building operation and maintenance, together with general office services (Kiprotich, 2014). Such organisations have had to focus on limited resources to ensure that their buildings, systems and services support core operations and processes, as well as contribute to achieving their strategic objectives (Alexander, 2001). Within those activities, organisations find that they need more structured approaches to improve daily routine tasks for designing, constructing, maintaining, relocating and disposing of facilities (Rondeau et al., 2012).

In practice, FM covers a wide range of services that provide support to an organisation's core business (Barrett and Baldry, 2003). According to Chotipath, (2004), for FM to be effective, FM must involve the management of people, facility resources and support services. In addition to this, Tay and Ooi (2001) assert that there must be synchronisation on the role and scope of FM in the organisation, and that FM must be seen to be contributing to the bottom-line of the organisation.

The scope of FM services includes facility planning, real estate, financial management, human resource management, building operations and maintenance, and cleaning and supply services (Binder, 1992). The scope is presented in the Table 2.1 below:

Table 2.1: The scope of FM

Facility planning	**Building operations and maintenance Management**
• Strategic space planning • Set corporate planning guidelines and standards • Identify user needs • Furniture layouts • Monitor space use • Select and control use of furniture • Define performance measures • Computer-aided facility management	• Run and maintain plant • Maintain building fabric • Manage and undertake adaptation • Energy management • Security • Voice and data communication • Control operating budget • Monitor performance • Supervise cleaning and decoration • Waste management and recycling
Real estate Management	**General Premises Management**
• New building design and construction management • Acquisition and disposal of sites and buildings • Negotiation and management of leases • Advice on property investment • Control of capital budgets	• Provide and monitor support services • Office purchasing (stationery and equipment) • Non-building contract services (catering, cleaning etc.) • Reprographic services • Housekeeping standards • Relocation • Health and safety

Source: Adapted from: Barrett and Baldry, 2003; Alexander, 2001; Atkin and Brooks, 2015; Binder, 1992; Rondeau et al., 2012.

2.1.1 Facility planning

Facility planning is a significant stage in FM, as it can determine whether an organisation has enough space to support its core business or not (Binder, 1992). It provides a structured way for space utilisation and supports core business. It has been asserted that the most important function of facility planning is to ensure the efficient, consistent and cost-effective use of space (Atkin and Brooks, 2015). There are two phases to facility planning: (i) designing where people work; and (ii) adjusting the physical conditions under which they work (Figgs, 2007).

The need for facility planning can arise from an organisational restructuring, relocation, change in management strategies, new technology, and increase in productivity, creativity and the number of employees (Addi and Lytle, 2000). The importance of facility planning is driven by the increasing rate of organisational change, the desire to accommodate new management strategies to increase creativity and productivity, and the continuing need to integrate new technology into the workplace (Figgs, 2007).

It is hence imperative that a space planner should have the ability to visualise space in three dimensions, a keen sense of composition, scale and proportion, and technical knowledge of equipment and furniture (Addi and Lytle, 2000). According Rondeau et al. (2012) space planning has standards and the standards are based on various aspects, which can be grouped into three broad categories namely space, fittings and personnel (Table 2.2).

Table 2.2: Space planning standards

Space	Fittings	Personnel
• Surface area requirements • Storage requirements • Configuration requirement • Conferencing/meeting requirements	• Technology/equipment requirements • Lighting • Wire management • Accessories	• Functional requirements for each position • Tasks performed • Organisational culture • Organisational status-job classification • Industrial or professional standards

Source: Rondeau et al., 2012.

The standards form part of the basic planning units in the development of space plans. A space plan is used to calculate the space needed per employee for each standard in the current period and is focused on the future period growth (Rondeau et al., 2012). Space can be classified as interior or exterior and is used, together with furnishings, for greater planning flexibility, physical separation, visual privacy, efficient space utilisation and easy communication (Rondeau et al., 2012).

Organisations wanting to use existing space more efficiently often require facility planning services (IFMA, 2009). Facility planning, in particular the interiors of older facilities, may require reorganisation to accommodate new equipment or new work processes (Addi and Lytle, 2000). It is therefore critical to use good interior design- and space-planning solutions. Current planning solutions have resulted in space allocation per employee decreasing, as opposed to large office spaces people enjoyed in the past (Rondeau et al., 2012). Organisations are opting for the use of cubicles and open-plan office layouts. The recent trends are more flexible and can accommodate future needs. However, there is no privacy.

2.1.2 Building operation and maintenance management

Facility Maintenance Management (FMM) is a set of work activities that take place during the operation phase of a facility lifecycle (Lin and Su, 2013). This orderly control of activities is essential in order to keep a building in its as-built condition, while maintaining its original productive capacity (Korka, Oloufa and Thomas, 1997). FMM comprises the decisions and actions concerning controlling and up keeping a facility, equipment, procedures, work/systems control and optimisation; and performance of routine, preventive, predictive, scheduled and unscheduled actions aimed at preventing equipment failure with the goal of increasing efficiency, reliability and safety (Sullivan, Pugh, Melendez and Hunt, 2004).

FMM is the longest phase, with a total cost that exceeds both the design and construction phases (Becerik-Gerber et al. 2012). Korka et al. (1997) further suggest that the most important universally considered objectives of maintenance management are:

- To extend the useful life of assets;
- To assure the optimum availability of installed equipment for production and/or services, and obtain the maximum possible return on investment;
- To ensure readiness of equipment needed for emergency use always;
- To ensure the safety of personnel using facilities; and
- To guarantee customer satisfaction.

Adequate facility management has an impact on the quality of services a facility will offer to its end user, thus effective FM is central to retaining the quality of a facility and to preserving the health and safety of its occupants (Mishra and Pathak, 2002). Whether a facility is constructed properly or not, a building is expected to stand for several years, hence making maintenance management a way of maintaining the facility's economic value (Pitt, Goyal and Sapri, 2006). Aging infrastructure and the negative infrastructure investment trend are the two most compelling challenges to maintenance management; it is therefore important to have an in-depth understanding of the two challenges as they shape the field of maintenance management (Grabby, 2010).

Maintenance management includes repairs or replacing of existing facilities including buildings, energy and water systems, machinery and plants. There are various types of building maintenance approaches to choose from. This research scrutinises;

1. Un-planned maintenance;
2. Preventative maintenance;
3. Predictive maintenance; and
4. Reliability centred maintenance.

Below are some Highlighting the advantages and disadvantages of these four maintenance strategies.

2.1.2.1 Unplanned maintenance

Unplanned maintenance also referred to as failure-based or reactive maintenance includes corrective, breakdown and emergency maintenance (Pitt et al., 2006). This type of maintenance is a day-to-day response to fixing or repairing building services and other elements before or after failure has occurred (Sullivan et al., 2004). According to Grabby (2010), reactive maintenance is the most basic approach to maintenance management. Although it is costly, it is the quickest and simplest strategy to restore the elements to their original functional performance.

The advantage of this strategy is that there is no capital needed until something breaks (or until maintenance is required). Thus, it provides cost saving in the short term, while minimising maintenance personnel and maximising the availability of production capabilities (Sullivan et al., 2004).

There are several disadvantages to reactive maintenance. The main disadvantage is that there is no maintenance plan in place, the lack of which results in random equipment breakdown (Sullivan et al., 2004). Equipment breakdown may increase operating cost due to unplanned downtime, with no revenue to compensate. In addition, small breakdowns may have a cascading effect which leads to possible secondary equipment failure or process damage from equipment failure (Grabby, 2010). Thus, there can be expensive long-term costs involved with repair or replacement of equipment due to the negative impact unplanned maintenance has on the lifespan of the equipment (Lawrence Berkeley National Laboratory, (LBNL), 2007).

2.1.2.2 Preventive maintenance

Preventative maintenance is planned, cyclic or time-based maintenance that is designed to improve equipment life and to avoid unplanned maintenance activities (Wireman, 2004). This strategy aims to reduce equipment breakdown or failure by controlling the levels of degradation (Grabby, 2010).

One of the advantages of preventative maintenance is that: equipment and process failure can be reduced via standardised maintenance procedures while keeping long-term cost of repairs low (Wireman, 2004). Even though in the short term it can be costly, periodic maintenance can increase the lifespan of equipment and improve safety by reducing the likelihood of a catastrophic equipment failure. It is a positive approach of avoiding equipment breakdowns.

Despite the advantages of this strategy, its disadvantage is that it is labour intensive and includes unneeded maintenance, which carries a huge potential for incidental damage to secondary components while conducting such maintenance Similarly, there are high costs associated with frequent maintenance actions (Sullivan et al., 2004). Irrespective of the disadvantages, preventative maintenance has more advantages over reactive maintenance in the long term (Graddy, 2010).

2.1.2.3 Predictive maintenance

Predictive maintenance is a condition-based maintenance strategy which includes refurbishment work done because of major infrastructure and equipment deterioration (Wang, Ye and Yin, 2016). This type of maintenance is scheduled and is long term – it allows for maintenance cost reduction by reducing the occurrence of faults.

There are a few advantages to a predictive maintenance strategy. This strategy allows maintenance managers to save an estimated 8–12% on maintenance costs as compared to a preventive maintenance strategy (LBNL, 2007). Some disadvantage with predictive maintenance includes increased investment in equipment used for diagnostics and the cost of training staff on how to use the diagnostic equipment.

2.1.2.4 Reliability Centred Maintenance

Reliability Centred maintenance (RCM) is a maintenance process used to determine the maintenance requirements of any physical asset in its operating context (Sullivan et al. 2004). It employs preventive maintenance, predictive maintenance and reactive maintenance techniques. The advantages are similar with the exception that RCM incorporates root cause analysis and can focus maintenance activities on critical components with minimal disruption to productivity. The only disadvantage is that RCM has a significant start-up cost for training and monitoring equipment.

The above is a clear indication that there is ample choice when it comes to maintenance strategies. It is always necessary to decide whether one must repair or replace an item, and whether to carry out periodic maintenance at fixed intervals or not (Pitt et al., 2006).

Once that decision has been made, a good maintenance strategy can be used to reduce the financial expenditures and the total life cycle cost of the equipment (Grabby, 2010).

2.1.3 Real Estate Management

Real estate management in the context of FM is the ownership and management of land and property by an organisation which is not mainly into real estate business. Within an organisation, this real estate function exists mainly to support its strategic and operational objective (Rondeau et al., 2012). Furthermore, real estate management incorporates the acquisition and disposal of buildings according to an organisation’s need for space.

Every organisation has a set of real estate strategies guide real estate tactical decisions which support the organisation’s overall objectives and strategies (Lindholm and Levainen, 2006). The main aim of strategic planning in corporate real estate is to add assets to an organisation that will facilitate revenue and profitability growth.

2.1.3.1 Real estate strategies

Lindholm and Levainen (2006) show that there are seven real estate strategies that add value to the core business of an organisation. These strategies are based on the areas of the business that creates growth in revenue profitability and facilitates employee wellness. The first strategy allows the organisation to increase the value of assets, which can be achieved by obtaining a suitable location, managing all risk associated with the property and by redeveloping obsolete properties and spaces.

The second and third strategies are related to each other in that they drive profitability in the business. The second strategy is to promote marketing and sales; this results in a work space that supports the brand and an environment that attracts customers. The third strategy is to reduce costs by controlling operational expenses and minimising acquisition costs (Lindholm and Levainen, 2006).

The fourth strategy is to increase innovation, which can be achieved through participation of users during the design phase and developing a facility that has innovative ideas. The fifth strategy focuses on increasing employee satisfaction by seeking a facility that is functional, has desired amenities and is located is an area that is convenient to employees (Lindholm and Levainen, 2006).

The sixth is focused on increasing productivity; for example, through promoting optimal operations and enhancing productivity through layouts and location of a facility. Lastly, for increasing flexibility, an organisation can choose leasing instead of owning, or opt for a short-term lease to give a more flexible workplace solution. The real estate strategies by Lindholm and Levainen (2006) are similar to those of Nourse and Roulac (2003). Other strategies such as those of Osgood (2004) and Acoba and Foster (2002) overlook productivity.

2.1.3.2 Real estate and space provision

As an organisation strives to improve its competitive position, the strategic use of all its resources, including real estate is necessary for its overall success. Unfortunately, corporate strategy is not directly translated into a real estate strategy to guide property decisions (Lindholm and Levainen, 2006), yet organisation must promote the most favourable use of real estate, which means that the use must be efficient as well as effective (Van den Beemt-Tjeerdsma, and Veuger, 2016). Table 2.3, which is adopted from Atkins and Brooks (2015), illustrates real estate and space provision options. It shows periods that apply to the options of owning, leasing or renting a space.

Table 2.3: Real estate and space provision options and occupancy period

Options		Occupancy period
1. New building	• Purpose-built • Long lease	• 25 years or more • Between seven and 25 years
2. Leased building	• Short lease • Tenant fitted-out	• Up to seven years • Between five and 15 years
3. Rented space	• Furnished • Totally serviced workplace	• Between one and five years • Up to one year

Source: (Atkins and Brooks, 2015)

There is a direct impact between real estate and space provision options and the organisation's financial position; for example, selling property results in a cash inflow, while buying will result in a cash outflow. It is the role of a facility management unit to decide whether it is advantageous to an organisation to acquire, dispose or lease a property.

2.1.3.3 Building Construction

During building construction, the facility management unit is responsible for procuring building designs and contractors. Atkins and Brooks (2015) believe that, if the organisation's view of real estate is that of acquiring new facilities, it takes a facility manager out of his or her core competences – which are to make sure that people within an organisation work safely, comfortably and effectively. Therefore, the manager will need to bring in additional expertise to assist with designs, construction and showing people how to make use of a facility.

Based on the information above, it can be concluded that the scope of FM is broad. And that, the use of information in FM is no longer limited to the maintenance records for routine, reactive or compliance purposes but rather it involves operational and strategic elements where data and information are captured, processed, shared, applied and reported (Achoru, 2015). Therefore, there is a need to link the primary functions of FM and information management.

2.2 Information Management

Information is an important resource in any organisation and continues to drive changes in how organisations do business Rondeau et al., (2012). There are various types of information and data that form part of a facility management unit. According to Lin and Su, (2013) maintaining a facility by relying on paper can be an inconvenience for FM practitioners. Hence, automated tools and procedures can be used to form part of a facility information management strategy to increase productivity and efficiency in FM (Alexander, 2001).

Effective information management is the cornerstone of successful FM which enables forward planning to support core business (Atkin and Brooks, 2015). It is in its electronic form that information can be easily stored, collected, analysed and shared (Teicholz, 2013). To emphasise the importance of information management, the benefits of managing information supersede data collections, storing and sharing.

Organisations can use common information technology tools and systems in the workplace to manage the different information and data. A good information management system is one that forms part of the basic infrastructure for FM. As a result, a well-structured information management system, which supports the collection, storage and retrieval of information throughout the lifecycle of a facility, lays a foundation for a good management strategy (Liu, 2012).

2.3 Information Management Systems for Facilities Management

According to Graddy (2010), the introduction of computers in the 20th century encouraged the prevalence of facility information management systems. Since then, computers have evolved from a large, encased, raised-floor room to a smaller personal computer. The emergence of the personal computer directed software companies to provide tools designed to make paper plans redundant and to help FM managers to keep track of an organisation's assets and to model changes with ease (Booty, 2006). During this time-frame, there has been a significant change in the approach towards FM (Pitt et al, 2006).

In their study, Cardellino and Finch (2006) identified problems such as collection, retrieval and sharing of data which is not integrated, as some of the contributors to the introduction of information technology systems in FM. Thus, innovation and research in FM and information technology systems is an ongoing process; it involves the introduction of various computerised tools and systems that support FM functions, such as storing, sharing, retrieving and maintaining various types of data and information such as drawings, inspection records and sensing data (Chen and Wang, 2009).

It was also found by Korka et al. (1997) and Alexander (2001) that an effective software system for FM must have tools which provide a means of accessing information in a way that assists in analysing physical resources, support services, human resources and business information.

These computer-aided management tools must also provide facility management practitioners with additional systems to assist in forecasting, processing and accessing larger amounts of pertinent information more quickly. Furthermore, they must ensure that quality records are available, that the decision-making process can be traced and that feedback mechanisms are in place to ensure effective communication amongst facilities practitioners (Alexander, 2001).

However, for this to be achieved all the information must be collected and made available during planning, design and the construction phase. Continuous accumulation of information is therefore necessary to maximise savings and reduce the total lifecycle costs of ownership (Motamedi, 2013).

Facilities Management companies can grow through adopting, developing and maintaining an appropriate level of technological hardware and software. Alexander (2001) suggests that it is imperative to maintain a relationship between facilities hardware and software. Facility managers need to work closely with architects to ensure that quality record keeping, and decision-making processes can be traced Alexander, 2001, as facility managers require a vast amount of information to operate facilities efficiently and effectively (Teicholz, 2013).

Thus, information technology systems are crucial in creating a golden thread between all stages of a facility's lifecycle.

Facilities Management requires a well-structured computer-aided maintenance programme which ensures that facilities are maintained without compromising on safety (Shohet, Lavy-Leibovich and Bar-on, 2004). Due to the diversity of the informational needs of an organisation, various information technology systems such as CAFM, CMMS, IWMS and EAM are introduced and used to support a wide range of FM information (Teicholz, 2013). Hence the sector is shifting from a 2D-based documentation and stage delivery process to a digital prototype and collaborative workflow (Eastman et al., 2011). Some FM functions can be performed manually whilst others are performed using computer-aided systems. There are several systems available in the market. This research will only discuss the four most commonly used systems.

2.3.1 Computerised Maintenance Management System

The Computerised Maintenance Management System (CMMS) is a management software with functions that support management and tracking of operations and management activities (Sullivan et al., 2004). The aim of using CMMS is to prolong the lifecycle of an asset while keeping expense at a minimal. According to Grabby (2010), CMMS focuses mostly on cost reduction and cost effectiveness, thus creating a strong link between CMMS and asset management. CMMS, which is also referred to as Enterprise Asset Management (EAM) is an FM system used to identify, track, locate and analyse physical assets and the work performed on them.

It provides functionality for defining time, material and labour costs in cost-charging arrangements and applying the charges to commercial agreements for maintenance work. Furthermore, it improves capital asset management by increasing reliability, enhancing predictive maintenance, ensuring regulatory compliance, reducing energy usage, and supporting sustainability initiatives (Infor EAM, 2009). There are five common types of CMMS software (Stazzone, 2017):

1. Asset tracking – maintains information about when an asset was purchased, its lifespan and its maintenance history;

2. Inventory tracking and purchasing – tracks parts and materials that must be bought to perform maintenance duties;
3. Preventative maintenance software – used to view current and future maintenance procedures on a calendar;
4. Predictive upkeep and condition monitoring – monitors the conditions of an asset and generates information on future maintenance date; and
5. Work orders – this software generate, tracks and manages work orders.

The use of CMMS as part of the maintenance strategy has a positive impact on profitability.

2.3.2 Computer-Aided Facility Management

Computer-Aided Facility Management (CAFM) software is a graphic-based system integrated with CAD that is used for space and planning management (Atkin and Brooks, 2015). CAFM, combined with 3D CAD, is a tool which can best support planning and monitoring of physical space, furnishings, fixed assets, capital expenditure and activities within the facility (Rondeau, 2012). The scope of CAFM is much broader as it extends to areas such as maintenance management, resource management, task management, stock control and purchasing as well as health and safety (Booty, 2006).

According to Booty, (2006) there are five basic CAFM modules. These modules expend the scope of CAFM from asset management and maintenance to a broader scope of infrastructure management, environmental management, maintenance management, security management and financial management.

2.3.2.1. CAFM basic modules

a. Infrastructure: buildings, space and asset management

A Property-based CAFM holds the data required to catalogue and monitor property and its contents. It involves holding property details regarding construction, ownership, leases and occupancy. It aids in routine tasks by flagging lease renewal and refurbishment dates or calculating multiple occupancy costs so that they can be recharged to groups of occupants. It can be linked to CAD space-plan drawings which are used for providing a comprehensive picture of space usage down to workstation level, allowing for effective management of telecoms and cable infrastructure (Booty, 2006).

b. Health, safety and environmental management

Health and safety CAFM ensures a safe working environment and demonstrates compliance with legislation and best practice. It can be used to monitor pollution levels across sites. Environmental CAFM allows for monitoring, comparing and managing the consumption of energy (Booty, 2006).

c. Maintenance, repairs and contract management

This keeps a full maintenance history for all equipment or plant held on all sites and in the facility. It supports the planning and implementation of preventive maintenance schedule and can be used as an online tool for purchase requisitions, material requests and work requests (Booty, 2006).

d. Helpdesk, service desk and security management

FM team can use this system to provide a responsive fault reporting and resolution service to facility users, to monitor all the physical, personnel and electronic aspects of security – access control, CCTV.

e. Financial, budget and inventory management

This module tracks and manages costs associated with capital assets, operations, consumables, work orders and training. Finance management assists in accurate measurement and forecasting of the cost of all activities and the control of budgets (Booty, 2006).

The five modules of CAFM are important tools that provide an effective FM information management system (Booty, 2006). CAFM combined with CAD enables facility managers to effectively store and manage FM information.

Nevertheless, CAFM has its own pitfalls, as building information and FM information is captured manually. This process of inputting information manually can result in the system not being used effectively and thus increasing the cost and the time of entering and updating the information (Teicholz, 2013).

2.3.3 Integrated Workplace Management System IWMS

An Integrated Workplace Management System IWMS is a combination of all the above systems. It allows users to track equipment and space, but it also tracks things such as environmental impact and lease management (Spence, 2013). According to Halligan (2012), IWMS combines CAFM and CMMS features with applications for real estate, project management and even applications for environmental sustainability – measuring energy consumption and forecasting usage, for example. Like any other information management system, IWMS can assist an organisation to manage and share FM information. Even though IWMS offers a global solution, it does not provide some of the special functionality of standalone systems.

2.4 Building Information Modelling

BIM is a term used to describe a model for defining the physical and functional characteristics of a facility in a digital form (Gardezi, Shafiq, Nurudin, Farhan and Umar, 2014). The Scope of BIM is to store, manage and convey information produced during the lifecycle of a building, with the ability to present the information in three-dimension 3D. BIM is applied in FM in broad categories which are discussed in the review. BIM for FM is discussed in its sub-divisions: BIM in building operations and maintenance management, BIM in facility planning and BIM in real estate.

2.4.1 Definition of BIM

BIM is a model that has been sought since the 1970s, by industrial and academic researchers. According to Liu (2012), the study of BIM has been around for decades and the earliest BIM concept was developed from a prototype Building Description Systems (BDS) by Eastman in 1975. Eastman described the BDS as a system which included ideas of parametric design, deriving 2D drawings from a model, and as a “single integrated database for visual and quantitative analyses”. He also suggested that “Contractors of large projects may find this representation advantageous for scheduling and materials ordering”.

In the 1980s, BDS evolved and were described as “Building Product Models” in the USA, and “Product Information Models” in Europe. According to Eastman et al., (2011), the model gained momentum and the term “Building Information Model” was first documented in English in a paper by Van Nederveen and Tolman (1992).The acronym BIM can be used to refer to a product – referring to a structured dataset describing a building, or an activity – meaning the act of creating a building information model, or a system – referring to the business structures of work and communication that increase quality and efficiency (National Institute of Building Sciences (NIBS), 2007).

In a survey done by Aranda-Mena, Crawford, Chevez and Froese (2009), empirical results show that BIM means different things to different professionals. BIM can be a software application; or a process to design and document building information, or a new approach to implement new policies, contracts and relationships amongst project stakeholders.

Volk, Stengel and Schultmann (2014) define BIM from a narrow and broader perspective; from a narrow sense, BIM is a central information management hub which offers a platform for integrated data management. While in a broader sense BIM can be divided into interrelated functional, informational, technical or legal issues. Broader BIM can be used by different stakeholders to support and perform expected services for building. Suermann and Issa (2007) shows that BIM is a 3D modelling and visualisation tool, while Liu (2012) shows BIM as a model to hold information for different stakeholders at different phases of a facility life cycle.

Holzer (2007) describes BIM as a platform where individual contributors can share information in a standardised format to manage project information. While, The National Building Information Standards (NBIS) define BIM as a three-dimensional digital presentation of a building and its intrinsic characteristics, which has building components that include data attributes and parametric rules for each object. In this research, BIM will be used to refer to the activity, technologies and processes used in creating the actual building models.

2.4.2 Scope of BIM

Howard and Bjork (2008) assert that the scope of BIM is to provide a single building model capable of being used through the whole building process. A BIM application typically has the capability to extract information from a 2D document, permitting the creation of intelligent contextual semantic digital models in terms of building elements and systems (Lu and Korman, 2010). The scope of BIM extends from 3D to n-D; n-D is infinite for now because additional dimensions can be added. BIM technology gives industry practitioners a platform to visualise the entire scope of a building project in an n-D model (Lui and Issa, 2013).

The 3D model is used to communicate visual aspects of a building, whereby building modules, geometry, space, location and contained systems are in relation to each other (Duke, 2013). The 4D model is a time aspect for schedules; through this platform, BIM promotes collaboration among all building officials (Lu and Korman, 2010). 5D is a cost component which helps to create cost estimates and material quantifications. 6D involves project control and building lifecycle management – providing a complete construction sequence for ordering, fabrication, delivery and on-site installation of building systems, while 7D is used for safety management to determine building systems conflict, interference and collision detection (Luthra, 2010, cited in Lui and Issa, 2013). Hence, BIM is a process not a tool or solution. It is a holistic approach for designing, constructing and managing a facility used in the built environment (British Institute of Facilities Management (BIFM), 2012).

2.4.3 BIM application

The application of BIM can be categorised into different disciplines within architecture, structural engineering, mechanical engineering, electrical engineering, construction and FM. Contained in these disciplines there are numerous programs which are used during building information modelling. Volk, Stengel and Schultmann (2014), Duke (2013) andLiu (2012) and identifies some of the programs as follows:

1. BIM authoring tools include architectural, structural, MEP and 3D site work modelling software. Examples of the program are ArchiCAD, Revit Architecture and Revit Structural;
2. BIM construction management and scheduling tools – this program supports coordination, scheduling, clash detection and estimation. Examples are Project Wise and NavisWorks scheduling; and
3. BIM for FM is a 3D tool utilised for creating and updating data throughout a facility lifecycle, in conjunction with allocating, maintaining and tracking workspaces. Examples are Bentley Facilities, ONUMA planning system and ArchiFM.

2.4.4 BIM adoption in AEC industry

According to Arayici, Coates, Koskela, Kagioglou, Usher and O'Reilly (2011), the building industry is under pressure to provide value for money and sustainable designs and construction. This pressure has created the need for the adoption of BIM. BIM implementation includes learning new software, modelling construction and workflow, staff training and assigning responsibilities.

Australia, the UK and the USA are some of the developed countries that have adopted BIM in the public and private sectors, with the public sector playing a large role in the implementation of BIM. Currently, BIM is used as a computerised modelling system that can create up to 6D models.

During design and construction, BIM tools such as model analysis, clash detection and project conceptualisation have been used internationally Takim et al., (2013).
The use of BIM in design and construction has yielded good benefits and opportunities Gu and London, (2010). Research suggests that financial benefits can be achieved through BIM adoption (Howard and Bjork, 2008: and Becerik-Gerber et al., 2010.)

The key goal of BIM is to ensure that there is collaboration between industry stakeholders, whereby BIM offers a single platform to store information from the planning stage to FM. The integration of planning and FM information into a single

BIM model ensures that facility managers have all the information they need – contained in one central database without having to maintain separate asset management systems (BIFM, 2012).

Potentially, BIM can help create and maintain facilities that are more efficient, have lower carbon emissions, cost less to run and are better, more effective and safer places to live and work (BIFM, 2012). Howard and Bjork (2008) recommend that for a more advanced use of BIM, the industry must create a special role in the project team for an information manager whose role is to coordinate the use of BIM throughout the lifecycle of a project

2.5 BIM for FM

BIM targets have been set worldwide, and there exists a high level of readiness for BIM technology in the industry (Venkatachalam, 2014). According to Atkin and Brooks (2015), the adoption of BIM is expected to grow speedily in FM, even though most of the FM functions are still being done manually. BIM offers an incredible opportunity for facilities managers to add meaningful value to the design or refurbishment of a facility (BIFM, 2012). Sabol (2008) adds that BIM can provide an integrated digital repository of all building space, systems and their components as a 3D model. Major building systems may be represented in distinct and separate BIM models which can be integrated into a single master model (Sabol, 2008).

A good BIM system enables an organisation to access and analyse FM modules in real time. BIM for FM has functions and tools that can be used to support FM functions for both new and existing buildings (Volk et al. 2014). Furthermore, BIM offers a new level of functionality for building and physical assets, as long as the information and data are captured once during the design and construction phase, using BIM (Teicholz, 2013).

One of the first examples used to illustrate implementing of BIM in FM was the case study of the Sydney Opera House in 2006. The case study was used to successfully demonstrate the potential benefit of BIM in FM. Other case studies include a renovation project at the University of Chicago, where BIM was linked to existing

CMMS and CAFM systems during the renovation of the administration building. Other examples of BIM in FM are documented in a book by Teicholz (2013).

In their study, Becerik-Gerber et al., (2012) interviewed FM practitioners on the role of BIM and found that using BIM decreases the chances of errors and increases efficiency. Korpela and Miettinen (2013) also found that in FM, BIM can be used for space management, planning and scheduling of maintenance tasks, operations data such as energy use, allocating and managing assets, and facilitating maintenance. Furthermore, BIM can be used as a tool to track the types and quantities of materials, equipment and spaces of a facility. Even though potential benefits of BIM for FM have been recognised by the AECO industry (Lui et al., 2015), there is a perception that the industry has been slow to participate in the developments of BIM, and that facility managers are not precisely certain about how BIM can be utilised effectively.

2.5.1 BIM in Facility Planning

The potential utilisation of BIM in space planning is important in FM. Space needs and space usages are usually dynamic, based on the ever-changing needs of organisations. The issues involved in space planning and maintenance are many, including the difficulty in continually changing the uses of the space and being able to clearly identify the owner of the space, the type of space, occupancy rate, future space needs, asset management and strategic planning (Khemlani, 2011). Within space management, BIM is used to assist organisations to maintain accurate documentation of existing building space, while streamlining the reporting of that space (Autodesk, 2013).

BIM, together with a Design Web Format (DWF) space management technology, can be used to combine the spatial and geometric information given in maps, 3D models and 2D floor plans with the data information in asset registers, tenant registers, performance data, etc. (Autodesk, 2013). The use of this platform enables organisations to effectively distribute, manage and track appropriate spaces and related resources within a facility.

A facility-building information model allows the FM team to analyse the existing use of the space and effectively apply transition planning management towards any applicable changes. Such applications are particularly useful during a project's renovation where building segments are to remain occupied (Messner, Anumba, Leicht and Kreider, 2013). Some of the benefits of utilising BIM in space planning are:

- High-quality 3-D visualisations. BIM provides improved visualisation for any space – allowing practitioners to develop and prepare presentations for the owner or tenant. According to Becerick-Gerber et al., (2012), the 3D model can also be used for training purposes, especially for evacuation plans; and
- Improving planning, operations and security during relocation, whereby BIM will provide a way of seeing and identifying security breaches by instant visualisation of the 3D spaces (Arayici et al. 2012).

2.5.2 BIM in Building Operation and Maintenance Management

FM practitioners who are tasked to perform maintenance and operation activities respond to trouble calls, replace obsolete items, and conduct predictive testing and inspection to maintain the built environment (Becerick-Gerber et al., 2012). In addition, practitioners can query, simulate and estimate activities and their effects of the building process as a lifecycle entity (Gillard et al., 2008, as cited in Arayici et al., 2012).

Some research shows BIM as a computational-based system performance prediction tool to aid in long-term and preventative maintenance planning. The use of BIM in FM is anticipated to benefit both the operational and management phase of a building's lifecycle. Areas of BIM application in operational and maintenance management are the location of building components, facilitating real-time data and checking maintainability.

2.5.2.1. Location of building components

During operations and maintenance management, practitioners are required to locate building components mechanical, plumbing and electrical components for corrective or preventative maintenance. To date, the practitioners rely on paper-based blueprints, intuition and experience to locate, detect and resolve building component problems (Becerick-Gerber et al., 2012). Becerick-Gerber et al. (2012) further add that Radio Frequency Identification (RFID) technology can be used to locate a building component and to display the data specification and maintenance history which relates to the component. RFID is an automatic data collection and storage technology used for tracking, inventory management, equipment monitoring, process management, material management and quality control (Motamedi, 2013).

The most popular use of RFID is to identify, track and locate objects. At the Frankfurt Airport in Europe, RFID is utilised as a mobile application which is fully integrated into the airport's management system to grow efficiency on maintenance documents and to improve process quality (Legner, 2006). Furthermore, (Motamedi 2013) used RFID to store location information on tags attached to fixed and movable assets. There are several types of RFID systems that are available for different data storage needs (Guven and Ergen, 2013).

2.5.2.2. Facilitating real-time data

Specific organisational goals and objectives during operations and management can be achieved by a systematic and explicit knowledge management database. Data and knowledge gained during operation and management can result in a knowledge-based database which is transferable through a BIM model (Becerick-Gerber et al., 2012).

Information exchange during the construction phase can be done through the Construction Operation Building Information Exchange COBIE (Motamedi, 2013). Paul and Charlesraj (2014) suggest a knowledge-based BIM framework, K-BIM, to be utilised in addressing the core competencies of FM, whereby practitioners can pull out, make queries, control and store work order information relating to a specific building component.

Since reactive maintenance is costlier than planned maintenance, a reliable maintenance database that holds information about assets, maintenance and repairs is necessary for planned maintenance decisions (Lui, 2012).

2.5.2.3. Checking maintainability

Maintainability is an important issue in design where the accessibility of certain parts is determined for routine maintenance (Chang and Lai, 1995). With the development of BIM, there is a need to expand BIM for maintainability problems that occur frequently and can otherwise be solved during the design phase "Design for Maintenance" (Lui and Issa, 2014).

In their survey, Lui and Issa (2015) identified lack of adequate ceiling space for containing the Mechanical, Electrical and Plumbing (MEP) systems, lack of equipment accessibility, poor design of equipment layout, lack of adequate space for mechanical room and limited space for air handler units, as the top five maintainability problems. A case study conducted in Solibri, by Lui and Issa (2014), shows that design defects which make maintenance activities impossible to perform can be detected during the design phase by using Revit Add-in.

In summary, BIM connects building and equipment information gathered from the design and construction phase to the building operation and management phase. The information created and collected provides FM practitioners with valuable data to manage and operate a facility and all equipment. During building operation and management, the use of BIM is beneficial in that it can be used to control cost. BIM enables FM practitioners to locate equipment and keep track of warrantees and when equipment is due for maintenance. Another added benefit to using BIM is that information relating to work order can be easily accessed, stored and retrieved, making BIM a critical tool for day-to-day maintenance management.

2.5.3 BIM in Real Estate

In real estate, it is imperative to capture a building in its 'as-is' condition, so that buyers and tenants can make an informed decision. A BIM model with geometric modelling and object recognition capabilities, such as a 3D laser scanner, can be utilised to scan the current layout and condition of a building (Mahdjoubi, Moobela and Laing, 2013). In their study, Mahdjoubi et al., (2013) used a 3D laser scanning tool at the auditorium of Aberdeen's Tivoli Theatre in Scotland to identify the benefit of a 3D laser scanner used in an old building with a high degree of internal defects.

The benefits were: to capture accurate information, identify certain defects, and to capture information while building continued, including material characteristics, details and texture.

Despite the benefits of BIM in FM, the industry is not motivated to change existing work practices and is hesitant to implement and learn new technologies (Sabol, 2008; Gu and London, 2010). The client has the possibility to increase the adoption of BIM by making it a requirement that BIM is to be used during design, construction and facility management phase (Booysen et al., 2013).

The adoption of BIM will result in many different types of opportunities and challenges, compared to traditional ways of working in the industry (Talebi, 2014). Sabol (2008) asserts that FM practitioners have the challenge of improving and standardising the quality of the information they have at their disposal, to meet day-to-day operational needs, as well as to provide upper management with reliable data for organisational management and planning.

2.6 Determinants of BIM Adoption

The adoption of any new technology comes with determinants and BIM is no exception Succar et al., (2012). Even though BIM is gaining momentum in AEC, Sabol (2013) asserts that the utilisation of BIM is a complicated matter with several challenges. It has been widely noted by authors such as Eastman et al. (2011), Kekana et al., (2014) and Azhar (2011) that BIM comes with challenges and that the challenges of implementing BIM can broadly be classified into two categories: process challenges to the business, and technological challenges.

2.6.1 Process challenges

Process challenges include legal, contractual, organisational and human challenges. These challenges of BIM standards and specifications include the following:

- Cost of implementation of software and training. High upfront costs for purchasing the pertinent software and to train staff on how to use the software have impacts on the financial standing of an organisation (Eadie, 2014; Talebi, 2014);

- Learning curve and lack of skilled practitioners;
- Lack of company investment in BIM;
- Lack of senior management support. Most senior managers are reluctant to introduce new technology;
- Contractual issues including controlling how information is exchanged and the liability and risk associated with the collaboration of project teams. This can originate from the uncertainty of the quality of work that is inserted into a BIM model; and
- Legal issues, determination of data ownership, copyrights and licensing issues. Legal challenges include the uncertainty of legal liability amongst AEC stakeholders (Wortmann et al., 2016).

2.6.2 Technology Risk and Challenges

During a construction project, various organisations use different types of software, thus interoperability between the software used is not guaranteed (Talebi, 2014). There are technical risks and challenges of interoperability around data sharing in its different formats. Technological determinants of acceptance which affect the adoption of BIM include the following:

- Lack of work process, standards for model integration and management by multiple disciplinary teams. There are various issues regarding who should develop and operate BIM and how the costs should be spread across industry stakeholders (Gu and London, 2010);
- Integration capabilities, which refers to the ability of BIM to deliver key objectives of integration;
- Full integration and proper selection of BIM tools. This relates to sharing, feeding and transferring of data into the model. It is important for different tools within the model to send and receive adequate information (Kekana, Aigbavboa and Thwala, 2014); and
- Requirements of standardised BIM processes and guidelines for implementation. There is no single BIM document providing instructions on BIM utilisation and implementation (Azhar, 2011).

The impact of technical challenges on FM is that the lack of interoperability may hinder information sharing between various stakeholders, leading to broken information sharing networks. Therefore, according to Eastman et al., (2008) standards must be developed to ensure a streamlined data exchange.

2.6.3 Challenges of BIM specific to FM

In addition, Mahdjoubi et al., (2013), Kelly et al., (2013), Eastman et al., (2011) and Becerik-Gerber et al., (2012), also identified challenges of BIM which are specific to FM. The impact of these challenges on FM is that it is still unclear on how BIM should be utilised in FM.

- The benefits of BIM in ongoing FM practices are unclear and invalidated for example, unclear productivity gains, or benefits gained from reduced equipment failure and better-automated building energy usage;
- The amount of work that needs to be done to define the specific FM needs for which a model is necessary and how that model may need to be prepared to meet the needs;
- Lack of interoperability among BIM solutions and between BIM solutions and FM systems;
- Lack of demand for BIM deliverables by the owner community due to the uncertainty about what BIM might be used for;
- Lack of clarity about responsibility for insurance and contracts;
- Lack of standardised FM tools and processes;
- Limitation of 3D laser scanning and BIM for real-estate services;
- Cost of the technology;
- Lack of contractual and legal framework for BIM implementation in FM;
- Limited compatibility between BIM and FM technologies; and
- The difference in lifespan of BIM technology and FM technology.

Literature findings further indicate that FM practitioners are only just starting to adopt BIM. They, therefore, have limited experience, inadequate knowledge and difficulties with using BIM software. According to Teicholz (2013), the processes, software and standards of BIM are still in the early stages of development and it is hence too soon for BIM to be fully integrated with FM software such as CAFM and CMMS. Furthermore, there are potential challenges to integrating BIM into FM software. The above challenges further contribute to putting FM practitioners off BIM as the practitioners are comfortable with the traditional methods of FM.

The challenges identified in literature affect the adoption of BIM in both developed and developing countries (Ogwueleka and Ikediashi, 2017). In developing countries, the main challenge in BIM adoption is cost and human issues (Kian et al., 2015). Developing countries have not arrived into the BIM scene (Arif and Sawhne, 2013). Hence, they still lack in the true utilisations of BIM (Masood, Kharal and Nasir, 2013). A potential solution for developing countries is that they can use the challenges of adopting BIM as tools to determine where to focus their energy and how to develop new strategies to overcome such.

2.7 The use of BIM in South Africa

Despite the fact that BIM is fairly new in South Africa, most companies are aware of the technology and are utilising BIM compliant systems (Venkatachalam, Mistry, Naidoo, and Khoza, 2013). In their study, Kekana et al., (2015) found that 70% of construction professionals have an average to excellent knowledge of what BIM is.

Although there is awareness of BIM in South Africa, the use of BIM in the country is very low Kekana et al., (2015). There is evidence that the usage of BIM in South Africa is high amongst architects as compared to contractors and other construction professionals (Froise and Shakantu, 2014). BIM has been used in South Africa on projects such as Kusile Power Station, Medupi Power Station and the 2010 FIFA World Cup stadiums (Booyens, Bouwman and Burger, 2013; Kipprotich, 2014).

In architecture, most organisations in South Africa have for some long time utilised various CAD systems, but in recent times different companies have been implementing BIM compliant software. Most architects are implementing 3D BIM compliant software such as ArchiCAD and Revit (Booyen et al., 2013), while a small percentage work exclusively in a BIM environment (Froise and Shakantu, 2014). Architects use BIM for drawing, visualisation, conceptual design functions scheduling, programming, costing and collaboration with other consultants (Froise and Shakantu, 2014).

Even though architecture companies are using BIM tools, Kipprotich (2014) asserts that most of them do not realise the extent to which BIM should be used and what BIM can do. Furthermore, architects are using BIM without FM in mind. During construction, BIM compliant software has been implemented increasingly for cost management, construction management and project management (Kekana et al., 2015). In South Africa, a BIM compliant system, Dimension X, is commonly used for cost estimating and quantity take-off (Booyens et al., 2013).

However, according to Froise and Shakantu (2014), less than 10% of South African contractors are familiar with BIM. According to Booyens et al., (2013), BIM technology is not being utilised as it is intended.

There is a lack of communication between various stakeholders, whereby architects are not designing with quantity surveyors, contractors and facility managers in mind (Booyens et al., 2013). This non-systemic approach results in further fragmentation of the sector as it causes hindrances in design collaboration and design data losses, leading to wasteful iterative design processes (Wortmann, Root and Venkatachalam, 2016).

There are no mandated or best practice BIM standards, specifications or protocols in South Africa (Wortmann et al., 2016). Thus, this lack of BIM regulation is affecting the rate of BIM adoption in the country (Froise and Shakantu, 2014). The concept of BIM adoption has a range of levels that are described as “Maturity levels”; these maturity levels represent the quality, repeatability and degree of excellence in delivering a BIM-enabled service or product (Kassem, Succar and Dawood, 2012).

The maturity levels range from zero to three. According to Succar (2012), the levels of maturity are adopted as a tool intended to evaluate the ability of an organisation to reflect the specifications of BIM capabilities, implementation requirements, performance targets and quality management. The BIM Maturity matrix can be used to explain why South Africa is lagging behind as compared to developed countries. Exhibit 2.1 illustrates BIM maturity levels.

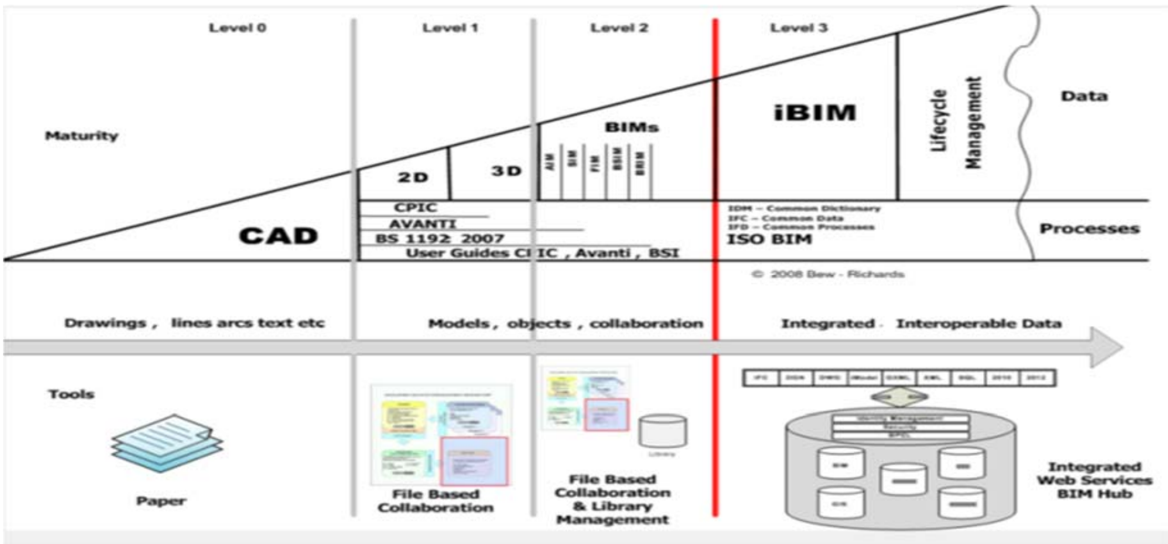

Exhibit 2.1: Maturity matrix

Source: Messner, 2013

Level 0: Is an unmanaged computer-aided design CAD including 2D drawings, and text with paper-based or electronic exchange of information, but without common standards and processes (Succar, 2012). Essentially this is a digital drawing board.

Level 1: This is a managed CAD, with the increasing introduction of spatial coordination, standardised structures and formats as it moves towards Level 2 BIM. This may include 2D and 3D information such as visualisations or concept development models. Level 1 can be described as 'Lonely BIM' because models are not shared between project team members (Succar, 2012).

Level 2: Consists of a managed 3D environment with data attached but created in separate discipline-based models. These separate models are assembled to form a federated model, but do not lose their identity or integrity. Data may include construction sequencing 4D and cost 5D information (Succar, 2012). This is sometimes referred to as 'pBIM' proprietary BIM. In May 2011, the UK Government Construction Strategy announced that the Government will require fully collaborative 3D BIM with all project and asset information, documentation and data being electronic as a minimum by 2016 (Eadie et al., 2014). This means that Level 2 BIM on centrally-procured public projects are now compulsory.

Level 3: Entails a single collaborative, online, project model with construction sequencing 4D, cost 5D and project lifecycle information 6D. This is sometimes referred to as 'iBIM' integrated BIM (Succar, 2012).

In terms of BIM application, Level 2 is mandatory in the UK for all government projects (Eadie et al., 2014). The policy creates a need for the establishment of a more structured information management model that recognises the types of information management methodology used for the operational phase. It is unfortunate that the implementation of BIM in South Africa lags behind developed nations. Evidence from literature reveals that BIM implementation in South Africa is minimal. Architects are leading in the adopting of BIM, while contractors and facility managers are lagging far behind (Kekana et al., 2014).

Even though literature reveals that BIM can improve design and documentation during a project lifecycle, it can be concluded that there is lack of integration between the various stages of construction and poor collaboration between construction professionals. The poor digital link hampers the concept of BIM, such that FM practitioners cannot receive and use as-built information and combine it with real-time sources of information for day-to-day maintenance and management.

2.8 Literature findings

The chapter discussed FM and adopted the definition of FM as stated by Figgis (2007, pp1), that FM' is a simple and an accurate label for the work done to ensure that a building or building complex works efficiently and effectively, that it meets the needs of the people active inside it"

From the discussion of literature and Table 2.1, it is clear that FM is not only about operation and maintenance. There are also strategic aspects of planning, which include real estate, space planning and general office services. Literature further shows that there is a relationship between different aspects of FM, forming a link between real estate management, space planning, operations and maintenance management and general premises management activities.

The current FM practise globally requires extensive documentation of information to effectively manage and operate buildings. Traditionally FM information was stored in paper format, making it difficult to store, share and manage information, until the introduction of computers and information management systems (Teichoz, 2013). One of the roles of a facilities manager is to effectively manage huge amounts of information at any given time.

Literature identified that there is a need for the industry to come up with new ways of collecting, accessing and updating FM information efficiently. The current status of FM practice requires FM practitioners who are responsive, flexible and are willing to implement technological changes to meet the day-to-day needs of the industry (Rondeau et al., 2012).

The literature review focused on some of the programs that are used for storing and managing information for building operations and maintenance, space planning and real estate. The concept of BIM was introduced together with its applications and tools, after which the chapter reviewed BIM as a tool in Facility Management. A strong focus was created on the level of BIM use and determinants associated with the adoption.

Within this chapter, it was also discovered that developed countries are currently promoting the use of BIM for efficient operations and that there are few case studies which illustrate the use of BIM in FM. In these case studies, it is clear that BIM cannot replace the wide range of FM information technologies, but that BIM can be utilised to support and enhance the use of those technologies. The literature review further suggests that even though BIM can assist facility managers to obtain data for their systems, there is inconclusive evidence of the successful use of BIM for FM.

Further, BIFM (2012) states that, for BIM to get to the same level of use in FM as compared to in design and construction, facility managers must become more involved in the development of BIM standards, systems of classification and datasets. Thereby ensuring that the technology is developed in a way that is useful for them. In addition, the determinants of BIM adoption globally were discussed, and the following tables represent the deductions thereof. In Table 2.4, the most prominent determinants as identified in literature are clustered into 6 groups.

Table 2.4: Determinants of BIM adoption

Group	Determinants	References
Management support	• Non-availably of support from top management.	Eadie et al. 2013, Liu et al. 2010
Technical issues	• Non-availability of market support/trends for BIM implementation. • Lack of standardised process and guidelines of BIM. • Lack of comparative analysis between traditional project delivery methods and BIM-based project delivery methods. • Lack of comparative analysis between the existing methods and BIM technology in terms of total cost of ownership vis a vee the benefits to the organisations.	Gu and London 2010, Becerik-Gerber et al. 2011, Wortman et al. 2016
Cost	• High initial cost of software/hardware. • High cost of training. • High cost of implementation.	Eadie 2014, Arayici et al. 2009

Group	Determinants	References
Compatibility of BIM	• Lack of BIM objects and standard modelling protocols. • Compatibility issues between software platforms. • Non-availability of opportunities to apply BIM.	Kekana et al. 2014, Azhar 2011, Mahdjoubi et al. 2013, Becerik-Gerber et al. 2011
Organisational Culture	• Weak support from organisation environment. • Weak culture of BIM implementation. • Behaviour of professionals to change from drafting to modelling. • Industry resistance to process change. • Absence of interoperable environment in the AEC industry. • Limited use of BIM in FM.	Becerik-Gerber et al. 2011, Eadie et al. 2013, Azhar 2011
Software/computer skills	• Non-availability of skilled professionals • Lack of skill to maintain and control BIM model	Gu and London 2010 Venkatachalam et al. 2013

The above determinants can be further classified into enablers and barriers, following (Becerik-Gerber et al., 2011 and Panuwatwanich et al., 2013). Table 2.5 represent a classification of determinants into barriers and enablers.

Table 2.5: Barriers and Enablers

Barriers	Enablers
• High cost of training • High cost of software/hardware • Industry resistance to change • Non-availability of skilled staff • Lack of BIM object libraries • Lack of standard modelling protocols	• Support from management. • Support from organisation, if BIM is required by client • Adequate technical support • Standardised modelling process • Benefits of BIM outweighing the cost of implementation • Create opportunities for BIM use

In the context of South Africa, the FM industry is still using the traditional methods to store, share and manage information. The literature review has also revealed that there are some examples where BIM was successfully used in design and construction. However, there is no evidence in literature about the use of BIM in FM in South Africa. Furthermore, BIM implementation standards in South Africa are yet to be developed. Literature also indicates that BIM standards and specifications will aid South Africa to get up to speed with BIM adoption.

From review of literature, it is evident there is scarcity of information regarding the adoption of BIM in practice in South Africa. The lack of evidence creates a knowledge gap in terms of best practice and case study examples to prove the benefits of BIM for FM in the context of South Africa. As such the level of BIM adoption in FM is not known. There is scarcity of information on the nature and occurrence of determinants of BIM adoption on FM locally, the opportunities and challenges.

2.9 Framework for Technology adoption

On the bases of the literature review findings, a conceptual framework for innovation and technology adoption will be used. The innovation in this case is BIM, which can be classified under technology and is an innovation that is becoming popular in research. Theoretically, the benefits and opportunities of BIM within AEC have been explored by many researchers. However, the adoption of BIM in FM is still very slow and there is scarcity of information on the benefits of BIM in FM in South Africa.

Moreover, the specific determinants of BIM in FM and the relative strengths have not been fully investigated. This research is about the adoption of a technology in practice, therefore there is a clear need to understand the factors which influence the adoption of BIM in FM.

The adoption of any technology can be understood through the use of various models of innovation and adoption. There are numerous models of innovation and adoption that examine an individual's choice to accept or reject an innovation. According to Straud (2009), some models of adoption deal with the adoption environment, while others deal with the type of innovation.

The following are some of the models existing in extant literature: Technology Adoption Model (TAM) by Davis et al., (1989) is a theory that models how users come to accept and use a technology, Theory of Planned Behaviour (TPB), (Ajzen 1985) creates a link between one's beliefs and behaviour , The Unified Theory of Acceptance and Use of Technology (UTAUT), (Venkatesh et al.,2013) aims to explain user intentions to use technology and their usage behaviour, Diffusion of Innovations (DOI), (Rogers 1995) explain how, why, and at what rate new ideas and technology spread, Technology Organization and Environment Framework (TOE), (Tornatzky and Fleischer 1990) refer to the process by which a firm adopts and implements technological innovations is influenced by the technological context, the organizational context, and the environmental context.

For this research, two of the models where discussed based on their ability to measure the use of technology. The TAM and UTAUT models are discussed below.

2.9.1 Technology Acceptance Model

TAM is a technology adoption model that provides a theoretical link between beliefs, attitude, action and intention. TAM utilises perceived usefulness and perceived ease of use as its key predictors of technology acceptance, with external variables such as politics, regulations and implementation process (Takim, Harris and Nawawi, 2013).

Perceived usefulness is a degree to which people believe that using an innovation will enhance their job performance, whilst perceived ease of use is the degree to which people believe that using the innovation will be effortless (Straud, 2009).

The TAM model hypothesis is that actual system use is determined by users' behaviour and intention of use, which in turn is influenced by their attitude towards use (Xu, Feng and Li, 2014). In a study by Takim et al., (2013), TAM was used to determine factors of BIM acceptance in AEC. The findings of the study were that regulation, policy, industry standards, benefits and competitive advantage are vital determining factors in the adoption of BIM.

Although TAM has been applied to understand the adoption behaviour in the field of AEC, Straud (2009) is of the opinion that predicting user behaviour based strictly on ease of use and usefulness ignores many other factors that are present in the UTAUT model.

2.9.2 The Unified Theory of Acceptance and Use of Technology

The UTAUT model was developed in 2003 when Venkatesh et al., (2003) examined eight technology acceptance theories and unified some elements from those models to form the UTAUT model. The UTAUT model identifies the key factors in acceptance of technology as measured by behavioural intention to use the technology and actual usage (Oye, Lahad and Rahim, 2012).

The original UTAUT model consists of four core determinants of intention and usage, and four moderating variables. The four determinants are: performance expectancy, effort expectancy, social influences and facilitating conditions (Venkatesh et al., 2003).

1. *"Performance Expectancy (PE) is the degree to which an individual believes that using the system will help him/her to attain gains in job performance".*
2. *"Effort Expectancy (EE) is the degree of ease associated with the system's use".*
3. *"Social Influence (SI) is the degree to which an individual perceives that important others believe he/she should use the new system".*

4. *“Facilitating Conditions (FC) is the degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the system”.*

According to Venkatesh et al., (2003) the four moderating variables are: Gender, Age, Experience and Voluntariness of use. The aim of the UTAUT model is to explain the user’s intention behind using a technology and the usage behaviour. The model further explains the relationship between perceived usefulness, ease of use and intention of use.

The UTAUT model has been used in various studies for technology adoption. For instance, Wu, Yu and Weng (2012) used the model to investigate acceptance and use of an electronic ticket developed based on RFID technology, used for public transit systems and ridership. Their results revealed that EE and SI have a positive influence on BI, while BI and FC have a positive influence on UB. Howard, Restrepo and Chang (2016) used the model to understand the perceptions that individuals have towards working with BIM and found that PE does not directly affect behavioural intention. Samuelson and Bjork (2010) used the model to provide the analytical framework for their semi-structured interviews. They found that the adoption of BIM is driven by individuals and not the organisation.

Although the UTAUT model is fairly new, it explains over 70% of all the technology acceptance behaviour, unlike other models which explain as little as 40% of the entire technology acceptance behaviour (Waehama, McGrath, Korthaus and Fong, 2014). This research will use the UTAUT model adapted from the original UTAUT model by Venkatesh et al., (2003) as a framework. The proposed UTAUT model was used by Howard et al., (2016). In their study, Howard et al., (2016) used the model to address individuals’ perception of BIM acceptance in AEC. The proposed UTAUT model follows below as illustrated in figure 2.1.

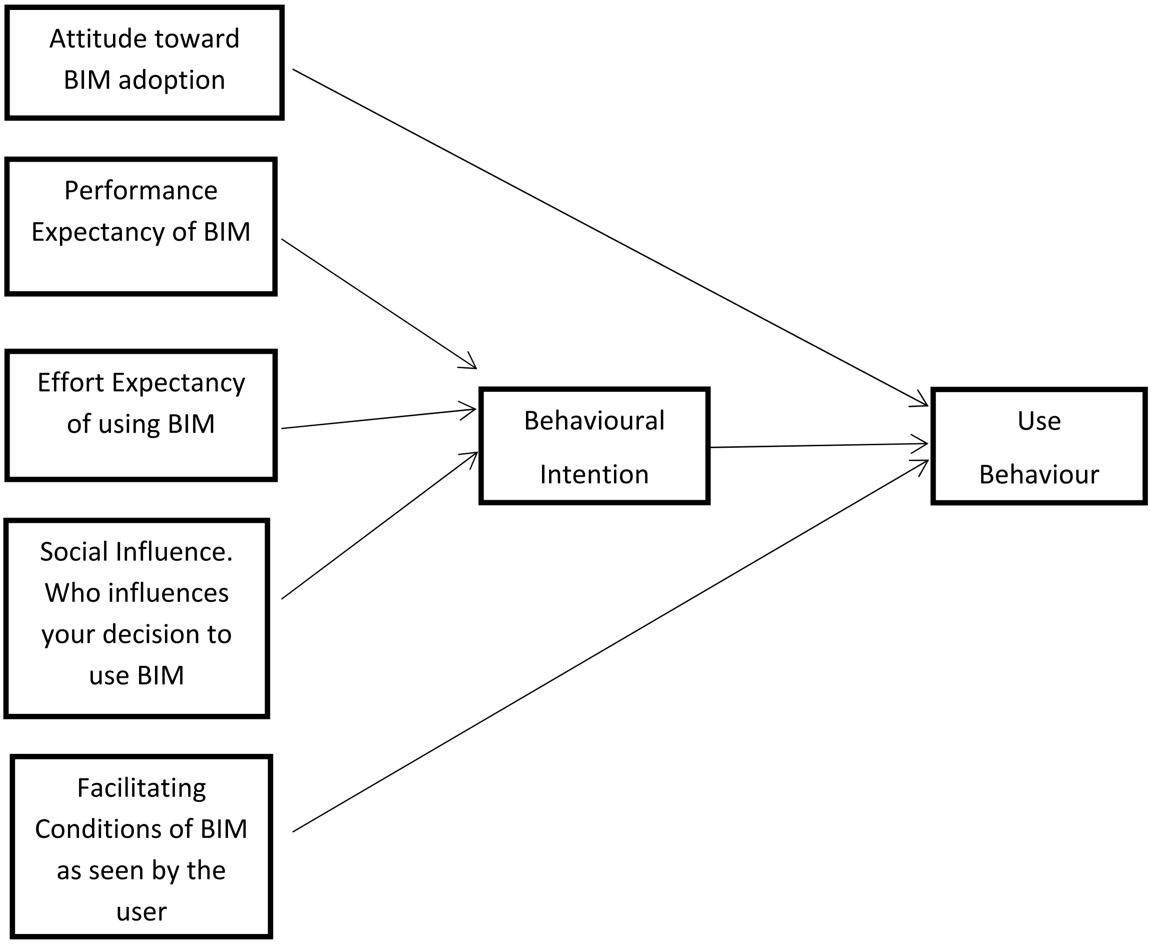

Figure 2.1: UTAUT model

Source: (Howard et al., 2016)

The proposed UTAUT model contains seven variables, two dependent variables and five independent variables. It uses Behavioural Intention (BI) as a predictor of the technology Use Behaviour (UB). BI is a mediating variable for PE, EE and SI. The model comprises of four core determinants of usage intention – Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI) and Facilitating Conditions (FC).

Howard et al., (2016) suggest that the quantitative Unified Theory of Acceptance and Use of Technology (UTAUT) model provides a more powerful and theoretical framework for collecting data and probing the perception of BIM at individual levels.

The UTAUT model was used by Howard et al., (2016) and revealed a series of correlations between Performance Expectancy and Social Influence, Performance

Expectancy and Facilitating Condition, and between Effort Expectancy and Facilitating Condition. These correlations assisted in explaining how the cited variables influence the utilisation of BIM.

Therefore, the adopted UTAUT model based on the original format of the UTAUT by Venkatesh et al., (2003) and that of Howard et al., (2016) was utilised to assess the research objectives and to test the UTAUT model variables. Each variable was measured within the questionnaire by a set of questions. The questions where tailor made to address questions specific to the utilisation and adoption of BIM in FM

2.10. Summary

This chapter integrated the theories about FM, information management technologies within FM and the utilisation of BIM in FM. Furthermore, the chapter reviewed the definition, benefits and challenges of BIM adoption in FM. The scope and functions of FM where discussed in general. The discussion included facility planning, building operations and Maintenance, real estate and building construction and general office services.

The literature indicates that there is a need for integrated information management software such as BIM for FM. Areas of BIM adoption within FM were discussed. Although BIM has gained attention internationally there are many challenges to BIM adoption. Furthermore, the adoption of BIM in FM lagging behind as compared to the adoption of BIM in AEC. In the case of South Africa, the latter is the same. The lack of BIM adoption in FM in South Africa is evident in the scarcity of literature on the topic.

Lastly, the UTAUT model was discussed and adopted as a theoretical framework to examine the determinants of BIM adoption in FM. The variables of the UTAUT model answered questions relating to the use of BIM in FM. The UTAUT model was used to develop a questionnaire subsequently the questionnaire was used as a tool for data collection. Data which was collected was analysed and presented. The following chapter on methodology discuss the methods of data collection and data analysis in full.

3. METHODOLOGY

This chapter discusses the methodology which was used in this research. The research methodology was chosen to satisfy the research aim and objectives which help to accomplish this research study. The chapter includes information about the research plan/strategy, population, sample size, data collection technique, interview and questionnaire design and development, face validity of the questionnaire, pre-testing of the questionnaire, pilot study, final content and application of the questionnaire, and analytical methods of data.

BIM in Facility Management is generally a new concept in South Africa; therefore, empirical evidence is needed to explore the use of BIM. In the absence of empirical evidence about the utilisation of BIM in FM in South Africa, there is need for an exploratory research. According to Saunders et al. (2012), an exploratory research aims to explore the research questions. It is an effective means to ask open questions that assist in discovering and gaining of insight into the topic. Although it is conducted to determine the nature of the problem, exploratory research does not necessarily provide conclusive evidence, but helps to gain a better understanding of the problem. A possible approach in exploratory research is to begin with the collection and analysis of qualitative data, a basis for, a second phase of quantitative data analysis which is conducted to test or generalise the initial findings (Creswell and Plano- Clack, 2011).

3.1 Research Aim and Objectives

3.1.1 Aim

The overall aim of this research was to conduct an explorative study of the BIM utilisation in Facilities Management in South Africa.

3.1.2 Objectives

The specific objectives were three-fold namely to:

a) To determine the levels and extent of BIM utilisation in Facilities Management practice among Facilities Management practitioners in South Africa.

b) To identify the challenges faced by Facilities Management practitioners in utilising BIM for practise in South Africa.
c) To find out and evaluate the determinants for the adoption of BIM for Facilities Management practise in South Africa.

3.2 Research design

The research strategy is the general plan for how and what data should be collected and how the results should be analysed (Bryman and Bell, 2011). The chosen research plan will influence the type and the quality of the collected data Ghauri and Gronhaug, (2010). To investigate the research questions about BIM utilisation in Facilities Management in South Africa, a mixed quantitative and qualitative methodological approach was adopted. The mixed methods approach combines qualitative and quantitative data collection and analysis techniques (Creswell and Plano-Clack, 2011). In addition, the data is analysed and integrated using both qualitative and quantitative methods (Creswell and Tashakkori, 2007).

The methodical choice for the mixed method uses a mix of two approaches; Hartman, Fischer and Haymaker, (2009) – who advocate the use of a more qualitative approach when exploring the use of technology in the construction industry. And Howard et al., (2015) who suggested the use of a quantitative approach. The rationale of using a mixed method approach is that it provides strength which offsets the weaknesses of both qualitative and quantitative methods (Morgan, 2013; Davies and Hughes, 2014).

3.3 Target population

The data was collected in 2016. The research population included facilities management professionals registered with the South African Facilities Management Association (SAFMA). The population from which a sample was drawn for this research comprised 950 FM practitioners registered with SAFMA, amongst which 360 are based in Gauteng Province, which is the geographical scope of the study. Gauteng is one of the nine provinces in South Africa. It is highly urbanised and contains the largest city, Johannesburg and the capital city Pretoria. The head office of SAMFA together with the head offices on some of the large FM companies are based in Gauteng., Based on the huge industry presents and building stock, Gauteng has a concentration of facilities which require FM services. Furthermore, Gauteng has highly experienced personnel and the uptake of technology is high. Hence, Gauteng is a suitable area to conduct this research

3.3.1 Sampling

This research used purposive sampling. According to Creswell and Plano-Clark, (2011), purposive sampling means that the researcher can intentionally recruit participants who have experience in the field of study and hold different perspectives. Furthermore, Saunders et al., (2012) assert that purposive sampling is used when working with a small sample and when one wishes to select cases that are particularly informative. The chosen method allowed the researcher to select a sample of people who would give the most accurate information. A small number of practitioners who provided in-depth information about the topic were selected from a sample of FM practitioners registered with SAFMA, to participate in the interview and questionnaire survey. The selected sampling method enabled the researcher to answer the research questions and to meet the objectives of the research.

For interviews, four members were selected from four firms one per firm; the selection method was based on the level of working experience and position held within the organisation. Member with more than 15 years working experience and who are in senior management were selected for the interview. Whilst for questionnaire statisticians believe a sample size of 30 or more will usually result in a sampling distribution, for the mean that is very close to a normal distribution (Saunders et al., 2012). For this reason, a sample size of 30 participants was deemed appropriate for this research. The above sampling method enabled the researcher to collect data from diverse individuals who hold different perspectives on the subject.

3.4 Data collection

Two data-collection tools were developed for data collection. The first was a qualitative interview guide and the second, a mixed open- and close-ended self-administered questionnaire. The use of both methods in the same study is a viable option to obtain complementary findings and to strengthen the findings (Thurmond, 2001). The two methods are different in approach;

Interviews are more exploratory, while a questionnaire is more confirmatory (Harris and Brown, 2010). Five fundamental stages were taken for constructing the data-collection tools:

1. Identifying the first thought questions for data collection;
2. Formulating the qualitative interview guide Tool Number 1;
3. Analysing the data collected from the qualitative interviews together with literature to inform the questions for the mixed open- and close-ended questionnaires;
4. Formulating the final questionnaire and
5. The wording of questions.

Identification of items for the research and preparation of the interview guide as well as the questionnaire was a crucial step for the success of the research. A significant amount of work has already been done on items of BIM functions, benefits and barriers and there is a well-documented and peer-reviewed set of those available items in the literature review in chapter 2. Using the latter, the two data-collection tools were developed for the study.

Interview Guide – Out of these three types of interview techniques namely structured interview, unstructured interview and semi-structured interview (Sapsford and Jupp, 2006; Walliman 2011), this study adopted the semi-structured interview method. Saunders et al., (2012), advocates that semi-structured interviews provide a good background and contextual material to an exploratory qualitative research, while Oppenheim (2005) suggests that in-depth interviews can broaden the research and throw up new ideas and hypotheses.

The interview guide had two sections. The first section had five questions aimed at collecting demographic and background information. The second section constituted of nine questions gathering information about operations at facility management companies. The interview took 30 minutes. Interviews were very important in collecting information used to develop the questionnaire.

Questionnaire – The selection of a questionnaire as a tool for data collection is informed by Hofstee (2006), who states that a questionnaire is an excellent way of finding out people's options and attitudes. According to Oppenheim (2005) a questionnaire is a quick, powerful and objective research tool that can be used to elicit information from a large number of individuals who are presumed to have the information one is seeking.

The questionnaire had 41 questions divided into three sections. Section 1 consisted of six socio-demographic questions to gain some knowledge about the characteristics of the participants who use BIM and those who do not use BIM. The type of biographical information included gender, age and educational level. The second section was more specific with 10 questions, aiming at those who are using BIM for FM activities and those who have used BIM previously. The third and final section had 25 questions employed the UTAUT model on a 7-point Likert Scale where 1 – Strongly agree and 7 – strongly disagree as a theoretical framework for the questionnaire to explore the use and acceptance behaviours. See table 3.1 below.

Table 3.1: The UTAUT indicators used for Questionnaire

Construct	Item code	Item
Performance Expectancy (PE)	PE1	I find BIM useful
	PE2	Working with BIM increases productivity
	PE3	Using with BIM increases my performance
	PE4	BIM enables me to accomplish tasks more quickly
Effort Expectancy (EE)	EE1	Learning to operate BIM is easy for me
	EE2	My interaction with BIM is clear and understandable
	EE3	It is easy for me to become skilful at using BIM
	EE4	I find it easy to use BIM
Social Influence Influence (SI)	SI1	People who influence my behaviour think I should use BIM
	SI2	People who are important think I should use BIM
	SI3	Senior management have been helpful in the use of BIM
	SI4	The organisation has supported the use of BIM

Construct	Item code	Item
Facilitating Conditions (FC)	FC1	I have resources necessary to use BIM
	FC2	I have knowledge necessary to use BIM
	FC3	BIM is not compatible with other computer systems I use
	FC4	There is assistance available with BIM difficulties
	FC5	Using BIM fits into my work style
Attitude (ATT)	ATT1	Using BIM is a good idea
	ATT2	I like working with BIM
	ATT3	Working with BIM makes work interesting
Behavioural Intention (BI)	BI1	I intend to use BIM whenever possible
	BI2	I have plans to use BIM in the near future
	BI3	I predict I will use BIM
Use Behaviour (UB)	UB1	I use BIM for different Facilities Management tasks
	UB2	I perceive using BIM as voluntary

3.5 Pre-testing the questionnaire

Pre-testing of the questionnaire was done to make sure that the questionnaire is going to deliver the right data and to ensure the quality of the collected data. Pre-testing the questionnaire was an important step for finding out if the survey has any logic problems, if the questions are too hard to be understood, if the wording of the questions is ambiguous, or if it has any response bias. According to Reynolds, Diamantopoulos and Schlegelmilch (1993), pre-testing is used to refine the questionnaire design and to identify errors in the questionnaire.

The pre-testing was conducted using the same four industry experts used during the face-validity phase. The first phase of the pre-testing resulted in some amendments to the wording of some words in the questions, and further explanation was added to some items to facilitate the understanding of the questions. The questionnaire was then modified based on the results obtained ensuring no further queries from any of the professionals and that everything was clear. The modifications were as follows:

- An additional question was added to accommodate those who are not using BIM currently but have used it before; and
- Skip logic was introduced to Question 8 so that those who answered no could skip Questions 9–16, and answer from question 17.

Accordingly, the questions were now clear to be answered in a way that helps to achieve the target of the study and to start the pilot phase of the pilot study.

3.6 Pilot study

After successfully pretesting of the questionnaire, a trial run on the questionnaire was done before circulating it to the whole sample. This was to identify any short-comings. Three copies of the questionnaire were distributed conveniently to respondents from the target group. All the copies were collected, coded, and analysed through Statistical Package for the Social Sciences SPSS version 23.

3.7 Conducting of the Survey

After face-validation, pre-testing and piloting, the questionnaire was administered to the respondents through an online platform Qualtrics© which is used for data collection and management. Qualtrics© has 6 different products. This study used Qualtrics© research core. Access to Qualtrics© research core account was made available by the University of Witwatersrand. Thereafter A link was generated through Qualtrics© and sent to 123 participants via email. The link was only sent to members of SAFMA whose core business is FM.

3.8 Data analysis

The framework for data collection and subsequent data analysis tools is summarised in Figure 3.1. As described in the methods section, the objectives are three-fold namely; to determine the levels and extent of BIM utilisation in FM practice among practitioners in South Africa; to determine the adoption of BIM relative to various aspects of FM and to find out and evaluate the determinants for the adoption of BIM for FM. Furthermore, data collection will be conducted using mixed-methods involving qualitative and quantitative data collection

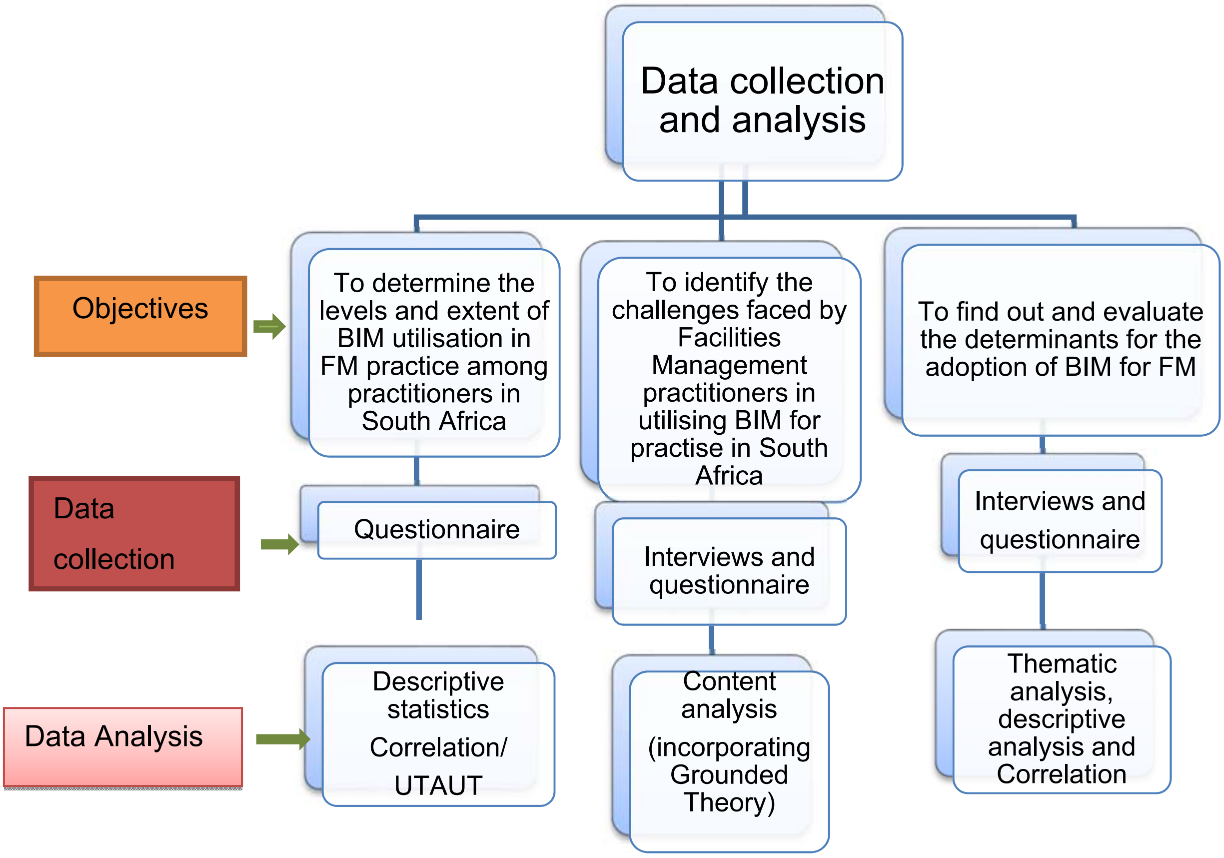

Figure 3.1: Framework for data collection and data analysis

3.8.1 Qualitative Data Analysis

According to Kendall (2008) cited in Harris and Brown (2008) it is important that qualitative data should not be used to illustrate quantitative results without being analysed, using techniques appropriate for the type of data collected. Qualitative data analysis was carried out using the grounded theory, which is premised on content analysis. Content analysis involves coding, dividing the text into small units and the grouping of codes into themes (Creswell and Plano-Clark, 2011). It requires the researcher to look for patterns, themes and explanations of why and how patterns occur (Walliman, 2011).

Thematic analysis is a common analytical approach in qualitative research (Guest, 2012). It emphasizes pinpointing, examining, and recording patterns or "themes" within data (Braun and Clarke, 2006).

Themes are patterns across data sets that are used to describe a phenomenon and are associated to a specific research question, in this case, the utilisation of BIM in FM in SA Daly (Kellehear and Gliksman, 1997).

The themes then become the categories for analysis (Fereday and Elimear, 2006). Thematic analysis is performed through the process of coding in six phases to create established, meaningful patterns (Braun and Clarke, 2006). These phases are Familiarization with data; Generating initial codes; Searching for themes among codes; reviewing themes; Defining and naming themes and conducting the analysis and producing the final report. The six phases are presented in a Table 3.2

Table 3.2: Thematic Analysis

Phase	Process	Result
Phase 1	Read and re-read data for familiarisation and initial patterns identification	Preliminary "start" codes and detailed notes.
Phase 2	Generate the initial codes by documenting where and how patterns occur.	Comprehensive codes of how data answers research question.
Phase 3	Combine codes into overarching themes that accurately depict the data. It is important in developing themes that the researcher describes exactly what the themes mean, even if the theme does not seem to "fit." The researcher should also describe what is missing from the analysis.	List of candidate themes for further analysis.
Phase 4	In this stage, the researcher looks at how the themes support the data and the overarching theoretical perspective. If the analysis seems incomplete, the researcher needs to go back and find what is missing.	Coherent recognition of how themes are patterned to tell an accurate story about the data.
Phase 5	The researcher needs to define what each theme is, which aspects of data are being captured, and what is interesting about the themes.	A comprehensive analysis of what the themes contribute to understanding the data.
Phase 6	When the researchers write the report, they must decide which themes make meaningful contributions to understanding what is going on within the data. Researchers should also conduct "member checking." This is where the researchers go back to the sample at hand to see if their description is an accurate representation.	A thick description of the results.

Source: (Braun and Clarke, 2006)

3.8.2 Identification of Themes for This research

A preliminary literature review identified that thematic areas in utilisation of BIM in FM is well documented. However, it is very important that they have not previously been applied in the context of South Africa. Consequently, without re-inventing the wheel, this part of the research focused on application of these thematic areas namely FM functions, Information Management; Challenges of Information Management and Utilisation of BIM in South Africa. See Figure 3.2.

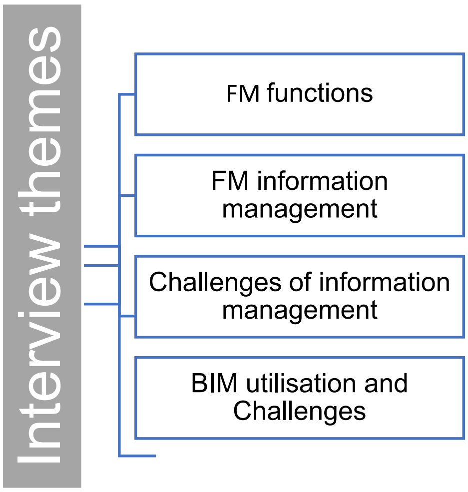

Figure 3.2 Research themes

Theme 1: Facilities Management - This thematic area seeks to characterise the FM landscape in SA in general and the functionality of the organisations in which the respondents operate. This includes but not limited to facility planning, Building Operations and Maintenance, Real estate and building construction, general office services, Outsourcing/Insourcing, Green Building and strategic planning.

Theme 2: Information management in FM - This theme aims to delineate whether the respondents are BIM ready. The latter meaning ability to receive, store and manage and share information digitally.

Thematic Area 3: Challenges of current FM information management systems - This area seeks to identify the key challenges encountered by the respondents. These would include possible difficulties with integrating information across FM systems with the ability to uptake and/or transfer the data stored in older versions of the same FM system. Apart from the latter, it should also be able to convert paper formats that are stored physically both on-site and off-site.

Thematic Area 4: BIM utilisation and Challenges - This thematic area was very key as it aimed to determine whether BIM was being utilised, if so which type and to what extent. This thematic area also identified the challenges faced by FM practitioners while using BIM for FM.

3.8.3 Quantitative data analysis

A quantitative method was adopted in the current research. Quantitative methods of data analysis can be of great value to the researcher who is attempting to draw meaningful results from a large body that includes qualitative data. The quantitative analytical approach. Statistical methods play a prominent role in most research that are dependent on quantitative data analysis. Statistical analysis also helps the researcher to identify the degree of accuracy of data and information of the study (Field, 2009; Abeyasekera, 2013). It allows reporting of summary results in numerical terms to be given with a specified degree of confidence (Treiman, 2009).

Analysis of the data was undertaken using IBM SPSS Statistical Package for the Social Sciences Version 23 IBM. The method of data analysis included Descriptive, Inferential statistic and Correlation. Table 3.3 shows previous studies and the methodology used.

Table 3.3: An analysis of previous studies using UTAUT model

Author and year	Model used	Sample size	Data collection method	Data analysis
Howard et al, 2015	UTAUT	84	Questionnaire	Structural equation modelling (SEM)
Thomas et al, 2013	UTAUT	322	Questionnaire	SEM
Attuquayefio and Addo 2014	UTAUT	345	Questionnaire	SEM
Sundaravej 2010	UTAUT	262	Questionnaire	Correlation analysis
Marchewka et al, 2007	UTAUT	132	Questionnaire	Descriptive statistic and Correlation analysis
Salim 2012	UTAUT	87	Questionnaire	Correlation analysis
Kumar 2013	UTAUT	125	Questionnaire	Correlation and Regression analysis

Based on Table 3.3, a two-step assessment approach was used. Step one: Cronbach's alpha for indicating reliability of UTAUT constructs. Cronbach's alpha is a tool used to evaluate assessments and questionnaires (Tavokol and Dennick, 2011). Cronbach's alpha ranges from 0 and 1. Step two: Correlation analysis to firstly determine the relationship between PE, EE, SI with effect to BI and secondly, the effects of FC and ATT on UB. According to Kumar (2013) correlation can be used to examine the relationship between two or more variables. Correlation coefficient range from -1 to +1 indicating whether there is a positive or negative relationship between two constructs (Pallant, 2011). A correlation of zero indicates no relationship while a correlation of 1 indicates a perfect positive correlation.

3.9 Validity and reliability

A Cronbach alpha analysis was used to validate the questionnaire. A reliability analysis is presented using factors loading and Cronbach's Alpha. According to Attuquayefio and Addo (2014), factor loading exceeding 0.5 and construct reliability exceeding 0.7 offers adequate evidence of validity and reliability. However, Cronbach's alpha less than 0.7 is acceptable, while Cronbach's alpha less than 0.5 is considered poor (George and Mallery, 2003,). In Table 3.4 all factor loadings exceed 0.5, while Cronbach's Alpha values for PE, EE, SI, FC and ATT are higher than 0.7 indicating a high level of reliability. The values of BI and UB are below 0.7 but above 0.5. The low alpha can be due to a low number of questions (Tavokol and Dennick, 2011). Based on the rule of thumb by George and Mallery (2003) the questionnaire is a reliable tool to measure these constructs.

Table 3.4: Standard item loading and Reliability

	Indicators	Factors loading	Cronbach alpha
Performance Expectancy PE	PE1	0.949	0.911
	PE2	0.943	
	PE3	0.924	
	PE4	0.605	
Effort Expectancy EE	EE1	0.921	0.882
	EE2	0.952	
	EE3	0.594	
	EE4	0.838	
Social Influence SI	SI1	0.887	0.911
	SI2	0.94	
	SI3	0.856	
	SI4	0.775	

	Indicators	Factors loading	Cronbach alpha
Facilitating Conditions FC	FC1	0.979	0.843
	FC2	0.954	
	FC3	0.884	
	FC4	0.872	
	FC5	0.721	
Attitude ATT	ATT1	0.848	0.879
	ATT2	0.853	
	ATT3	0.94	
Behavioral Intentions BI	BI1	0.954	0.680
	BI2	0.896	
	BI3	0.796	
Use Behavior UB	UB1	0.826	0.527
	UB2	0.733	

3.10 Ethical Considerations

Full ethics approval for this research was obtained from the University of Witwatersrand, school of Construction Economics and Management Research Ethics Committee on 29 August 2016, Protocol Number: CEM/16/09/FD/MSC

3.11 Summary

This chapter discussed the methodology used in this research. It included information about the research plan/strategy, population, sample size, data collection technique, questionnaire design and development, face validity of the questionnaire, pre-test the questionnaire, pilot study, final content of the questionnaire, and analytical methods of data.

4. RESULTS AND DISCUSSION

This research, aimed at determining the level of BIM utilisation and the determinants of adoption in FM is South Africa. Chapter four presents an analysis of all the data collected via interviews and an internet web questionnaire. Qualtrics survey software, SPSS 24 and Ms Excel 2010 were used to collect and analyse data. A small sample of four industry expects took part in the interviews. Furthermore, 38 out of the 94 practitioners who were invited took part and completed the online survey.

4.1. Interview Data

4.1.1 Industry Experts Interview

Four industry experts from FM organisations were identified and interviewed in Gauteng Province. Three were male and one female. The age range was between 35 and 55 years of age. In terms of education, two had only bachelor's degrees whilst the other two had masters' degrees. See Table 4.1.

Table 4.1: Position, age, gender and qualification of interviewee

Code	Position	Age	Gender	Qualification
A	FM consultant	Over 55	Male	Degree
B	FM manager	35-46	Female	Masters
C	FM director	Over 55	Male	Degree
D	FM director	35-46	Male	Masters

4.1.2 FM functions

Both respondents C and D work within organisations that focus on all areas of FM. These organisations manage many facilities over 100 facilities. Respondent B is only involved in facility planning and real estate, while Respondent A, functions in building operation and management, strategic planning, outsourcing and insourcing.

Table 4.2: FM functions which the respondents are involved

Organisational functions	Interviewee
Facilities planning	C, D
Building operations and maintenance	A, C, D
Real estate and building construction	B, C, D
General office services	C, D
Other. Specify	
1. Outsourcing and insourcing	A, C, D
2. Green building	A, C
3. Strategic planning	A, C, D

4.1.3 Information management in Facilities Management

Sections of the questions asked in relation to this theme are presented below in Table 4.3. The results indicate that the respondents are BIM ready, as all four of them receive, store and manage information digitally.

Table 4.3: Information management

Name	Receive	Store	Manage	Share
A	Digital and paper	Digital	Digital	Digital
B	Digital	Digital	Digital	Digital
C	Paper and Digital	Digital	Digital	Digital
D	Paper and Digital	Paper and Digital	Paper and Digital	Paper and Digital

4.1.4 Challenges of current Facilities Management information management systems

Respondent A expressed that they have difficulties with integrating information across FM systems. The information management systems they are currently using do not offer a single platform for integration. This means that some of the data stored in older versions cannot be transferred to a newer version of the same FM system.

Even though most information is stored digitally, there are significant amounts of information in paper format such as service records, invoices, equipment manuals etc. that are stored physically both on-site and off-site.

Both respondents’ B and C indicated that ‘on-time’ information gathering, and shortage of skilled personnel are some of the challenges they experience with the current FM systems. Furthermore, they have challenges of filling all the hard copies. They believe that receiving information in paper format, filling it manually and scanning some of it into a server is time consuming.

All the interviewees agreed that upgrading to some single platform and sourcing skilled personnel can address some of the challenges they face regarding the FM information management systems they are currently using.

4.1.5 BIM utilisation

The interviews revealed that only respondent, A had used BIM previously as an employee, but he was not using BIM currently. Respondents B, C and D have never used BIM even though they are aware of it. They all suggested that the directive to use BIM must come from the designers and contractors and that they will follow suit.
In addition, Respondent A believed that BIM will only be fully considered in FM if the government imposes certain rules, such as in the UK where a level 2 of BIM is required for public projects. Respondent C further suggested that their organisation is willing to explore BIM for FM. Furthermore, respondent C proposed a public sector driven BIM adoption for FM.

4.2. Survey data

The survey was based on the results of the interviews and literature review. The survey was made available online to the respondents and was distributed through emails and personal software links. As discussed in Chapter 3: Methodology, the questionnaire had three sections addressing different themes. 38 people took part in the survey and only 34 completed it. This meant that more people responded to the first part of the questionnaire as compared to the final sections of the questionnaire. The findings are presented below.

4.2.1. Demographics

The first section of the questionnaire was designed to gather descriptive information such as gender, age, level of education and areas of specialisation within FM refer to Table 4.4. There was a reasonable distribution of age, but the majority 71% of the respondents were males.

Table 4.4: Demographics of survey respondents

Gender	Total count	Age		Level of education
Males	27	Below 25	0	
		26 - 35	9	8 Degree, 1 MSc,
		35-46	10	2Msc, 5 Degree, 2Diploma
		46-55	5	2 Degree, 3Diploma
		Over 55	3	1 MSc, 2 Degree
Females	11	Below 25	1	1 Degree
		26-35	1	1 Degree
		35-46	6	5 other, 1 Diploma
		46-55	2	Diploma
		Over 55	1	Other

Based on Figure 4.1 only 19% of the respondents offer all the services, while 38% respondents are into building operations and management. The 9% which specified 'other' included Occupational health and safety and project management as some of the services they offer.

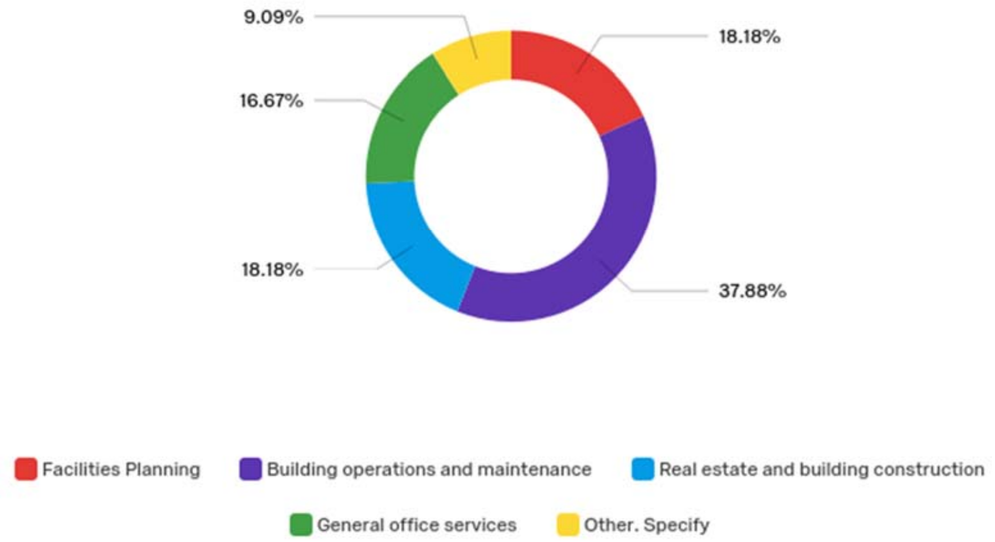

Figure 4.1: FM services

4.2.2 FM information management

For the question, "In which format do you usually require FM information?" respondents could choose any format, and the question also allowed for multiple selections. Some of the respondents chose more than one response, therefore the total number of responses were more than those of the participants. Table 4.5. Shows that 36% of FM information is received in paper formats, 44% in digital copy on CD/DVD, 17% in BIM, 22% through BIM integrated into CMMS, and 19% through other means. Those who specified other means mentioned emails with a PDF attachment.

Table 4.5: FM information formats

Information format	Percentage of responses
Physical paper copy	36.11%
Digital copy on CD/ DVD	44.44%
BIM	16.67%
BIM integrated into CMMS	22.22%
Other. Specify PDF, MS excel, Cherwell	19.44%

The respondents were asked how they store, share and manage FM information. The respondents indicated that most information is stored and managed digitally on a server via MS excel, PDF and Cherwell, however there are also significant amounts of paper involved such as service records, invoices and equipment manuals stored physically both on-site and off-site. In addition, FM information is shared via emails, SharePoint and drobox.

4.2.3 BIM utilisation

Table 4.6: Use of BIM model for Facility Management

	Answer	Percentage
1	Yes	20.%
2	No	80.%
	Total	100%

The survey sought to establish current BIM up-take in FM. Respondents were asked whether they have used BIM or are currently using BIM. A total of 20% responded yes while 80% responded no. Of the 20% who have used BIM or are currently using BIM, 50% consider themselves as intermediate users, 25% as beginners and 25% are expects. See figure 4.2 below

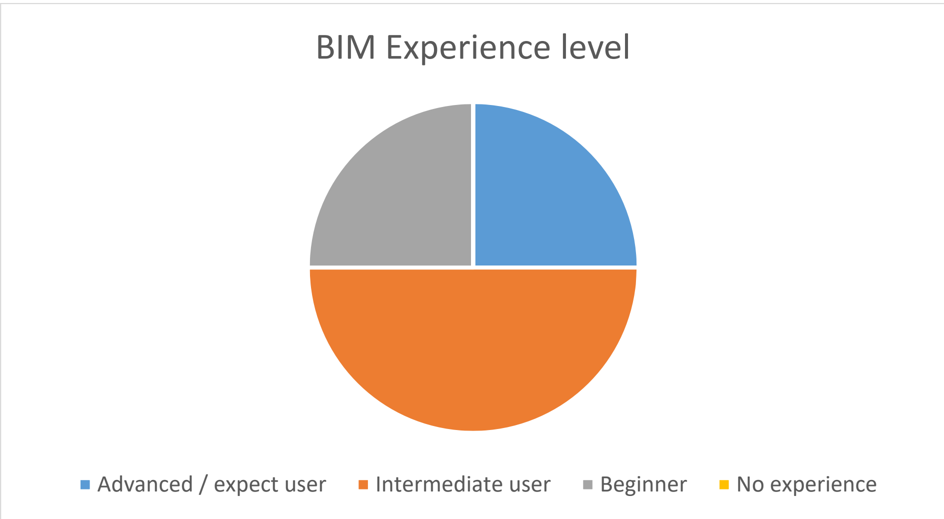

Figure 4.2: BIM experience level

Figure 4.2 illustrate that 37.5% of BIM users use BIM in facility planning and building operations and maintenance, while 25% use BIM general office services. Findings also indicate that 75% of BIM users believe the system carries part of the information they require for FM, and that manual inputs are still required.

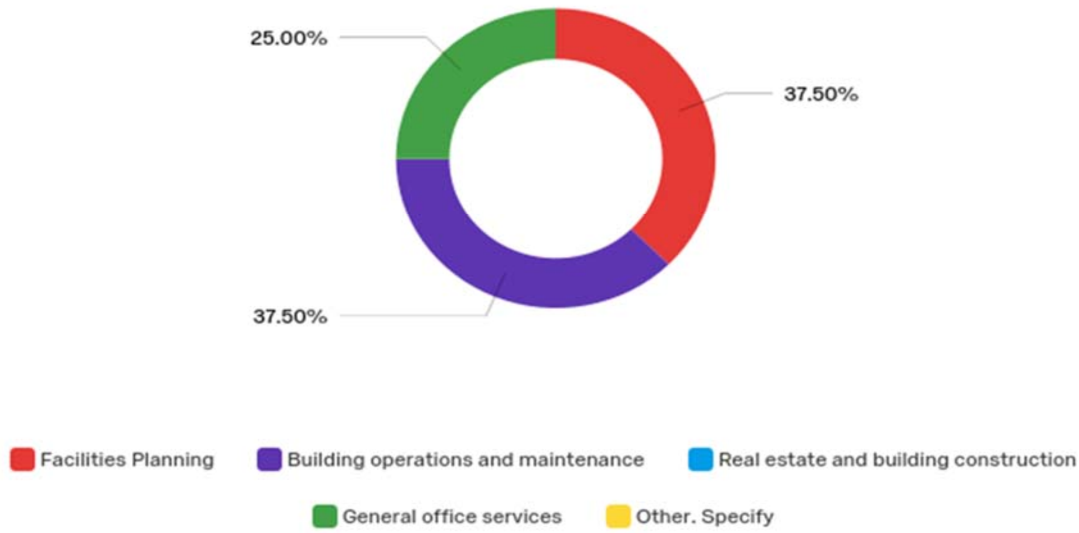

Figure 4.3: Area of FM where BIM is utilised

Table 4.7: Barriers of BIM adoption

Groups	Barriers	Percentage of respondents
Management support	Non-availably of support from top management.	7.69%
Technical issues	Non-availability of market support/trends for BIM implementation.	11.54%
	Lack of standardised process and guidelines of BIM.	12.5%
	Lack of comparative analysis between traditional project delivery methods and BIM-based project delivery methods.	0%
	Lack of comparative analysis between the existing methods and BIM technology in terms of total cost of ownership vis a vee the benefits to the organisations.	0%

Groups	Barriers	Percentage of respondents
Cost	High initial cost of software/hardware.	26.92%
	High cost of training.	26.92%
	High cost of implementation.	15.38%
Compatibility of BIM	Lack of BIM objects and standard modelling protocols.	15.38%
	Compatibility issues between software platforms.	15.38%
	Non-availability of opportunities to apply BIM.	30.77%
Organisational Culture	Weak support from organisation environment.	19.23%
	Weak culture of BIM implementation.	11.54%
	Behaviour of professionals to change from drafting to modelling.	11.54%
	Industry resistance to process change.	19.23%
	Absence of interoperable environment in the AEC industry.	4.2%
	Limited use of BIM in FM.	8.3%
Software/computer skills	Non-availability of skilled professionals	19.23%
Others	Lack of reliable information to input into BIM. Old or no Plans	7.41%

To determine the reasons for not using BIM, the main barriers preventing FM practitioners from using BIM as conceptualized from literature were presented in Table 4.7. The respondents were asked to select from the table those factors which they felt were hindering them from implementing BIM in FM. Those who specified ‘other’ included lack of sufficient reliable information to input into a BIM system, buildings are old with no plans or records available. Also, the cost of surveying, measuring, capturing and loading of BIM information is a question of cost vs benefit. The results suggest that barriers of BIM adoption relating to Cost (23%), Compatibility of BIM (21%), software/ computer skills (19%) and Organisational culture (12%) are the most cited reasons for not utilising BIM in FM, while Technical issues (6%) and Management support (8%) are the least cited.

4.3. DATA analysis using UTAUT indicators

The UTAUT model was used to explain user intention to use BIM and usage behaviour. Data collected via the UTAUT tool measured dependent, independent and mediator variables. Each variable was measured by a set of question. Each question used the 7-point Likert scale ranging from 1 to 7. The scale was as follows: 1 – Strongly agree; 2 – Agree; 3 – Somewhat agree; 4 – Neither agree nor disagree; 5 – Somewhat disagree; 6 – Disagree; 7 – Strongly disagree.

4.3.1 Descriptive statistic

Table 4.8: Descriptive statistic

Variables		Indicators	N	Mean	Std. Deviation
Performance Expectancy	PE1	I find BIM useful	36	3.61	2.06
	PE2	Working with BIM increases productivity	36	3.61	2.088
	PE3	Using BIM increases my performance	36	4.94	1.788
	PE4	BIM enables me to accomplish tasks more quickly	34	4.81	2.095
Effort Expectancy	EE1	Learning to operate BIM is easy for me	36	4.5	2.091
	EE2	My interaction with BIM is clear and understandable	36	4.47	1.859
	EE3	It is easy for me to become skilful at using BIM	36	3.64	2.031
	EE4	I find it easy to use BIM	36	2.72	1.446
Social Influence	SI1	People who influence my behaviour think I should use BIM	36	3.64	2.031
	SI2	People who are important think I should use BIM	36	3.64	2.058
	SI3	Senior management have been helpful in the use of BIM	36	4.94	1.788
	SI4	The organisation has supported the use of BIM	34	5.36	1.659
Facilitating Conditions	FC1	I have resources necessary to use BIM	36	4.44	2.157
	FC2	I have knowledge necessary to use BIM	36	4.44	1.889
	FC3	BIM is not compatible with other computer systems I use	36	4.03	1.158
	FC4	There is assistance available with BIM difficulties	36	3.78	1.245
	FC5	Using BIM fits into my work style	36	3.58	1.251
Attitude	ATT 1	Using BIM is a good idea	36	2.69	1.47
	ATT 2	I like working with BIM	36	3.39	1.293
	ATT 3	Working with BIM makes work interesting	36	3.25	1.18

Variables		Indicators	N	Mean	Std. Deviation
Behavioural Intention	BI1	I intend to use BIM whenever possible	36	2.92	1.228
	BI2	I have plans to use BIM in the near future	36	2.92	1.317
	BI3	I predict I will use BIM	35	2.67	1.454
Use Behaviour	UB1	I use BIM for different facilities management tasks	36	4.36	1.641
	UB2	I perceive using BIM as voluntary	36	3.47	1.647

Table 4.8 illustrates the descriptive statistics for the UTAUT indicators. The results from table 4.8 on PE 1-4 are between 3 and 4, the respondents are neutral in terms of their perception that BIM enables them to accomplish tasks faster and that working with BIM increases productivity. Although the respondents agree that BIM is easy to use (EE4) the descriptive analysis of EE 1-3 shows that the respondents are neutral on their interaction with BIM. The mean values of FC 1-5 are also between 3 and 4, which means that most of the respondents' answers fall within the range of somewhat agree and neither agree non-disagree. In addition, SI 1-4 is between 3 and 5, it shows that people disagree or may not be influenced by people important to them to use BIM. ATT 1-3 is between the values of 2 and 3, meaning that the most common answers were agree and somewhat agree. These results indicate that the respondents have a positive attitude towards using BIM. The results for BI 1-3 indicate that the respondents intend or have plans to use BIM. UB 1-2 values are between 3 and 4, respondents neither agree nor disagree.

4.3.2 Correlation analysis

The research adopted a UTAUT model with two dependent variables UB, a mediator BI and five independent variables SI, EE, PE, AT and FC. After descriptive statistics, correlation analysis was used to further analyse the UTAUT data. Correlation analysis was used to work out the extent and nature of relationships between the different variables as follows:

a) Relationship between attitude and use behaviour;
b) Relationship between performance expectancy and behavioural intention;
c) Relationship between effort expectancy and behavioural intention;
d) Relationship between social influences and behavioural intention and
e) Relationship between facilitating conditions and use behaviour.

The Correlation matrixes shows the P-values and correlations coefficients. The P value was set at $p \leq 0.05$. As shown in Table 4.9, the p value is significant at 0.01. A summary of correlations analysis is presented in Table 4.9.

Table 4.9: Correlation Matrixes

Correlations								
		PE	EE	SI	FC	ATT	BI	UB
PE	Pearson Correlation	1	.917**	.929**	.846**	.862**	**.763****	.494**
	Sig. 2-tailed		0.000	0.000	0.000	0.000	0.000	0.002
EE	Pearson Correlation	.917**	1	.947**	.921**	.955**	**.852****	.496**
	Sig. 2-tailed	0.000		0.000	0.000	0.000	0.000	0.002
SI	Pearson Correlation	.929**	.947**	1	.856**	.888**	**.807****	.506**
	Sig. 2-tailed	0.000	0.000		0.000	0.000	0.000	0.002
FC	Pearson Correlation	.846**	.921**	.856**	1	.946**	.932**	**.729****
	Sig. 2-tailed	0.000	0.000	0.000		0.000	0.000	0.000
ATT	Pearson Correlation	.862**	.955**	.888**	.946**	1	.876**	**.650****
	Sig. 2-tailed	0.000	0.000	0.000	0.000		0.000	0.000
BI	Pearson Correlation	.763**	.852**	.807**	.932**	.876**	1	**.721****
	Sig. 2-tailed	0.000	0.000	0.000	0.000	0.000		0.000
**. Correlation is significant at the 0.01 level 2-tailed.								

Table 4.10 shows that there is a significant correlation between PE — BI of 0.763, EE – BI of 0.852, SF-BI of 0.807, BI — UB of 0.721, FC - UB of 0.729 and ATT — UB of 0.650. Moreover, the results show that the correlation coefficient is above 0.50, showing that the relationship between all variable is a positive one.

4.4. Discussion

The data collected contains very diverse opinions and information from experienced FM practitioners. In analysing the data, the answers to all questions were linked to the objectives to form a conclusion. Four thematic areas namely FM functions, Information Management, Challenges of Information Management and Utilisation of BIM in South Africa. Figure 3.2 where identified.

According to literature, FM functions include facility planning, Real Estate, building operations and maintenance management and general premises management. Figure 4.1 illustrates that approximately 38% of FM organisation within South Africa focus on building operation and maintenance management. This is similar to Kiprotich, (2004) who suggested that the main focus of FM organisations is building operations and maintenance. FM information is better stored and received in a digital format (Teicholz, 2013) but most buildings store their documentation in paper formats (Sabol, 2008). The survey confirms that 44% of the respondents receive FM information in digital formats, while 36% receive information in paper format Table 4.5. The 44% of people receiving and storing information in digital format indicates that the FM industry is transforming. FM in South Africa is moving towards total digitalisation.

The data from questionnaires show that a small amount 20% of FM practitioner use or have used BIM for FM as shown in Table 4.6. This finding supports the statement by Becerik-Gerber et al., (2012), which refers to the fact that globally there are some organisations pushing for the use of BIM in AEC, but industry-wide adoption of BIM in FM has not been embraced. In addition, findings by Kekana et al., (2015) were that only 38% of AEC practitioners are currently using BIM in South Africa. Meaning that the use of BIM in FM in South African is lagging behind its use in AEC.

Secondly, the findings show that BIM users use BIM to store, share and manage information and that some of the information that is required is still received and stored in paper format. This finding is supported by Bjork (2010) and Becerik-Geber et al. (2012), they believe that in FM information is still received, stored and shared in paper format. This hinders the use of BIM in FM as Practitioners are of the option that it takes too much effort and time to input FM information into BIM. Thus, resulting in many FM practitioners that have not used BIM and are currently not using BIM.

Moreover, the findings indicate that the five main reasons why BIM is not used were:

1. Non-availability of opportunity to use BIM;
2. High initial cost of software and hardware;

3. High cost of training;

4. Weak support from the organisation's environment and culture in implementation of BIM; and

5. Industry resistance to process change.

High initial cost of software and hardware was also identified by Gardezi et al., (2014) as a prominent challenge. In addition, the five least barriers were:

1. Lack of comparative analysis between the existing methods and BIM technology in terms of total cost of ownership Vis a vee the benefits to the organisation;

2. Absence of interoperable environment in AEC industry;

3. Non-availability of support from top management;

4. Lack of standardised process and guidelines for the implementation of BIM in FM;

5. Absence of interoperable environment in the AEC industry.

These findings support the findings of Becerik-Gerber et al., (2012): the main barriers of BIM adoptions are not related to technology but to process and organisational culture. See Table 4.7

The survey findings confirm that 50% of BIM users are intermediate users, 25% are beginners and 25% are expects. Studies have identified the cost of training as a key determinant for the adoption of BIM. Also, interviews suggest that there is lack of skilled professionals with which to implement BIM.

It was further identified that BIM is not being used effectively due to the challenges of sufficient reliable information to input into the system. The lack of information is because many buildings are fairly old with no plans or records available. The costs of surveying, measuring, capturing and loading of BIM information is a question of the cost versus benefit argument. Practitioners are aware of BIM; however, they say there is lack of understanding regarding the benefits of BIM in FM and how BIM will support FM. This is supported by Sabol (2008), despite the benefits of BIM in FM; the industry is not motivated to adopt BIM for FM.

A total of 38% of those who use BIM say that they use it mostly for facility planning and operation and maintenance management. This finding supports Teicholz (2013), who believes that BIM for FM is mainly used in asset management and maintenance. Becerik-Gerber et al., (2012) assert that BIM can be implemented faster in locating components, facilitating real-time data, checking maintainability and automatically creating digital assets.

The literature review indicated clearly that BIM for FM can be used across all aspects of FM (Sabol, 2008; Gu and London, 2010; Lui, 2012; Motamedi, 2013; Khemlani, 2011). However, from the interviews, FM practitioners feel that BIM for FM does not have all the required information and that BIM for FM requires too much effort and time to input all the relevant information required for day-to-day FM activities.

Finally, a correlation analysis was conducted to examine the data from the UTAUT survey. The UTAUT model demonstrates that the independent variables PE, EE, SI, FC and ATT have a direct influence on UB and BI; and, further, that BI impacts on UB. The model was used to determine if PE, EE and SI can strengthen the intent to use BIM in FM. Based on the validity and reliability analysis PE, EE and SI are determinants of BI to use BIM in FM.

A p value of less than 0.05 was set to achieve significance. The data from Table 4.9 show that the p-value of PE, EE and SI to BI is 0.00, indicating that PE, EE and SI are significant to BI. The correlation Coefficient for PE, EE and SI to BI are above 0.7. According to Pallant (2011) a value between 0.5 and 1 is consider large and it indicates a high and positive correlation between the variables. Therefore, there is appositive relationship between PE, EE, SI and BI. The results further suggest that BI has a significant effect on UB. These results coincide with the finding of Venkatesh et al., (2003). Thus, it can be deduced that PE, EE and SI influence the prediction of future use of BIM in FM in South Africa.

The original model by Venkatesh et al., (2003) predicts that BI affects the actual UB of individuals; this is also the case with this research. BI has a correlation coefficient of 0.721. The results also show that ATT and FC have a significant effect on UB, with a p-value of less than 0.05. The correlation coefficient is also high Hence, ATT and FC have a positive influence on UB. These results are similar to those of Attuquayefio and Addo (2014) and Howard et al., (2015) who stated that ATT significant affect UB. In summary, these findings reveal that the five independent variables have a positive effect on BI and UB. Therefore, the findings from the UTAUT survey are in agreement with the proposed model.

5. CONCLUSION

The aim of this research was to explore the nature and occurrence in terms of the extent of BIM utilisation in FM in South Africa and the barriers of BIM adoption. It was important to note that the use of BIM during the design and construction phase has been comprehensively discussed and researched in literature. However, literature on BIM for FM is not adequately discussed. The gap in literature was identified and the research problem was presented as follows: There is limited research on the adoption of BIM in the Facilities Management sector in South Africa, leading to poor foundational knowledge, undocumented lessons, and an inaccurate picture of the current BIM adoption status of the local Facilities Management sector and the attendant challenges.

The literature review demonstrated that there are many benefits together with potential areas of BIM utilisation in FM. Even though BIM in FM has various benefits, there are several barriers that are hindering the use of BIM in FM. The most prominent Barriers were cost, and organisational culture conduct related. Furthermore, the literature review provided evidence that BIM for FM can be used in facility planning, real estate and operations and maintenance management. However, the findings illustrate that BIM users utilise BIM for facilities planning and maintenance management. The discussion, chapter 4 presented the findings in relations to literature review. Findings on FM services, BIM utilisation and the determinants of BIM adoption where highlighted.

5.1 Addressing the research objectives

The first objective was to determine the levels and extent of BIM utilisation in Facilities Management practice among FM practitioners in South Africa. As such, it is important to note that FM practitioners in South Africa are still receiving, sharing and storing FM information in paper format. Those who use BIM find that BIM for FM does not have enough information for FM. Some of the information that they require for FM must be captured manually into the system and it is costly and time consuming to capture/input all the necessary data into a BIM model.

The findings of the research further suggest that FM practitioners are not taking the initiative to use BIM and that they do not understand how BIM can improve their work. For FM practitioner to start using BIM there is need for the industry to educate the practitioners on the benefits of BIM in FM. The maturity levels model that was discussed in literature assisted in the understanding of how the AEC industry is approaching BIM. However, the maturity matrix does not contain significant information in relation to BIM in FM. Therefore, the level of BIM utilisation in FM cannot be solely based on the matrix.

The second objective was to determine the adoption of BIM relative to various aspects of Facilities Management practice. The fact that only 20% of the respondents had used or are using BIM indicates that the adoption of BIM in FM is very slow. Areas of BIM use in South Africa included facilities planning and building operation management. Those application areas included locating components, facilitating real-time data, checking maintainability and automatically creating digital assets. To fast-track the adoption of BIM, organisations can encourage FM practitioners to start using BIM in those areas as they are viewed as easy areas of BIM implementation.

The third objective was to explore the barriers for the adoption of BIM for FM practise in South Africa: The top four determinants of BIM adoption as indicated by those who had not used BIM were presented. This research proved that within these top four determinants, “Non-availability of opportunity to use BIM” was one of the top determinants. It is evident that adoption of BIM in FM is lagging behind the adoption of BIM in design and construction. To bridge this gap in literature it was important to understand the individuals’ perception on the use and the adoption of BIM for Facilities Management practise in South Africa. Drawing on the UTAUT, this research identified factors affecting the adoption of BIM. The results showed that performance expectancy, effort expectancy and social factors have strong effects on behavioural intention.

5.2. Addressing the question and problem statement

From the survey, there is a small number of people who are currently using BIM. Although the percentage is low 20% the nature of BIM utilisation in FM Practice in South Africa resemble that of developed countries.

5.3. Brief review of methodology and limitations

Two data collection methods were utilised for the research, namely: a quantitative questionnaire and qualitative interviews. The results from the data collection, as discussed in Chapter 4, highlighted the current status of BIM in FM in South Africa. Given that a large amount of FM practitioners are not utilising or have not utilised BIM, the adoption of BIM in FM in South Africa is still in its infant stages.

This research has a limitation in that a small sample size for the questionnaires and interviews was used, and the sample size may not be a true reflection of the FM industry in South Africa. A larger sample could have given a wider range of responses and a level of depth not attained within this research. This limitation, together with the fact that BIM in FM is a new concept with little information in literature, means that a well-adjusted sample may be required in the future. The delimiter (scope) was in Gauteng.

5.4. Summary of findings

Although FM practitioners are aware of BIM only a few are using BIM. The survey findings indicate that there is a low up-take of BIM in FM in South Africa. Majority of the respondents identified cost and resistance to change as some of the factors which are hindering BIM adoption in South Africa. FM practitioners have been reluctant to use BIM for FM as it requires large amount of manual data input. The results of this research suggest that the use of BIM in FM in South Africa is lagging behind the use of BIM in FM in developing countries. Respondents had similar views regarding BIM for FM having insufficient information for FM.

BIM is an innovation, therefore a conceptual framework for technology acceptance was used to create a holistic understanding of how individuals adopt technology Through the UTAUT instrument, this research demonstrated that a strong relationship between Performance Expectancy and Behavioural Intention suggests that practitioners regard BIM as a tool which can be used to increase productivity, increase work performance and enable individuals to complete tasks faster. This perception can be seen as an encouraging factor towards the implementation of BIM in FM in South Africa.

Secondly, the *p*-value of Social Influence towards Behavioural Intention was significant, meaning that the adoption of BIM in FM can be influenced by organisations and senior management, if senior management supports the use of BIM in FM, the use of BIM will gain momentum and bridge the gap between the use of BIM in design and construction.

Thirdly, Attitude was not part of the original UTAUT model but Howard et al., (2015) included it. Thus, this research also included attitude as a variable. The results confirm that Attitude has a large effect on Use Behaviour. Similarly, the feeling towards working with BIM was more important than the idea that using BIM is good in determining intent to adopt BIM.

In conclusion, it might be more realistic to also recognise that most companies manage old buildings, and that most of the old buildings do not have digital data. These results in FM practitioners using the traditional methods to receive, store, manage and share FM information. Some of the FM systems used currently may not be compatible with BIM and may therefore hinder interoperability with BIM tools. Therefore, the adoption of BIM in FM in South Africa may take longer than expected.

5.5. Implications of findings

- BIM in developing countries is gaining momentum, however in South Africa it is lagging behind. If the up-take of BIM in South Africa does not pick up, FM companies in South Africa will continue to be marginalised;
- Lack of skilled FM professionals who can use BIM and lack of sufficient FM information within BIM is contributing to the slow up-take of BIM in South Africa; and

- Continuous use of traditional methods is limiting BIM exposure and inhibits collaboration amongst AEC practitioners. Industry experts should develop strategies to encourage and reduce the amount of information received in paper format

5.6. Recommendations based on finding implications

- BIM for FM can be adapted for multiple uses. A case study on the implementation of BIM in the context of South Africa should be developed to illustrate the benefits of BIM in FM. The results can be communicated to various stakeholders within FM;
- Once a study has been completed the government and clients must impose the use of BIM for all their projects. This will speed up BIM adoptions in South Africa;
- The appropriate resources must be made available to ensure planning success. It is important to encourage open communication channels between design, construction and FM industries on the use of BIM. Open communication will encourage collaboration and the use of BIM to its full benefits;
- Identify the following application areas – locating components, facilitating real-time data, checking maintainability and automatically creating digital assets, as easy areas of BIM adoption.
- Reduce the cost of training and software so that FM practitioners can afford BIM for FM; and
- Introduce BIM training at university level to reduce the cost of training that must be carried by the client and increase the number of skilled professional.

5.7. Suggested area of future studies

- A study to identify BIM specific tools that can be used in FM in South Africa;
- Develop BIM maturity level specific to BIM for FM; the current BIM level focus on Architecture and not on FM. Developing BIM maturity level will enable the government or the client to specify the level of BIM required to manage their Facilities

- A case study illustrating the benefit of BIM in FM in South Africa; if the benefits of BIM in FM in SA are documented and presented to the relevant stakeholder, industry interest will increase; and
- Explore the benefits of introducing BIM as a subject in Universities. One of the determinants of BIM adoption was cost of training. A study exploring the benefit of BIM training as a subject in University will highlight some of the benefits.

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7. APPENDIX A: QUESTIONNAIRE

Q1 Gender

❍ Male 1

❍ Female 2

Q2 Age

❍ Below 25 1

❍ 26-35 2

❍ 36-45 3

❍ 46-55 4

❍ Over 55 5

Q3 Highest Education Qualification

❍ Diploma 1

❍ Degree 2

❍ Masters 3

❍ Ph.D. 4

❍ Other 5

Q4 In which area of Facilities Management is your organisation specialised?

❑ Facilities Planning 1

❑ Building operations and maintenance 2

❑ Real estate and building construction 3

❑ General office services 4

❑ Other. Specify 5 ____________________

Q5 In what format do you usually require Facility Management information?

- ❑ Physical paper copy 1
- ❑ Digital copy on CD/ DVD 2
- ❑ BIM Building information modelling 3
- ❑ BIM integrated into CMMS 4
- ❑ Other. Specify 5 ____________________

Q6 How do you store, share and manage Facility Management information and documentation?

Q7 Have you used a BIM model for ?

- ❍ Yes 1
- ❍ No 2

Q8 Do you currently use a BIM model for Facility Management?

- ❍ Yes 1
- ❍ No 2

Display This Question:

If Have you used a BIM model for Facility Management? No Is Selected

Or Do you currently use a BIM model for Facility Management? No Is Selected

Q9 Please use the table below to tick the reasons for not using BIM.

- ❑ High initial cost of software and hardware 1
- ❑ High cost of training 2
- ❑ High cost of implementing the process and technology. 3
- ❑ Behaviour of professionals to change from drafting to modelling i.e. change from current practices 4
- ❑ Weak support from Organisation environment and culture in implementation of BIM. 5
- ❑ Non-availability of support from top management in organisations for implementation of BIM 7
- ❑ Non-availability of skilled professionals 8

- ❑ Lack of BIM object libraries and standard modelling protocols 9
- ❑ Industry resistances to process change 10
- ❑ Lack of standardized process and guidelines for implementation of BIM in facilities management. 11
- ❑ Compatibility issue between software platforms 12
- ❑ Absence of interoperable environment in the construction industry 13
- ❑ Limited use of BIM in facilities management 14
- ❑ Non-availability of market support/trends for BIM implementation 15
- ❑ Lack of comparative analysis between traditional project delivery methods and BIM based project delivery methods 16
- ❑ Lack of comparative analysis between the existing methods and BIM technology in terms of total cost of ownership visa vee the benefits to the organisations 17
- ❑ Non-availability of opportunities to apply the technology 18
- ❑ Other. Please specify 19 ____________________

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q10 How would you define your personal BIM experience level?

- ❍ Advanced / expect user 1
- ❍ Intermediate user 2
- ❍ Beginner 3
- ❍ No experience 4

Display This Question:

If Do you currently use a BIM model for Facility Management? Yes Is Selected

Or Have you used a BIM model for Facility Management? Yes Is Selected

Q11 In which areas of Facility Management do you use a BIM model?

- ❑ Facilities Planning 1
- ❑ Building operations and maintenance 2
- ❑ Real estate and building construction 3
- ❑ General office services 4
- ❑ Other. Specify 5 ____________________

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q12 How do you use BIM?

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q13 In your experience, have manufactures and suppliers provided adequate information regarding the BIM in Facility Management?

- ❍ Adequate information 1
- ❍ Some information 2
- ❍ No information 3
- ❍ Other. Specify 4 ____________________

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q14 Does the BIM Model have enough information for Facility Management?

- ❍ It carries enough information 1
- ❍ It carries part of the information, manual inputs are required 2
- ❍ Other. Please specify 3 ____________________

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q15 What are some challenges being experienced with BIM model?

Display This Question:

If What are some challenges being experienced with BIM model? Text Response Is Not Empty

Q16 For the challenges noted state how they are been addressed

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q19 I find BIM useful

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q20 Working with BIM increases productivity

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q21 Using BIM increases my performance

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q22 BIM enables me to accomplish tasks more quickly

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6

- Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q23 Learning to operate BIM is easy for me

- Strongly agree 1
- Agree 2
- Somewhat agree 3
- Neither agree nor disagree 4
- Somewhat disagree 5
- Disagree 6
- Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q24 My interaction with BIM is clear and understandable

- Strongly agree 1
- Agree 2
- Somewhat agree 3
- Neither agree nor disagree 4
- Somewhat disagree 5
- Disagree 6
- Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q25 It is easy for me to become skilful at using BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Display This Question:

If Have you used a BIM model for Facility Management? Yes Is Selected

Or Do you currently use a BIM model for Facility Management? Yes Is Selected

Q26 I find it easy to use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q27 People who influence my behaviour think I should use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q28 People who are important think I should use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q29 Senior management have been helpful in the use of BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q30 The organisation has supported the use of BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q31 I have resources necessary to use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q32 I have knowledge necessary to use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q33 BIM is not compatible with other computer systems I use

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q34 There is assistance available with BIM difficulties

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q35 Using BIM fits into my work style

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q36 Using BIM is a good idea

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q37 I like working with BIM

- ❍ Like a great deal 1
- ❍ Like a moderate amount 2
- ❍ Like a little 3
- ❍ Neither like nor dislike 4
- ❍ Dislike a little 5
- ❍ Dislike a moderate amount 6
- ❍ Dislike a great deal 7

Q38 Working with BIM makes work interesting

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q39 I intend to use BIM whenever possible

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q40 I have plans to use BIM in the near future

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q41 I predict I will use BIM

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q42 I use BIM for different facilities management tasks

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

Q43 I perceive using BIM as voluntary

- ❍ Strongly agree 1
- ❍ Agree 2
- ❍ Somewhat agree 3
- ❍ Neither agree nor disagree 4
- ❍ Somewhat disagree 5
- ❍ Disagree 6
- ❍ Strongly disagree 7

8. APPENDIX B: INTERVIEW SCHEDULE

Interview schedule

Gender	Male	
	Female	
Age	Below 25	
	26-35	
	35-46	
	46-55	
	0ver 55	
Highest Education Qualification	Diploma	
	Degree	
	Masters	
	Ph.D.	
	Other	
In which area of Facilities Management is your organisation specialised?	Facilities Planning	
	Building operations and maintenance	
	Real estate and building construction	
	General office services	
	Other. Specify	
In what format do you usually require Facility Management information?	Physical paper copy	
	Digital copy on CD/ DVD	
	BIM	
	BIM integrated into CMMS	
	Other. Specify	

1. How many facilities do you manage?
2. How do you store facility management information and documentation?

4.2 How do you share facility management information and documentation?

4.3 How do you manage facility management information and documentation?

3. What challenges are experienced in storing, sharing and managing information in the course of managing those facilities?
4. Which challenges are specific to the ICT tools you use?
5. How have you addressed such challenges?
6. Have you used BIM for facility management?
7. Are you currently using BIM for facility management?
8. What BIM tools do you use for facility management?
9. Do you have plans to use BIM in the near future?

9. APPENDIX C: LETTER OF CONSENT

Letter to Respondent

Masters research consent form

Study Title: Utilisation of Building Information Modelling in Facilities Management: A South African Study

Dear Respondent

My name is Faith Dowelani. I am currently studying towards a Masters in Property Development and Management at the University of Wits, School of Construction Economics and Management. I am conducting research on the utilisation of BIM in Facilities Management. The aim of the research is to explore the extent of BIM utilisation in Facilities Management and the challenges thereof.

If you are a practitioner in Facilities Management, could you please take the time to partake in the study by completing the survey that has been designed. Your participation in this study is very important; however, your participation is voluntary. The study will be extremely helpful to understand the level of BIM utilisation, challenges and possible areas of adoption in Facilities Management in South Africa.

This is an anonymous study survey; therefore, your personal details are not required. It should not take you more than 20 minutes to complete it. There are no risks associated with this survey. If you would like to receive feedback on the study, please email me.

Kind regards

Faith Dowelani

Email: 0310654y@students.wits.a.za or fdowelani@gmail.com

CONSENT

I hereby agree to participate in research on: Utilisation of Building Information Modeling in Facilities Management: A South African Study. I understand that I am participating freely and without being forced in any way to do so. I also understand that I can stop participating at any point should I not want to continue, and that this decision will not in any way affect me negatively. I understand that this is a research project whose purpose is not necessarily to benefit me personally in the immediate or short term. I understand that my participation will remain confidential.

…………………………..

Signature of participant Date:…………………..

10. APPENDIX D: ETHICAL CLEARANCE CERTIFICATE

School of Construction Economics & Management

University of the Witwatersrand, Johannesburg -PO Box 20, Wits 2050, South Africa • Tel: +27 (0)11 717 7652/77669 · Fax: +27 (0)11 717 9729 Email:CEM@wits.ac.za

SCHOOL OF CONSTRUCTION ECONOMICS AND MANAGEMENT RESEARCH ETHICS COMMITTEE

CLEARANCE CERTIFICATE	**PROTOCOL NUMBER** CEM/16/09/FD/MSC
PROJECT TITLE	Utilization of Building Information Modelling in Facilities Management: A South African Study
INVESTIGATOR	**Faith Dowelani (0310654y)**
SCHOOL/DEPARTMENT	**SCHOOL OF CONSTRUCTION ECONOMICS AND MANAGEMENT**
DATE CONSIDERED	21/8/2016
DECISION OF THE COMMITTEE	Approved conditionally with respect to the declaration and forwarded minor corrections
EXPIRY DATE	28th August 2017
DATE 29 August 2016	**CHAIRPERSON** ______________________ Dr. Kola Ijasan

cc: Supervisor : Dr O. Ozumba

DECLARATION OF INVESTIGATOR (S)

To be completed in duplicate and **ONE COPY** returned to the Secretary Mrs. M. Sithole at the CEM reception desk.

I fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to completion of a yearly progress report.**

Faith ______________________
Signature

Date 07 / 09 / 2016