BIM-FM Implementation:
An Exploratory Invesigation

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ABSTRACT

Considerable amount of research has been developed that investigate the benefits of Building Information Modelling (BIM) for design and construction. However, as suggested in the UK Government Strategy, the relevant gains and difficulties related to the adoption of BIM in the operational stages of the project life cycle are considerably less explored in the available literature. In this respect, a gap of knowledge exists in relation to the value that design and construction information modelling can generate after construction is finished. Moreover, the difficulties involved in shifting from traditional to BIM-Based FM processes are not known. In this article a discussion is proposed that address some of the issues involved in the adoption of BIM from an owners' perspective. In addition, enablers and barriers to BIM implementation in FM are identified. The discussion is drawn from the results of a case study carried out during the design and construction stage of a major re-development project in Manchester, UK. Data was gathered through interviews with designers, contractors and client's representatives, real-time observation of BIM development and use and documental analysis. Results indicate a lack of awareness related to the benefits that BIM can offer to FM processes. It also suggests that guidance is necessary for the establishment of the necessary steps for the implementation of BIM for FM purposes such as the identification of key deliverables (capabilities), the establishment of the level of integration, the definition of the maturity level and the standard BIM protocols.

Keywords: *BIM Implementation, Building Information Modelling (BIM), Construction, Design, Facilities Management (FM)*

1. INTRODUCTION

In the UK and all over the world the race for better results in architectural / engineering / construction (AEC) industries has been supported by an improved and instrumental information modelling system – Building Information Modelling (BIM). In North America (in particular), more and more successful cases of BIM implementation start being reported (McGraw Hill, 2008). In Europe, the adoption of BIM has increased considerably in the last five years (McGraw Hill, 2008) as BIM implementation is seen as extremely beneficial to AEC clients. More recently, this subject has also attracted the attention of AEC clients, who

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can benefit the most from BIM adoption, thus playing pivotal role influencing change in AEC industry (Eastman et al., 2011).

To date, it is still difficult to define what BIM is and involves. As discussed by Succar (2005) "The boundaries of Building Information Modelling as a term-definition, set of technologies and group of processes is fast changing even before being widely adopted by the industry. As a term, BIM seems to have somehow stabilised now, but as a set of technologies/processes, its boundaries are rapidly expanding". In this article, BIM is the result of a step change towards better-integrated information and processes, enabled by technology and collaborative working practices across and within disciplines and functions of a project, organisation or industry.

The interdisciplinary and inter-functional characteristic of BIM within and beyond AEC demands a series of actions from all members of a project team pre and post construction. For instance, the design and construction team must establish standard protocols that support information being exchanged across teams within different phases. Also, inefficient processes must be identified up-front so implementation can target relevant problems and results can be measured afterwards. Moreover, the level of integration needs to be defined and required changes in processes to support integration agreed. Despite some understanding about what it is required to adopt BIM, quite often the necessary actions for extending the use of BIM to the operational phase of the project life cycle are not clear. Thus, lessons have to be drawn from what is known about BIM as applied to design and construction.

With regard to BIM lessons, these have been framed into several different subjects according to what is needed for its implementation or in relation to what the benefits are from its adoption at project and organisation levels. In regards to guidance for its implementation, textbooks and articles in this filed discuss issues such as BIM implementation at strategic (Smith & Tardif, 2009) and operational levels (Kiviniemi et al., 2007; Underwood & Isikdag, 2010; Eastman et al., 2011) including the support it provides to design (Ma et al., 2005; Treeck & Rank, 2006; Brandon & Kocaturk, 2008; Sacks & Barak, 2008; Barack et al., 2009; Cetiner, 2010; Kocaturk & Medjdoub, 2011), production management (Koo & Fisher, 2000; Dawood et al., 2003; Jongeling & Olofsson, 2007; and Russell et al., 2009) or to achieve improved sustainability (Azhar et al., 2011) and interoperability (Lertlakkhanakul et al., 2006; Olatunji & Sher, 2010). In relation to operations and facilities management (FM) from both project and organisational perspectives, examples include CRC (2007), Sabol (2008), Smith and Tardif (2009), Onyenobi et al. (2010), Rebolj et al. (2010), Autodesk (2011) and Forns-Samso (2011).

With regards to BIM for FM in particular, the UK Government Strategy indicates that the relevant gains from BIM adoption will be perceived in the operational stages, where more efficient processes for managing the utilisation of public assets can be established (BIM Industry Working Group -IWG- 2011). However, evidence that sustain the predicted operational gains does not exist and research addressing the implementation of BIM for FM purposes remains scarce. Thus, this article aims at contributing to this theme by exploring issues emerging in the implementation of BIM for FM purposes. The research presented here differs from the previously mentioned research as it was based on the investigation of a case where a bottom-up approach to the implementation of BIM for FM started being considered by the client in the early stages of design and construction. Several aspects were investigated including those related to BIM standard protocols, maturity levels, scope of work, collaboration pathway, implementation process and benefits from adoption. The necessary background and the findings of the research are presented in the following.

2. TOWARDS BIM FM

The positive results achieved through the adoption of BIM within design and construction phases have inspired its use in other areas such as facilities management. In this respect, there is a general perception that BIM works as an enabler for improvement in FM. Eastman et al. (2011), for instance, argue that "owners can realize significant benefits on projects by using BIM processes and tools to streamline the delivery of higher quality and better performing buildings". The UK government shares the same expectation and predicts considerable gains in terms of accurate asset information, improved carbon efficiency and better decision-making process (BIM IWG, 2011).

Despite the high level of expectation, very little is known in terms of measured FM benefits. According to Bew and Underwood (2010) hard evidence that demonstrate benefits within FM is rare. This aspect is discussed by Eastman et al. (2011) through a number of BIM applications along with the related benefits for owners. It is argued here that the benefits presented by these authors are project-based, i.e. improves the design and construction phase rather than supports the business proposition of the client. Similarly, The UK BIM IWG (2011) suggests that improved access and generation of information will support decision-making at operational and strategic levels. In this case, the focus seems restricted to hard FM[1]. This emphasis on design and construction related benefits indicate and reinforces a level of uncertainty in regards to BIM benefits for facilities management beyond building construction and fabric maintenance. The same emphasis (on design and construction related outputs) is noted in relation to BIM capability maturity levels for FM.

As discussed by Succar (2009a, 2009b), a general lack of understanding exists in terms of BIM capabilities and maturity levels. For Succar (2009b) BIM capability refers to the ability of generating BIM deliverables and services, whereas BIM maturity levels refer to the extent, depth, quality, predictability and repeatability of these deliverables and services. For FM purposes, examples of BIM capability will include information about the building fabric, statutory rules and key operations that are part of the core business offered by owners. In this respect, the set of core capabilities varies due to its dependency on the type business. However, common to all BIM capable businesses is the need to embrace a 'model-based multi-disciplinary collaboration environment', or a "network-based, interdisciplinary and interfunctional integration (Succar, 2009b).

Despite a clear academic definition, the lack of real cases makes the understanding of its operationalization difficult. There are only a few reported examples available where clients (public or private) can relate to and draw analogies from so to define their own capability model. Notwithstanding the lack of clarity and preparedness, the available recommendation is that clients should request specific information to be delivered by the supply chain at key defined points in the delivery process (BIM IWG, 2011) so to support the use of BIM within operational stages.

More advanced though is the situation related to maturity levels. Generally speaking, 'maturity model' is simply a set of performance improvement levels that can be achieved by an organisation or a project team (Succar, 2009a)". Thus, Capability Maturity Models identify a set of standardised process improvement levels (or maturity levels) which allow implementers to achieve significant business benefits" (Succar, 2009b). For this purpose, myriad models exist as presented by Succar (2009a). For Succar (2009b), the measurement of maturity levels, in general, fits two mains purposes. First, it shows the state of the art of an organisation in relation to its use of BIM-enabled set of technologies and group of processes. Secondly, this understanding provides direction for improvement. This principle applies to design, construction or FM processes.

In relation to capability maturity models, none of the existing models were developed specifically for FM purposes and their adequacy to FM remains untested. In this respect, a current initiative to fulfil this gap relates to the adoption of the BSi B/555 maturity matrix (BSi, 2011) for public projects developed in the UK. The UK government strategy is set to achieve Level 2 of maturity (BIM IWG, 2011) and this model provides guidance in terms of the necessary steps to be undertaken for BIM implementation. For instance, a project or organisation aiming at achieving Level 2 should use COBie for the exchange of information between designers, contractors and the client. According to the BIM IWG (2011), COBie should deliver consistent and structured asset information useful to the owner-operator for post-occupancy decision-making.

In general, the adoption of BIM requires changing from traditional non-intelligent data to BIM-based intelligent information system. According to Jung and Gibson (1999) and Jung and Joo (2011) these changes impacts in many areas within an organisation, but in particular 3 areas are of concern: Technology (Property, relation, standards and utilisation), Perspective (Project, organisation and industry) and Business Function (e.g. Planning, design, estimating, scheduling, etc.). Similarly, Eastman et al., (2011) argues that significant changes are necessary in thedelivery process, the selection of service providers, the approach to projects and in order to incorporate the use of BIM-based processes and technologies into their projects owners also need to change contract language and specifications, as well as project requirements.

In addition to Jung and Joo (2011) framework for implementation, other models exist to assist the implementation of the necessary changes. For instance, the BIM Project Execution Planning Procedure (CIC, 2010) was designed to steer owners, program managers, and early project participants through a structured process to develop detailed, consistent plans for projects. These models promote an incremental approach to the implementation. By this way, critical processes are streamlined and project/organisation integration is achieved gradually taking into account that the mount of information generated through this process can increase considerably.

Although BIM promise to generate benefits and overcome problems in the design, construction, and management of buildings, the obstacles to its adoption cannot be neglected. According to Kiviniemi et al. (2008) these obstacles can be typified in four categories: Legal problems refer to the undefined responsibilities of data content in the models and the legal status of these models compared to other documents. Business problems are concerned with the allocations of roles, responsibilities, and rewards as identified by Bernstein and Pittman (2004) and Yan and Damian (2008). Human problems are related to the fear of changing and resistance to alterations in roles (Yan & Damian, 2008). Finally, technical problems are related to the immaturity of software, particularly in terms of data exchange and interoperability (Bernstein & Pittman, 2004; Yan & Damian, 2008). With regards to BIM adoption for FM purposes, Forns-Samso (2011) argue that the inherent reluctance to change and the costs of changing are relevant factors precluding the adoption of BIM. Also of significant importance is the general lack of knowledge and understanding about the benefits that BIM can offer, the lack of documented metrics and general problems related to data updating and maintenance.

Finally, despite all the uncertainty and lack of clarity within the industry, the push for the adoption of BIM from a clients' perspective represents a relevant step forward. Many areas have improved considerably, but there are none that cannot benefit from examples and discussions related to the topics discussed above, i.e. expected benefits, levels of maturity and collaboration, as well as other areas such as the establishment of protocols for data gathering and exchange, implementation and leadership issues, and the impact BIM can have on the scope of work of designers and contractors if requested by their clients.

3. MIRAGES OF BIM

Lawson (1998) discusses some mirages concerning the application of computer to architectural design. These were related to the introduction of computer-automated design (CAD) software in architectural practices and how people expected them to change the design process. Nowadays, these software are mainstream tools used in the design process and the extent of the benefits generated by these is further understood. Nonetheless, a new set of mirages has emerged, driven by the introduction and popularisation of new computational tools that support the devising of building information models. In this section, five mirages in terms of what BIM is (and is not) able to deliver are discussed. These do not aim to create an extensive list, but to draw attention to the role of BIM and how it contributes towards an organisation's goals.

Firstly, information models should be viewed as tools and because of that it is still necessary to have clear goals in using them in order to achieve the desired benefits. An information model is not a silver bullet nor a panacea that will solve all problems of an organisation (Coates et al., 2010). Nor will it resolve all the interdisciplinary inefficiencies in the construction industry. As any tool, it has limitations and they need to be recognized. A first mirage is to consider BIM as a solution to all problems.

Secondly, the design process has problems that result from its intrinsic features. Although, building information modelling can assist in better addressing these, it cannot completely change the nature of the design process. For instance, the design process is usually complex and multi-disciplinary (Lawson, 1998). The problem of how the agents are managed, how they communicate with one another, and how they make decisions is at the core of the design process (Lawson, 1998). Integrated building information models foster communication and greater integration across the agents involved in the design process. Nonetheless, it is mirage to consider that the introduction of BIM solely, without changes in the organisation's processes and overall culture, will enhance the communication and facilitate the decision-making process.

A third mirage is that a building information model is a single model. Although this could happen in simple projects, usually there is a set of shared data that is formed by building information models from different domains (Kiviniemi et al., 2005a). For instance, there is the architectural model, the mechanical and electrical model, the structural model, the construction model, the maintenance model and so on and these are integrated in a structure that supports these different models (Kiviniemi et al., 2005a). The difficulty lies in managing the changes introduced by the proprietary agents of the different models and in how the models from the different domains related to one another (Kiviniemi et al., 2005b).

A fourth mirage, usually closely associated to the third one is that additionally to being a single model, a building information model is an all-purpose model. Again, although this can occur, it cannot be assumed to be the overall situation. By all-purpose model, it is meant that a the single model could be used interchangeably in different software for performing different analysis such as energy performance, structural analysis, quantity take-offs, among others. More often than not, such 'interchangeability' is not possible and it is necessary to edit and modify the model in order for the different analysis to be adequately performed (Bazjanac and Kiviniemi, 2007). This means that the use of a model for different purposes is not as effortless or as quickly as it might look like.

A fifth mirage, also associated to the two previous ones, is that a building information model should contain all types of information. In fact, aiming to introduce too much information without considering how it will be managed and used can create unnecessary work to be carried out upfront that do not generate benefits downstream. In general, different types of information are needed at different stages of a product development process. Also, different projects call for different types of information depending on the goals to be achieved. This leads back to the first mirage and the need to clearly defined the purpose of an information model and its goals, taking into account the benefits that an organisation is seeking to achieve. (Rothenberg, 1989)

4. REMARKS

Within this section several aspects related to the adoption of BIM for FM purposes were discussed including current problems, barriers and over-optimistic expectations. Among the main problems and issues identified are the lack of evidence BIM supports improvements in FM, the general lacking of understanding regarding BIM capabilities and related maturity levels and the absence of cases where to draw analogies and lessons from.

Amongst the barriers to BIM adoption are the unwillingness to change the current process; the cost required for undertaking process change; lack of personnel resources, and problems related to data updating and maintenance; the seamless interfaces with current software, the lack of proven benefits, the time required to produce the models, the lack of standards and process, lack of contractual documentation, and the lack of readiness of BIM for addressing operations and management issues.

Five mirages related to BIM were also identified. Firstly, BIM as a panacea solution that will eliminate all the problems within a project; Secondly, it is mirage to consider that the introduction of BIM solely, without changes in the organisation's processes and overall culture, will enhance communication and facilitate decision-making. Thirdly, that a building information model is a single model; Fourthly, that BIM generates all-purpose models that can be used interchangeably in different software for performing different types of multi-disciplinary and inter-functional and organisational analysis; and Finally, that an information model should contain as much information as possible about all characteristic of the artefact being developed or operated.

These issues identified to this point are relevant in supporting the data analysis of the study carried in this research project. In this respect, the research method and findings of this investigation are presented in detail in the following section.

5. METHODOLOGY

The research strategy adopted for this research was case study. As defined by Yin (2003) case study research is used to contribute to our knowledge of individual, group, organisational, social, political, and related phenomena. As the aim of this research was to explore issues related to BIM implementation, a decision was made to follow as project where BIM was being implemented as opposed to a project where this process was completed. By following this process, the research team could identify the issues as they were emerging and discuss them with the project team at the point of occurrence. In this respect, a major (12500sqm / £40m) construction redevelopment of a public building in Manchester UK was chosen. The redevelopment consisted in major works in two existing buildings that were originally built in the 1870s and 1930s. In this project, the client established that BIM had to be used in design and construction. This process was used by the client as an initial step towards the implementation of BIM for FM purposes. Several techniques were used for data collection as presented in the following.

5.1. Data Collection

- **Non-Participant Observations of Design Development:** Included observing design work progress in the work environment. This activity had researchers staying in the design working space (*Open Plan Project Office*) during working hours. Researcher observed ad hoc meetings between the design and contractor team and clients as well as the design team modelling the building. In instances where there was doubt about the procedures observed, the researcher asked the observed person/group of people to provide details. The design team was required to provide images of the model in development as a source of evidence of the work developed. The observation was registered with process register protocol.

In total 15 days (6 hours a day) were used to collect data.

- **Interviews:** In total 11 semi-structured interviews were conducted with the multidisciplinary project team (i.e. designers, contractor and client's representatives). The duration of interviews varied between 45 to 60 minutes. A semi-structured interview pro-forma was devised to guide the interview process. The interview had 3 main areas including the background of the interviewee, the use of BIM within the project and facilitators and barriers to its implementation. Interviews were tape-recorded and a consent form was provided to all interviewees. Two interviews were also carried out with two facilities managers in order to investigate their requirements and needs in relation to maximising the use of BIM for FM purposes. The interviews were also used to assess the integration between the data organized into the room data sheet and the information demanded to manage the facility.
- **Archival Documental Analysis:** A documental analysis was carried out to identify BIM related roles and responsibilities within the project. It also aimed at identifying the BIM related scope of activities that have been established and practiced amongst the participants of the project. Documents analysed included the Invitation to Tender (Business Case) and the Contract between the client and the project team.
- **Workshop:** A 3 hours workshop was conducted with the project team (designer, contractor and client's representatives) in order to validate the research findings. In total, 11 people attended the workshop and 4 researchers were involved in capturing participants' views (agreement and disagreement) of the results presented). The main objectives of the workshop were: a) to validate the perceived BIM Maturity Level. For this purpose, the NBIMS Capability Maturity Matrix (NBIMS, 2007) was given to attendees for assessment. The NBIMS CMM is a framework composed of 11 areas where BIM can be implemented and a range of 10 levels varying from non-BIM to completely BIM supported. This model was used do its practicality in assessing maturity in short periods of time; and b) to validate perceived BIM benefits, barriers within the project. For this objective, an information package containing the results of the research was sent 2 days prior the workshop.

5.2. Data Analysis

The research had several smaller units of analysis drawn from the literature that supports better understanding the implementation and use of BIM from owners' perspectives as presented below:

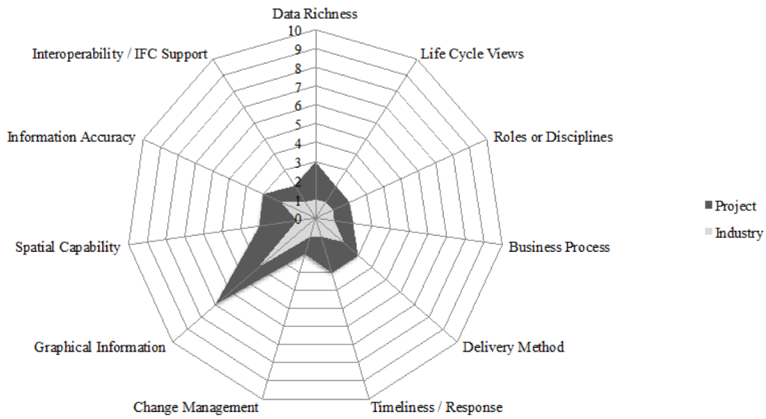
- **Capability Maturity Level:** The assessment of the level of capability and maturity of BIM implementation was made *a priori* by the research team. The results of the assessment were presented to project team members for validation. To this end, 3 frameworks were used: the NBIMS exchange tiers (NBIMS, 2007); the BSI BIM implementation maturity model (BSI, 2011); and the NBIMS capability maturity model (NBIMS, 2007). Only the latter is presented in this article.
- **Formal and Informal Contractual Relationships:** Interviews and documental analysis were used to understand the contractual relationships (formal and informal) between the stakeholders involved in the project. The object of analysis was work relationships between team members and the unit of analysis was the capacity of setting work tasks for each other.
- **Scope of Works:** Interviews and documental analysis were used to understand the scope of works for the project team (designers and contractors). The unit of analysis was contracted work, expected work content and delivered work.

- **Consideration of FM Needs:** Interviews and documental analysis were used to understand the FM needs for BIM. In this respect, the unit of analysis was problems and inefficiencies in hard and soft FM processes that could benefit from BIM.
- **BIM Assisted Design:** Non-participant observations and documental analysis were used to understand the extent that BIM supports design decision making in all phases of the project.
- **Information Exchange Standards***:* Interviews and documental analysis were used to understand how information was exchanged and stored including the identification of software packages, protocols for information manipulation and media for information exchange.
- **BIM Implementation Process:** Interviews and documental analysis were used to understand what steps and initiatives were undertaken and the perceived facilitators and barriers to the successful implementation of BIM.
- **Expected BIM-FM Benefits:** Interviews were used to identify the expected use of BIM for hard and soft FM after project completion.

6. RESEARCH FINDINGS

- **Capability Maturity Level Assessment:** The assessment of the BIM maturity level according to the NBIMS CMM framework shows that project (at the assessment point) was at an early stage of BIM implementation scoring between 2 to 3 in many areas (Figure 1). The scores given initially by each of the 11 project team representatives varied considerably in each area of assessment. This was expected as each member had a different background and role within the project. The figure below represents the final agreed level of maturity as discussed by the project team. The only area that received a high score was Graphical Information and this was due to its relationship with the production of 3D drawings (all disciplines were requested to develop their proposals in 3D). During the validation process, project team members questioned the relatively low scores of the other areas, as in their perception considerable amount of work and effort had been put into implementing BIM. This was considered a deficiency of the tool used, therefore a baseline for comparison[2] was introduced. This has changed the perception of the team that the results achieved were negative and also gave direction for improvement for all project teams including FM.
- **Project Contractual Organisational Assessment:** In the project, the client acted as the central hub for the development. Figure 2 illustrates the project organization relationships amongst the different parts involved in the project. In this respect, direct links between the client and the design team, contractor and subcontractors were identified, i.e. the contracts were managed and controlled by the client. Direct links between the design team, contractors, and subcontractors were considered as indirect, i.e. issues such as scope of work, format of delivered, etc. were coordinated with the support of the client who held the control of the project. During the workshop for data validation project team members argued that a formal link exists. In this respect, contractual documentation between designers and contractors was not collected to identify the type of relationship between these parts. In addition, according to interviewees the current model lead to gaps in terms of data flow and to the establishment of roles and responsibilities. In regards to the client and its relationship with suppliers, it was identified that both direct and indirect contractual relationships exist. From a clients' perspective, formal/direct contractual interaction exists with key suppliers. These relationships, according to the client, are long term and were established prior the project.

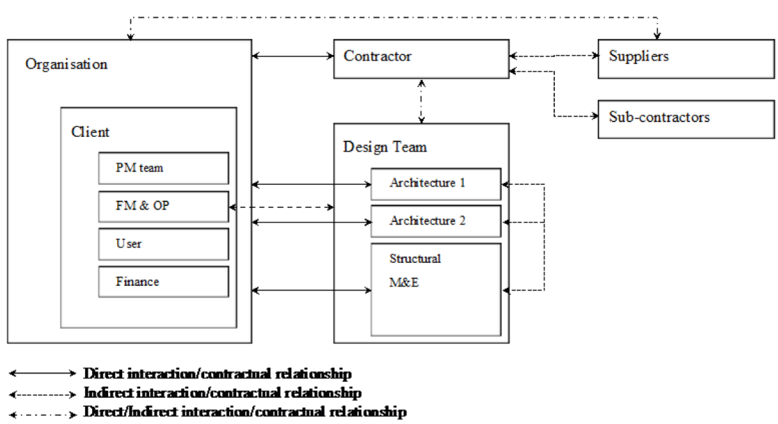
Figure 1. NBIMS CMM Analysis of the project



Also related to the contractual arrangement was the level of collaboration amongst the different parts. In this respect, a key beneficial component identified was the creation of a collaborative environment that could overcome communication barriers between project team members. For this purpose, an open plan project office was created by the client with the aim of bringing together the core team (circa 100 people, including the client and key suppliers) in one physical space.

- **Scope of Works:** The organisation, development and administration of the project followed the RIBA Plan of Work as determined by the client. In this respect, the data collected through interviews and documental analysis showed that the scope of work did not increase considerably with the utilisation of BIM at the stage the research was conducted (stage D – Design Development), the only exception being an increase in modelling activities. According to interviewees, the library of the software

Figure 2. Project participants' interaction analysis



used for modelling did not have objects that were equivalent to old parts of the existing building, thus leading to surveying and modelling activities.

In addition, it was identified that at this stage there was considerable amount of uncertainty regarding the range of possibilities that BIM could offer to the project. In this respect, whilst the client sought, with the project team, information about what BIM capabilities were available that they could benefit from, the project team was seeking what the client needs were, so to identify what capabilities they could offer. The lack of awareness regarding BIM capabilities to support FM (from both sides, client and project team) was perceive as normal, considering that this project was pioneering the utilization of BIM for FM in the UK.

- **The Consideration of Fm Needs:** It was observed that some modelling work related to the incorporation of FM intelligent data within the model was being done by the time the research occurred. For instance, BIM-based room data sheets were prepared in order to make information about the facility available within the model. The information was organised according to room/space, including data from several design disciplines such as architecture, engineering and FM. In this respect, the interviews with client's representatives revealed that the key driver for using BIM in the project was the utilization of the information model for FM purposes, despite the fact that the BIM deliverables explored were focused on the design and construction phases. In terms of FM, the key expected BIM benefit was related to displaying accurate digital models of the facility. According to the FM representatives, considerable amount of time is spent in finding accurate information (material specifications, warranties, and accurate drawings) before maintenance services are performed. In respect to the incorporation of FM information within the building model, it was observed that FM team representatives contributed/participated in the design phase. The information provided by them was addressed in the design, however not incorporated within the model. Amid the issues discussed between the FM and designer are: options for better maintaining the facility (according to current FM practices); increased accessibility to difficult areas both internal and external to the building; manoeuvrability of equipment used for maintenance services (e.g. eye bolts, hooks, lifts).
- **BIM Assisted Design:** The use of BIM to assist design started at the conceptual design level. That means that the "as is" model of the existing facility was not developed to support the pre-design phase and no baseline for measuring improvement was devised. In this respect, since the project was based on the re-development of an existing facility, a building survey was conducted to support the development of the geometrical model. This process was considered challenging by the interviewees due to a certain level of incompatibility between software used and highly detailed building elements of the existing facility (e.g. ornaments). At the point where the research was carried out, the BIM support to design development and decision-making was considered limited and focused on 3D visualisation. Moreover, modelling has been done at building site level and its adjacencies. Urban scale intelligent data (at town level and organisation level) was not incorporated in the model.
- **Information Exchange Standards:** In relation to information exchange standards, the research team did not identify a shared Information Exchange Protocol in the project. However, protocols were identified amongst members of the project team such as Data Protocol Standard (contractor) and Drawing Protocol Standard (design – architectural - and contractor). It was identified that the contractor has protocols that sets the minimum building model content for each

design discipline. The contractor defined the information content protocol with a basis on the necessary information to perform its management tasks (such as costing, site planning, construction programming, etc). The contractor does not expect to receive complete models from the design teams. However, the protocols are used to assess the level of completeness of each building model received from designers. Due to the pioneering nature of this project, the client was developing capacity within the FM team so to support the establishment of standard protocols for data/information exchange. At the project level, the scope of services was unclear with regards information exchange content. No evidence was found about the establishment of types and levels of detail, modelling tolerances and content at different stages of design development.

- **BIM Implementation Process:** BIM implementation did not follow any prescriptive implementation model. Within the project, the implementation of BIM started with the selection of a BIM-capable design and construction teams. It was perceived that the client expected some support for implementing BIM (at FM – project level – and organisational level) from the design and contractor teams. However, it was identified that the implementation of BIM at organisational level for non-construction related business was not a service offered by the design or construction team at the time the research was done. In this respect, it was also perceived that the project team shared enthusiasm to explore the benefits of BIM within and beyond the project. However, no evidence was found that an implementation plan was devised to drive the team. Other factors indicating a less structured BIM implementation within this project, included
  - Lack of awareness regarding a wide range of BIM deliverables that the client could or not benefit from (benefits different from the explored ones);
  - Capability and maturity goals were not clear for the project team and for the organisation;
  - Lack of BIM coordinator within the client's representatives. In this respect, a BIM expert was selected from the design team (first) and from contractor (later). However, BIM implementation within the organisation was not included in the scope of work contracted by the client within the project. Thus, the coordinator acted as a facilitator for BIM within the project.
  - The design process was set in a traditional manner, i.e. involvement of stakeholders at different stages; "over-the-wall" approach to design;
  - Lack of awareness regarding key problematic organisational processes that could benefit from BIM being implemented.
- **Expected BIM-FM Benefits:** The level of understanding regarding BIM benefits evolved during the development of the project. It was perceived that the initial emphasis on project benefits (such as improved design coordination through automated clash detection, automated quantity take off, improved decision-making through 3D and 4D visualisation/simulation and sustainability analysis) shifted to FM. At this stage, it was perceived that the FM team changed their posture from client to leading In this respect, the FM team made explicit their expected requirements in order of priority as presented below.
  - **Priority 1 (Short-Term):** This category included benefits that could be achieved through incrementally developing the model devised during design and construction by incorporating: a link between the 3D model of the facility with the FM management system use by the client; Detailed M&E asset register; support to scheduled maintenance (fabric) activities; detailed room data sheet (including

list assets, supplier details and service schedules and statutory requirements)

- **Priority 2 (Medium-Term):** This category included benefits that could be achieved through incrementally developing the model devised during design and construction, but having an intermediary level of priority (e.g. 3D routes and M&E distribution, 3D of all service routes, GPS asbestos location and draining infrastructure, distributions, and connections). This category also included benefits to be achieved from the development of additional elements to be linked to the existing model or services (e.g. Link to energy management system, i.e. zoning, out of hours use, event management, capacity development regarding the adaptation and updating of the model to reflect planned changes; development of a staff BIM induction tool, customer interface communication tool, link with marketing tool, events and community schemes)
- **Priority 3 (Long Term):** This category included benefits to be achieved from the development of additional elements to be linked to the existing model or services, but having a low level of priority (e.g. universal access to fully integrated 3D fly through, link to fire risk assessments, link to operational zoning, i.e. cleaning, events, etc., development of capacity for the simulation of logistic scenarios and link thermal model to real time thermal comfort monitoring system.

7. SUMMARY AND CONCLUSION

It is believed that the main benefits from adopting BIM are yet to be seeing as a result of its application to FM as hard evidence that demonstrates its benefits does not exist. In this respect, the aim of the research was to better understand the impacts of implementing BIM for FM purposes. To this end, a case was investigated where BIM was being implemented at project level as a way to support its implementation for FM purposes. Several aspects were investigated including: the capability maturity levels of project participants, formal and informal contractual relationships between involved parts, impact on the scope of contracted work, BIM-FM requirements, BIM support to design, adopted information exchange standards, BIM implementation process and expected BIM benefits to FM. Key lessons

In relation to the capability maturity levels, results show that the measurement of capability maturity levels provided a more realistic view of the state-of-the-art level of BIM as well as direction for improvement for all project team members. This exercise revealed that there was an unreasonable high level of expectation in relation to achieving high levels of maturity for all capability areas that was adjusted once the maturity performance was assessed.

With regards to project contractual organisation, it was identified that the lack of contractual arrangements amongst certain project participants can lead to gaps in data flow and the establishment of roles and responsibilities. In this respect, the client has the pivotal role of coordinating (or facilitating) the establishment of standards for data/information gathering and exchange. The absence of clients' expertise to perform this role can lead to the definition of standards that are incomplete for FM purposes as identified in the investigated case. The same principle applies for the implementation process of BIM for FM purposes, i.e. the process ownership must be uphold by the group who benefit most.

Concerning the project scope of works, the adoption of BIM suggests that there was only a small increase in the scope of works contracted contradicting an expected high increase in the scope of work. It was understood that this small increase in relation to BIM-FM client was related to the client's lack of awareness of BIM deliverables for both project and FM purposes, i.e. had they known more, more services could have been contracted. Similarly, an augmented awareness from the project team could have led to the offering of additional BIM deliverables.

In respect to BIM-FM requirements and expected benefits it was confirmed that emphasis is still placed upon construction/maintenance/management issues of hard FM. This is also evidenced by the type of activities identified as priority one within the expected BIM benefits. However, it is perceived that as the FM team gained more understanding about BIM, other activities related to the core business (soft FM) started being incorporated in the medium and long term plan of development.

As regards BIM support to design, the research showed that there is a potential for using BIM in early pre-design phases, which in the case of refurbishment and redevelopment projects is the same as the period after construction, i.e. use and operation of the facility. Even though this aspect was not explored within the investigated case, the FM team perceived that the assessment/simulation of service and building performance in use can lead and direct decisions such as to whether or not to progress with refurbishment and the extent that refurbishment should occur.

Finally, similarly to the construction industry in general, the findings indicate that the client was at the early stages of implementation but continually progressing rapidly. The willingness of the client to implement BIM and their vision in using BIM to improve facilities management is paramount in this process. Also crucial to success was the ability of participants to use BIM as a standard process and the good team spirit created within this project.

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ENDNOTES

1. The term hard FM is not presented in detail in this article but it refers to the scheduled and unscheduled maintenance of the fabric of the building.
2. The baseline for the overall industry level of maturity from an owners' perspective was based on the opinion of experts. In this respect, more research is necessary to validate this view.