



University of Wales Trinity Saint David

Measuring Asset Criticality: A Study into the use of risk
assessment tools within the Facilities Management
industry to inform Maintenance Strategies.

MSc Property & Facilities Management

Student: Paul Greatbanks

Date: 4th May 2020

Student No: P152359

Supervisor: Trevor J Francis MSc. MRICS, MCIQB. MCABE. P.G. Diploma

Architectural Conservation

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Abbreviations

FM (Facilities Management/ Facilities Manager) - a profession that encompasses multiple disciplines to ensure functionality, comfort, safety and efficiency of the built environment by integrating people, place, process and technology.

CAFM – Computer Aided Facilities Management.

M&E – Mechanical and Electrical.

CBRE (Coldwell Banker Richard Ellis) – An American commercial real estate and investment firm.

IWFM (Institute of Workplace and Facilities Management) – Professional association for the Facilities Management sector.

RICS (Royal Institution of Chartered Surveyors) - Professional body promoting and enforcing the highest international standards in the valuation, management and development of land, real estate, construction and infrastructure.

CRE – Corporate Real Estate.

TPM (Total Productive Maintenance) – Maintenance Strategy

RCM (Reliability Centered Maintenance) – Maintenance Strategy

IFMA (International Facility Management Association) - Professional membership association for facility management professionals.

BIFM (British Institute of Facilities Management) – Now known as IWFM

IT – Information Technology.

IoT (Internet of Things) - A system of interrelated computing devices, mechanical and digital machines provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction.

CIBSE (Chartered Institution of Building Services Engineers) - An International professional engineering association that represents building services engineers.

ISO (International Organisation for Standardisation) - Promotes worldwide proprietary, industrial, and commercial standards.

HSE (Health and Safety Executive) - A UK government agency responsible for the encouragement, regulation and enforcement of workplace health, safety and welfare, and for research into occupational risks in Great Britain.

ROI – Return on Investment

SFG20 – The standard maintenance specification for building engineering services.

BS EN (British Standard European Norm) – The British adoption of a European standard.

IPWEA (Institute of Public Works Engineering Australasia) - The peak association for the professionals who deliver public works and engineering services to communities in Australia and New Zealand.

Assets – Also known as Fixed Assets, Building Elements and Plant and equipment - is a term used in accounting for assets and property that cannot easily be converted into cash

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Abstract

Strategic management and delivery of corporate real estate facilities can not only provide significant cost savings, but if managed in the correct manner, can have a significant impact that supports corporate branding, improved worker productivity and happiness and importantly, have an estate that is flexible and can adapt to future business decisions.

This study gathered research from the FM industry to test the use of risk assessment models, to assess property assets within an operational real estate portfolio for criticality in the event of failure. The study provided an untested prototype assessment based on the findings of the literature review and primary research.

A number of objectives were set to meet the aim which included evaluating the standard of data being produced by CAFM systems and the use of this data to influence maintenance strategies explore the use of risk assessment models by FM's to evaluate assets for their criticality and whether the results of these assessments influenced maintenance delivery. A study objective aimed to produce a set of risk criteria for assets to be measured against which was imbedded into a prototype assessment to allow it to be tested and developed in future research.

The research focused upon examining gaps that exists between data interpretation and the common use of strategic maintenance practices within an operational estate. The active use of risk assessment modelling to evaluate asset criticality was explored as a solution to filling the gap.

This aim was met by an extensive relevant literature study, fused by practical research undertaken by collecting data via an online survey of participants who have Facilities Management experience within an operational environment.

Key findings: A lack of accuracy in the process of collecting asset data and the inputting of this data into the CAFM system exists and critical assets are rarely being identified and evaluated for their impact if failure should occur.

A criteria of measurement was established, ranking 9 criteria for their importance. Participants indicated that in order to perform an assessment of critical assets a significant level of technical competence would be required.

The main conclusions drawn from this research were that CAFM systems were not being fully utilised to manage property portfolios due to inconsistencies in the collection and input process of asset data. The study found CAFM data continued to follow the trend of previous research where asset data from the CAFM system was not being used by FM's to make strategic decisions. Evaluation of assets for criticality is not being actively practiced across the industry leaving organisations open to high levels of risk if critical assets were to fail. The study established a criteria to measure assets for their criticality. Measuring this criteria through the use of the prototype assessment provided clarity and filled the gap that exists in data interpretation, providing a strategic pathway for strategic maintenance practices to be developed for assets that differ in criticality rating.

1.0 Introduction

1.1 Background

A key driver within the FM industry is the ability to make key decisions quickly, based on accurate data. CBRE (2017) predicts that by 2025, data analytics will be crucial for addressing subjects such as energy savings, reduction of total life cycle cost, business efficiency and sustainability.

Hodge, Poglitsch and Ankerstjerne (2014) recognised that in order to achieve strategic real estate goals, enhanced quality and accuracy of data is key. Although the technology tools exist to allow this to be achieved and there is no shortage of data, harnessing it to address strategic challenges was still a major task.

There are increasing demands on FM service providers and internal FM departments to add value to property portfolios through agile maintenance strategies, as well as complying with internal and external regulation. A shift towards predictive maintenance strategies driven by data, are part of the key trends identified for the FM industry in the near future. A recent publication by a recognised and widely respected industry publication supports this and has identified the top trends for 2020 in FM being: Buildings must become revenue generators, preventive maintenance becomes obsolete as predictive maintenance drives operations and Data analytics is a required FM skill set. (IWFM, 2020)

1.2 Research focus

Top trends for 2020 in a FM article, published by Facilitate magazine makes clear that there is a desire within the FM industry to focus on maintenance strategies and using data to drive these strategies forward in the near future. Supporting these trends, research from Streather (2016) argues that the introduction of systems connected to the Internet of Things (IoT) is key to providing data that is able to assist with more effective asset management, generating operational efficiencies from better building usage and compliance adherence and fully auditable evidence-based data sets to name a few.

Although the trends support the generation of data to tackle strategic challenges RICS (2018) identified that Facilities Managers find it challenging to collect the right level of data, interpret it effectively and communicate its implications to the business. Examining the use of CAFM systems in their current form, Araszkiewicz's (2017) discovered that although Computer Aided Facilities Management are proven in practice to be useful, there remains a lack of interoperability, which largely limits their functionality. Within the summary of the paper Araszkiewicz (2017) concludes that the challenges associated with the development of systems within FM are; interoperability and enhancement of data integration; augmented knowledge management and enriched training and competence development for facility managers, supporting the RICS (2018) research.

This research paper will focus on bridging the gap of data interpretation between CAFM systems and the desire to implement more strategic maintenance strategies. It will do this by examining the use of risk assessment tools to assess asset criticality in the FM industry and whether their use would determine the maintenance strategy to be implemented. Risk assessments are widely utilised within the context of health and safety to evaluate risk and introduce control measures and where necessary to mitigate risks. The research will examine if a similar model can be utilised by the FM

industry to identify critical assets, rate them on their risk to the business and provide clear guidance on the strategic pathway to an effective maintenance strategy.

1.3 Research Aim and Objectives

The aim of this study is to gather research from the FM industry to test the use of risk assessment tools that assess property assets within an operational real estate portfolio for their criticality in the event of failure.

The study provides an untested prototype assessment based on the findings of the literature review and primary research in the study.

Objectives that allow the overarching aim of this research paper to be achieved is as follows:

1. An assessment of whether data collected, inputted and produced by CAFM systems is used to influence maintenance practices currently.
2. Assess if FM's are actively evaluating assets for their criticality and whether the results are influencing maintenance delivery
3. Establish a criteria for the FM industry, in order of importance, to measure an assets criticality against.
4. To evaluate if the level of technical competence of an FM will be a factor in their ability to carry out an assessment of the assets.

To achieve this the study will review past journals, articles, blogs and literature produced by leading figures and organisations within the FM industry, to form a literature review of the subject. Primary research will be conducted via an online survey targeting participants that are working within a FM operational environment. This will be conducted by contacting participants via the online social media network, LinkedIn.

2.0 Literature Review

2.1 Maintenance Strategies

Strategic design, delivery and management of corporate facilities can not only provide significant cost savings, but if undertaken properly, can provide significant flexibility for future business decisions, endorse and support corporate branding, and improve worker productivity and happiness. In short, the value that real estate and the workplace lend the business is dramatically increasing and as such, the contribution that corporate real estate (CRE) must make to the business is changing. (Cushman and Wakefield, 2012)

The view of Velmurugan and Dhingra (2015) is that maintenance management dealt with the short-term issues such as resources, cost, and manpower. In recent past, maintenance management has changed its concerns towards the consideration of long-term goals of being competitive, sustainable and strategic. For these reason maintenance management needs to be viewed in a strategic perspective.

There is scope for improving the formulation of maintenance strategies, selection of maintenance strategy of specific equipment, or process, and effective implementation of the maintenance strategies selected. These activities are required to be clearly integrated and monitored. Yet there is a lack of interest among maintenance practitioners for a structured maintenance strategy formulation and implementation. Reasons for this:

- i. Maintenance approaches, methods and concepts are resource demanding, so that less suitable for the maintenance function in the industry; and
- ii. Organisations are reluctant to experiment with the new maintenance methods developed such as total productive maintenance (TPM), reliability centered maintenance (RCM). (Velmurugan, R.S., Dhingra, T. 2015)

A key area for adding value to an estate is the Building Maintenance strategy adopted across the portfolio. Horner, El-Haram and Munns (2017) believes that a new approach needs to be taken when delivering maintenance to an estate, this being to carry out as little maintenance as possible as infrequently as possible while at the same time preserving the availability of the services facilities, the building elements and the whole building. In other words, maintenance should be carried out only when necessary to ensure the continued, safe and profitable use of the building at acceptable levels of satisfaction or when there is the possibility of extending the useful life of the elements of the building.

The journal set out 3 distinctive maintenance strategies being; Corrective, Preventative and Condition based, although condition based can be viewed as a form of preventative maintenance. Similarly, other literature has described these maintenance strategies as Reactive, Preventative and Predictive but essentially these strategies are the same.

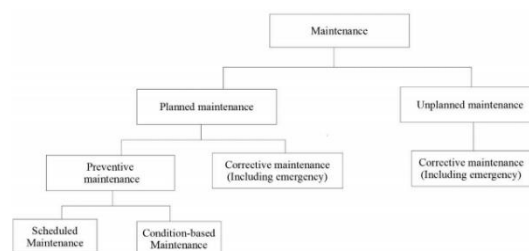


Figure 1: Maintenance Hierarchy (Source: Horner, El-Haram, Munns. 2017)

2.1.1 Reactive Maintenance Strategy

Rani *Et al* (2014) state corrective or reactive maintenance is the simplest maintenance strategy. It involves just the repair or replacement of an element that has failed in its function. Reactive maintenance tasks often take place in response to a breakdown or user request. Corrective maintenance is the strategy most used by maintenance managers to perform daily maintenance tasks, although this approach can be extremely expensive because the failure of an item can cause a large amount of consequential damage to other elements in the building, and failure of an item can occur at a time that is inconvenient to both the user and the maintaining authority.

Research by Lateef (2010) produced similarities. The study explains that Corrective maintenance is initiated after the asset has failed and is intended to restore the asset to its original condition. What this means is that an asset is maintained up on receiving a complaint about decay, deterioration or defects or any of their combinations, or it was discovered by those concerned with the asset that the asset has failed. Lateef's (2010) opinion of this method is in most cases it is very expensive, and usually leaves the users dissatisfied. It often leads to a maintenance backlog, as available resources are often inadequate to address the maintenance needs. Another major shortcoming of this approach stated by Lateef (2010), is that it disrupts and disturbs the activities that are carried out in and around the building.

An article written in MRO Magazine (2018) sets out the negative impacts a reactive maintenance strategy may pose to a business if implemented. These impacts are:

- It is hard to create an accurate budget for reactive maintenance;
- Relying on reactive maintenance often results in unplanned downtime which can jeopardise business as usual activities;
- Poor time management. The building/ organisation can lose time unnecessarily when a critical asset breaks down because it was not placed on a servicing schedule. The time spent trying to diagnose and fix the problem could be better used on other tasks;
- Labour and spare parts may not be available causing more delays, downtime and losses;
- Poses a safety risk when maintenance personnel are under pressure to fix the problem as fast as possible; and
- Continuous reactive maintenance will keep teams distracted and disorganised which can lead to a build-up of unfinished work.

The article also makes comment as to why a reactive maintenance strategy might be a favourable approach to many organisations. These are;

- Reactive maintenance requires no initial cost and less planning when compared to preventive maintenance. You simply let the asset run until it breaks down
- Requires less standby manpower. There is no need for frequent inspections and staff to carry out these inspections. You could even choose to completely outsource reactive maintenance and thereby not need to include that skill set on your payroll
- It can prove more cost effective for equipment that is not critical for overall service delivery and has minimal impact on operations.

Hupje (2018) summarises the reactive approach by explaining that a reactive strategy restores the function of an asset after it has been allowed to fail. It is based on the assumption that the failure of the asset is acceptable i.e. no significant impact on safety, environment and business as usual activities, and preventing failure is either not economical or not possible.

A reactive strategy is used most effectively where the consequence of failure is limited and would not necessitate the need for an urgent repair. When opting for a reactive maintenance strategy it is essential to ensure that the failure modes under consideration do not have the potential to be emergency maintenance.

2.1.2 Preventive Maintenance Strategies

Preventive maintenance is described by Bader (2018) as a detailed program that keeps equipment operating efficiently, extends the lifetime of physical assets, enhances the safety of your employees keeps the facility comfortable, attractive and energy efficient and helps avoid large and costly repairs down the road.

Preventive maintenance was introduced to overcome the disadvantages of corrective maintenance, by reducing the probability of occurrence of failure and avoiding sudden failure. This strategy is referred to as time-based maintenance, planned maintenance or cyclic maintenance. Preventive maintenance tasks are performed in accordance with a predetermined plan at regular, fixed intervals, which may be based on operating time. (Horner, El-Haram, and Munns. 1997)

Key advantages of preventative maintenance over reactive maintenance, described by Raymond and Joan (1991) are:

1. Maintenance can be planned and performed when it is convenient to the building's user;
2. Maintenance costs can be reduced by avoiding the cost of consequential damage;
3. Downtime, the time that an element of the building or the whole building is out of service, can be minimised so the habitability of the building can be increased; and
4. The health and safety of the user can be improved.

Mays (2015) states that a focus on preventive maintenance can benefit organisations in several ways. Firstly, a preventive approach can significantly reduce the costs associated with maintenance, where a reactive approach to maintenance can cost as much as five times more than the same activity done with a planned approach in mind. Secondly, preventive maintenance allows the organisation completing the maintenance tasks to focus on high level priorities therefore elevating planning from a tactical approach to a strategic which can help extend the life of essential assets.

Further justification for the use of a preventive maintenance strategy by Au-Yong, Ali, and Ahmad (2014) is that system failure causes negative impacts to the organisations users and customers. These negative impacts could be on the aspects of output, safety, environmental integrity, system quality, customer satisfaction, and additional repair cost incurred. Thus, implementation of preventive maintenance is necessary to replace the need of corrective maintenance. Consequently, unnecessary costs such as emergency repair costs after a failure occurs can be reduced or avoided as well as minimising capital investment required on maintenance.

Au-Yong (2013) claims the disadvantages with using preventive approach is maintenance activities performed at fixed time intervals is meant to reduce the probability of failures and breakdowns, scheduled maintenance is deemed not cost effective, whereby the replacement of components is often performed regardless of the condition therefore creating additional labour and material costs. Horner, El-Haram and Munns (1997) supports this. These researchers identified that planned maintenance is performed irrespective of the condition of the building elements. The consequence was a large number of unnecessary tasks was carried out on elements that could have remained in a safe and acceptable operating condition for a much longer time.

2.1.3 Predictive Maintenance Strategy

Hemmerdinger (2014) captured the advantages and disadvantages of a predictive maintenance strategy in a paper written for Schneider Electric. The paper explains that like preventive maintenance, predictive maintenance is based on the belief that a proactive approach is better than a reactive one. However, instead of making repairs based on a predetermined calendar schedule, the predictive approach makes repairs based on the actual condition of the equipment. For example, a predictive maintenance program, key operating parameters of equipment are checked regularly by staff or monitored automatically by sensors. The readings are analysed and used to evaluate the condition of the equipment and predict the future performance or likelihood of failure. The key to predictive maintenance is that equipment and system condition determines what maintenance is performed, rather than a set planned schedule. This means that repairs are performed at the ideal time, resources are not wasted on unnecessary work and equipment is maintained at a higher level of performance.

Figures used in Hemmerdinger (2014) paper, which were taken from the Operations & Maintenance Best Practices: A Guide to Achieving Operational Efficiency, written by the US Department of Energy, details the savings that can be achieved by adopting this approach:

- 10 X return on investment;
- 25–35% deduction in maintenance costs;
- 70–75% fewer breakdowns;
- 35–45% reduction in downtime; and
- 20–25% increase in production

Deloitte's (2017) position paper about predictive maintenance reveals similar information. The paper highlights that this strategy maximises runtime of assets where maintenance can be conducted just before an asset breaks down. They reviewed research that showed that unplanned downtime costs an estimated \$50 billion each year to industrial manufacturers. Deloitte (2017) also commented that preventive maintenance practices can also be used to ease logistical challenges by maintaining machines at convenient times – for example outside of production hours or while the needed personnel is close by. It can also assist purchase departments by predicting which spare parts will be needed at which point in time.

Analyses conducted by Deloitte (2017) concluded that material cost savings amount to 5 to 10% on average, equipment uptime increases by 10 to 20%, overall maintenance costs are reduced by 5 to 10% and maintenance planning time is reduced by 20 to 50%. The profit of predictive maintenance increases with the underlying maintenance costs. The higher the expenses caused by failure the bigger the benefits. Deloitte (2017) state that the benefits of predictive maintenance are dependent on the industry or even the specific processes that it is applied to.

As with any strategy there are the challenges to overcome in order to deliver it. Data, is the biggest challenge when trying to deliver a preventive maintenance strategy. Deloitte (2017) claim that data is the fuel of any predictive maintenance engine. The quality and quantity of the data is the limiting factor for analysing root causes and predicting failures well ahead of time. Major challenges inherent to any predictive maintenance programme is increasing data quality. The more information that is available on events to be predicted the better predictions become. One could distinguish between required data – without which predictive maintenance cannot be applied – and additional data, which improves the quality of predictions. Crabb (2019) also raises the lack of data as a significant challenge for the implementation of preventive maintenance strategies. The research supported the findings of Hemmerdinger (2014) and states that preventive maintenance is based on making

maintenance decisions when an asset exhibits the signs of an impending issue or subtleties that may allude to a future malfunction. As a result, maintenance is not scheduled until a problem is found, contributing to reactive maintenance.

Predictive maintenance is an investment, which reveals implicitly the second key challenge: Establishing the needed processes initially creates costs. Businesses need to add sensors to their machines and set up a wide array of IT infrastructure, processes and trained personnel. Data from various sources must be integrated and transformed so it can be made available on a suitable platform. Dashboards, email or SMS warning systems must be put in place to coordinate the necessary maintenance efforts. 'Process experts' and 'data scientists' knowledge is needed to build and maintain a functioning predictive model. Also, personnel need to be trained to handle the information inflow and interpret alerts correctly.

2.2 Factors that affect selection of maintenance strategy

2.2.1 Skills and competence

Research issued jointly by RICS (Royal Institute of Chartered Surveyors) and IFMA (International Facility Management Association) in 2017 identified a shortage of skills in Facilities Management as one of most significant challenges facing the industry. The research identified that more RICS' Facility Management professional members are over 70 than under 30, and less than 15% of them are under 40 years of age. IFMA evaluation of its members produced similar results. It discovered the average IFMA member is 50.9 years old based on a 30% sample of its 24,000 plus members. (IFMA, RICS, 2017.) Although this research demonstrates that the people practicing in the industry are increasingly getting older, there is a level of professional experience required in order to gain RICS status, even for people entering at associate level. This indicates a lack of desire to obtain membership status within the FM industry, although it could also demonstrate that professional individuals within Facilities Management are not being skilled to the level where they are able to provide evidence that meets the requirement for membership status to be achieved.



Figure 2: What are the biggest skills shortages in your business? (Source: BIFM, 2018)

Results of a survey completed by BIFM in 2018 affirm that there is a skills shortage opening within the Facilities Management sector. An online survey was completed by 297 people where 42% of the respondents were in senior management positions and 13% were Managing Directors or CEO's. Figure 2 shows the response with regards to the skills shortage within the industry where just under half of the respondents (47%) cite 'skilled trades' such as electrical and mechanical engineers as the biggest skills shortage. The next largest skills shortage is Professionals/Managers with 31%. (BIFM, 2018) Although participants of this survey were in senior positions within their organisations, 297 responses is a small percentage of people working within the industry and is not enough to categorically prove that a skills shortage exists.

Within the 'Raising the Bar' report, deskilling of in-house teams was a concern. Findings found, talented in-house individuals migrating to service provider organisations where they could benefit from higher salaries, greater professional stature, peer group interactions, and a formal career

structure with growth opportunities. As a result, service providers have been aggressively upskilling, in what is, after all, their core business. However, it could be argued that if the FM professionals migrating to service providers are taking operational skills and physical environment knowledge with them, this is not a complete loss to occupier organisations. Instead, it could free up senior FM 'in-house' leaders to focus even on business strategies secure in the knowledge that their service providers will deliver the operational services they have been contracted to provide. (IFMA, RICS, 2017.)

2.2.2 Digital Maturity of Organisations.

Research by RICS (2018) revealed that technology and digital connectivity are increasingly important in achieving resource optimisation and delivering efficient customer services. Nevertheless, the majority of FM contracts are typically dominated by the delivery of manually intensive tasks with limited automation. This manual labour tends to be very expensive, difficult to integrate and traditionally, such contracts only concern the monitoring of core systems such as heating, ventilation, air cooling, lighting and metering.

RICS (2018) identified facilities managers found themselves unable to fully implement strategic maintenance practices throughout their business as they are unable to collect the right level of data, interpret it effectively and communicate its implications to their business. Reported root causes toward the reluctance to use technology in the FM industry:

1. Reliance on inefficient and time-consuming searching interfaces;
2. A lack of a unified interface for exchange of information; and
3. The inability of the average system to store and process large volumes of data.

Kane *et al* (2016) states that preparing for a digital future is no easy task. It means developing digital capabilities in which a company's activities, people, culture, and structure are in sync and aligned toward a set of organisational goals. Kane *et al* (2016) research discovered most companies are constrained by a lack of resources, a lack of talent, and the pull of other priorities, leaving executives to manage digital initiatives that either take the form of projects or are limited to activities within a given division, function, or channel.

Research by Morley (2017) identified many organisations are left feeling disappointed, along with high ongoing expenditure following the implementation of a new operating system, where the system does not provide the benefits that it was promised to do so. In fact, between 50 – 80% fail. The reasons given by Morley (2017) for these failures were:

- Software is not delivered on time or within budget;
- Technology and feature set deficit;
- Cumbersome user interfaces;
- Unable to produce useful reports; and
- Lack of strategic planning capabilities.

2.2.3 Use of CAFM Systems in Facilities Management

Madritsch and May (2009) write since the 1990s computer-aided facility management (CAFM) has been providing efficient information technology (IT) tools for the mapping, evaluation and

controlling of facility management structures and processes. Since then numerous software systems with various systematic approaches, functions and varying degrees of success have been established on the market.

CAFM systems are increasingly turning into process-oriented integration platforms created on the basis of state-of-the-art software architectures and technologies, such as, web services. The interest in web-based software is on the rise, and approximately one half of the users already utilise web-based solutions. (Madritsch and May, 2009)

An article written jointly by Facilities Excellent Magazine and FSI (2008) stated an increased proliferation of IT in facilities management has changed the profile of data importance. Information influences an organisation's tactical use of facilities while acting as a direction setting mechanism to help the facilities manager be proactive and to predict and foresee change, hence optimise strategic decisions to meet the aims and objectives of the business's long-term goals. The article predicts that the future of CAFM systems will be increasingly driven by a more globalised view of the facilities management function and the services it provides. Innovative attitudes and expectations in international markets will be a positive influence on UK CAFM strategies. Global organisations now expect to be able to deploy CAFM systems throughout their infrastructure, regardless of international borders, rather than focusing on individual buildings or premises at a local level – and without any impact on the functionality of the system.

The article above supports the integration of IT in FM to achieve a strategic approach towards FM delivery in the future. A study by Bainbridge and Finch (2009) into the use of CAFM data discovered that CAFM systems are not utilised to its maximum function. The study discovered approximately two thirds of its respondents (69 per cent) using a CAFM system do not currently use it for strategic planning. It discovered the activities which were most widely being delivered utilising CAFM systems, were work order management (87.5 per cent), fault management (83 per cent), asset management (80.4 per cent) and planned maintenance (80.4 per cent). More recent research by Araszkiewicz (2017) identified that although Computer Aided Facilities Management have been proven in practice to be useful, a lack of interoperability exists, which largely limits their functionality. As separate systems, they work smoothly, but they cannot communicate where there is no platform for exchange of information. Araszkiewicz's (2017) summary of the paper concludes that the challenges associated with the development of systems within FM are interoperability and enhancement of data integration, augmented knowledge management and enriched training and competence development for facility managers.

2.2.4 Introduction of the Internet of Things within Facilities Management

IoT is defined by IWFM (2018) as the network of physical devices and objects embedded with electronics, software, sensors and network connectivity which enable these objects to collect and exchange data. Therefore, IoT is essentially a system of machines or objects that can collect data and communicate with one another. The machine-to-machine data that is generated has a wide range of uses but is commonly seen as a way to determine the health and status of things.

For Facilities Management, IoT offers the possibility to understand in real-time what is happening throughout every aspect and component of a building and its operation and can provide valuable contextualised data for analytics. The utopia for facilities management is the attainment of predictive instead of reactive maintenance to reduce downtime of assets and aid efficient labour management, amongst other benefits. (IWFM, 2018)

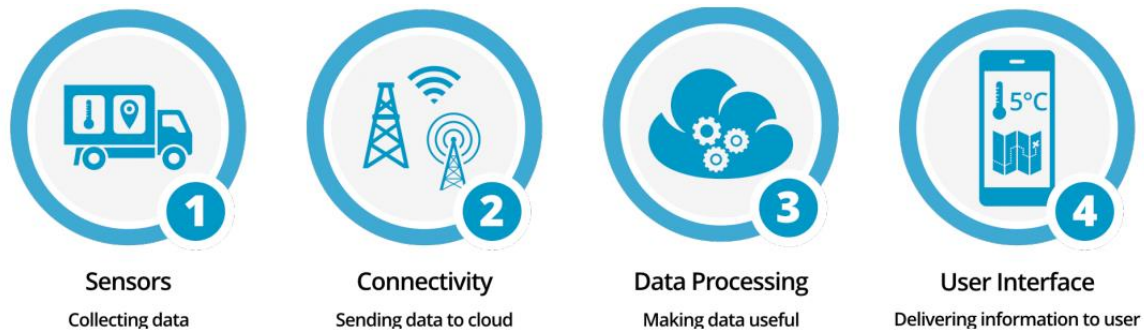


Figure 3: IoT application (source IWFM, 2018)

The last decade has highlighted the potential of software-led models to disrupt Facility management industry and provide large-scale efficiencies. As commercial real estate portfolios grow, facility managers are significantly challenged by the economies of scale. Hardware-centric solutions for these problems are limited by their capital-intensive nature and inability to scale.

The facility management market has shown considerable interest in a software-driven approach with the potential of technologies like IoT. Corporate Real Estate Managers and FM's are keen to utilise software to provide flexible, agile, and unified solutions that drive continuous operational efficiency and sustainability, at scale, across building portfolios. (Pandey, A. 2018)

Key benefits of the use of IoT in Facilities Management outlined by Streather (2016) are:

1. More effective asset management;
2. Operational efficiencies from better building usage;
3. Environmental efficiencies including less consumption of energy;
4. Procurement efficiencies ultimately leading to greater return on investment;
5. Compliance adherence – fully auditable evidence-based data sets;
6. Improved customer opinion through instant rectification;
7. Providing a bespoke service to clients based on actual building usage not planned preventative measures;
8. Collecting data for Business Improvement projects that can guide estimating for future bids; and
9. Demonstrate innovation and thought leadership to clients

The table below demonstrates some of the applications of IoT used in Facilities Management currently.

FM Area of Interest	IoT Application	Practical example / use / scenario
Smart buildings	Sensor Controlled HVAC	Air conditioning/heating switched on at the optimum time based on the first booking in a meeting room to ensure the desired temperature is reached with minimal energy wastage
	Smart navigation (including emergency evacuation).	A smartphone app can guide an occupant to their meeting room or a colleague. In an emergency, room

		signage devices use information from smoke sensors to lead staff to safety.
Resource Management	Sensors on resources – rooms, desks, parking spaces, providing real-time data on space usage and availability.	Staff can view hot desk and meeting room availability throughout the building from a reception kiosk or mobile app. Users can also search for the nearest available meeting room relative to their location or the location of their colleagues.
	On-demand estates.	A company with a flexible working policy can analyse their past and future hot desk bookings and realise demand for space is 50% lower on Mondays and Fridays. They close zones, floors and buildings to save on energy and personnel costs on these days.
	Embedded beacon in portable equipment.	Mobile equipment such as projectors and laptops can be tagged so their location can be tracked within an estate and alerts generated if they move outside of the estate boundaries. The objects can also be easily found within a given space.

Table 1: Applications of IoT used in Facilities Management

There are disadvantages with the introduction of advanced and new technologies. Although there is much literature on the positive impacts IoT will have, arguments regarding the negatives of IoT are more difficult to come by. There have been a number of IT expert's blogging and giving readers a balanced view of both the positives impacts and pitfalls of such technology. Chao (2019) states that one of the main disadvantages is the security of data. Hackers are now actively targeting IoT devices such as routers and webcams because their inherent lack of security makes them easy to compromise. The main problem being that the bugs within the IoT systems themselves makes them easier to attack. These comments are supported by Jing *et al* (2014) where they state that hackers, malicious software and virus' in the communication process might disturb data and information integrity. With the development of IoT technology, information insecurity will directly threat the entire IoT system.

Jing *et al* (2014) continue and state that IoT is widely applied to social life applications such as smart grid, intelligent transportation, smart security, and smart home. Access cards, bus cards and some other small applications also belong to IoT. Applications of IoT can bring convenience to people, but if it cannot ensure the security of personal privacy, private information may be leaked at any time. The security of IoT cannot be ignored. Once the signal of IoT is stolen or interrupted, it will directly affect the security of the entire information of IoT. Further challenges Jing *et al* (2014) highlight is the issue of scalability. Where IoT applications require large numbers of devices it is often difficult to implement due to restrictions on time, memory, processing and energy constraints. One example given, was the calculation of daily temperature variations around all of the country may require millions of devices and result in unmanageable amounts of data.

2.2.5 Asset Management Strategy of the Organisation

2.2.5.1 Asset Management in the Context of Facilities Management.

In the context of facilities management, asset management is the management of physical assets, from their initial acquisition to their operation, maintenance, inspection, renewal or disposal. A good asset management strategy can optimise operational performance, minimise whole life cost and support the organisation's corporate goals and objectives. It can also manage risk and drive business continuity strategies. Asset management is not something an organisation can buy, but rather a discipline it must follow to efficiently and effectively maintain its asset base. (Service Works Global, 2017)

2.2.5.2 Operations and Maintenance

The operation and maintenance phase of the asset management strategy provides the greatest source of revenue, and ultimately, the return on capital investment. It is the longest and most expensive phase in an asset lifecycle and as can contribute as much as 90% of the total lifecycle cost.

It is highly desirable but hardly feasible or achievable to produce buildings that are maintenance-free, although much can be done at the design stage to reduce the amount of subsequent maintenance work. All elements of buildings deteriorate at a greater or lesser rate depending on material and methods of construction, environmental conditions and the use of the building (Zulkarnain *et al*, 2011)

Literature published by the Institute of Asset Management (2015) states that although the traditional business case for asset management has been focused on cost savings through reduced operation and maintenance costs, along with improved productivity through increased reliability and availability, there are many other benefits that are equally or more important:

- Effective management of value, risk and liability;
- Effective asset management improves both personal safety and process safety, reducing the risk of injury and catastrophic events;
- Improved understanding of asset performance through improved data and analytics; and
- Accurate allocation of operational and capital expenditures across business units and divisions.

Early defect detection is critical for preventing catastrophic failures which is why it is important to provide sufficient time to plan and schedule maintenance activities. (Stevenson, 2018) Maintenance strategy has been discussed in this paper, but Stevenson (2018) identifies that before a maintenance strategy can be implemented it is important to define the characteristics of the assets that require maintaining. The first steps will include;

1. Use within facility – mission and regularity of use
2. Consequences of failure on facility and its stakeholders
3. Maintenance history, including both preventative and reactive
4. Asset reliability, known as mean time between failures, together with how quickly the asset might fail (for example a carpet wears out over a long period of time whereas an asset which fails quickly such as a boiler would have a higher criticality ranking)
5. Lead time for spares/ Obsolescence.
6. Replacement value of asset

2.3 Risk Assessment and Management

A subject of particular relevance to this paper and researched in many asset management and corporate real estate papers, is risk assessment and management. Gibson and Louargand (2002) have identified three distinct business risks relating specifically to corporate real estate. These strategic business risks are: operation risk, asset impairment risk and competitive risk. For the purposes of this paper operational and asset impairment risk are the key areas of discussion.

2.3.1 Operational Risk

Operations risk results from a breakdown in a core operating, manufacturing or processing capability. At the strategic level, it is related to the activities of the organisation that are critical to the creation of value. From a corporate real estate view, the potential for structural failure of a key facility could create operations risk. For instance, a leaky roof or a power failure in a data centre of a financial services organisation might lead to loss of revenue and reduced customer confidence thus inhibiting future growth and overall competitiveness.

This demonstrates the link between corporate real estate and an organisations operational capability. Understanding the severity of the impact of a structural failure on the business is essential in any risk assessment. A similar problem in a building that is not critical to the core operations would have much lower risks. For instance, leaks in the roof of a sales support office might lead to no more than minor disruption. Although the property failure is identical, the consequences for the organisations are divergent.

2.3.2 Asset Impairment Risk

Asset impairment risk can be focused on several areas. One being the reduction in intangible value, along with the physical impairment of the assets. Given that corporate real estate is a key asset and a significant proportion of the net tangible assets of most corporations, these risks are highly relevant.

Physical asset impairment relates to physical damage to an asset. Property assets are exposed to fire, floods, power outages and other catastrophic events. The corporate real estate manager must assess these risks in each situation determining to what extent, on the one hand they are likely to occur and on the other hand whether the facility houses operations that affect the business value. Organisations insure themselves against many of these risks, but in many cases it is the job of the corporate real estate manager to develop contingency plans for re-housing the critical operations.

2.4 Asset Performance and Monitoring

The Institute of Asset Management (2015) states that effective monitoring of asset performance is essential for good asset management. A robust measurement framework should include measures and indicators that relate to the performance and health of the asset or asset system.

It is important that the measures are aligned to the organisation's asset management objectives and strategy and provide feedback on, and understanding of, the assets. This feedback is a key input to the asset management decision making process.

To manage the current and future performance of assets a range of performance measures will be required, including lagging (or outcome) measures to monitor the past performance (incidents,

failures and defects) and leading (process) measures to predict future performance to avoid incidents and failures. Condition monitoring is a form of predictive monitoring for physical assets. This can range in sophistication from periodic visual inspection to on-line continuous monitoring.

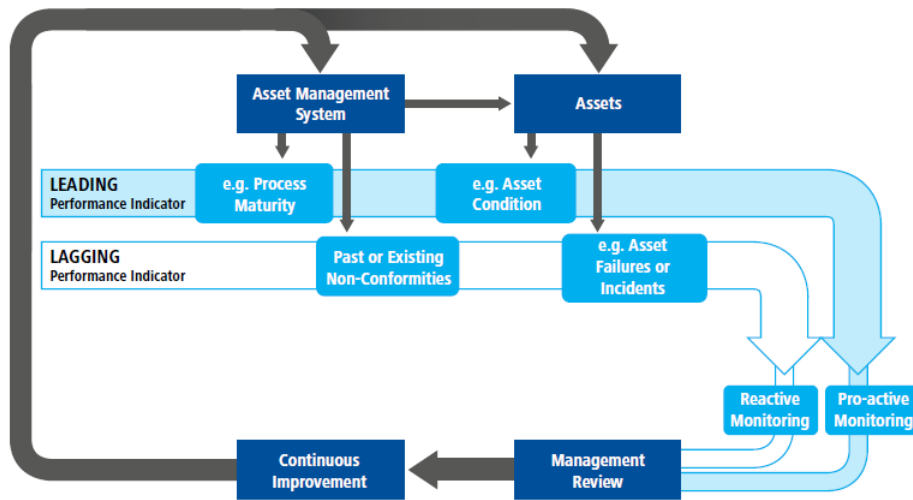


Figure 4: Performance measurement for assets. (Source: Institute of Asset Management, 2015)

2.5 Risk Profiling of Assets and Asset Systems

Designers and maintainers of buildings have a unique insight into the way the building operates, and it is a key responsibility for them to be involved in identifying and controlling risks. Risk is present where damage, injury, liability, loss, or any other negative occurrence can be caused by external or internal vulnerabilities and it is the risks that may be avoided through pre-emptive action that should be focused on. (CIBSE Guide M, 2014)

The risk management process involves the systematic application of policies, procedures and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risk. The figure below demonstrates this process.

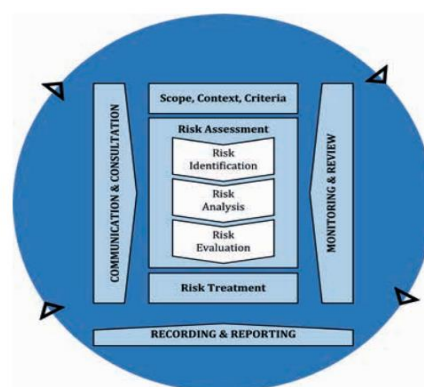
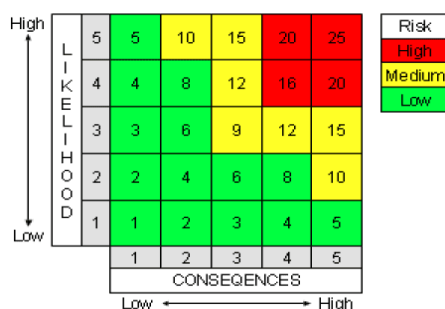


Figure 5: Risk Assessment Process (Source: ISO 31000, 2018)

The risk management process should be an integral part of management and decision-making and integrated into the structure, operations and processes of the organisation. It can be applied at strategic, operational, programme or project levels. (ISO 31000, 2018)

Risk profiling is an exercise that it utilised in many different industries to strategically evaluate processes, systems and practices. Assessing the risk of an activity is one that most people will be familiar with. In this context the purpose of carrying out a risk assessment is to determine whether the level of risk arising from workplace activities is acceptable, or whether more needs to be done to control or reduce the risk. HSE (2003) explains a risk assessment involves both an estimation of the magnitude of the risk (i.e. how big is it?) and an evaluation of the significance of the risk (i.e. is it acceptable?). The process of risk assessment should be carried out in a rational, logical and structured manner.



The findings from a risk assessment can be used to inform decisions as to whether any existing precautions or control measures are adequate, or whether additional prevention or control measures are needed. Risk assessments can also be used to perform a systematic comparison of different risk control/reduction options so that the optimal decision can be made. (HSE, 2003)

Figure 6: Risk Rating Matrix. (HSE, 2003)

Figure 6 is an example of the assessment scoring criteria used to evaluate risk within the context of health and safety.

A similar matrix is used when assessing the condition of a building. Abbott *et al*, (2007) writes about the development of a five-point colour coded rating system which was refined through experience gained during an audit of the National Health Facilities in South Africa.

Researchers discovered a five-point scale proved to be the most effective. A three-point scale is too coarse for reliable results, while a seven point or more scale is too fine and difficult for assessment staff to interpret consistently.

They add that colour introduces another dimension to reporting by making reports more user friendly and accessible to non-technical users of the information. Colour also makes graphic reports more effective and easier to interpret. The figure below demonstrates the five-point colour coded condition assessment rating used during their assessments.

CONDITION RATING	CONDITION	ACTION REQ'D	DESCRIPTION
5	Very Good	Planned Preventative Maintenance	The component or building is either new or has recently been maintained, does not exhibit any signs of deterioration
4	Good	Condition-based Maintenance	The component or building exhibits superficial wear and tear, minor defects, minor signs of deterioration to surface finishes and requires maintenance/servicing. It can be reinstated with routine scheduled or unscheduled maintenance/servicing.
3	Fair	Repairs	Significant sections or component require repair, usually by a specialist. The component or building has been subjected to abnormal use or abuse, and its poor state of repair is beginning to affect surrounding elements. Backlog maintenance work exists.
2	Bad	Rehabilitation	Substantial sections or component have deteriorated badly, suffered structural damage or require renovations. There is a serious risk of imminent failure. The state of repair has a substantial impact on surrounding elements or creates a potential health or safety risk.
1	Very Bad	Replacement	The component or building has failed, is not operational or deteriorated to the extent that does not justify repairs, but should rather be replaced. The condition of the element actively contributes to the degradation of surrounding elements or creates a safety, health or life risk.

Figure 7: Condition Assessment Rating (Source: Abbott *et al*, 2007)

2.6 Practical examples of risk-based maintenance

2.6.1 Case Study 1 – Maintenance Strategy Transformation in the Aeronautical industry in the United States of America.

Literatures published by Patino-Rodriguez and Guevara Carazas explored maintenance strategy transformation within the United States of America. They found that prior to the Second World War maintenance was corrective in nature. Between the 1950's and 1970's a maintenance strategy was adopted where the implementation of process planning was introduced. This was mainly down to the advancements in technology and more complex equipment. At this point maintenance was based on well-defined cycles of spares, replacement and reconstruction of equipment. In the pursuit of high reliability levels, these cycles were very short and ultimately drove an increase in maintenance costs.

Preventive maintenance strategies were established which was very much influenced by the aeronautical industry due to the maintenance needs demanded by the Federal Aviation Administration. This change in maintenance strategy brought financial hardship to many organisations. United Airlines formed a team to evaluate potential means of developing a preventive strategy that could find a balance between safety and costs in the operation of commercial aircraft.

Some years later Maintenance Steering Group – 3 (MSG-3) led to the current methodology of reliability – centred maintenance, where for the purposes of this paper is described as Predictive maintenance. It was characterised by increasing the demands in terms of quality for products and services. In turn, increased standards and regulations called for a change in the traditional ways of operating a production system. In the quest for optimal conditions for preventive maintenance, the probability and reliability studies from the aeronautical industry were applied to the production as well.

The application of maintenance reliability concepts started a new generation of maintenance strategy and standards which exemplified the need for high quality production. Concepts of risk assessment and operational excellence are incorporated as a target of maintenance activities to minimise system failure and guarantee reliability and availability. This stage of maintenance has now made way for risk-based maintenance techniques such as risk-based maintenance and risk-based inspections.

2.6.2 Case Study 2 – Risk based approach in the Energy and Resource industry

In 2015 Deloitte conducted a benchmarking survey of the Energy and Resources industry exploring the use of a risk-based approach to their asset management tasks. It discovered that the majority (95%) of survey participants have fully or at least partially integrated risk management into their asset management processes. They reported that companies have realised that risk-based asset management can maximise the business value of their asset base where these organisations have, or are considering, employing dedicated Asset Risk Managers.

Deloitte (2015) identified key drivers towards this approach are: legal and regulatory compliance, safety, finance, quality, environment and reputation. It reported that risk-based asset management helps asset intensive companies to understand the risk they run related to business value in a cost effective way. Supplementing risk with a value-based system, overall wealth for the organisation is optimised. The benefits were widely recognised by the participants, although only half quantify these benefits and report on them indicating further progress is to be made.

Whilst evaluating the extent asset risk management is incorporated with the business asset management processes, Deloitte (2015) produced the figure below. Of particular interest to this paper is the extent in which risk-based management was used to determine, prioritise and plan maintenance of assets. It is clear that the use of risk-based maintenance is not of high priority to the participants, although there are arguments within the literature reviewed that state risk-based maintenance can have a huge impact on ROI and business decisions. The data collected from asset maintenance can better inform investment, acquiring and disposal of assets so it can be argued that it should be higher on the agenda.

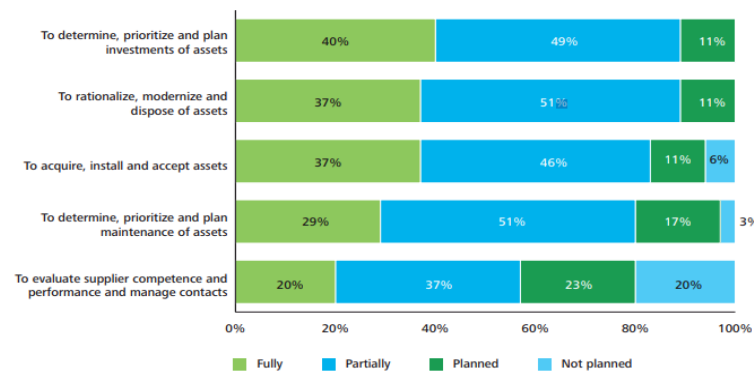


Figure 8: Incorporation of asset risk management into asset management processes. (Source: Deloitte, 2015)

2.7 Maintenance Standards

Hon Yin Lee and Scott (2008) state there are different interpretations among organisations about the acceptable standard of maintenance. The standard is influenced very much by the available resources, where maintenance personnel must define maintenance standards by looking at the balance between the facility cost and maintenance resources, although it is understood and accepted that the baseline should comply with statutory regulations.

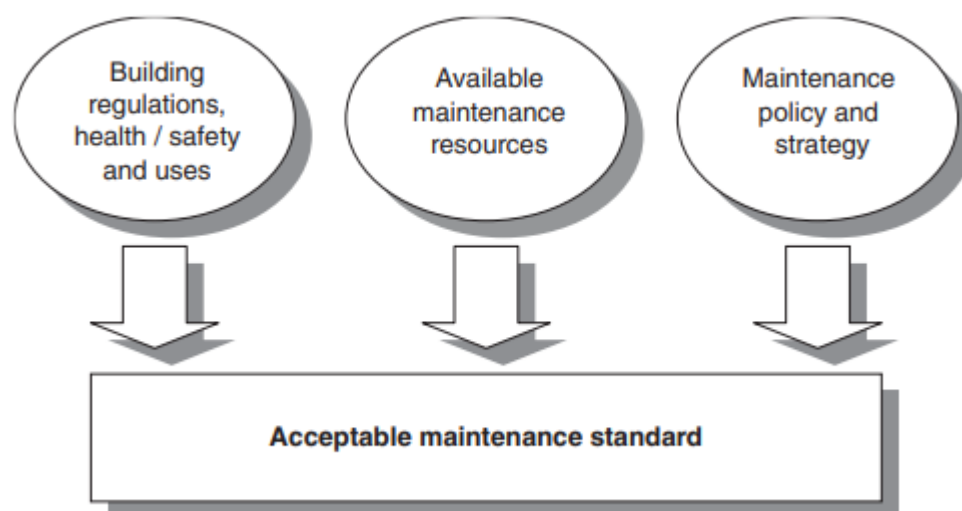


Figure 9: Major influences on acceptable maintenance standard. (Source: Hon Yin Lee and Scott, 2008)

A number of organisations provide guidance and set standards for building maintenance. E.g. in the United States of America the Model National Building Codes set guidelines and regulations and in

the UK standards are set by the British Standard documents. Other guidance in the UK specifically aimed at Facilities Management is provided by SFG 20 and CIBSE Guide M.

2.8 Summary

The review of maintenance strategies provided both positives and negative influences to the use of each strategy. The greatest opportunity for adding value to a property portfolio lies within the implementation of a predictive maintenance approach. Literature discovered that this approach can provide significant savings over a long time period. One of the key elements required to implement this strategy was the access to good quality data provided through the effective use of CAFM systems or output data produced by sensors. However, Hodge, Poglitsch and Ankerstjerne (2014) recognised in their study that harnessing good quality data for strategic purposes posed major issues which re-enforced the aim of this study to fill the gap in data interpretation.

Computer-Aided Facility Management (CAFM) systems have been in extensive use since the 1990's with the aim to provide efficient information technology (IT) for mapping, evaluation and controlling of facility management structures and processes. Bainbridge and Finch (2009) explored the use of CAFM systems and found that 69% of their research participants did not use their systems for strategic influence. More recent investigations of CAFM systems by Araszkievicz (2017) discovered the challenges associated with systems within FM are: interoperability and enhancement of data integration, augmented knowledge management and enriched training and competence development for facility managers.

The reviewed literature highlights operating CAFM systems are not providing FM's the strategic information required to make key decisions. Without further research into the uses of CAFM systems it is unclear as to how this can be remedied, although IoT has potential to be a useful alternative in the future. This does however confirm that good quality asset data that is presented within the correct format or framework is key, and further supports the need for this study.

The introduction of IoT is set to change the way data is gathered. Corporate Real Estate Managers and FM's are keen to utilise the IoT software to provide flexible, agile, and unified solutions that drive continuous operational efficiency and sustainability, at scale, across building portfolios (Pandey, A. 2018). Advantages of IoT set out by Streather (2016) show that this technology could significantly impact how data is utilised in the future to improve the workplace experience.

The comment from Araszkievicz (2017) regarding competence development of facilities managers was explored further within the review. RICS (2018) found that Facilities Managers find it challenging to collect the right level of asset data, interpret it effectively and communicate its implications to the business. Furthermore, studies by BIFM (2018) and IFMS, RICS (2017) all confirmed a skills gap was developing in the industry, although this study felt further research into industry skills gap is required to explore other factors could be contributing to a lack of skills. Discovering a skills gap is significant to this study. IWFM (2020) reported that data analytics is a required skill set for FM in the near future indicating robust skill development in this area will be required to fill this gap. It further confirms the need for this study.

Literature by Institute of Asset Management (2015) and Gibson and Louargand (2002) re-enforced the aim of the research within this study. The review discovered effective management of risk, liability and process could reduce the risk of injury and the occurrence of a catastrophic event due to asset breakdown. Operational risk was viewed as of high significance when managing risk within a corporate real estate environment. Their research on the subject of operational risk focused on the understanding of the severity the impact failure of assets can have on a business. This is of

significance to this study as the prototype assessment will attempt to measure this, although is defined as 'criticality' within the prototype.

To put this in the context of a real scenario, in May 2017 British Airways experienced a reported power surge on their IT system which had been overlooked and not considered a risk. This caused flights to be cancelled and 75,000 passengers stranded. This issue had a significant effect on the value of the company where shares fell and a reported value of £170m was lost on the airline group. (The Guardian, 2017)

Overall, the literature review demonstrated the value an alternative approach to maintenance can provide. It supported the need for this study and identified a gap in the quality of asset data being produced and the ability of FM's to interpret it to enable maintenance strategies to be developed. The review of risk management and profiling was discussed as being a form of predictive maintenance where the case studies provided valuable insight into the use of a risk based approaches and the benefits it can bring. This paper will explore the gap in data interpretation further and provide a prototype assessment, informed by the research, as a possible solution.

3.0 Establishing a Criteria to measure critical assets against

3.1 Introduction

Risk is often described in terms of risk sources, potential events, their consequences and their likelihoods. An event can have multiple causes and lead to multiple consequences. Consequences can have a number of discrete values, be continuous variables or be unknown. Consequences may not be discernible or measurable at first but may accumulate over time. Sources of risk can include inherent variability, or uncertainties related to a range of factors including human behaviour, organisational structures or societal influences for which it can be difficult to predict any event that might occur. It follows that risk cannot always be tabulated easily as a set of events, their consequences and their likelihoods. Risk assessment techniques aim to help people understand uncertainty and the associated risk in this broad, complex and diverse context, for the purpose of supporting better-informed decisions and actions. (BS EN IEC 31010:2019)

Curtis and Carey (2012) write that within the risk assessment process, the first step is to develop a common set of assessment criteria. Risk is not only viewed in terms of financial impact and probability, but also subjective criteria such as health and safety impact, reputational impact, vulnerability and speed of onset.

Redmill (2002) similarly describe the process of risk assessment and the techniques used, involve subjectivity. The study discovered there is always uncertainty, the need for judgment, considerable scope for human bias, and inaccuracy, with the result being that the results of one risk analyst are unlikely to be obtained by others starting with the same information.

Redmill (2002) highlights the natural impediment to arriving at 'correct' risk values. The future is implicit in risk, which does not define a current problem or a future certainty, but the potential for future harm. Thus, risk may be estimated but not measured, and its values cannot be assumed to be correct.

3.2 Criteria established from previous research

Guidance notes written by the Institute of Public Works Engineering Australasia (IPWEA) defined critical assets as those which have a high consequence of failure (not necessarily a high probability of failure). The document created a list of criteria of which a risk of failure is to be measured against:

- Structural: where the physical condition of the asset is the measure of deterioration, service potential and remaining life.
- Capacity / utilisation: where it is necessary to understand the level of under- or overcapacity against the required level of service to establish remaining life or timing for renewal.
- Level of service failures: e.g. reliability, image, where performance targets are not achieved.
- Obsolescence: technological change or lack of replacement parts can render assets uneconomic to operate or maintain.
- Cost or economic impact: where the cost to maintain and operate an asset is likely to exceed the economic return expected, or the customer's willingness to pay, to retain an asset.

Khan and Haddara (2003) describe a consequence assessment where the objective is to prioritise equipment and its components on the basis of their contribution to a system failure, supporting the view of IPWEA. An example within the research was in the case of a pressure containment, a pinhole leak on a process line may not lead to a total loss of production. In contrast, a failure of a pipe valve

may cause a shut-down of the line demonstrating a failure of particular assets can have greater consequences.

The criteria of measurement used by Khan and Haddara (2003) was: System Performance loss, financial loss, human health loss and environmental and/or ecological loss.

Nordgard and Samdel (2009) published a report that focused on the experiences of established Risk-based maintenance strategies within a group of Norwegian electricity distribution companies. Their research explored risk assessing assets and from group brainstorming sessions with the experts, they were able to establish consequence categories which risk would be evaluated against. These categories were: Safety, Environmental impact, Reputational impact, and Economic impact.

Nordgard and Samdel (2009) made comments in the closing remarks that noted that due to the vast number of components in the system, the approach taken was based on establishing maintenance strategies for a limited number of component archetypes. This was to minimise the number of risk analyses to be performed, instead of doing it for each and every one of the components in the electrical grid. Their experience showed that it was hard to find representative statistical data which could support a risk assessment in this context. The risk assessments were therefore based on input from company experts, utilising their judgments in a structured risk analysis framework.

3.3 Summary

The literature demonstrated no way of establishing a firm criterion to measure the impact of assets against. It established a criteria for measurement is broadly based on what the organisation or institute feel is most important to measure.

The review of previous work by the Institute of Public Works Engineering Australasia (IPWEA), Khan and Haddara (2003) and Nordgard and Samdel (2009) gave examples of criteria used within in past exercises relating to the measurement of asset risk. Analysing the criteria and the context in which these criteria were established confirmed that establishing a criteria remained subjective and relied on experts within the sectors they were researching to brainstorm and discuss the criteria for measurement. This study extracted a set of criteria from the review of these papers which will form part of the primary research to answer one of the research objectives. This criteria is as follows:

1. Condition;
2. Capacity/ redundancy in the system;
3. Number of service failures;
4. Obsolescence – lack of spares;
5. Safety to People;
6. Environmental impact;
7. Performance Loss;
8. Financial Loss; and
9. Statutory Compliance

4.0 Research Methodology

4.1 Introduction

The aim of the research is to gather data that will allow all of the objectives to be assessed. The results of which will aid in the understanding of the use of risk assessment models to measure asset criticality in the FM industry. These results will be considered and incorporated into the untested prototype produced as a result of the research.

This chapter will review the research strategy used in this paper, justify the methods used and those that have been discounted, and how the data has been analysed.

4.2 Research Strategy

The research strategy chosen for this paper is the collection of data via Surveys. Strengths that this type of strategy is that surveys are capable of obtaining information from large samples of the population. They are also well suited to gathering demographic data that describe the composition of the sample. Surveys are also inclusive in the types and number of variables that can be studied, require minimal investment to develop and administer, and are relatively easy for making generalisations.

Weaknesses of their use are that they are generally unsuitable where an understanding of the historical context of phenomena is required. Biases may occur, either in the lack of response from intended participants or in the nature and accuracy of the responses that are received. Other sources of error include intentional misreporting of behaviours by respondents to confound the survey results or to hide inappropriate behaviour. Finally, respondents may have difficulty assessing their own behaviour or have poor recall of the circumstances surrounding their behaviour. (Glasow, 2005)

The primary reason for choosing this strategy was the minimal amount of time to collect data and analyse results. The weaknesses of this strategy were considered as the questions rely upon participants to recollect experiences. The study felt that this would not have a detrimental effect on the results as the target population focuses on gathering results from individuals currently working within an operational FM environment negating the need for participants to recollect experiences that may have been from many years ago.

4.3 Alternative research strategies

Alternative strategies for collecting data were considered. A case study was considered but research studied in the literature review demonstrated that FM organisations are not actively practicing a risk based approaches to maintenance and therefore finding a case study suitable would be difficult. Other strategies such as Action and Grounded theory research were looked into but discounted as not being suitable.

4.4 Qualitative and Quantitative research

Broadly speaking, data can be collected in two methods: qualitative and quantitative.

Muhammad Sajjad Kibir (2016) states that qualitative data is mostly non-numerical and usually descriptive or nominal in nature. This means the data collected are in the form of words and sentences. Often (not always), such data captures feelings, emotions, or subjective perceptions of

something. Qualitative questions are open-ended which uses include focus groups, group discussions and interviews.

Quantitative data is statistical and is typically structured in nature – meaning it is more rigid and defined. This type of data is measured using numbers and values, which makes it a more suitable candidate for data analysis. Quantitative data is much more concise and close-ended. It can be used to ask the questions “how much” or “how many,” followed by conclusive information. Quantitative data can be generated through Tests; Experiments; Surveys; Market Reports; and Metrics. (Pickell, D., 2019)

This study will take a quantitative approach as the data that will be collected will be in numerical form. Quantitative data can also be tested and checked where anyone has ability to replicate both the test and the results. This makes the data that is gathered more reliable and less open to argument. With regards to analysis of results, interpreting the data and presenting those findings is straightforward and less open to error and subjectivity. (Devault, 2019)

4.5 Target Population

The target population for this study were individuals that are working in an operational environment delivering Facilities Management services. Targeting FM professionals that are practicing ensured that responses are accurate and factual, which mitigated the chance of collecting results where individuals are required to recollect information from many years previous to answer the questions. This removed the weaknesses associated to using the survey research strategy.

Consideration has been given to how the target population will be contacted. The study decided to contact individuals via the social media networking platform, LinkedIn.

LinkedIn is a social network specifically designed for career and business professionals to connect. Over 65 million professionals use LinkedIn to cultivate their careers and businesses. Unlike other social networks in which you might become "friends" with anyone and everyone, LinkedIn is about building strategic relationships. (Duermyer, 2019)

Researchers are faced with two recurring problems whilst conducting research: finding relevant respondents and convincing them to dedicate time and energy to answer questions. Laurent, Muriel and Camille (2013) believe that utilising social media networks could be useful for alleviating such issues and enhancing traditional data collection methods. Interestingly, using the social network of executives in order to contact potential respondents (mailed surveys) was found to lead to a higher response rates. It is shown that, by drawing on existing social ties in the industry, professional groups, industry contacts to name a few, researchers are able to access people with greater motivation in spending the time required in surveys and interviews than if they are contacted directly through cold call mailings.

The study considered narrowing the target population to include participants that had the job title Facilities Manager as the only targeting strategy. This was discounted as the number of participants completing the survey would be limited. Care was be taken not to widen the target population beyond participants that have operational experience within the FM industry. This was considered as strategy 3 of the data collection process involved posting the survey on the platform, opening the survey to participants not directly working with operational FM environments. To avoid the chance of participants taking part in the survey that do not form part of the target population one of the

survey questions will ask participants to confirm their current job titles. During analysis of the results, job titles that are unclear as to the position the participant holds, or are not one of the commonly used job titles throughout the FM industry will be discounted.

4.6 Sampling of Target Population

A convenient sampling approach was taken for the pilot survey in this research. This approach was taken as the pilot survey was intended to be a form of exploratory research, giving ideas and insight with the aim of completing further and more representative research later. A sample questionnaire was created in Excel format and sent to 10 colleagues, fellow students and members of the IWFM South West regional committee. Appendix A is a copy of the pilot survey that was disseminated. Participants were asked to complete the survey and provide constructive feedback on the content.

Questionnaires were returned (50%) and analysis of the data completed. Several questions were removed as it was felt that they did not add anything to the research overall. Minor grammar and spelling checks were amended for the final survey.

4.7 Data Collection

The first step in the data collection process was to build a survey. This was completed through an online survey platform called SurveyMonkey, which allowed a link to be sent to the chosen participants of the research.

The second step was to identify potential candidates that fitted within the target population of this study. The search criteria from LinkedIn was used via an account of a member of the study team to identify 1st, 2nd and 3rd degree candidates within the network. A quick search for the keyword 'Facilities Manager' revealed over 3,050,000 results which represents a sizable coverage of the target population without accounting for other participants with FM operational experience without Facilities Manager as their current job title.

The number of degrees represents the network distance between the LinkedIn survey researcher and the profile of the person searched. People connected in the 1st degree have agreed to be connections of one another and share all their profile information with one another. Connections of the 2nd degree nature are people that have at least one person in common in their 1st degree connections, while 3rd degree connections are made of people that are connected to someone that in turn is connected to someone in their 1st degree group of connections. Thus the number of degrees between two people represents the social network distance between them. (Laurent, Muriel, Camille, 2013)

4.7.1 Data Collection Strategy 1 – Direct messaging of 1st degree connections with the job title Facilities Manager.

The study searched 1st degree connections with the job title 'Facilities Manager' within the researchers LinkedIn network of contacts. The initial search produced over 600 connections. It was discovered that this approach also took into consideration the past job title of the connection which inflated the actual number of participants. The decision was made to further filter the search where

the approach was to contact 1st degree connections where the connections current job title was Facilities Manager.

The chosen participants were contacted directly via the direct messaging function within the platform containing the details of the survey and the participants consent letter.

4.7.2 Data Collection Strategy 2 – Direct messaging of 1st degree connections that hold operational positions managing property estates.

This strategy involved searching 1st degree connections within the LinkedIn search engine for participant working within an operational role but crucially did not have the job title of Facilities Manager. This strategy aimed to collect responses from participants with similar job titles to the participants in strategy 1 such as; Property Manager, Head of FM, Workplace Manager, Engineering Manager etc. that is working within an operational FM environment. The search began in the same way as adopted in strategy 1 by searching 'Facilities Manager. This allowed for the capture of participants that previously held this job title, therefore able to demonstrate that these participants have operational experience, albeit now in positions with a different title.

4.7.3 Data Collection Strategy 3 – Post Survey Monkey link on LinkedIn.

This strategy involved posting a link on the social network inviting people to participate. This link can be viewed by all individuals within the LinkedIn connections network of the account used for this study, but more crucially can be shared within their network which will ultimately widen the scope for gathering more data.

The study considered that people may complete this survey that are working in an operational environment within the FM industry. In an attempt to mitigate against this and avoid false responses, participants are asked to provide their current job title as part of the question set within the survey. Analysis of the responses will discount job titles that are not widely recognised or associated with operational roles within the FM industry. Example job titles will include: FM administrator, FM recruiter, project manager etc.

4.8 Ethics

Care was taken in the approach to the way data was collected. Townsend and Wallace (2016) produced a guidance paper on the ethics of using social media for research purposes which identified key concerns for this approach. Those concerns were:

- Private vs Public
- Informed consent
- Anonymity
- Risk of Harm

Careful consideration to these areas were observed throughout the data collection process.

4.9 Limitations and bias

Perdersen (1992) states that a general limitation of survey research is the simplification of reality. The arbitrary design of questionnaires and multiple-choice questions with pre-conceived categories

represents a biased and overly simple view of reality. Individual responses to questions lead to the mathematical manipulation of figures, creating frequencies, averages and rates that represent "average replies", ratios or proportions that carry no real significance on their own, and rather mystify reality. Other disadvantages highlighted in other research are dishonest answers, lack of responses and respondents having a hidden agenda.

The disadvantages were considered when deciding the approach to collecting research data. Advantages relating to survey research, such as the rate in which results can be collected and the anonymity of participants outweighed the disadvantages and were more attractive due to the time constraints of data collection process and the strategies used to collect the data.

A significant limitation to this research were the number of participants that undertook the survey. Although strategy 3 aimed to open the survey to a wider population. The study was restricted in the number of 1st degree connections within the researcher's account falling within target population of the study.

4.10 Review of Methodology

The survey was circulated to 267 people. 79 participants were captured within strategy 1 and 188 captured within strategy 2. The study was unable to obtain the number of participants that contributed via strategy 3 but the post received 5 'reactions' and 521 views. A total of 38 surveys were completed demonstrating a 14.2% uptake of the survey.

Undertaking a pilot survey offered a good insight into the potential data the survey questions may produce. Some of the original question were removed or reworded in order to capture more meaningful data.

On reflection, an alternative approach to the collection of data may have resulted in a larger number of participants being sent the survey, which in turn, would increase the uptake percentage of the survey. Increasing the amount of time the survey was open may have resulted in further participation. The survey was available to be completed for 11 days. Considering the length of time the survey was available for completion and the number of participants the survey was sent to, the uptake was within the average response rate range for external surveys of 10 – 15% stated by Fryrear (2015).

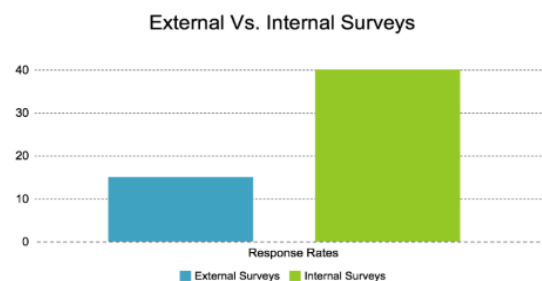


Figure 10: External vs Internal survey response rates. (Source: Surveygizmo, 2015)

5.0 Findings of the survey: Description, Analysis and Synthesis

5.1 Introduction

This chapter will discuss the findings of the data collected from the research strategies set out in chapter 4.2. The findings were collected via an online survey which asked individuals working within an operational FM environment, to participate. The results are described, analysed and compared against findings of the literature review.

5.2 Target population

The results of this research depend on the participants of the survey working within an operational FM environment. As previously documented in this paper, there was a risk of participants with no operational experience completing the survey during the implementation of strategy 3 of the research strategy. For this reason, the study included a question that required the participant to provide their job title. Any job titles that were not consistent with recognised industry job titles were removed from the results.

The figure below shows a list the job titles of the participants that completed the survey.

FM Consultant	Facilities Manager	Head of Asset Management	Operations Officer	Senior Facilities Manager
Group Technical Compliance Manager	Associate	Senior Engineer	Contract Delivery Manager	Specialist Operations Supervisor
Operations Director	FM Manager	Contracts Manager	FM Project Manager	Technical Supervisor
Principle FM Consultant	Project Manager	Technical Solutions Manager	Consultant Engineer	Operations Manager
Managing Director FM	Global FM	City Operations Manager	Operations Manager	Engineering Manager
Estates and Asset Director	Managing Director	Facilities Manager	Head of Facilities Management	FM Manager
Deputy Director of Capital Projects and Estates Transformation	Director	Senior Technical Manager	Lead Facilities Manager	Head of FM
Director	Critical Environment Facilities Manager	Skipped		

Table 2: List of job titles of the participants of the survey

There were a number job titles that either didn't make clear the field of work they were part of or were considered not to be sufficient in determining if the participant worked with an operational FM environment. The discounted job titles are marked in red within the figure above. This resulted in the overall response rate being reduced to 11.9%, still within the average uptake stated by Fryrear (2015).

5.3 Participant's area of Portfolio Management

The study believed it was necessary to understand the type of property portfolios the participants were actively managing. This was to ensure as reasonably practical, that a balanced view across all

sectors could be obtained and that the research aim would be of benefit to all operational FM's. The figure below demonstrates the type of property portfolios the participants who fell within the target population of the study are responsible for managing.

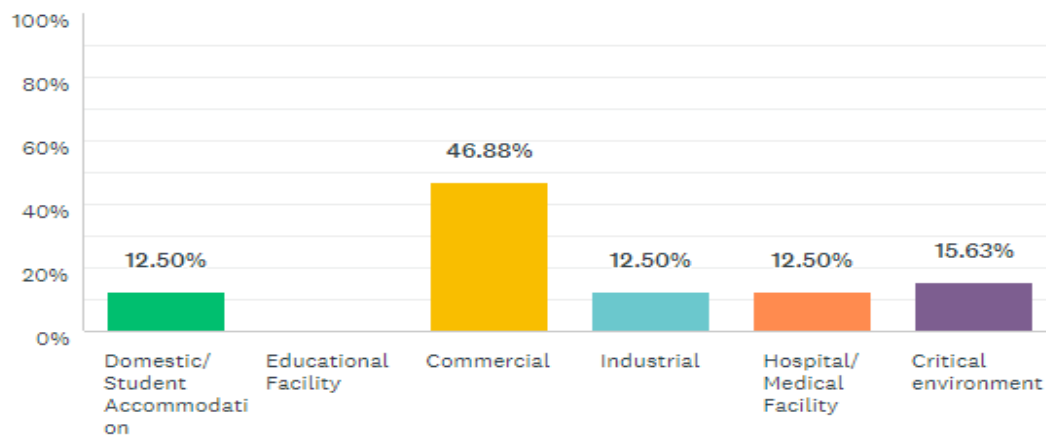


Figure 11: Types of property managed by survey participants

The majority of the participants were responsible for commercial premises, with a relatively balanced sample taken from Domestic/ Student accommodation, Industrial, Hospital/ Medical facilities and Critical environment. There were no respondents from the educational sector but this is not viewed as having a detrimental impact to the overall result.

5.4 Accuracy of asset data collection

Question 3, 4 and 5 of the survey were created to answer objective 1 of the research objectives. The questions were split to enable each of the data collection processes to be evaluated, with a separate question to understand whether CAFM systems are used to influence maintenance strategies and practices.

Question 3 was aimed at the collection of asset data and how accurately the participants this data was collected. All 32 participants answered the question and on average they believed that the asset data collected was 55% accurate.

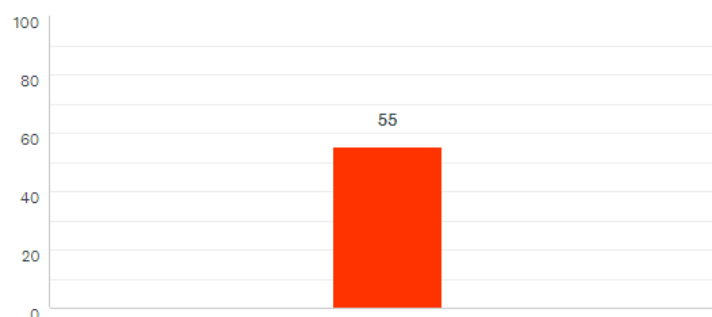


Figure 12: Average level of accuracy of asset data collected.

Question 4 evaluated the accurately of the data that has been collected, is inputted into the CAFM system. Of the 32 participants, 31 answered the question where on average the participants belived that the data that was inputted into their CAFM system was 65% accurate.

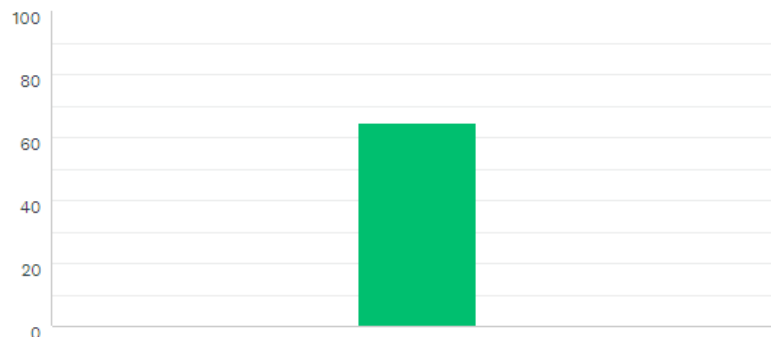


Figure 13: Average level accuracy of the data inputted into CAFM system.

Question 5 asked participants to evaluate whether the level of information they received from their CAFM system helped them to make decisions on maintenance strategy and service delivery. 30 of the 32 participants answered the question where an average of 51% said that their CAFM system helped them make key decisions on maintenance strategy.

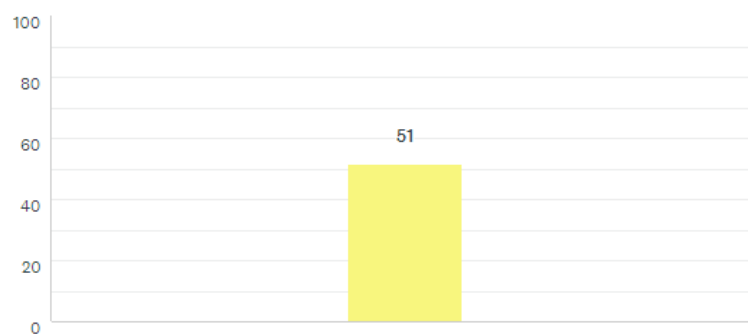


Figure 14: Average response to whether CAFM systems aided in decision making for maintenance strategy.

Question 3, 4 and 5 of this survey were key in assessing the levels and accuracy of data available to operational FM's and was fundamentally linked to research objectives. Although the results improved since the study completed by Finch (2009), the results continued to support their research which discovered that CAFM systems are not used to make strategic decisions.

The results show that the participants feel that the accuracy of the data being collected and inputted into CAFM systems is not sufficient. The result of question 5 in not surprising where participants felt that they could rely on the asset data from the CAFM system 51% of the time to positively influence the strategic direction of maintenance delivery. Digital maturity may be a contributing factor in the results gathered from these questions which would support the research from RICS (2018) that FM contracts are typically dominated by the delivery of manually intensive tasks with limited automation indicating a lack of experience in the use of this technology.

5.5 Evaluation of critical assets

The questions relating to objective 2 of the research objectives focused on the evaluation of critical assets within property portfolios. The aim was to assess whether FM's were evaluating asset risks within their property portfolios and changing their maintenance strategies to proactively manage any risks identified. The results of these questions confirmed a gap exists and reinforced that the research in this paper has purpose.

Question 6 of the survey asked the participants if critical assets within their systems were accurately identified. The results showed that on average 49% thought that assets were sufficiently identified. Out of the 32 participants 30 answered the question.

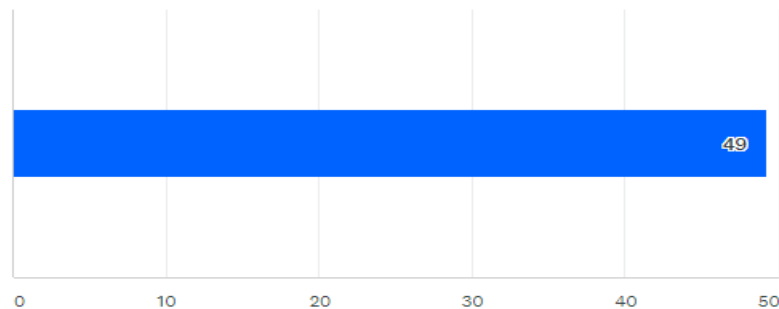


Figure 15: Are the critical assets within your systems accurately identified?

Question 7 asked participants if the assets within their systems underwent a risk evaluation to understand the impact failure could have on business operation. The question was answered by 27 of the participants where the average response was that assets were evaluated 46% of the time.

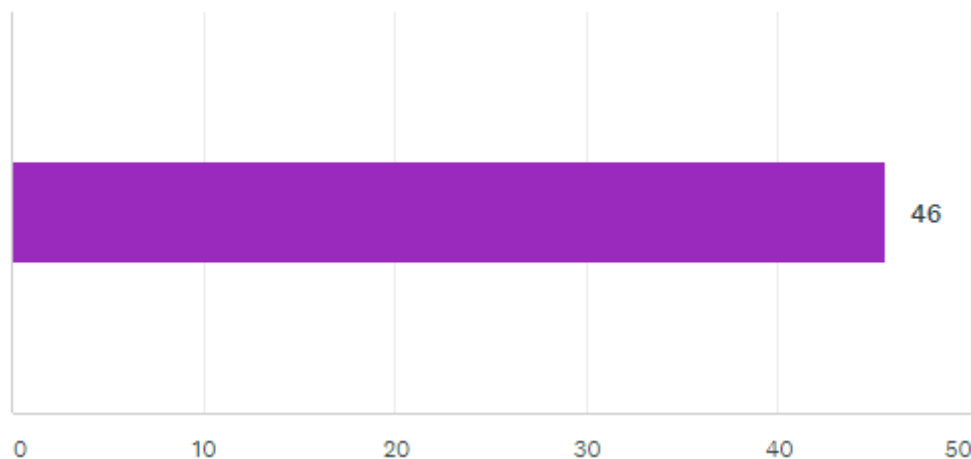


Figure 16: Average response to whether assets underwent a risk evaluation.

Question 8 within the survey was an optional question where the participants were asked if applicable, do the results of the risk evaluation influence the maintenance regime towards the asset or system. As this question was optional 16 of the 32 participants answered it. The results found that on average 65% of the time the results of the risk assessment influenced the maintenance regime.

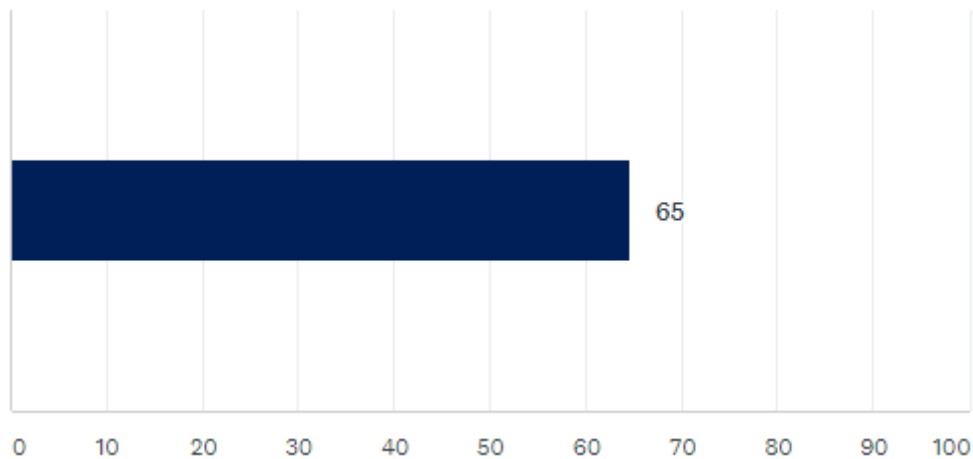


Figure 17: Average times the risk evaluation influences maintenance regimes.

It was assumed that the participants that didn't answer the question did not use the results of any risk evaluation exercise to influence their maintenance regimes. Calculating the results with this assumption decreased the average score to 50% which was consistent with the results gathered for the other questions relating to this objective.

5.6 Establishing a Criteria to measure against

The result of this question (9) is fundamental to the achievement of the overarching objective of this paper and will influence the criteria imbedded into the untested risk assessment model (Appendix 5). This question asked participants to rank a set of criteria in order of importance, if they were to measure an asset for its criticality. The results of this question are set out in the figure below.

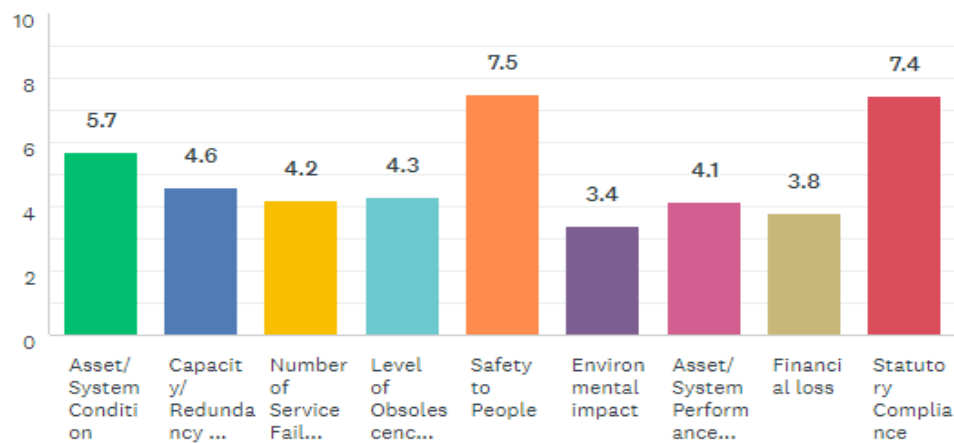


Figure 18: Criteria for measurement

The results found that there were two distinct categories picked by the participants for their importance, these being Safety to People and Statutory Compliance. The next criteria ranked highest in importance was Asset/ System condition. The remaining criteria were scored evenly with Capacity/ Redundancy in the System chosen as the fourth most important.

5.7 Level of Technical Competence to complete the assessment

The literature review identified a skills gap in the industry, so it was important for this paper and for future development of a risk evaluation tool, to understand what level of technical competence participants felt would be required to complete an assessment of their critical assets.

The survey asked participants to use the sliding scale to answer what level of technical competence would be required to undertake an assessment of critical assets. The results to this question represent a high level of technical competence would be required to undertake an assessment of the critical assets.

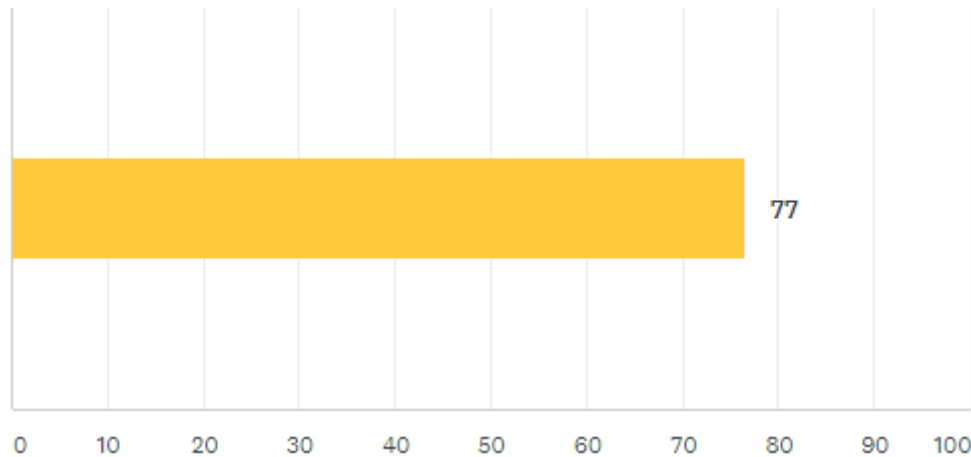


Figure 19: Level of M&E Technical competence required to complete assessment

5.8 Summary of Findings

Results from questions 3 - 5 identify that CAFM systems are not utilised to their full potential. Although the gap has closed between the research conducted in this study and the results captured in research by Bainbridge and Finch (2009), 51% and 69% respectfully, a gap exists where CAFM systems are not used for strategic planning.

The results identified a shortfall in the process of collecting and inputting asset data into the CAFM systems that FM's rely upon to manage their property portfolios. It was unsurprising that the result to question 5 confirmed that participants felt that the level of information they received from the CAFM system influenced their strategy towards maintenance 51% of the time. Accuracy of asset data was highlighted by CBRE (2017) as a key driver for addressing challenges in the future, and these results confirmed processes need to be improved.

The results of this survey supported the findings from Bainbridge and Finch (2009) and Araszkievicz (2017) in the literature review. It's important to highlight research by Hodge, Poglitsch and Ankerstjerne (2014) that recognised that the technology tools exist to allow strategic management to be achieved, and that there is no shortage of data, but harnessing it to address strategic challenges is still a major task. Another factor discovered in recent research by RICS (2018) reported that facilities managers find themselves unable to collect the right level of data, interpret it effectively and communicate its implications to the business.

In summary, although the results of the survey in this paper supported previous research that show a gap in the use of CAFM data, other factors such as the ability to interpret data play a part and would support the research in the literature review that discovered a skills gap in the industry.

Participants were asked a series of questions (6 – 8) that aimed to understand if Facilities Managers were carrying out risk evaluation assessments of their assets, and whether the results of any assessments were used to influence the maintenance strategy for that asset.

Collectively, the answers to the questions give insight in the use of risk assessments to evaluate critical assets within the FM industry. In summary, although some FM's are evaluating their assets for the impact they could have on their business, it has not been fully adopted as best practice across the industry. The results confirmed that where risk evaluations are taking place, the result of this question produce an average response of 65% but further analysis discovered that a number of participants skipped this question. The assumption was made that the participants that chose not to answer the question were not using results of assessment to influence their maintenance regimes. Applying this assumption reduced the overall score to 50%. The results suggest that the process of completing a risk evaluation is either not viewed as being beneficial to the overall delivery of maintenance or there is a reluctance to move away from traditional maintenance practices where high risk assets have been identified. The latter was discovered within the literature review. Velmurugan and Dhingra (2015) state that organisations are reluctant to experiment with the new maintenance methods developed such as total productive maintenance (TPM), reliability centered maintenance (RCM).

Comparing these results to the literature review demonstrated that the FM industry is lagging behind. Deloitte (2015) review of companies in the Energy and Resource industry found that 95% of their study participants have fully or at least partially integrated risk management into their asset management processes, compared to 50% in this study.

Institute of Asset Management (2015) identified the benefits of a risk management approach to asset management. These results confirmed that this research would contribute to the subject of risk assessing asset for criticality in the FM industry to close the gap on other organisations through the use of the prototype model produced.

The results to question 9 in the survey produced key data that will influence the criteria that is imbedded into a risk evaluation prototype for the FM industry. Past papers from the Institute of Public Works Engineering Australasia (IPWEA), Khan and Haddara (2003) and Nordgard and Samdel (2009) were reviewed and gave examples of criteria used within organisations and institutes they researched. Results of their study produced a set of criteria which form the basis of question 9. Analysing the way in which their research established these criteria, it is clear that the criteria was subjective dependant on the industry and relied upon experts within the sectors they were researching to brainstorm and discuss the criteria of measurement.

Results of this survey produced a criteria to which Facilities Managers felt were the most important items to measure when undertaking a risk evaluation of the assets or asset systems. The points raised of subjectivity were confirmed, where the criteria in the pilot survey were ranked differently to the criteria in the final results, albeit three of top four criteria featured in both sets of results but in a different order. Although these results will not impact this study, future development of the

prototype model could involve weighting each of the criteria based on their ranking, which will dramatically alter the results gathered in the assessments.

The results to the question relating to the level of technical competence revealed participants felt strongly that a significant level of technical competence in M&E systems was required to enable an assessment to be completed (77%). Reviewed literature by BIFM (2018) identified areas of the industry that lacked skills. The prototype will require a level of technical competence in order to produce results. Based on the results of this research it is unlikely that the prototype will be used by Facilities Managers due to the lack of competence.

However, guidance from IFMA (n.d.) on the core competencies of a facilities manager, discovered that competence 4 (Operations and Maintenance) of the guidance document states that a Facilities Manager should be able to assess the condition of the facility. Particularly, manage/oversee the assessment of building systems' condition and assess the condition of the facility's structure, interior, exterior and grounds.

This would suggest that it is not unreasonable to expect a Facilities Manager to be competent enough to be able to complete an assessment of the systems they are responsible for.

6.0 Conclusion

6.1 Research Objectives

The overall aim of this research project was to gather research from the FM industry to test the use of risk assessment models to assess property assets for their criticality in the event of failure. The study also aimed to provide an untested model based on the findings of the literature review and primary research in the study. To achieve this the study set 4 research objectives. These were;

- 1 An assessment of whether data collected, inputted and produced by CAFM systems is used to influence maintenance practices currently.
- 2 Assess if FM's are actively evaluating assets for their criticality and whether the results are influencing maintenance delivery
- 3 Establish a criteria for the FM industry, in order of importance, to measure an assets criticality against.
- 4 To evaluate if the level of technical competence of an FM will be a factor in their ability to carry out an assessment of the assets.

6.2 Assess if the data collected and produced by CAFM systems influence maintenance practices.

The results found that Facilities Manager felt that the process of collecting and inputting of asset data into the CAFM system was not accurate enough. As a result of this the participants felt that the information produced by these CAFM systems could only be used 50% of the time to influence any strategies towards maintenance practices. The results supported the literature review on the subject of underutilisation of the CAFM system and difficulties with operability. The literature review identified research that stated there was enough information within CAFM systems that could be used to strategically influence real estate goals, but that Facilities Managers found it difficult to interpret the information. The results of this research and the literature review supports that a gap in data information exists but other factors are likely to be contributing to the under use of information CAFM systems are supplying.

In conclusion, the process of collecting assets and inputting these assets into a CAFM systems needs to be addressed. It is the view of this study that this process is the foundation in which maintenance strategies can be influenced on. Too much data can result in information being wrongly interpreted. Too little, not enough factors are taking into consideration to make an accurate judgement. By improving these processes Facilities Managers will have the confidence to use the information and more crucially, trust the information being presented.

Of more significance, addressing the skills gap in the ability of Facilities Managers to interpret the data should be considered high priority for businesses that wish to develop their maintenance strategies further. Data analytics was stated by IWFM (2020) as being a key skill for FM's and upskilling of FM's in this area should be a priority.

6.3 Assess if FM's are actively evaluating assets for their criticality and whether the results are influencing maintenance delivery

ISO 13000 (2018) state the risk management process should be an integral part of management and decision-making and integrated into the structure, operations and processes of organisations.

The literature review identified a number of industries that were successfully using a risk based approach to their asset management processes and evaluating their assets for how critical they were to the overall operation of their business.

The results of survey in this study discovered that on average critical assets were accurately identified 49% of the time. Similarly, the participants felt that on average a risk evaluation assessment to identify risky was completed 46% of the time. Approximately half the participants answered the question to whether the risk evaluation assessment influenced the maintenance regime. The result of this question revealed that the information was used 65% of the time. This result would have been a positive outcome to the research objective and demonstrated that the industry is transitioning towards this type of maintenance delivery, but as the uptake was so small this result could not be relied upon. The study made an assumption that the participants that skipped this question were not using the results of risk evaluation assessments to influence their maintenance regime. Taking this into consideration this brought the overall percentage score down to 50%.

In conclusion, the results confirmed that risk assessment models were being utilised by the industry to test the criticality of assets however, this practice is being fully adopted across the industry. This is leaving organisations with high levels of unknown risk across their property portfolios. If a failure of critical assets were to occur business operations within these organisations are likely to be significantly affected. It is unclear as to why FM's are not actively evaluating these risks. The literature review discovered that organisations are reluctant to experiment with new maintenance methods which is a likely factor, but a theory that this study believes is that benefits are not widely recognised and there is no guidance in the industry that sets out how to assess assets for their risk.

If this theory was tested further and proved that guidance was a factor, it would confirm that this research has contributed significantly by providing a prototype assessment to enable assets to be measured based on their criticality, and would significantly reduce risk within organisations immediately.

6.4 Establish a criteria for the FM industry, in order of importance, to measure an assets criticality against.

The results of this question were fundamental to the research aim of this study. The study found it difficult to find previous research where a risk criteria had been established to evaluate assets for their risk within the FM industry. The study instead reviewed literature of instances where a risk criteria had been established in other industries. The review of these industries found that it was hard to find representative statistical data which could support a risk assessment. Therefore, risk assessment criteria's were based on input from company and industry experts, utilising their judgments and experiences to produce a structured risk analysis framework.

The review of literature allowed this study to produce a list the criteria that formed the basis of question 9. Participants were asked to rank the criteria in level of importance. The results found 4 criteria that were ranked the highest. In rank order these were:

1. Safety to People
2. Statutory Compliance
3. Asset/ System Condition
4. Capacity/ Redundancy in the System

In conclusion, the results provide a foundation based on research from participants that have Facilities Management experience at an operational level. The criteria established in this study will be imbedded into the prototype assessment produced by this study.

Where this criteria is used to measure asset criticality, whether through the use of the prototype assessment in this study or by other means, the results will have significance for a number of reasons:

1. The results will provide clarity and a strategic pathway for the management of assets differing in criticality (the maintenance strategy).
2. Will reduce the overall risk and impact critical asset pose to the operations of business operations.
3. Prolong the lifecycle of critical assets as the maintenance frequency will likely increase to avoid failure.
4. Allow maintenance activities to be streamlined, where the focus is maintaining assets that are important to the organisations they affect.

The results can have a positive impact not only to reduce the potential risk failure could cause to organisations, but also change the way maintenance is delivered allowing a move towards a predictive approach to be achieved.

A review of the criteria produced by this study by peers, felt that more should be included to measure asset impact. They felt each criteria was as important as the other and therefore should undergo scrutiny within the prototype assessment. This was considered but discounted as to stick to the research conducted in this study. There is however, the opportunity for this to be investigated in more detail in future research.

6.5 To understand if the level of technical competence of an FM will be a factor in their ability to carry out such an assessment of their assets.

The results discovered that the participants felt significant technical competence was required to complete an assessment of this nature. The literature review identified that a skills gap is present in the industry so result unsurprising. Guidance on the core competencies of Facilities Managers, published by IFMA stated that FM's should be competent to both, manage/oversee the assessment of building systems' condition and assess the condition of the facility's structure, interior, exterior and grounds.

In conclusion, the level of technical competence of an FM managing property portfolios at present is not at a level which will enable them to complete an assessment and produce results that will be of any value. It is likely that FM's will not actively use the prototype assessment produced as part of this study, instead it may be of greater benefit to businesses that support FM's with technical expertise.

6.6 Creation of a prototype assessment based on the findings of the literature review and primary research in the study.

An aim of this study was to provide an untested prototype assessment created from the findings in both the literature review and empirical research. Appendix D is an example of the prototype produced.

The Prototype begins by issuing an asset number. In the case of the example, the study used 1, 2 and 3. In future development this column may contain a specific asset number from within the CAFM system which an enable a link to be established between the operating system and this assessment.

Standard information such as building name, location and asset description have been included. A box for a photo has been included so a visual representation of the asset can be viewed, although this was based on the preference of the lead researcher and may or may not be used in future development.

The criteria established from the research in this study was imbedded in the criteria rating section of the assessment. The requirement is for the assessor to provide a score between 1 and 5 (1 being very good and 5 being extremely bad) for each of the four elements. The literature by Abbott *et al* (2007) discovered a five-point scale proved most effective. A three-point scale is too coarse for reliable results, while a seven point or more scale is too fine and difficult for assessment staff to interpret consistently.

To quantify the results of the assessed criteria, an average score cell was created. The cell was calculated by counting all of the scores for each criteria and dividing by 4 (Safety to People + Statutory Compliance + Asset or System Condition + Capacity or Redundancy in the system = Sum / 4). This sum allowed a 'likelihood' score to be calculated based on the results of the assessed assets against the criteria.

The process of risk profiling relies on the evaluation of the significance of the risk. This is also known as the consequence. The assessment relies on the assessor to rate the consequence in the same way as the criteria rating was established, with 1 being of no consequence and 5 being highly critical. The consequence rating measures the impact the failure of an asset will have on the operations of the business this asset serves.

Multiplying the Average Criteria Rating and the Consequence Rating (Average Criteria Rating x Consequence Rating) provided the 'criticality rating' for the asset. In the prototype assessment the study chose to RAG rate the results based on the level of criticality, with Red being highly critical and green being non critical. The study chose to do this based on literature by Abbott *et al* (2007) that stated colour adds another dimension to reporting by making reports more user friendly and accessible to non-technical users of the information.

The overall criticality rating has been established and the maintenance strategy for that asset can be assigned. In the prototype assessment a section at the end of the report asks for a maintenance strategy to be inputted. Assets that had a high criticality rating were assigned a predictive maintenance strategy, amber rating assigned a preventive maintenance strategy and green assigned a reactive maintenance strategy.

Although the prototype is untested, some example assets were assessed to demonstrate the use of the prototype. The assets assessed within the assessment scored between 3 and 3.25 against the criteria rating which provided the 'likelihood score'. By itself this score did not provide tangible

results to accurately assign a maintenance strategy. When a consequence score is assigned to each of these assets it becomes clear as to the importance each asset has within the portfolio and clearly shows the type of strategy to be implemented.

Section 3.3 of this paper highlighted the flaws that can be found by completing risk assessments. Redmill (2002) and Curtis and Carey (2012) explained that risk assessments are subjective and there is a degree of uncertainty, the need for judgment, considerable scope for human bias, and inaccuracy when conducting the risk assessment process. Therefore, the results produced by one risk analyst are unlikely to be obtained by other analysts starting with the same information. Although there are flaws in this approach, risk assessment techniques attempt to help people understand uncertainty and the associated risk to enable better informed decision making to happen.

7.0 Recommendations and Future Research

Recommendation	Description
Asset data collection and input processes	Research into the process of collecting asset data and inputting it into a CAFM system should be undertaken. Reviewing previous literature on the subject, making use of the lessons learned where asset data exercises have been both successful or failed and undertaking primary research will enable a robust process to be established and adopted as best practice across the industry. The benefit is that the CAFM system will contain information and produce data that is of value to the Facilities Manager and will enable the information to be used in a strategic manner further closing the gap in data interpretation.
Data Analytic skills of FM's	This study recommends that greater emphases is placed on the teaching of data analytic skills during the completion of professional qualifications and forms part of the ongoing training development of FM's in their workplace.
Brainstorming exercise with industry experts	The study provided a valuable insight into the type of criteria which FM's would find useful when assessing assets for criticality. It is recommended that this research is taken further and that extensive investigation into a criteria specific to the FM is established. Results of this study confirmed that establishing a criteria is subjective so following the approach of other industries such as, round table discussions and brainstorming exercise with industry leaders and experts will greater understanding of the criteria to be considered in future development of this subject area.
Piloting of an assessment model	This study provided an untested prototype derived from the information collected within the literature review and incorporated the criteria established as part of the empirical research of this study. Piloting this tool will provide a greater understanding of how it can be best used and what benefit it could be to the industry overall. Analysis of the portfolios where the findings of the assessment have been implemented will provide valuable insight as to whether cost savings, greater efficiency of resources and reduction of risk can be gained from by using this approach.

Table 3: Recommendations and Future research

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Appendix A – Pilot Questionnaire

Pilot Survey results

From the list below, which best describes the type of buildings your organisation is responsible for maintaining? One or more can be chosen.

Domestic/ Student Accommodation	3
Educational Facility	1
Commercial	2
Industrial	1
Hospital/ Medical Facility	2
Critical environments	

Please indicate how comprehensive your asset data is for your sites using the scale below, 1 being poor and 5 being excellent

1	2	3	4	5
1	1	2	1	

Please indicate the level of understanding you have of the maintenance strategy used in your organisation. 1 being No knowledge and 5 in-depth knowledge

1	2	3	4	5
		1	2	2

Which statement best describes the maintenance strategy you deliver across your portfolio?

Reactive only	1
Planned time based Maintenance	5
Predictive Maintenance	1

On the scale below, please indicate how digitally mature your organisation is currently. 1 being basic and 5 actively embrace and use new technologies

1	2	3	4	5
1	1	1	2	

Does your organisation use a computer aided facilities management (CAFM) system or employ the use of one supplied via a service provider?

Yes	4
No	1

What level of sophistication would you describe the system you use? 1 being basic use and 5 using the system data to influence maintenance strategy

1	2	3	4	5
1		1	3	

In your opinion, are the critical assets within your systems accurately identified? 1 being assets are not identified and 5 assets are identified.

1	2	3	4	5
3		1	1	

Do critical assets within your systems undergo a risk evaluation exercise to understand the impact of failure could have on business operation? 1, no evaluation completed to 5, fully evaluated and risks understood

1	2	3	4	5
3	1	1		

If applicable, how do the results of the risk evaluation influence the maintenance regime to the asset or system? 1 no influence and 5 results influence maintenance regimes and delivery of services

1	2	3	4	5	N/A
		1			4

If you were to undertake an assessment of M&E assets against a set criteria, From the list below, please rank the importance of each of the criteria, with 1 being the most important to you and 9 being the least important.

Asset/ System Condition									
1	2	3	4	5	6	7	8	9	
1	1	0	0	0	0	1	0	0	
9	8	0	0	0	0	3	0	0	34
Capacity/ Redundancy in the System									
1	2	3	4	5	6	7	8	9	
0	0	0	2	0	0	0	3	0	
0	0	0	12	0	0	0	6	0	18
Number of Service Failures									
1	2	3	4	5	6	7	8	9	
0	0	1	0	0	0	3	1	0	
0	0	7	0	0	0	9	2	0	18
Level of Obsolescence - Lack of Spares									

1	2	3	4	5	6	7	8	9	
0	0	0	1	0	0	1	1	2	
0	0	0	6	0	0	3	2	2	13
Safety to People									
1	2	3	4	5	6	7	8	9	
2	0	2	1	0	0	0	0	0	
18	0	14	6	0	0	0	0	0	28
Environmental impact									
1	2	3	4	5	6	7	8	9	
0	0	0	0	3	1	0	0	1	
0	0	0	0	0	4	0	0	1	20
Performance loss									
1	2	3	4	5	6	7	8	9	
0	0	0	0	2	1	0	0	2	
0	0	0	0	0	4	0	0	2	16
Financial loss									
1	2	3	4	5	6	7	8	9	
0	1	0	1	0	3	0	0	0	
0	8	0	6	0	12	0	0	0	26
Statutory Compliance									
1	2	3	4	5	6	7	8	9	
2	3	0	0	0	0	0	0	0	
18	24	0	0	0	0	0	0	0	42

In your opinion, what level of technical knowledge would be required to undertake an assessment of asset criticality on your portfolio? 1 no technical experience required to 5 technically qualified to chartered status

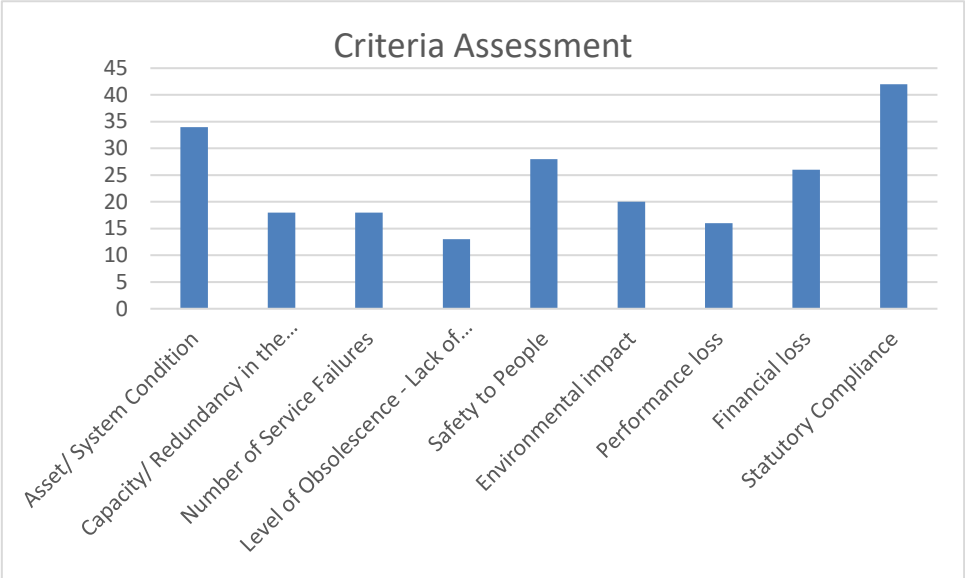
1	2	3	4	5
			5	

Additional comments

Question 4 - Add a short narrative to explain each strategy.

Putting things in order of importance can quite often lose the respondent as they just want to point or click.

Perhaps give consideration to a standardised asset maintenance process that supports the business by identifying KPIs which specifically aim to monitor and also help understand how assets and risks are being managed. Regular asset assessments by way of audits and inspections should be considered and conducted at agreed intervals however, as we know every environment can differ in its requirements therefore management should be supported in making the right decisions in relation to asset management by being given accurate evidence about each and every asset.



Appendix B – Participants consent letter

Dear Participant,

I invite you to participate in a research study entitled 'A Study into the use of Risk based asset assessments to inform M&E maintenance strategy'. I am currently enrolled in the Property and Facilities Management course at The University of Wales Trinity St. David's in Swansea, South Wales, and am in the process of writing my Master's Thesis. The purpose of the research is to provide a tool for FM professionals that allows the accurate evaluation of M&E assets and asset systems for their potential risk to core business operations. The document aims to aid the process of assessing assets and asset systems for their criticality within the real estate portfolio, where the results can be used to inform the maintenance strategy to be adopted based on the level of risk evaluated. Essentially this will allow a predictive, risk based strategy to be developed. The survey will determine the use of CAFM information, attempt to confirm a set of criteria from which an assessment of assets can be made, and whether this assessment will require any technical knowledge to complete.

Your participation has been requested as you fall within the target population of this study. The target population has been identified as people who are working within an operational environment delivering FM services. You have been selected via a 1st degree search on the social media network LinkedIn where you are a connection of the lead researcher, Paul Greatbanks.

Your participation in this research project is completely voluntary. You may decline altogether, or leave blank any questions you don't wish to answer. There are no known risks to participation beyond those encountered in everyday life. Your responses will remain confidential and anonymous. Data from this research will be reported only as a collective combined total. No one other than the researchers will know your individual answers to this survey. Data will be collected via the survey platform SurveyMonkey where the anonymous responses function within the survey parameters has been selected.

If you agree to participate in this project, please answer the questions within the survey as best you can on the link below. It should take approximately 5 minutes to complete.

<https://www.surveymonkey.co.uk/r/M7WCGJC>

If you have any questions about this project, feel free to contact Paul Greatbanks on 07847805910 or email p.greatbanks@tbanda.com. Information on the Research Ethics & Integrity Code of Practice is available through the UWTSD website on the link below:

<https://www.uwtسد.ac.uk/media/uwtسد-website/content-assets/documents/research/research-ethics-integrity-code-practice.pdf>

Thank you for your assistance in this important endeavour.

Yours Sincerely,

Paul Greatbanks

Appendix C – Research survey questions

1. What is your job title?

2. From the list below, which best describes the type of buildings you are responsible for maintaining?

- ☐ Domestic/ Student Accommodation
- ☐ Educational Facility
- ☐ Commercial
- ☐ Industrial
- ☐ Hospital/ Medical Facility
- ☐ Critical environment

3. How accurate is the asset data collected ready for input into the CAFM system?

Not accurately collected Assets accurately collected

☐

4. How accurate is the collected asset data inputted into the CAFM system?

The collected assets are not inputted as collected The collected assets are inputted accurately

☐

5. In your opinion does the level of information you receive from your CAFM system help inform decisions regarding maintenance strategy and service delivery?

Information does not inform strategy decisions The information collected informs key decisions on strategy and service delivery

☐

6. In your opinion, are the critical assets within you systems accurately identified?

Assets not identified Assets fully identified and logged

☐

7. Do critical assets within your systems undergo a risk evaluation exercise to understand the impact failure could have on business operation?

No evaluation

Fully evaluated and risks understood

8. If applicable, how do the results of the risk evaluation influence the maintenance regime to the asset or system? (If N/A move to next question)

No influence

Results influence maintenance regimes and delivery of services

9. If you were to undertake an assessment of M&E assets within your portfolio against a set criteria, from the list below, please rank the importance of each of the criteria, with 1 being the most important to you and 9 being the least important.

		Asset/ System Condition
		Capacity/ Redundancy in the System.
		Number of Service Failures over a period of 1 year.
		Level of Obsolescence - Lack of spares for repairs
		Safety to People
		Environmental impact
		Asset/ System Performance loss
		Financial loss
		Statutory Compliance

10. In your opinion, what level of M&E technical competence would be required to undertake an assessment of critical assets within your portfolio?

No Technical competence required

Technically competent to Chartered status

Appendix D - Untested prototype assessment

No.	Building	Asset Location	Asset Description	Picture of Asset	Criteria Rating (1 -Very Good, 5 - Extremely Bad)				Average Criteria Rating	Consequence Rating (1 - Low, 5 - High)	Criticality Rating	Comments	Maintenance Strategy
					Safety to People	Statutory Compliance	Asset/ System Condition	Capacity/ Redundancy in the system					
1	Building A	External	Standby generator		2	5	2	4	3.25	5	16.25	The generator is located externally to the building and poses minimal risk to people. The asset is in good condition although there is little redundancy in the system if failure should occur.	Predictive Strategy
2	Building A	Plant room	Toilet extract fan		2	1	5	5	3.25	1	3.25	The asset is not critical to the operation of the business and poses no risk to people in the event of failure. There are no statutory obligations to be completed on this asset.	Reactive Strategy
3	Building A	Data centre	A/C split unit		1	5	4	2	3	4	12	The condition of the air conditioning unit is very poor but there is redundancy in the system overall in the event of failure. The Fgas regulations applies to this unit. The unit is located in an area where people have limited access. The consequence to the business remains high.	Preventive Strategy

