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THE DEVELOPMENT OF KEY PERFORMANCE INDICATORS TO MONITOR EARLY FACILITIES MANAGEMENT PERFORMANCE THROUGH THE USE OF BIM TECHNOLOGIES IN PUBLIC SECTOR PROJECTS

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Abstract: One of the biggest threats faced by governments in delivering greater efficiency on public works is the need for the public sector to have an enhanced physical environment to operate from. The physical environment can either enhance or impede worker productivity, therefore contributing to its bottom line profits and success of the organisation. This has now resulted in the AEC sector witnessing the development and adoption of Building Information Modelling (BIM), so as to ensure a new level of functionality for the management of buildings. Despite enhanced Facilities Management (FM) being the goal of BIM, there is still reluctance and a lack of perceived benefits of having the Facility Manager involved earlier in the design phase. There remains a lack of clear evidence on what improved contribution the Facilities Manager can provide at the early design phase. This paper outlines how through early involvement of Facilities Managers, they can reduce waste and improve team productivity. The paper will detail a new process, in which the Facilities Manager will operate as a key professional and further suggests a unique set of Key Performance Indicators (KPIs) to measure the effectiveness of their contribution. The data collation methodology includes the use of data from a pilot project, which was primarily focused on shifting the project focus from design to FM, by earlier deployment of the Facilities Manager. It is hoped that the research findings will support the business case for the adoption of a more robust FM process for the public sector, facilitated by use of integrated BIM solutions.

Keywords: Building Information Modelling, Facilities Management, Facilities Manager, Key Performance Indicators, Public Works, Ireland

1. INTRODUCTION

Governments are now recognising the need to takes steps to better manage their property and must rationalise their assets to near term cost pressure. In the medium term their remains a set of structural and capability weaknesses that demand attention, not only to professionalise public sector asset management, but also to ensure property takes its rightful place at the heart of work to modernised government (Deloitte, 2012). This has resulted in a more rewarding methodology of construction being explored in recent years and has now seen the emergence of a relatively new process being adopted by international public sector bodies called Building Information Modelling (BIM). BIM is a tool that can foster project integration on different levels within the Architecture Engineering Construction /Facilities Management (AEC/FM) sector, because it can facilitate information exchange, access to real time information, and information gathering among project members (Ospina and Castro, 2010). BIM as pointed out by Hijazi and Aziz (2013) allows for progressive collection of building data and could play a key role in streamlining the data collection process, as it can be used as a platform to research and publish information by engaging a variety of stakeholders due to its user-friendly 3D visualisation. In more recent years BIM has captured the attention of the global construction industry, as a possible solution to unlocking the potential for a more productive and efficient industry. BIM can reduce the start-up time of a project and for government this translates to reduced costs both financial and in-kind (Furneaux and Kivvits, 2008).

The global impact of BIM is evident through the wide spread introduction of BIM by governments, including the USA, Finland, Norway, Denmark, Australia, UK, Germany, Singapore and Korea, who are all at various stages of implementation. This has now seen a number of these stakeholders, as observed by Samso et al. (2012), especially owners and operators, now focusing in on implementing BIM to support the Facilities Management (FM) and operations phase, with an emphasis on improving energy efficiency of their facilities. Despite the promise of enhanced FM through the use of BIM, there is still reluctance to involve the Facility Manager earlier in the design process. Samso et al. (2012) offer a number of reasons why BIM is not used for FM which include a reluctance to change, lack of knowledge, and a lack of documented metrics that have prevented Facility Managers from adopting BIM to support the Operations and Maintenance (O&M) phase. In order to advance the FM profession the authors have tasked themselves with establishing a unique set of Key Performance Indicators (KPI) that can be used to help measure and guide Facility Manger interaction within the BIM process from an early stage. It is also hoped that these KPIs can be used to measure and guide a new process being researched by the authors in which the Facilities Manager will operate as a key professional (McAuley et al. 2013).

2. LITERATURE REVIEW

The authors conducted a review of journal papers, professional publications and research articles. The literature review focused on the three main areas detailed below, in order to establish the benefits of early FM involvement in the BIM process in regards to public sector projects:

- Relevance of BIM to the Facility Management discipline;
- Early involvement of the Facility Manager in the BIM process and
- Measuring the impact of early Facility Manager involvement

2.1 Relevance of BIM to the Facility Management discipline

Facility Managers are continually faced with the challenge of improving and standardising the quality of the information they have at their disposal, both to meet day to day operational needs, as well as to provide upper management with reliable data for organizational management and planning (Sabol 2008). In specific relation to public estates BIM can attempt to streamline this process, as it can be used to integrate "digital descriptions of a built asset with all the elements that contribute to its on-going function and describe the relationship between each element e.g. air conditioning, maintenance (Furneaux and Kivvits, 2008). The authors contend that applying BIM on Public works projects can ensure better visualisation and quality of data, which can be used for FM, resulting in better management of assets.

While some of the Facility Managers needs are addressed by several existing FM information systems, as highlighted by Gerber et al. (2011), BIM, holds undeveloped possibilities for providing and supporting FM practices. Langdon (2012) outlines a number of benefits in the FM field when it comes to the BIM model including the;

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

Coates (2011) outlines that historically building operators have often been provided with O &M manuals in hardcopy or electronic form. These documents have been provided several months after the building has been in operation, and may also take considerable time to be integrated into the systems used by the Facility Managers. Sabol (2013) outlined how BIM can avoid this as it offers Facility Managers and building owners a powerful means to retrieve information from a visually accurate, virtual model of a physical facility.

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

2.2 Early involvement of the Facility Manager in the BIM process

A Facility Manager who is responsible for the maintenance management activities throughout the operational lifespan of the facility, will make a greater impact on enhancing functionality, sustainability, economy, time, and maintainability of projects and should at least play an active role in the briefing process, as this will result in operational issues been addressed from the outset (Kelly et al. 2005 and Mohammed and Hassanain, 2010). BIM can offer this opportunity as proposed by Azhar (2011), as Facility Managers can enter the picture at a much earlier stage, in which they can influence the design and construction, as the visual nature of the BIM model will allow stakeholders to make more important decisions.

Mohammad and Hassanain (2010) outlined the value that BIM can bring to the FM sector but there remains still little literature available on the role the Facilities Manager can play in this process. In the past, Facilities Managers have been included in the building planning process in a very limited way, implementing maintenance strategies based on the as-built condition at the time the owner takes possession (Azhar, 2011). The author claims that in the future, BIM modelling may allow Facilities Managers to enter the picture at a much earlier stage, in which they can influence the design and construction, as the visual nature of the BIM model will allow stakeholders to get important information e.g. tenants, service agents, etc. However finding the right time to include these people will undoubtedly be a challenge for owners. This was also highlighted by Wang et al. (2013) who identified that little research was available in outlining the benefit of integrating FM in the early design stage.

The Facilities Managers through their direct knowledge of the buildings day to day needs are in a position to offer the client an enhanced resource that could assist in leading the process from beginning to end. However, if this is to be a reality, Facilities Managers will need to have the skills to manipulate the models in a similar way as occurs at design stage (Coates, 2011) .The time for FM to be adventurous is now more than ever given the tools now been offered within the BIM process (Gannon et al. 2013). The authors claim that building owners are now in a unique position to demand change in the delivery of construction projects. The technology is available, the costs have been quantified, and the global economy has forced all parties to look for more economical solutions. Like or not, change is needed in how one designs, builds and operates facilities.

2.3 Measuring the impact of early Facility Manager Involvement

Measurement is an important part of performance management. Adages such as "you can't manage what you can't measure" and "what gets measured gets done" are common elements of management texts (Amaratunga and Baldry, 2002). FM is seen to be able to contribute to the performance of an organisation in many ways e.g. strategy, culture, etc., thus it is important to have systems to measure the effect of the FM functions on an organisation's core business, together with systems to measure FM's own performance (Pitt and Tucker, 2008). The authors advocate the use of benchmarking techniques which can significantly help FM organisations drive innovation in their performance measurement systems.

Meng and Minogue (2011) explain that performance measurement is new to FM. There is still a lack of a systematic investigation of performance measurement in the context of FM, making it difficult to justify whether these models are effective or not. Four different methods of measuring FM were reviewed which included Balanced Scorecard (BSC), Business Excellence Model (BEM), Key Performance Indicators (KPI) and Capability Maturity Models (CMM). It was ultimately found that the KPI is more popular with FM practitioners and organisations, with BSC, BEM and CMM rarely adopted by FM practitioners in their work

Jensen et al. (2012) highlights a number of ongoing research gaps within the FM field which include a continued search for the best possible KPIs on different levels (strategic/tactical/operational) and reliable and valid measurement methods. Coates et al. (2010) insist that the following attributes should be within defined KPIs:

- Does the KPI motivate the right behaviour?
- Is the measurement of this KPI affordable?
- Are the factors affecting this KPI controlled by you?
- Is the KPI measurable?
- Is the target value attainable?
- Is the KPI meaningful?

Suni and Zhou (2010) further detail more KPIs that are helpful in comparing the actual and estimated performance in terms of effectiveness, efficiency and quality of both workmanship and product. The five primary BIM KPIs that were selected by the authors included quality, cost, time, safety and energy. The area of performance management in regards to FM is still an ongoing and extremely active research area, with leading academics still voicing the need for further investigation. The importance of a measurement tool or performance indicators are required to promote the eventual move towards a standardised approach for BIM. More concerning is the lack of a measurement matrix or indicators in regards to the performance of the Facility Manager within the BIM governed design and construction. Without these important performance indicators there is no method to efficiently calculate or understand if the Facility Manager can enhance the design and construction process.

3. TECHNOLOGY PILOT

The Irish AEC in recent years are taking notice of the global adoption of BIM for public works projects. In order for the Irish Government to successfully guarantee a more reliable method of cost certainty and greater value, it is recommended, that they move towards the mandatory use of BIM on public works projects. This could potentially ensure that public sector clients would ultimately commission assets that are smarter and better equipped to face a low carbon economy, with associated reductions in delivery and carbon emissions (McAuley et al. 2012). The Forfás Report (2013) echoes this sentiment and proposes to work with industry organisations to promote the use of BIM and develop the appropriate technical skills amongst Irish construction firms, so that they can successfully compete in markets where BIM is widely adopted or a requirement. A virtual project was identified by a team of Irish Professionals who wanted to offer the opportunity to experience and disseminate practical lessons on proof of concept and the potential benefits/risks involved in utilising BIM from an FM perspective. Through the integration of the team and using smarter workflows and technologies to facilitate more collaborative practice, could result in better value for all involved, particularly the client and facility operation. One of the key objectives of the Technology Pilot was to deliberately shift project focus from design and construction to FM and operation/ whole life cycle.

3.1 Key Performance Indicators

As the FM Team would not normally be involved in a traditional process the pilot permitted the opportunity for their early input, as to what they wanted in the building, and how the information was to be delivered, so as to facilitate their job in reducing the impact on the overall lifecycle cost. The purpose of the pilot was not just to focus on the FM Team but on the overall contribution which each member within the Pilot Team can offer in reducing life cycle costs. This was important as the FM Team within the Pilot were primarily focused on best practice for the collection and handover of documentation. The focus of the entire pilot team shifting project focus from design and construction to FM permitted a greater understanding of how a new more digitally focused FM practice can be realised through early FM involvement. The authors were tasked with creating a set of KPIs that could be used to measure the benefit of the pilot process. Taking into account all of the pilot aims, the following KPIs were selected for the pilot:

1. **Pilot Team Skills and Knowledge Development (KPI 1)**
   - This will measure the pilot team's reaction and acceptance, their cultural attitudes, their skill and knowledge level and related software training will also be measured.
2. **Trust (KPI 2)**
   - This will aim to measure the high levels of trust and respect within the pilot team, effective communications, pilot team satisfaction and cultural alignment between client and pilot team.
3. **4D and 5D Technologies: Time, Safety and Budget (KPI 3, 4, 5).** On further research these are the three main KPIs that are valued the highest when it comes to 4D and 5D Technologies:
   - **Time:** This should measure the benefits of using a 4D scheduling and planning approach and the possible reduction in the pilot programme.
   - **Safety:** This will measure health, safety and environmental considerations the client and stakeholders.
   - **Budget:** This will aim to measure the savings in regards to how the adoption of current technologies can result in savings for the project.
4. **Early FM Involvement: Environmental, Financial Management, Functionality and Effectiveness, and, FM and Construction Team Engagement (KPI 6, 7, 8, 9).**
   - **Environmental:** The measurement of energy usage pre and post occupancy. This should measure energy including embodied carbon.
   - **Financial Management:** The operational expenditure.
   - **Functionality and Effectiveness:** What was achieved at the end of the whole process and was it fit for purpose. This should measure construction and quality assurance.
   - **FM and Construction Team Engagement:** To measure the value and barriers associated with the involvement of the Facilities Manager with the design and construction team.
5. **Client Satisfaction (KPI 10)**
   - This will measure if the client's awareness has become more sophisticated and their financial budgeting moves towards a more holistic process.
6. **Waste (KPI 11)**
   - To measure the part that technology can play in the reduction of waste and, therefore, CO_2 emissions through the fostering of better off- site fabrication techniques.

3.2 Pilot Process

The original framework for the pilot resulted in a development map that highlighted very complicated topographical areas, resulting in it being too difficult to design in 2D. This resulted in an enhanced brief being suggested to the client for the creation of a virtual model for the whole area which could be further used to analyse and investigate best design options. This model further presented an interesting building in the form of a Community Centre. The Community Centre was in need of refurbishment and offered the chance for the pilot team to create a sustainable and functional building. Survey data through three combined methods consisted of firstly setting up a Global Positioning System (GPS) grid of the area, and then secondly, as there were no drawings of the area or detailed surveys, an unmanned aerial vehicle (UAV) was flown over the area capturing digital information. The UAV was pre-programmed using Google earth and GPS, and was flown over the area to create a digital model of the area. Thirdly this data was combined with a laser scan of the building.

Fig 1: Model of existing building

Fig 2: Model of Scheme Design

Through combined point cloud data and orthorectified imagery a building model was constructed. As textures where applied to the model, it became more realistic and gave a good platform to make decisions on which plans, sections and elevations could be easily generated. The model was shared through Tekla BIM sight and Solibri through Industry Foundation Class (IFC). A further meeting also took place with the client and a brief was created. This brief involved two phases of the project with phase one ultimately aiming to re-evaluate the current structure and produce a solution for a more functional building. This has been based around the client's needs, which includes better thermal comfort, enhanced artificial lighting, improved acoustics, upgrade to the Crèche, as well as the addition of a shop unit. Through the use of Skype and Dropbox amongst other methods the building began to be designed while interacting online. Layers were created in Photoshop and once an outline design was created it could be modelled and checked in Ecotect wind mode.

The model was incorporated with all structural information and then used for an initial inspection to help understand the structure better. In regards to M&E the spaces where divided into four different areas of retail, office and general use areas, meeting rooms, general purpose hall and crèche. It was agreed to reuse the original floor ducts and put a package unit at ground floor level for maintenance purposes for easy access. This would improve the ventilation through the space by providing heating and cooling, so it could modulate to match the occupancy levels. A plant space was created in a hidden area behind the roof by the architect. Fan coil units were placed in the meeting room's areas, as these areas would fluctuate quite differently from one day to the next depending on occupancy levels. The crèche was treated as an independent area, as so it could be metered separately with the idea to put a small heat pump for underground heating to avoid high surface temperature for the children.

The objective of the pilot Quantity Surveying (QS) Team was to produce a cost plan which was prepared utilising both 2D and 3D software. The IFC file was pulled into the Exactal software tool Cost X that supports BIM by using digital design data to accurately estimate quantities and costs. In comparison of both methods it was found that despite the mapping issues being frustrating and tedious there were significant benefits to be reaped, as any changes to the model can be filtered quiet easily.

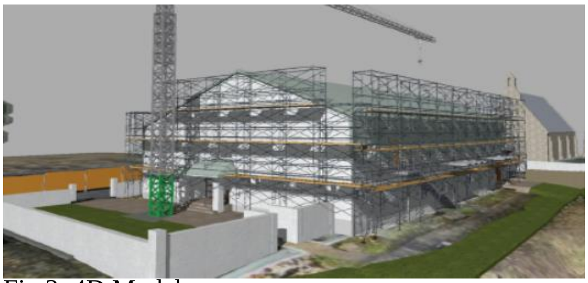

Fig 3: 4D Model

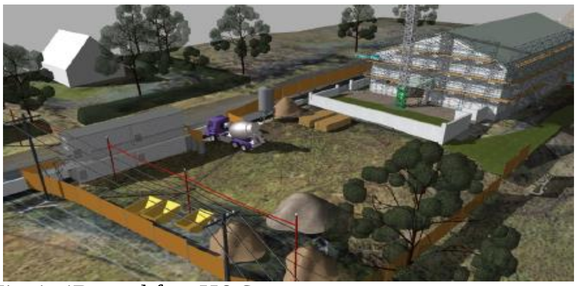

Fig 4: 4D used fort H&S

The contractors followed a construction sequence that involved site set up, demolitions, sub-structure, super structure, external envelope, M&E services, internal finishes and site work. Synchro was used for site logistics and mapped with a project schedule. The survey data showed a large drop resulting in the only place to position the on-site compound being beside this. The model permitted a Health & Safety (H&S) assessment to be carried out in which a number of precautions could be accurately estimated. Clash detection was also performed throughout this process.

A full manufacturing schedule of parts, as well as drawings of items, such as stairs in which weights where calculated was produced. The model produced files for the CNC machines, which is a process used in the manufacturing sector that involves the use of computers to control machine tools. These were exported to a German standard known as DSTV. This is a simple format that machine handlers could easily use. A manufacturing team who specialise in prefabricated BIM structures were introduced into the pilot team, so to allow for a number of pre-fabricated elements to be modelled. The IFC file was imported into Tekla Structures in which obstructive and irrelevant surfaces where filtered out, so as to identify what products could be used for the building. The model on completion was handed over to a documentation control company who were responsible for the output of all documentation. They noted that there was a number of different disciplines feeding into the model which resulted in 8-9 different IFC files all containing different pieces of information. The FM team had to merge all these pieces of information together and try to come up with a single solution. Utilising Construction Operations Building Information Exchange (COBie) and IFC data and the FM team's in-house software, a digital handover document was created of all the information for the building for the client.

3.3 Measurement of KPIs

The first five months of the pilot where analysed in the paper by McAuley et al. (2013). The results detailed below are the final results of the pilot. In order for this progress to be translated into KPIs an extensive online survey was conducted. This was complemented by on-going interactions with all the pilot team members to help further validate the KPIs accuracy. Each of the pilot team company members were emailed an online link to complete an online survey. Each question had five options of no change, little change, some change, significant change and much change. A selection of the pilot team were also interviewed to validate their responses in the survey. The results focused specifically on the FM Team's experience to-date. The following results where noted:

- **KPI 1: Skills and Knowledge Development -** 80% of participants noted some too much change when it came to knowledge, communication and collaboration skills, software skills and attitude. Compared to the previous measurement there was no change in knowledge but a significant increase in both communication and collaboration skills, as well as software skills were recorded. The FM Team who originally registered no change in communication, collaboration and software skills in the first half of the pilot reported some change in this areas as the pilot progressed. On further interviews the FM Team recognised that they gained valuable experience in terms of interacting and collecting information from a building model.
- **KPI2: Trust** - 60% of the pilot participants reported some to much change. Trust in regards to effective communication amongst other pilot team members remained low throughout the whole of the pilot with a drop noted in the second half. A reason provided for no change in this area was that traditionally all parties do their job satisfactorily and that BIM does not change this. The FM Team reported only a small change in trust in regards to other disciplines or effective communication within the pilot team in the second half of the project. They also recorded no change throughout the course of the entire project when it came to trust in either effective communications or cultural alignment between the pilot and the Client. On interview they did concur that there was more cohesion between the project team once it was working on the BIM model, leading to in some cases a better relationship in regards to trust.
- **KPI 3: Time -** There were divided opinions in regards to reduction in the pilot programme by using 4D technologies compared to other traditional construction projects. The FM and BIM QS consultant reported no change and the M&E team stating much change. The M&E team further noted that the time expended was far more than a conventional project, and they failed to complete what they would have produced in less than one week having spent hundreds of hours working on the project. This KPI stayed the same throughout the course of the pilot. The FM team's KPI measurement did not vary and there was evidence that despite early FM involvement they never had any input into any 4D Practises.
- **KPI 4: Safety** - 67% of participants noted much change in regards 4D technologies providing an advantage in health and safety, with the FM and M&E teams noting no change. The Quantity Surveyor (QS) noted that 4D technologies can result in forecasting being easier and therefore problems can be more easily foreseen and accidents can be prevented. The FM team once again noted no change in the KPI and had not perceived any benefits to be derived from 4D technologies.
- **KPI 5: Budget** - 56% of participants noted some change in 5D technologies offering an advantage compared to traditional construction methods and also in helping to predict budgets. There was a noticeable drop in the first measurement of the KPI. There was also a noticeable drop recorded in regards to the use of 5D technologies in reducing time spent predicting budgets, with the pilot team unconvinced in the second half of the pilot. The FM noted no change when it came to all three areas of this KPI. The FM team believes that 5D technologies can help make the QS more aware of the initial spend required for handover documentation. On interview the FM Team noted there was insufficient finances set aside for proper handover documentation and it is an afterthought in most jobs. The BIM QS Consultant on interview warned that there is a disconnect with designers or model authors who are not aware of how models will be consumed downstream, something that looks good to them in 3D, when one peels back the layers, may reveal gaps.
- **KPI 6: Early FM Involvement (Environmental) -** 50% of participants claimed that there was some to a significant change from having early FM input in regards to the measurement of energy usage pre and post occupancy. The KPI stayed the same throughout the course of the project with the general consensus from the pilot being that there has been some to a significant impact from early FM involvement in assisting with the measurement of energy usage pre and post occupancy, as well as evaluating sustainability options.The FM noted some change for both criteria. The QS noted that early FM involvement can inform the design and avoid the designing of non-environmentally friendly systems. The M&E contractor warned that when it came to evaluating sustainability options in some cases Facility Managers have a different agenda than a "sustainability" role.
- **KPI 7: Early FM Involvement (Financial Management)** - 78% of participants believed that the Facility Manager can help reduce future operational expenditure through early involvement. This KPI shifted throughout the course of the pilot with some of the pilot team experiencing a significant shift in their view that the Facility Manager can help improve operational expenditure. The QS noted that early FM involvement can inform the design and avoid waste of unwanted systems. The Structural Engineer added that from a holistic point of view firstly early FM involvement really means that there is a better chance that the people who procure and have to operate a building over its lifetime actually get what they thought they were going to get. This early input means that they can plan earlier and optimise/streamline the facility according to their needs, not just for finances but for everything including occupant comfort and satisfaction. The QS BIM Consultant argued that as QSs do not know what components are good or bad in a building and that early FM interaction

can assist in providing practical information that may result in a piece of equipment, such as a valve lasting longer. The FM team on interview quoted that despite an upfront cost from having them involved earlier, this could result in a big payback on the operating and maintenance side in the long term.

- **KPI 8: Early FM Involvement (Functionality and Effectiveness)** - 80% of participants noted advantages across the board in regards to early FM involvement in increasing functionality and effectiveness. This KPI recorded a spike in movement from some change to significant change in the second half of the pilot. The KPI used for measuring early FM involvement offering an enhancement in quality assurance for the client fluctuated but stayed similar throughout. The FM team noted some change across the board for each KPI. The QS believes that clients/FM input can inform the design early and can advise the design team of which products/systems suit their business / requirements.
- **KPI 9 Early FM Involvement (FM and Construction Team Engagement) -** 78 % of participants believes that the Facilities Manager can add some to much added value to the design team. This represented a small drop from the first half of the pilot. The FM documentation control team noted some change. The QS further adds that they do not foresee any barriers apart from cost i.e. the client may not see the benefit of paying a Facilities Manager from an early stage to be involved in the design. The Structural Engineer commented that one must start with the end in mind and in this case this means start by clarifying employer's requirements and especially what they want to manage (or not) over the life of the facility. The 4D specialist on interview explained that BIM is all about collaboration of all parties. It would be foolish to exclude a profession who will have a significant impact on the complete operational life of the building

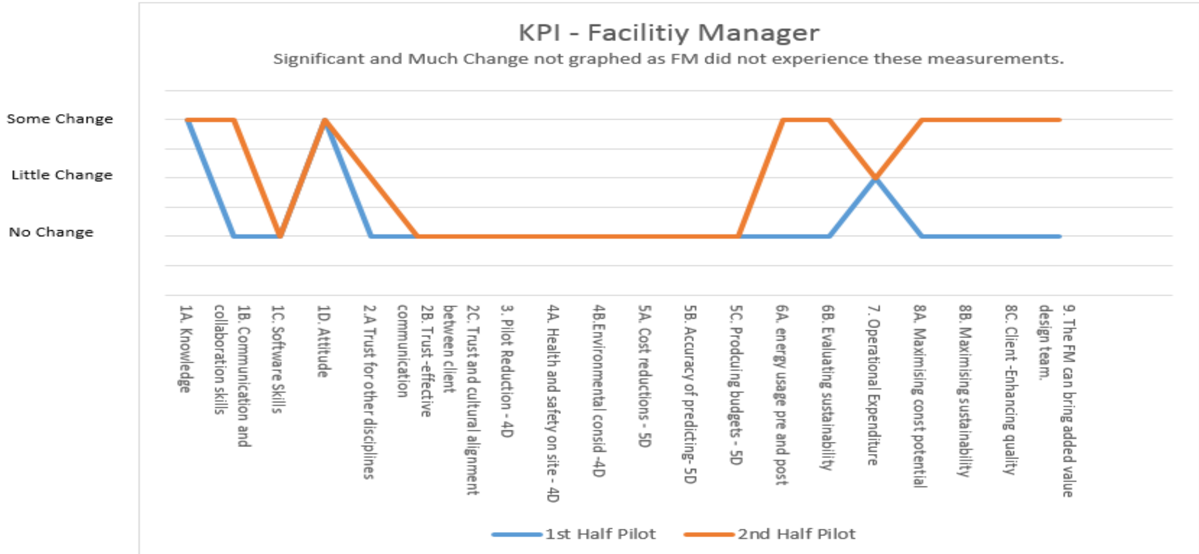

Fig 5: FM KPI 1- 9

- **KPI 10: Client Satisfaction** - 67% of participants believe that there has been some to a significant change in regards to the client's overall awareness, as well as their financial budgeting moving towards a more holistic process to incorporate wider environmental considerations. There was an encouraging 78% of the pilot participants who have recorded some to a significant change when it came to the effective management of the client's requirements. This KPI did not change much throughout the entire pilot. The pilot team believed that through understanding the building and systems it will allow the client to use all of the building's systems to their fullest capacity which will ensure value for money, the occupants and for the built environment.
- **KPI 11: Waste**- The whole pilot team are in agreement that BIM can play a part in the reduction of construction waste. Also an encouraging 88% of the pilot team indicated that technology can help reduce CO_2 emissions in regards to the pilot. This KPI did not change from the previous recording. The prefabrication contractor added that by virtually designing a building it can be readily altered to take advantage of many passive and green technologies to reduce cost, CO_2 emissions, during construction, through its lifetime.

4. CONCLUSION

This papers established a set of unique KPIs to help measure the benefits of the BIM process and the beneficial impact of the earlier involvement of the Facilities Manager. The majority of the pilot team were in agreement that the Facilities Manager can play a significant role throughout the BIM process. The Facilities Manager can help advise the design team of the clients overall needs and should be engaged by the client at early design stage to assist in evaluating the design from initial concepts onwards. The FM team believe that they could help streamline the needs of the clients to focus on the total costs over the lifecycle of the building and not just on the construction budget. There are strong synergies as evidenced through the KPIs that the Facilities Manager can play a role in the 5D process through contributing their practical knowledge to the QS's pricing expertise, to ensure a more rounded life cycle approach. Despite the lack of involvement of the FM team in the overall pilot design there is still a strong belief that they can better help co-ordinate the thoughts of the designer with the end user. The authors will aim to focus the results of the pilot to further develop a unique set of KPIs that can be used to help measure and guide Facility Manager interaction within the BIM process from an early stage.

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