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Developing Key Performance Indicators to Measure the Effectiveness of Early Facilities Management Performance on BIM Governed Public Sector Projects

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Abstract− Governments across the globe are now recognising the need to take steps to better manage their property portfolios due to the escalating costs of operating these buildings over their lifetime. This has seen them turn towards innovative work practices and technologies offered by Building Information Modelling (BIM). It is now becoming increasingly evident that BIM can bring significant added value to the design, construction and most importantly to the operational life of a public sector development project. This experience has resulted in a number of governments moving towards implementing BIM for all public works projects. BIM allows the building to be designed collaboratively within a unique integrated environment which aims to produce a more rewarding and cost efficient building for the end-user. Despite enhanced Facilities Management (FM) being the goal of this collaborative BIM approach, there is still a reluctance and a lack of perceived benefits of having the Facility Manager involved earlier in the design phase. Some of the reasons for this is a clear lack of metrics to quantify the contribution that the Facility Manager can provide at the early design phase. This paper will detail a new process, in which the Facilities Manager will operate as a key professional at an early stage and further suggest 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 number of public sector pilot projects and extensive surveys that have been scientifically analysed through thematic analysis to establish common themes and trends. These common themes represent some of the key areas where the Facilities Manager can have the greatest effect when introduced into the construction team. 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 the use of a suite of unique KPIs.

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

I BACKGROUND

Public sector bodies are responsible for diverse, expensive but capital intensive assets, which require the adaption to all changes taking place in their environment, as well as anticipation of future challenges [1]. One of the biggest threats faced by international 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 [2]. A poorly designed public building can now significantly impact on an international government's monetary budget. With 85% of the life cycle cost of a facility occurring after construction is completed, this demonstrates that the information needs of the Facilities Manager far outweigh those of the design and construction professionals [3]. Liu and Issa noted that the largest building cost component over its life-cycle is maintenance which can be ignored in the design phase [4]. This was reinforced by

Kassem et al who reported a $15.8 billion loss caused by interoperability inefficiencies, with $10.6 billion attributed to the operations and maintenance phase of a building [5].

These reported losses have seen a number of governments turn towards Information and Communications Technology (ICT) in order to explore new ways of getting improved productivity and cost savings from public sector construction projects. The primary objective for this approach is to seek a pre-construction digital representation of all the required information [6]. The ICT tool increasingly being chosen is BIM [7]. Samso et al., observed that public owners and operators are increasingly focusing on implementing BIM, to support the FM and operations phase of their facilities [8]. Governments around the world have recognised the inefficiencies affecting the construction industry in general, and have either recommended or mandated the use of BIM as a strategy for addressing declining productivity [5].

BIM for FM in the Public Sector

The 2014 McGraw Hill Smart Market Report asserts that BIM usage is gaining powerful momentum, with major private and government owners now utilising the benefits of a faster, more certain project delivery, and more reliable quality and cost. [10]. The application of BIM can be used by FM departments for renovations, space planning, and maintenance operations, as well as to perform forensically a graphical analysis that can highlight possible failures, maintenance defects, etc. [11]. In specific relation to public estates BIM can attempt to streamline this process, as it can be used to digitise a detailed description of the building and the important elements that contribute to its ongoing O&M, as well as describing how each element is linked [7].

Volk et al. also acknowledge that there are significant additional benefits for BIM that include valuable 'as-built' documentation, maintenance of warranty and service information, quality control, assessment and monitoring, energy and space management, emergency management and using structured up-to date building information to reduce errors with regards to deconstruction or retrofitting [12].

For Facility Managers, BIM Software can be a powerful new tool to enhance a building's performance and manage O&M activities more rewardingly throughout a building's life. The model can help to automate the creation of inventory lists for equipment, populate current FM systems and reduce redundancy in the maintenance of facility data for FM activities [13]. With BIM, the Facility Manager will be better equipped to perform an interrogation of the reported problem which will save time and effort that would have been otherwise wasted looking for relevant and accurate information [14]. Despite the promise of enhanced FM through the use of BIM, there is still a reluctance to involve the Facility Manager earlier in the design process.

The Role of the Facilities Manager in the BIM Process.

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 [15]. BIM will offer a new dimension of maintenance, as it will offer a platform for the building's lifecycle, it will also allow the Facility Manager to challenge the model in respect to the impact on operational cost or maintenance [16] [5].

The Facilities Manager can help advice the design team of the client's overall needs and should be engaged by the client at early design stage to assist in evaluating the design from initial concepts onwards. They can further help co-ordinate the thoughts of the designer with the end-user [17]. BIM brings Facilities Managers closer to project conceptualization and pre-construction stages than they were in traditional processes of project development. BIM will only add value to the FM process where modellers or designers are able to share facilities managers' values right from the very early stages of project life [18]. Facility Managers have traditionally been included in the building lifecycle in a very limited way, which has resulted in different design decisions not usually challenged for their impact on operational cost or maintenance. BIM in FM will facilitate the future involvement of Facility Managers at a much earlier design stage, in order to convey their input and influence on the design and construction of a building. [5].

Despite the claims made by a number of authors with regards to early Facility Manager involvement in the BIM process, it is still not a common or established procedure. Wang et al., has outlined that little research is evident in investigating the benefit of integrating FM in the early design stage [19]. Kelly et al further highlight a number of procedural and cultural mind-set issues as to why BIM for FM is not readily adopted, which includes the need for Facility Managers to be involved earlier instead of at a very late phase in the project [9].

A number of significant developments have attempted to include the end-user in the BIM-governed construction processes. These include the UK Government Soft Landings (GSL) in where the end-user has been brought in to help refine the design in half day workshops [20]. The General Services Administration (GSA) has used building managers to help define essential FM data [21]. In Penn State the Facility Managers have access to the latest attribute information and geometric data [22]. Despite the contributions made here by the end-user as a group or the Facility Manager in a number of cases, their involvement has been unstructured and is dependent to a large extent on the open mindedness of the design team.

In order to justify their inclusion the authors sought to develop KPIs to translate their specific contribution.

Quantifying Early Facility Manager Involvement

Sarkar et al. sought to identify the KPIs that affects the usage of BIM as a FM tool. Through the use of a questionnaire aimed at the Indian AEC/FM sector they established 15 KPIs from 69 responses that where further grouped into five different components as detailed in Table 1.

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

Table 1: BIM for FM KPIS – Source Sarkar et al (2015, pp 373)

The above table details some areas where using the BIM model for FM purposes is of most benefit and identifies the potential KPIs to measure these. The framework as intended is generic in nature and is intended to offer guidance on how to use the model. These KPIs do not offer any guidance of how the Facilities Manager can play a role in the construction process and focuses more on the technical aspects of FM, not the strategic relevance [23].

Zadeh et al. detailed a BIM quality assessment approach for FM where they detailed three critical areas that must be represented in the model from a FM perspective, in order to avoid significant quality issues, including inaccurate, incomplete, or unnecessary information. The three detailed areas of FM include asset information, MEP systems and spaces. The authors advocate the use of this research to be deployed by owners to create suitable BIM-quality strategies and assure the quality of required information for the operations, in the early phases of the project. These areas could be possible categories in which early deployment of the Facilities Manager could assist [24].

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

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

There has been some positive results in recent UK pilots that include Shonks Mill and Liverpool Prison. However the KPIs are extremely generic and do not provide a focus or any particular guidance of where the Facilities Managers expertise can be best realised. The KPIs are at most a guidance to help measure generic areas of benefit which early FM could possibly contribute. The results range from involvement in workshops and structured questions in face to face meetings. The strong majority of the case studies involved post occupancy evaluation and showed little

involvement in the actual BIM design process. [20].

The area of performance management with regards to FM is still an ongoing and an active research area, with leading academics still voicing the need for further investigation. More concerning is the lack of a measurement matrix or indicators with 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. This is the overreaching aim of the authors' research.

II Methodology

The author's research to-date has sought to identify the KPI's that would be of most benefit in quantifying early Facilities Manager involvement in the BIM process on publically funded projects. This has involved a research approach that has encompassed both quantitative and qualitative data. In order to further validate this data before final testing in the field it was decided to perform an extensive scientific analysis of all qualitative data recorded to date. The purpose of this was to ensure that there was a high level of rigor and analysis placed on the results, as so to justify the KPIs to be tested before final refinement of the results. This involved the thematic analysis of all qualitative data from three public sector BIM projects and two extensive surveys. A total of 104 sources are represented in the results. However this has been reduced to 19, as each survey has been designated as a single source despite having multiple responses to open ended question from a number of professionals. Each interview was treated as a separate source.

Thematic Analysis can be described as a method for identifying, analysing, and reporting patterns (themes) within data. Braun and Clarke describe a six phase process to thematic analysis which has now become the predominant approach [25]. These phases have been followed by the authors in the analysis of the data. The authors choose to adopt Nvivo software for the thematic analysis as it less labour intensive than manually assigning and analysing codes though paper transcripts.

The first phase involved interrogating the research and generating nodes within each piece of primary research. This involved manually scrolling through all the data and systemically coding lines of text to the relevant nodes. The second phase involved developing categories in which consisted in the collating of codes into themes. This involved going through each of the nodes and then organising them into categories. The third phase involved reviewing the categories to ensure the coded themes work in relation to the extracts. This involved reviewing the categories and breaking down the now restructured categories into sub-categories to offer a more in depth understanding. The next phase of the thematic analysis involved defining and naming themes and the reduction of data. This produced 3 key themes that had a total of 69 nodes. Memos where further linked to the analysis as this enabled one to record the ideas, insights, interpretations or growing understanding of the material in the project. Important aspects of the interview or data where recorded through annotations. This permits the recording of comments, reminders or observations about specific content in a source or node.

The following key themes have emerged as detailed in Table 3:

1. Management of Irish Public Sector Assets.
2. Role in the Design and Construction Stage.
3. Key Performance Areas.

Theme		SC	CC
Theme 1	Management of Irish Public Assets	8	196
Theme 2	Role in the Design and Construction Stage	13	347
Theme 3	FM Key Performance Areas	13	349

Table 2: Key Themes (SC = Sources Coded i.e. a total of 19 different elements of primary research were coded.SC represents how many elements of primary research this theme was coded in within this figure. CC= Citations coded i.e. how many times this theme was coded within all of the primary research. A theme could be coded multiple times within one element of primary research).

Theme 1

In establishing any criteria that will be used as a basis for early Facilities Manager involvement it was paramount that current problems within the Irish estate are assessed. This involved breaking theme one into four distinct nodes, as detailed in Table 4. Each node within Table 4 was further broken down into its further sub themes.

Theme 1: Management of Irish Public Assets	SC	CC
Government Estate Problems	**7**	**51**
Government Facilities Management	**7**	**66**
Early Facility Manager Involvement	**6**	**36**
BIM for FM	**5**	**43**

Table 3: Management of Irish Public Assets

The theme of "Management of Irish Public Assets" aimed to establish prevalent themes with regards to the operating of public sector assets. It was discovered that the most prevailing themes with regards to public sector estate problems involved the improper use of the building, lack of documentation and staffing concerns due to a lack of knowledge in the operating of the building. It was discovered that public sector buildings, apart from third level institutions, do not have Facility Managers as defined by traditional standards but instead use district inspectors and accommodation officers. This results in these professionals contacting the property maintenance division through a helpdesk that has ultimately resulted in a reactive based maintenance division that has cost substantial monies in Dublin alone. This is despite the use of Measured Term Maintenance (MTM) contracts to provide reactive and planned maintenance services for Government offices in the Dublin Region.

The concept of FM is not lost on the Irish public sector as seen through recent initiatives, such as the Public Sector Reform Plan (PSRP) and its commitment to adopting current European FM standards, with a focus on maximising workstation spaces. The public sector has also sought to commission a number of BIM public works governed projects such as the Greystones Coastal project. BIM adoption on publically funded projects in Ireland is slow but incremental adoption within the public sector design process has occurred with the overall goal of providing an enhanced FM solution. This is where concerns begin to surface in regards to the poor Integrated Project Delivery (IPD) system in place within the public sector due to its fragmented nature.

Despite BIM being advocated as one of the greatest benefit to the public sector from an FM perspective, the property maintenance sector is not engaging with BIM. If a strategic FM consultation is required the normal process is to deflect to the M&E department, who at present are not in the positon to contribute sufficiently to the model.

Early FM input during design and construction is usually restricted to the district inspector or accommodation officer. When consulted they usually operate as a clerk of works and have little opportunity to contribute to the construction process. The property maintenance division is usually overlooked, as they are not viewed as possessing any additional knowledge to that of the architect or M&E engineer.

The Office of Public Work (OPW) who are charged with the operation and maintenance of many public buildings in Ireland are excluding the people who will be responsible for operating the building and have confined them to an operational contribution in targeting reactive maintenance issues.

Theme 2

The results derived from the Irish Public Sector Estate theme are in direct conflict to literature reviewed by the authors[15] [17] [26]. While the overreaching aim of introducing BIM into the public works is to offer a more rewarding FM practice, it has been discovered that the FM discipline as a whole is not viewed as a contributing factor to this. The inclusion of the Facilities Manager in the construction process is not a concept that is practised on publically funded Irish projects.

It was important to create a theme to investigate the role of the Facility Manager in the construction process. This would permit the coding of all relevant data to this theme node and enable the researcher to establish the key themes within this area. This involved breaking the theme two into three distinct nodes, as detailed in Table 5. Each node within Table 5 was further broken down into its various sub themes.

Theme 2: Role in the Design and Construction process	SC	CC
Design Contributions	12	135
Consultant Role	11	149
Perceived Barriers	6	63

Table 4: Role in the Design and Construction process

The node of "Role in the Design and Construction Process" aimed to establish the prevalent themes with regards to the best place for the Facility Manager to occupy within the overall BIM governed design and construction process. The most prevailing theme was that they should be involved within the initial design, as they can assist the design team due to their in-depth understanding of how the building will be used. They are viewed as being able to offer a different perspective and in some cases possibly inputting or deciding data to go into the model.

On further exploration it was revealed that the role best suited to achieve this was a maintenance and plant / M&E consultant. It was suggested that these persons could provide feedback to the design team with regards to maintenance related issues. Their knowledge of what M&E systems and parts work most efficiently is significant.

As already highlighted in the first theme, the M&E department is viewed as the strategic arm of the public sector when it comes to plant related items. It will be hard for the Facility Manager to justify a contribution within this area.

Other areas of contribution that were prevalent include that of an energy consultant. Another prevailing theme that has been revealed is that of the Facilities Manager in assisting with life cycle costs. They can provide the QS with a more accurate life cycle figure based on their knowledge of existing O&M criteria. This will help provide different costing alternatives for the client. A number of barriers to their involvement still exists as evident from the analysis. These included a fear that their presence would result in additional consultant fees and a lack of understanding with regards to the construction process. There was also a concern that they do not have the knowledge required to add to the construction process which in turn will slow the design down due to it becoming too congested.

Theme 3

The first two themes have analysed the current state of the Irish public sector and its management. It has found that the Facility Manager is not viewed as a strategic partner in the construction process. Despite this the public sector tentatively pushes forward with BIM despite no FM involvement except for the M&E arm of the state. The application of BIM in partnership with early Facility Manager involvement has been voiced as part of a solution that will more effectively address common public sector problems. The purpose of the next node is to thematically analyse the contribution of the Facilties Manager within each of these areas.

This again involved breaking the theme down into distinct nodes, as detailed in Table 6. Each node within Table 6 was further broken down into further sub themes.

Theme 3: Key Performance Areas	SC	CC
Maintenance	11	136
M&E	6	74
Energy Management	5	49
Space	4	27
Occupant Behaviour	3	25
Costing	5	18
Data Control	6	13
Materials	3	7

Table 5: Key Performance Areas

The node of "Key Performance Areas" aimed to establish the prevalent themes with regards to where the contribution of the Facility Manager in the early BIM process would be of most benefit. The most prevailing theme is that they can have the greatest influence with regards to maintenance related issues. This is aligned with the findings of theme two, where it was discovered that one of their most beneficial roles is that of a maintenance consultant. They can use their knowledge of operational efficiency as a skillset in helping to reduce operational costs by using their knowledge to specify equipment with minimal maintenance requirements. This will ultimately reduce future costs. This will ensure more focus is placed on the operational expenditure and not on the capital cost. They can also reduce the functionality risk by providing an in depth analysis of how the building will be required to function on a daily basis. They can make more certain that systems installed are not only functional but are easily maintained and accessible from a maintenance perspective.

Other strong themes include their contribution from an M&E perspective, where, they can use their skillset to reduce operational costs. They can ensure that the systems installed are not only functional but are easily maintained therefore avoiding plant down time. They can assist in specifying heating systems, as they will have an in depth understanding of how the building will be used and can contribute to the layout of the plant room, so as to ensure ease of access for maintenance purposes. They can help reduce power consumption by specifying equipment with low energy demand. However, as previously analysed given that the public sector already has a strategic M&E department these expectations may need to be managed.

Within theme two there was a recognition that the Facility Manager can assist in the role of an energy consultant. As seen with the maintenance and M&E sub theme the Facility Manager by default through selection of environmentally friendly systems can help in reducing energy usage. They can specify equipment that is functional but also energy conscious. This is important as the operational costs as previously detailed by Aguilar and Ashcraft, can be as much as 85% of the complete life cycle cost [3]. The Facility Managers can provide professional advice on energy performance based on previous sustainability strategies from similar buildings.

Other sub themes that developed included their early introduction in contributing their practical knowledge for the floor layout in regards to the better utilization of the work space and more prac-

tical layout of the office from a services point of view. The correct utilisation of space can increase worker productivity. Their intimate knowledge of occupant behaviour can assist with communicating the needs of the end-user to the design team therefore ensuring the building can be tailored to the exact requirements of the occupant. Their knowledge of occupant behaviour and their working habits, as well as end-user feedback can ensure that a more accurate model is produced, as well as more accurate energy analysis.

A further sub theme that also developed was within the area of the Facility Manager assisting the QS in producing a more focused life cycle cost by providing a greater focus on the operational cost. Other sub themes include the Facility Manager validating the model from an FM perspective with regards to specifying the type of information and the level of detail they want in the model. There was also evidence that they may be able to assist in materials selection by illustrating how the selection of high-quality materials may result in less replacement costs.

III CONCLUSIONS

The purpose of this thematic analysis was to ensure the proposed KPIs for early Facility Manager involvement address some of the key concerns now faced by the Irish public sector estate, so that a combination of BIM and early Facility Manager involvement could be justified as a valid approach. This involved analysing current public sector problems and the current management role of the Facility Manager.

It was ultimately found that the most prevailing themes in regards to public sector estate problems involved improper use of the building, lack of documentation and staff concerns with regards to the operation of the building. The analysis also showed that the Facility Manager and their team are confined to an operational role that respond through a helpdesk system to reactive maintenance requests.

FM involvement, as seen through the analysis, is a fundamental ingredient in the design of a building in regards to reducing the operational spend. The analysis further showed that the Facility Manager could have an important role in the BIM process during the design.

The dominant theme included the operational efficiency skillset of facility managers in helping to reduce operational costs and provide important information on the daily function of the building, therefore reducing the associated functionality risk. Facility managers can work with the design team to ensure they design for safe maintenance and accessibility. They can further assist in the layout and selection of M&E plant for both accessibility and efficiency related criteria. Their knowledge of occupants and their working habits can be fed to the design team who can translate these concerns into the model. They can further assist in working with the QS to provide more realistic life cycle cost estimates

While the Facility Manager can have an impact on some of the current estate problems other areas will need to be addressed from a staffing viewpoint. Buildings designed for a set purpose are being further impacted on by not having the correct staff to operate them. It can be argued that early FM involvement and the production of a valid asset information model will position the building in a better position for emergency preparedness and therefore continued business continuity. The early involvement of the Facility Manager can assist in a more rounded handover, therefore avoiding some of the issues associated with poor completion of works.

The scientific analysis of the data collated by the authors has assisted in the establishment of a set of KPIs that will be further validated in the field.

REFERENCES

[1] Rymarzak M. and Trojanowski D. (2012), Asset Management of the Public Sector in Poland, *Real Estate Management and Valuation,* vol. 21, no. 1, pp. 5-13.

[2] Teicholz, E. (2001) *Facility Design and Management Handbook,* McGraw Hill.

[3] Aguilar, K.A. and Ashcraft, H.W. (2013) Legal Issues when considering BIM for Facilities Managerment, *BIM for Facility Managers,* John Wiley and Sons, pp 85 -106

[4] Liu, R. and Issa, R.R.A (2013) Issues in BIM for Facility Management from Industry Practitioners'
Perspectives, *Journal of Computing in Civil Engineering*, pp 411 -418

[5] Kassem, M., Kelly, G., Dawood, N., Serginson, M. & Lockley, S. (2015), BIM in facilities manage-ment applications: a case study of a large univer-sity complex, Built Environment Project and As-set Management, Vol. 5 Iss 3 pp. 261 - 277

[6] Howard, R. and Bjork, B.C. (2008) Building Information Modelling –Experts' Views on Standardisation and Industry Deployment, *Advanced Engineering Informatic*s, Volume 22, Issue 2, April 2008, Pages 271-280

[7] Furneaux, C. and Kivvits, R (2008) BIM – implications for government, *CRC for Construction Innovation,* Brisbane.

[8] Samso, F.F., Laine. T. and Hensel, B. (2012) Building information modelling supporting facilities management, *Proceedings of the ECCPM 2012 conference on eWork and eBusiness in Architecture, Engineering and Construction, pp 51-57,* Reykjavik, 25-27th July.

[9] Kelly, G., Serginson, M., Lockley, S., Dawood, N. & Kassem M. (2013). BIM for facility management: a review and a case study investigating the value and challenges. In: N. Dawood and M. Kassem (Eds.), *Proceedings of the 13th international Conference on Construction Applications of Virtual Reality, pp191-199,* 30-31 October, London, UK

[10]McGraw Hill Report (2014) The Business Value of BIM for Construction in major Global Markets, How Construction around the World are Driving Innovation with BIM, *McGraw Hill Smart Market Report*

[11] Azhar, S. (2011) Building Information Modelling (BIM): Trends, Benefits, Risks, and Challenges for the AEC Industry, *Leadership and Management in Engineering*, 11(3), 241–252.

[12] Volk, R.; Stengel, J. and Schultmann, F. (2014) BIM for existing buildings – literature review and future needs, *Automation in Construction,* 38, pp.109-127

[13] Brinda1, T.N and. Prasanna, E (2014) Developments of Facility Management Using Building Information Modelling, *International Journal of Innovative Research in Science, Engineering and Technology,* Vol. 3, Issue 4, available at < http://www.ijirset.com/upload/2014/april/70_Developments.pdf> accessed (31/08/2015)

[14]Codinhoto,C., Kiviniemi, A., Kemmer, S., Essiet, U.M, Donato, V. and Tonso, L.G. (2013) *BIM-FM: Manchester Town Hall Complex,* Manchester City Council, available at < http://www.academia.edu/6833145/BIM_FM_Manchester_Town_Hall_Complex_-_Research_Report_2> accessed (31/08/2015)

[15] McAuley, B, Hore, A.V. and West, R. (2013), Establishing Key Performance Indicators to measure the benefit of introducing the Facilities Manager at an early stage in the Building Information Modelling Process, *International Journal of 3-D Information Modeling,* Vol 2, Iss 4, pp 38-51.

[16] Lindkvis, C. (2015) Contextualizing learning approaches which shape BIM for maintenance, *Built Environment Project and Asset Management,* Vol. 5 Iss 3, pp. 318–330

[17] McAuley, B, Hore, A.V. and West, R. (2015) The Development of Key Performance Indicators to Monitor Early Facilities Management Performance Through the Use of BIM Technologies in Public Sector Projects, *Proceedings of the 2nd Proceedings International Conference on Civil and Building Engineering Informatics*, pp 1-8, Tokyo, Japan, 23-25th April

[18] Olatunji, A.O. and Akanmu , A. (2015),BIM-FM and consequential loss: how consequential can design models be?, *Built Environment Project and Asset Management,* Vol. 5 Iss 3, 304 - 317

[19] Y.Wang, X.Wang, J.Wang, P. Yung, and G. Jun, Engagement of facilities management in design stage through BIM: framework and a case study, Advances in Civil Engineering, *vol. 2013,* 8 pages, *Article ID* 189105,

[20]GSL (2015) *Government Soft Landings,* available at http://www.bimtaskgroup.org/gsl/ accessed 9 24/8/2015)

[21]Yee, P. (2012) An Owner's Perspective on BIM
and Facility Management, *Journal of Building Information Modeling,* The National Institute of Building Sciences buildingSMART alliance, Spring Edition, available at < https://www.wbdg.org/pdfs/jbim_spring12.pdf> accessed (31/08/2015)

[22] Gannon, E.J., Kasprzak, C.J. and Nulton, E. (2013) Developing Effective BIM Implementation Methodologies within an Owner Organization, *Proceddings of the CITA BIM Gathering,* Dublin, Nov 14th – 15th, pp 85-89

[23] Sarkar, D., Raghavendra. H.B. and Ruparelia. (2015) Role of Key Performance Indicators for evaluating the usage of BIM as tool for Facility Management of Construction Projects, *International journal of civil and structural engineering,* Volume 5, No 4, available at< http://www.ipublishing.co.in/ijcserarticles/twelve/articles/volfive/EIJCSE5034.pdf> accessed (31/08//20150

[24] Zadeh1, P.A, Staub-French, S. and Pottinger, R. (2015) Review of BIM Quality Ass*essment Approaches for Facility Management, 5th International/11th Construction Specialty Conference*, Vancouver, British Columbia, June 8 to June 10, available at < https://circle.ubc.ca/bitstream/handle/2429/53726/Zadeh_P_et_al_ICSC15_342_Review_Of_Bim.pdf?sequence=1> accessed (31/08/2015)

[25] Braun, V. and Clarke, V. (2006) Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3 (2). pp. 77-101.

[26] McAuley, B, Hore, A.V, West, R. And Rowland, D. (2013) Enhancing the Facilties Management Process through the application of BIM as a tool for managing the Irish Public Sector Estates, *Corporate Real Estate Journal*, Vol 3, Iss 2, pp 119-133.