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Establishing Key Performance Indicators to measure the benefit of introducing the Facilities Manager at an early stage in the Building Information Modelling Process

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The Facilities Manager occupies a unique position within the lifecycle of a building asset, as he/she is one of the only Architectural, Engineering, and Construction/Facilities Management (AEC / FM) professionals who is in a position to view the product of the entire design and build process. Despite the potential benefits that the Facilities Manager offers, this profession still remains largely undeveloped and still does not command the recognition it deserves within the AEC/FM sector. This is beginning to change through the introduction of Building Information Modelling (BIM) which can offer a new level of functionality for the management of buildings and the physical assets within them, resulting in significant potential in regard to optimising facilities and life cycle management. However, in order for this process to be maximised it is imperative that the Facilities Manager plays a much more important role within the design and construction process, as he/she will be responsible for the operational phase which incurs approximately five times the initial capital cost. Despite this, at present the role of the Facilities Manager within this process is still uncertain with no set Key Performance Indicators (KPI) or role designation being specified to date. This paper outlines how the Facilities Manager can play a pivotal role in the BIM process and will aim to establish the basis for a number of KPI's that can be used for further study to help measure the benefits of earlier FM involvement. The data collation methodology included the use of a BIM pilot project facilitated by the Construction IT Alliance in Ireland, which is primarily set around enhancing project focus from AEC to FM. It is hoped that the research findings will demonstrate the business case for the adoption of BIM and, in particular, the adoption of particular KPIs by Facility Managers leading to a more robust Lean FM practice.

Keywords Building Information Modelling, Facilities Management, Facility Manager, Key Performance Indicators, Pilot Project

I BACKGROUND

In ever changing financial landscapes it is imperative that the construction sector reacts and participates in a new digital age and utilises the available tools at its disposal. One of the most interesting technologies to have emerged within the construction sector in recent years has come through the Building Information Modelling (BIM) process.

a) Building Information Modelling

BIM is effectively a more productive method of managing the construction process with a long term view towards reducing life cycle costs of the associated assets within the project. The AEC / FM industry, as indicated by Azhar has long sought techniques to decrease project cost, increase productivity and quality, and reduce project delivery time in which BIM offers the potential to

achieve these objectives, as it stimulates the construction project in a virtual environment. [1]

b) *BIM for FM*

As the AEC / FM Sector is undergoing a radical shift it's hardly surprising that facility managers would be among the first professionals to recognise the value of having their buildings designed, built, and operated using the BIM method as outlined by Ruiz. The author further adds that this is in part due to the slumping economy; facility managers are concerned about how to operate and maintain their buildings more efficiently in order to save money [2]. Facilities management (FM) as stated by Su et al represents one of the fastest growing sectors in real estate and construction. FM encompasses and requires multidisciplinary activities, and thus has extensive information requirements [3]. While some of these needs are addressed as highlighted by Gerber et al by several existing FM information systems, BIM, which is becoming widely adopted by the construction industry, holds undeveloped possibilities for providing and supporting FM practices with its functionalities of visualization, analysis, control, and so on. [4].

In a recent survey of more than 60 building owners and FM professionals by Mortenson Construction shows that BIM/ Virtual Design and Construction (VDC), is key among owner professionals. When asked to identify the most exciting trend in FM and project delivery, 42% cited BIM/VDC as their top trend. [5]. Some Advantages of BIM for FM as detailed by Sabol include:

- Unified information base, providing a business owner's manual.
- Effective support for analysis, particularly for energy and sustainability initiatives.
- Support for emergency response and security management and scenario planning. [6]

Gerber et al further details some of the technology, process and organisational related challenges that include:

- Unclear roles and responsibilities for loading data into the model or databases and maintaining the model.
- Diversity in BIM and FM software tools, and interoperability issues.
- Lack of effective collaboration between project stakeholders for modelling and model utilisation.
- Necessity yet difficulty in software vendor's involvement, including fragmentation among different vendors, competition, and lack of common interests.

- Cultural barriers toward adopting new technology.
- Organisation wide resistance, need for investment in infrastructure, training, and new software tools.
- Lack of real-world cases and positive proof of return of investment. [4]

c) *The Role of the Facilities Manager in the BIM Process.*

BIM as detailed by Sabol is undergoing rapid adoption in the AEC / FM industry but is still a young technology and is just beginning to be adopted for use in FM [6]. We have barely scratched the surface of the "BIM for FM" topic, which is a vast and complex field by itself as claimed by Khemlani [7]. The value of what BIM can bring to the FM sector as outlined by Mohammad and Hassanain is well detailed but there is still little literature available on the role the Facilities Manager can play in this process. Direct involvement of the Facility Manager in the design stage as has the potential to reduce maintainability problems during the operational phase of a facility [8]. McAuley et al explains that the Facilities Manager, if introduced at the beginning of a structure's life-cycle, has the potential to ensure that all the operational needs of the client are addressed at the onset of construction, as the Facilities Manager would adopt a longer term perspective on the facilities created, in the construction and design of the structure. [9]. There has been as outlined by Wang et al. little research performed that has identified a framework to the approach and benefit of integrating FM in the early design stage. This can avoid and reduce the potential issues, such as rework and inappropriate allocation of workspace in the operational phase [10].

The authors in expanding on this research have set through a pilot project, about measuring the value which early FM involvement can add to the BIM process. The authors have created a unique set of Key Performance Indicators (KPI) to measure the complete Pilot process, in which it is hoped that a further set of KPI's can be established to help build on the role in which the Facilities Manager can play in the BIM process if incorporated into a design role from the beginning.

II CITA TECHNOLOGY PILOT

At present the uptake of BIM within Ireland is slow and there has been little encouragement from the Irish Government. The reality as highlighted by McAuley et al is that this is highly unlikely, as the Government Construction Contracts Committee forms of contracts would have to provide BIM procedures or an execution plan template, as part

of the Capital Works Management Framework guidelines, which at present seems unlikely due to low tender prices been already achieved [11]. While a real project as outlined by the pilot chair Paul Sexton is not available at this time, a virtual project was identified which would offer the opportunity to experience and disseminate practical lessons on proof of concept and the potential benefits/risks involved. 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. The key objectives of the Technology Pilot are:

1. Focus on integrating the team and fostering collaborative working/ decision making throughout all stages of the process.
2. Use a variety of 'BIM' authoring and interface tools/ technologies plus other ICT to enable/ streamline the efficiency of the process.
3. Deliberately shift project focus from design and construction to FM and operation/ whole life cycle.
4. Focus on the removal of waste (time, material, resources and effort) and only those things that add value for the Client & project Team.
5. Focus on the Real Value created with attempt to qualify/ quantify during the process for project team including client and FM. [12]

The key objectives are strongly based around ensuring that the FM process is brought to the beginning of the design process. To achieve this along with the other goals a transparent environment was established in which all pilot companies had open communication and access to each other's work. This also resulted in an attempt to incorporate all professions into an Integrated Project Delivery (IPD) environment which included the FM Team. As the FM Team wouldn't normally be involved in a traditional process it permitted the opportunity for their early input, as to what they want in the building, and how they want the information to be delivered at the end, so as to facilitate their job in reducing the impact of the overall lifecycle cost. The purpose of the pilot was not just to focus on the FM Team but on the overall contribution to what each member within the Pilot Team can offer in reducing life cycle costs. This is important as the FM Team within the Pilot are 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 will permit a greater understanding of how a new more digitally focused FM practice can be realised through early FM involvement. This will offer the opportunity for the authors to put in place the development of a Lean FM process through mapping the interactions of the FM Team and other professionals within the BIM Process.

The authors were tasked with creating a set of KPI's that could be used to measure the benefit of the pilot process.

a) Key Performance Indicators

The concept of using indicators as outlined by Haponava and Jibouri, to assess performance originates from the theory of benchmarking used in many industries for improving business processes and products. The concept involves measuring one or more aspects of the business or part of it and comparing it with the best in its specific sector [13]. Barbuio explains that KPIs are used because they highlight those aspects of performance that are integral above all others in providing insights on performance and how it can be improved[14]. Coates et al. claim that the following attributes are sought for the definition of KPIs:

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

The author's further state KPIs can form a method of comparing the success of different BIM adoptions in terms of:

- Measuring the quality of projects.
- Standardising information and measurement process throughout the community.
- Setting appropriate benchmarking targets.
- Recording effectiveness of action [15]

Sun and Zhou further detail more KPI's 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 [16]. BIM adopters as outlined by Mom and Hseih may choose a single or mixed framework based on their own needs. The performance measures should be as small as possible and new measures are added to account for changes [17].

The KPI's were designed around the five overarching aims of the CITA Technology Pilot. The overall attributes detailed below were used to help define the major KPIs:

- Acceptable – they can be understood;
- Suitable – they measure important things;

- Feasible – they are easy to collect;
- Effective – they concentrate on encouraging the right behaviour; and
- Aligned –non financial measures must link to financial goals.

Taking into account all of the pilot aims and attributes in establishing KPIs and recent KPI suggestions, the following KPIs have been drafted for the CITA Technology 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 and managed accordingly. This should seek to measure where the value for each member of the team lies.
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. This should ultimately aim to quantify the benefits of team integration and close collaboration.
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 that comes with this process. This should also aim to measure the team's time and expenses associated with the pilot, as well as, preparation for Building Regulations Submission.
 - Safety: This will measure Health, safety and environmental considerations for both 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). The following KPIs (6,7 and 8) are being used by the UK FM Cabinet Office to establish the key measures / areas from the early stage of design into post occupancy, as they pass through the whole BIM process. These KPI's will aim to measure the:

- 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 it 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 from the start of the BIM process.
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 to incorporate wider environmental considerations. This will also aim to measure the effective management of the client's requirements and where the value lies for the client.
 6. Waste (KPI 11)
 - To measure the part that technology can play in the reduction of waste and, therefore, CO2 emissions through the fostering of better off-site fabrication techniques and better practices both financially and environmental.

b) Pilot progress to date

The pilot project timeframe was commissioned from January to November to run in tandem with the CITA Technology Series. The following progress to date represents work carried out from January until early June. The authors' role within the Pilot was to act as the chief researchers and to ensure a measurement tool was in place to map the progress of the Pilot Team. Though the KPIs were not the focus of the pilot team, it was one of the main research goals of the authors. The pilot project as outlined in the next section will give a generic look of the pilot to date in which will be translated into KPIs. It is hoped through the broad scope of KPI's used to measure progress to date, will lead to the development of a future set of KPI's primarily related to the FM profession. This will be achieved through a greater understanding of how each profession interacts with the FM Team and uses their knowledge to bring the FM process to the beginning of the design process. This will allow the authors an understanding, as so to further suggest key areas where early FM interaction and decisions could prove key to the BIM process.

The original framework for the Pilot Project resulted in a development map that produced a number of interesting areas in which the topographical areas where complicated,

resulting in it being too difficult to design on a 2D campus. This resulted in an enhanced brief being suggested to the Client for the creation of a virtual model for the whole area which could be further used to analyse and investigate best design options. This virtual interactive model could also be utilised by the planning department to analyse planning applications. This model further presented an interesting building in the form of Rowlestown community centre. The community centre was in need of some form of refurbishment and offered the chance for the CITA Pilot Team to create a sustainable and functional building.

Survey data was provided for the project through three combined methods that consisted of firstly setting up a Global Positioning System (GPS) grid of the area, and then secondly, as there were no drawings of the area or detailed surveys, a 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 over a four hour period. Thirdly this data was combined with the laser scan of the building. Using a cloud based solution provided by Team Platform a full colour point cloud could be given to every team member.

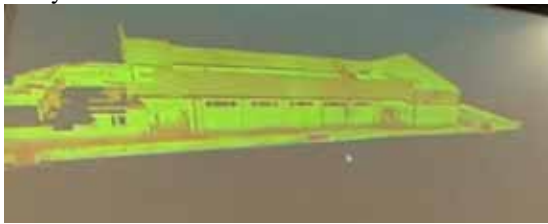


Fig 1: Point Cloud of Building

Before commencement of the scheme design there were a number of different standards investigated. The AEC (UK) BIM Standards were consulted before modelling began and it was decided through these standards that file naming convention would be adapted. All the library objects would also be renamed with a uniclass 2. The 3D terrain model received from survey data was then imported into Archicad, which was further taken through Google Sketchup. Cloud data was also received. The point data was explored by importing into Google Sketchup. The team received a complete model of the building which was 30GB in size. The survey information originally imported into the platform of Archicad took up to 8 hours to import. A simplified model (300 Mb) was used with 20 million point cloud and a setting filter distance which took only an hour and half to import, thus creating a simplified 3D model picture. Through combined point cloud data and orthorectified imagery a building model was constructed. As textures were applied to the model, it became more realistic and gave a good

platform to make decisions in which plans, sections and elevations could be easily generated.

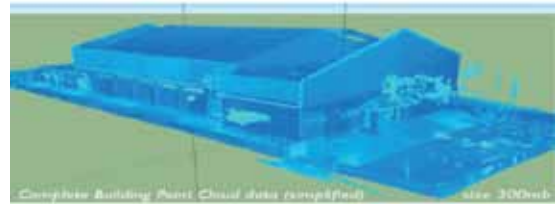


Fig 2: Complete Building Point Cloud Data (Simplified)

The model was shared through Tekla BIM sight and Solibri through IFC. By running the model through both Tekla BIM sight and Solibri it represented the opportunity to verify the integrity of the model through two different platforms. Some issues were raised between Tekla and Solibri included a 5-10% difference in quantities. 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 reevaluate the current structure and produce a solution for a more functional building. This has been based around the Clients 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 model. It was found the new suggested extensions to the building would deflect the wind.



Fig 3: Model of Existing Building



Fig 4: Model of Scheme Design in Context

The FM Pilot Team began to become involved and informed that COBie would be used as the main data exchange for the deliverables for FM data. Data for FM only comes in at the end of a project but in a true environment this data should be received from them at the start. The first opportunity to see information coming from the model was through an IFC file created by the pilot

Architect. This was exported into a software tool that would develop a documentation index called InControl DFM Software. The FM team noted that there is no direct means of getting a datasheet from a BIM model. The documentation for the item within the model is embedded and may have ten pieces of information leading to a very large Spreadsheet. The model was revised to incorporate all the information put in by the FM team. 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. This allows the contractor from the offset to see where a number of possible problem areas may occur. It also allows for a number of construction methodologies to be examined and further savings for the client. The building's interior was modelled so that an informed design could be undertaken. This resulted in the client and planning authorities being able to easily understand the design intent within the location.

The pilot team along with the M&E designer sat around the table and discussed the vision with regards to plant. The space was divided into four different areas of retail, office and general use areas, meeting rooms, general purpose hall and crèche. The first task was to reduce the energy cost and so, therefore, it was important to go around each of the elements and assess the possible U-value that can be achieved, air tightness and sealing around elements. The M&E pilot consultants conducted heat analysis and cooling loads on these elements. In terms of ventilation and heating there was not a passive solution that lent itself to the structure in regards to the hall. It was agreed to reuse the original floor ducts and put a package unit at ground floor for maintenance purpose for easy access. This would improve the ventilation through the space by providing heating and cooling, so it could modulate to match the occupancy levels. A plant space was created in a hidden area behind the roof by the architect. 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. This ensures that there would be heat ventilation circulation to make sure the place could be heated without having to open all the windows.

The areas of FM and whole life cycle costing were strongly taken on board. There was a deck area and below it directly is the plant room. The AH Package unit was placed there and the heat pump located within a room beside it. This was also designed with the view of ease of access to ensure that all future maintenance could easily take place. A

BMS was also considered which would depend on price which would enable the building to become more user friendly and prevent a lack of information causing further problems. This would allow the option to control running costs and a web alert or sms alert to be sent to designated people to inform them if the building needs attention.

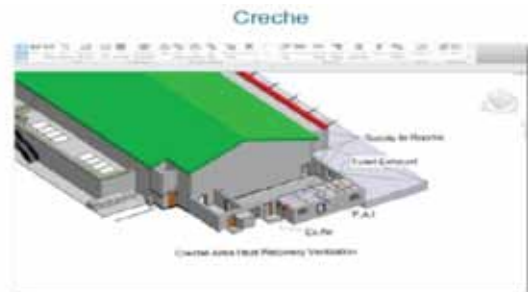


Fig 5: Creche

The model has incorporated all the structural and M&E information. Some outline specification has been drafted for the purpose of the QS, with all elements being classified in accordance with uniclass 2. The objective of the pilot QS Team was to produce a cost plan from both 2D and 3D. The preliminary cost plan has been calculated in both 2D and 3D information

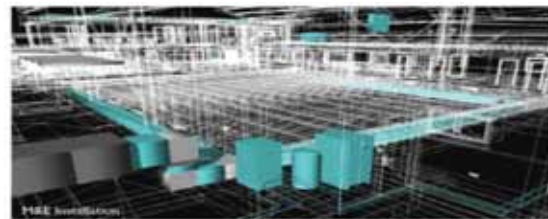


Fig 6: Structural Design

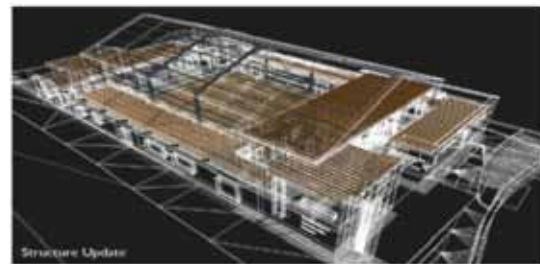


Fig 6.3 M&E Design

c) Measurement of KPI's

The previous section provided a detailed summary to date. In order for this progress to be translated into KPIs an extensive online survey was conducted. This was complimented with on-going interaction with all pilot team members to help further validate the KPI's accuracy. Each of the pilot team company members were emailed an online link to complete the survey. Each question

had five options of no change, little change, some change, significant change and much change. The results will focus more strongly on the FM Teams experience to date. The following results were noted:

- KPI 1 - 70% of the team reported some to significant change across the board when it came to knowledge, communication and collaboration skills, software skills and attitude. Everyone within the pilot team received some change in their knowledge. The FM Team were the only pilot team members who have had no change in communication, collaboration and software skills to date. Despite this it was noted that it has been a positive experience and it is encouraging to see how other consultants work, what their requirements are etc.
- KPI 2 – There was a high change of trust across the board with 80% of the pilot team members reporting some to significant change. The FM Team reported no change in trust in regards to other disciplines or effective communication within the pilot team. There was a belief by some of the pilot team that there has been transparency through open discussions in regards to true experiences which has allowed an understanding of the pilot team member's requirements better.
- KPI 3 – It must be noted that the contractor was changed during the pilot, and the new contractor did not have really have an opportunity to use 4D constructability review and planning and health & safety review through BIM. There was divided opinions in regards to reduction in the pilot programme by using 4D technologies compared to other traditional construction projects, with the FM and QS team reporting no change and the Geographical Survey team stating a significant change. 50% of the pilot team reported some change in their time and expense which they have encountered by working within the pilot.
- KPI 4 – The views were split in regards to 4D technologies providing an advantage in regards to health and safety, with the FM team reporting no change and the geographical survey team and Architect reporting a significant change. 75% of the pilot team reported some to a significant change in environmental considerations through the use of 4D technologies.
- KPI 5 –83% of the pilot team believed that 5D technologies have been an advantage in predicting budgets; reducing time spent on budgets and cost reductions in the budget. The Architect noted that for investigation of design options it would be significant if 5D costing occurred in the earlier stages for optimal feedback.
- KPI 6 - 75% of the pilot team 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. Early involvement and early adoption of end user FM systems was seen as vital component within the BIM process. Early FM management can dictate the best positioning and materials and processes to be used in any project. There has been very little done in this regard to date as noted by the FM Team and has predominantly been carried out by the M&E consultant.
- KPI 7 - 75% of the pilot team believed that the Facilities Manager can help improve operational expenditure. The Architect and steel manufacturing team indicated a significant change while the contractor indicated no change. The Architect has noted that the earlier systems are specified and integrated into the design the better chance they have to impact the financial management. Other pilot team members have noted that the preference for sustainability and low running costs post contract has led to the M&E estimates being quite high as stated by the QS. The FM Team have noted that early indications suggest that it will cost more at design stage for FM Involvement.
- KPI 8 - 87.5% of the pilot team noted advantages across the board in regards to early FM involvement in increasing the Functionality & Effectiveness. There was a significant change noted of 50% when it comes to maximising the sustainability potential. The pilot contractor stated that there has been no change from early FM involvement. The QS noted that early involvement will inform the design team of the Facilities Manager needs post contract and can therefore design accordingly from the outset instead of changing during tender stage or post contract stage. The geographical surveying pilot team member stated that early FM involvement is a must for the functionality of the project, bringing in new skills at an early stage can only be beneficial, for energy use/ building layout. The Architect acknowledged that advance knowledge and FM systems choice means advanced ways to simulate and optimise the systems to be installed.
- KPI 9 - The whole pilot team believed that the Facilities Manager can bring some to significant added value / change to the design team. The FM team believed the Facilities Manager can bring added value / change to the design

team but there has been little involvement to date. The Architect noted that it was important to have the Facilities Manager involved early on, as the consultant has requirements on how objects are encoded to contain as much COBie data as possible.

- KPI 10 –50% of the respondents claimed that there has been a significant change in the clients awareness and 81% reported some to significant change in the clients budgeting moving towards a more holistic approach and effective management of the clients requirement.
- KPI 11 – All of the pilot team claimed that technology can help reduce construction and CO² waste in some to a significant way. The geographical surveying team noted that technology reduced the time they spent on site by 45%.

III Conclusion

The CITA Pilot's aim was ultimately to shift project focus from design and construction to FM and operation/ whole life cycle. To achieve this the Facilities Manager was integrated, as part of the design team, within the BIM process. The authors established a set of unique KPI's to help measure the benefits of the BIM process and the role early adoption of the Facilities Manager can play. The pilot project to date is mid-way and all of the pilot team are in the agreement that the Facilities Manager can play a significant role in ensuring the most functional and practical structure can be realised. The Facilities Manager can help ensure that the most relevant data is embedded into the model that will be of most benefit when it comes to the operation of the building. However, there are signs within the pilot that the Facilities Manager is unsure of the benefit that they can provide and have not like other professions advanced their communication, trust, collaboration and software skills. The most benefit that has been achieved in the FM field within the pilot has resulted from the M&E team who have designed the building to be more sustainable and energy efficient. There is also the concern that it will cost more at design stage for FM Involvement. The FM team believe that the Facilities Manager can bring added value to the design team but as of yet there has been little involvement. This may change as the pilot advances and the role of the Facilities Manger will continue to be measured and monitored. The pilot project has helped establish the beginning of a new Lean FM practice to be developed by the author. Though the Facilities Manger to date has not participated in the role that the feel they could offer the most potential as a professional, it has permitted the author the opportunity to view and record first hand through the transparent nature of the pilot the barriers that currently exist. This result will help further develop a unique set of KPI's 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 been researched by the authors in which the Facilities Manager will operate as a key professional. It is hoped that this will advocate the adoption of a more robust Lean FM.

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