8.2 Inefficiency in FM, can BIM help?

Giulia Carbonari
University of Greenwich
Giulia.Carbonari@greenwich.ac.uk

Spyridon Stravoravdis
University of Greenwich
S.Stravoravdis@greenwich.ac.uk

ABSTRACT

Purpose: The Digital Built Britain (BIM Level 3) aims to extend BIM into operation, by promoting a life cycle approach for buildings through an integrated digital environment. Nevertheless the main focus of both BIM level 2 and level 3 is mainly on design, construction and hand over, therefore the current understanding and use of BIM for facilities management is still limited. Current literature and research focusing on BIM and FM show only a marginal use of the technology, especially in terms of how BIM can be used beside maintenance. The purpose of this research is to determine which tasks, among the ones performed by facilities managers are perceived to be more inefficient. By identifying the data needed to improve the performance of tasks, the study aims to establish if building models can retain this information and increase the efficiency of FM practices.

Findings: This paper presents the results of an online questionnaire survey aimed to ascertain the level of perceived inefficiencies in facilities management. Through the analysis of Industry Foundation Classes (IFC) data models, the research identifies the data set needed to improve inefficiencies and indicates the benefits of implementing BIM within the FM industry.

Keywords
Facilities Management, Building Information Modelling, Industry Foundation Classes, Inefficiency.

1 INTRODUCTION

The last decade has been characterised by an ever increasing adoption of IT in the construction industry (Laakso and Kiviniemi, 2012) that has replaced traditional manual processes and improved the industry's practices (Mitropoulos and Tatum, 2000). However, this adoption can be considered uneven, with rates that vary significantly between companies and stages of the building life cycle. Since the 1980s, when facilities managers had their first encounter with IT, the impact of technology on the industry has been profound and caused many changes in the way the industry developed. Although FM is often considered a cost centre (RICS, 2014), the role of facilities management is to allow employees to work in an efficient and productive environment (May and Williams, 2012) by reducing at the same time the business bottom line. From building control systems to videoconferencing facilities, from Computer Aided Facility Management (CAFM) to Computerized Maintenance Management Systems (CMMS), IT has allowed facilities managers "to do more and accomplish many tasks faster" (May and Williams, 2012). Due to the nature of their work, facilities managers deal with tremendous amount of data in heterogeneous formats, like text, spreadsheet and database. Most of the documents are still paper based (Kassem et al., 2015) and part of the

FM role is to recreate incomplete and inaccurate information (Lucas, 2013). A variety of software tools have enabled facilities managers to collect, store and manage information, increasing the accuracy and allowing cost and trend analysis (May and Williams, 2012) but they are not perceived as an enabler for strategic value (Antoniou and van Harmelen, 2008).

Compared to other fields in the construction industry, FM always had a more pragmatic behaviour regarding the implementing of new technologies to support the business needs. In the technology adoption lifecycle, the FM industry cannot be considered as part of the early adopters, but rather a laggard industry, always monitoring new developments before implementing them. Nowadays the same is happening regarding the implementation of Building Information Modelling; by integrating all the data and information needed for a project, BIM is supporting project teams in working together and improving project outcomes (Hadzaman et al., 2015). While the adopters report great benefits from its implementation, both at company and project level (Muñoz and Arayici, 2015), FMs are showing limited interest in the process and technology, creating a vicious circle that inhibits BIM adoption in FM applications (Kassem et al., 2015).

2 EFFICIENCY AND TECHNOLOGY

For long time the construction industry has been challenged to improve its efficiency (Oman and Dulaimi, 2015). In 1998 Sir John Egan together with the Construction Task Force wrote the “Rethinking Construction Report” with the scope of improving the quality and efficiency of UK construction. One of the substantial changes they suggested to enable improvements and achieve a modern construction industry was the use of technology. More recently, as part of the Construction 2025 strategy published in 2013, the UK Government views the construction industry in 2025 as efficient and technologically advanced. Many of the recognised problems within the construction industry can be overcome by adopting new technologies, such as BIM (Oman and Dulaimi, 2015). The same applies for facilities management, and technology is now considered a part of the facility infrastructure (Best et al., 2003). To improve efficiency in FM, technology should have a twofold role, as highlighted by Best et al. (2003):

1. Enable strategic decision, supported by statistically significant information derived from real data;
2. Supports the day-to-day operation by providing relevant and real time data.

BIM is currently used both for strategic decision and as a support tool for day-to-day tasks in numerous construction projects during design and construction. Nevertheless, the literature confirms that BIM in FM is still at an early stage of implementation and acquiring the data necessary to manage a building is one of the major obstacles (Ebbesen, 2015).

3 BUILDING INFORMATION MODELLING

“A ‘building information model’ is a digital representation of the building, from which views and data appropriate to various users’ needs can be extracted and analysed to generate information that can be used to make decisions and improve both the process of delivering the building and the entire life-cycle use of the building.” (Barnes, 2013). Although BIM has been utilised since early 2000 (Eadie et al., 2013), only recently in the UK, due to the

Government demand of BIM Level 2 from April 2016 for publicly funded projects, BIM has become more widely utilised. The literature offers now numerous case studies presenting the results of using information modelling for design and construction, compared to the "traditional" CAD. The model availability and the use of BIM seems most appropriate for new buildings, although the major opportunities for improvement comes from utilising information models for the existing building stock. However, the process of implementation of existing buildings' information models can be complicated. The most commonly used process to create as-built 3D models is Scan-to-BIM, a technology that uses 3D laser scanning (Hajian and Becerik-Gerber, 2010) to collect detailed data of existing building (Bosché et al., 2014). Although the methodology is faster than traditional surveys (Lijing and Zhengpeng, 2008), researchers agree that there are still several limitations such as time (Saidi et al., 2011), cost, scanning range (Fard et al., 2011) and accuracy that reduce to few the percentage of buildings and users that are actually interested in modelling existing buildings.
Although the creation and implementation of information models for existing buildings is still a big issue (Volk et al., 2014), the potential benefits of using BIM for FM seem to be significant. The role of the model would be to act as unique source of data that can be used for multiple purposes while managing the building.

Becerik-Gerber et al. (2012) identify the following possible application areas of BIM for FM:

- Locating building components
- Facilitating Real-Time data access
- Visualization and marketing
- Checking Maintainability
- Creating and updating digital assets
- Space management
- Planning and feasibility studies for noncapital construction
- Emergency management
- Controlling and monitoring energy
- Personnel training and development

As part of a three years project, the researcher is developing a new methodology, called RetroBIM framework, envisioned to enable the creation of information models for every typology of existing buildings and addressing the different requirements of breadth and depth of information. The framework is based on an iterative process with increasing level of information details that will allow facilities managers to create a model tailored on the building, its use, the management strategies and the users. This paper presents part of the RetroBIM framework aimed at identifying, through the analysis of Industry Foundation Classes (IFC), the data set needed in order to use BIM as a tool for improving the inefficiencies in FM.

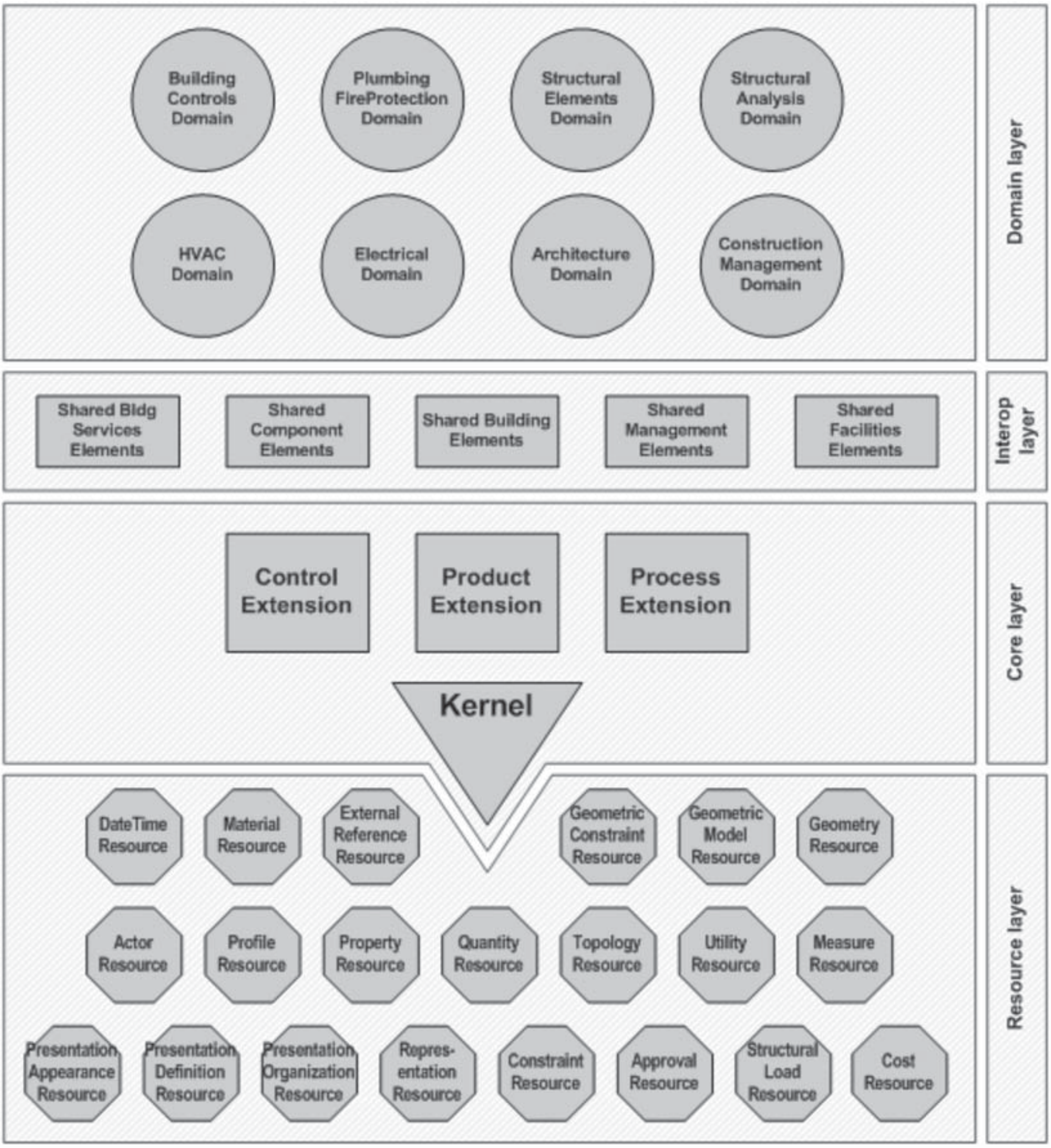
3 INDUSTRY FOUNDATION CLASSES (IFC)

The "Industry Foundation Classes" (IFC), developed by buildingSMART, is a conceptual data schema that defines all components of a building (Vanlande et al., 2008) and aims to integrate information required by different stakeholders (Kang and Hong, 2015). The specification includes terms, concepts and data originated within the construction and facility management industry (buildingSMART, n.d.). The IFC4add1, latest version released in July

2015 and used for this paper, can hold interdisciplinary information about the geometry and the attribute data of the different elements in a building information model, and can be used to exchange file format for BIM data (Sun et al., 2015) between different software applications used in AEC (Kang and Hong, 2015). The purpose of IFC is to standardise the sharing and data access in information models while enabling interoperability between heterogeneous software (Mitchell and Schevers, n.d.).

The IFC model represents a series of four conceptual layers, providing an increasingly specialised functionality.

Figure 7 Data schema architecture with conceptual layers (BuildingSmart, n.d.)



The layers, as described by builingSmart (n.d.), are:

- Resources layer – the lowest layer includes all individual schemas containing resource definitions
- Core layer – the next layer includes the kernel schema and the core extension schemas, containing the most general entity definitions, all entities defined at the core layer, or above, carry a globally unique id and optionally owner and history information
- Interoperability layer – the next layer includes schemas containing entity definitions that are specific to a general product, process or resource specialization used across several disciplines, those definitions are typically utilized for inter-domain exchange and sharing of construction information
- Domain layer – the highest layer includes schemas containing entity definitions that are specializations of products, processes or resources specific to a certain discipline, those definitions are typically utilized for intra-domain exchange and sharing of information.

The Facilities Management Domain is defined by the IfcSharedFacilitiesElements Schema, together with IfcProcessExtension, IfcSharedMgmtElements and IfcFacilitiesMgmtDomain, providing a set of elements that can be used to share information concerning facilities management.

Each building element (or entity, as defined in the IFC) is identified in a unique way through a hierarchical structure that starts from the IfcRoot. The first level of specialization from the IfcRoot comprises three fundamental entity types: the object definition (IfcObjectDefinition), the relationship definition (IfcRelationship) and the property definition (IfcPropertyDefinition). The object definition includes all physically tangible items, such as wall, beam or covering. The IfcRelationship handles the relationships among objects while the property definition generalised all the characteristics of the different objects. This first level of specialization develops further in several subtype tree, as illustrates in Fig. 2 that presents the example of the hierarchical tree definition of a boiler.

Figure 8 IfcBoiler (BuildingSmart, n.d.)

The different entities have also sets of specification, not required to be implemented, that can be used to provide specific information related to the item.

For example, every boiler insert in the model can be described by five different groups of information: object typing, property sets for objects, quantity sets, material constituents and post nesting. The object typing defined details such as the boiler type (e.g. water, steam, etc.), quantity sets describes values for the length, area, volume, etc. of the boiler, the material constituents provides details on the material from which the casing is constructed while the port nesting indicates possible connection to other objects such as pipes. The property sets that can be add to the boiler are summarised below (Fig. 3). For details on the single values please refer to the IFC website.

Figure 9 Boiler property sets

Condition
Assessment Date
Assessment Condition
Assessment Description

Boiler Type Common
Reference
Pressure Rating
Heat Transfer Surface Area
Water Storage Capacity
Is Water Storage Heater
Nominal Energy Consumption
Nominal Part Load Ratio
Water Inlet Temperature Range
Outlet Temperature Range
Status
Operating Mode
Energy Source

Electrical Device Common
Power Factor
Number of Poles
Has Protective Earth
IP Code
Rated Current
Rated Voltage
Nominal Frequency Range
Conductor Function
Insulation Standard Class

Environmental Impact Indicators
Reference
Functional Unit Reference
Unit
Expected Service Life
Total Primary Energy Consumption Per Unit
Water Consumption Per Unit
Hazardous Waste Per Unit
Non Hazardous Water Per Unit
Climate Change Per Unit
Atmospheric Acidification Per Unit
Renewable Energy Consumption Per Unit
Non Renewable Energy Consumption Per Unit
Resource Depletion Per Unit
Inert Waste per Unit
Radioactive Waste Per Unit
Stratespheric Ozone Layer Desctruction Per Un
Photochemical Ozone Formation Per Unit
Eutrophicaltion Per Unit
Life Cycle Phase

Environmental Impact Values
Total Primary Energy Consumption
Water Consumption
Hazardous Waste
Non Hazardous Waste
Climate Change
Atmospheric Acidification
Renewable Energy Consumption
Non Renewable Energy Consumption
Resource Depletion
Inert Waste
Radioactive Waste
Stratespheric Ozone Layer Desctruction
Photochemical Ozone Formation
Eutrophicaltion
Lead In Time
Duration
Lead Out Time

Manufacturer Occurrence
Acquisition Date
Bar Code
Serial Number
Batch Reference
Assembly Place

Manufacturer Type Information
Global Trade Item Number
Article Number
Model Reference
Model Label
Manufacturer
Production Year
Assembly Place

Service Life
Mean Time Between Failure
Service Life Duration

Sound Generation

Warranty
Warranty Identifier
Warranty Start Date
Warranty End Date
Is Extended Warranty
Warranty Period
Warranty Content
Exclusions

Due to its strong link with FM industry and interoperability among AEC/FM software, the research is based on the IFC specification. The researcher used IFC entities, based on the concept that if the information can be exchanged between different software, the information exists in the model.

5 METHODOLOGY

In order to identify the efficiencies of the tasks performed by Facilities Managers, a questionnaire survey was created. Based on a literature investigation and the analysis of over 300 job descriptions, the researcher identified 68 different tasks, divided in eleven groups:

property management, service provision, procurement, budget management, client-stakeholders management, security, safety health & environment, contract management, business continuity management, maintenance and project management. The questionnaire included three different sections – respondent’ profile, task efficiency and information modelling – but for the purpose of the paper only the results of the first two sections are presented. The questionnaire was available online between October and November 2015 and the participant were invited directly through email in order to assure consistency in the population sample and not bias the results. The participants were asked to rate only the tasks they are usually involved with using a 5 point Likert scale ranging from very inefficient to very efficient. For the purpose of the research, efficiency is defined as the ratio of all the inputs in producing an output and an efficient process aims at minimising the resources required to complete the process. The questionnaire objective is to understand, through the participants’ evaluation of the different tasks, the respondents’ perception of efficient and inefficiency of the tasks they perform. The tasks identified as most inefficient were then mapped against the IFC to verify if BIM can store useful information to improve the efficiency and the volume of information required.

6 RESULTS

A total of one thousand responses were received of which 752 were considered for the final analysis, all based in the UK. Of these, approximately 26% were executive managers (responsible for strategy), 46% senior managers (responsible for a building or a group of buildings), 21% managers (responsible for specific service/s e.g. maintenance) and 7% were operational and other roles. The participants worked for different types of companies: the majority were from national based organisations (41%) and multination organisations (39%).
All the 68 tasks provided were rated very inefficient or inefficient by some of the participants, with a percentage that varied between 27% and 3%. The tasks defined as most efficient are the ones regulated by norms or laws, such as safe working practices, risk management, emergency procedures, building certifications and compliance with statutory requirements.

On the contrary, the tasks identified as the most inefficient, as shown in Figure 4, are the ones not regulated by norms.

7 ANALYSIS

Some of the tasks identified as having the highest percentage of inefficient, such as asset record and whole life costs, can be improved by using BIM, as discussed previously but some of the other tasks, such as satisfaction survey and market intelligence, might not have a direct link with BIM. If the BIM model is not available, as is the case for the majority of existing buildings, it is helpful to understand the amount of information required to assist facilities managers and which information should be implemented first in the model to improve the inefficiencies of certain tasks.

The mapping process of the tasks against the IFC was limited to the entities that can be implemented alone in a model, without the need of supporting information. The single entities contained in the IFC were considered both for direct use during the performance of the task and as supporting information for analysis. Figure 5 summarised the results of the mapping and indicates the number of data related to each task.

Figure 10 Inefficiency in FM

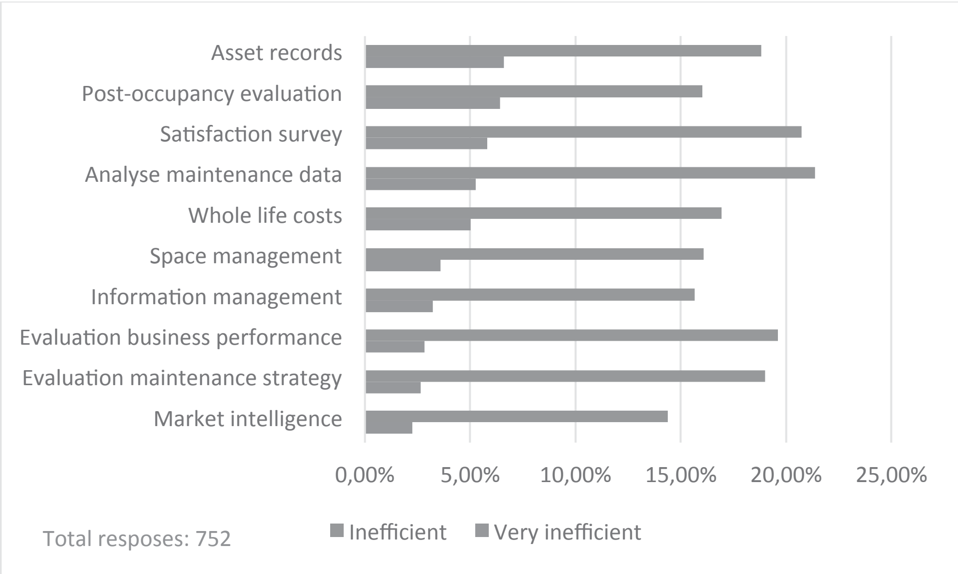
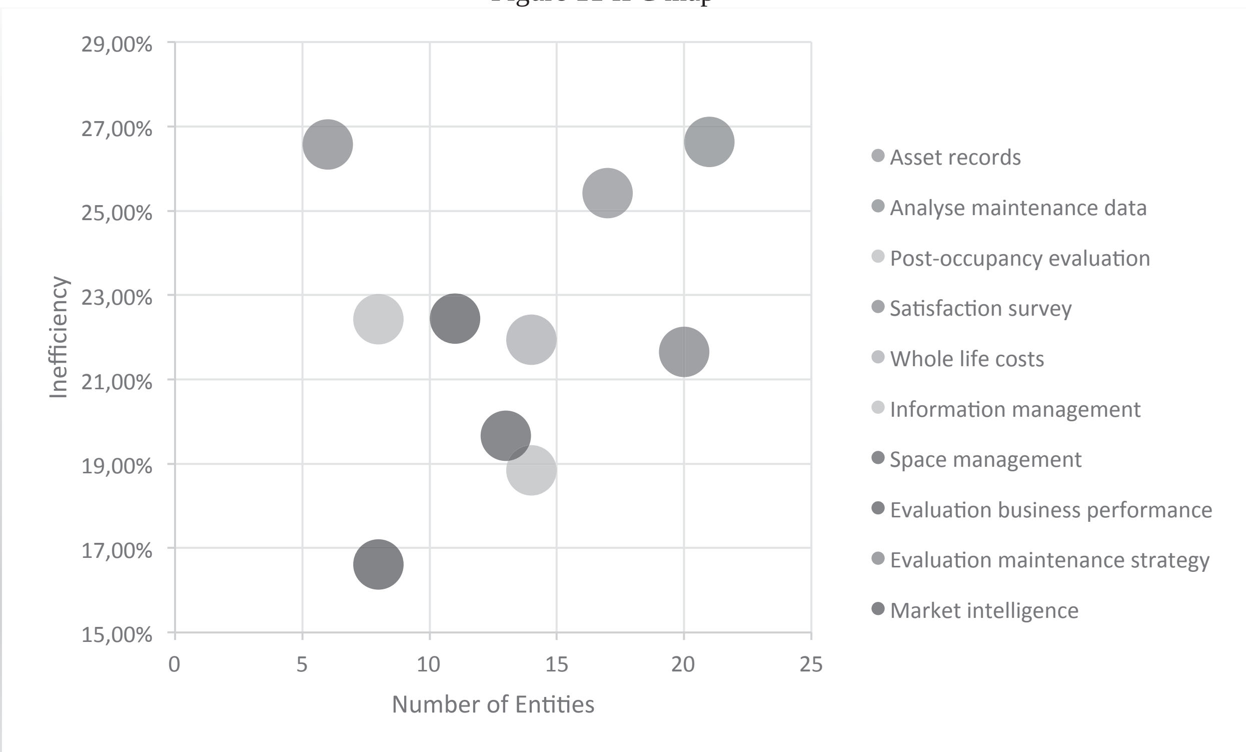
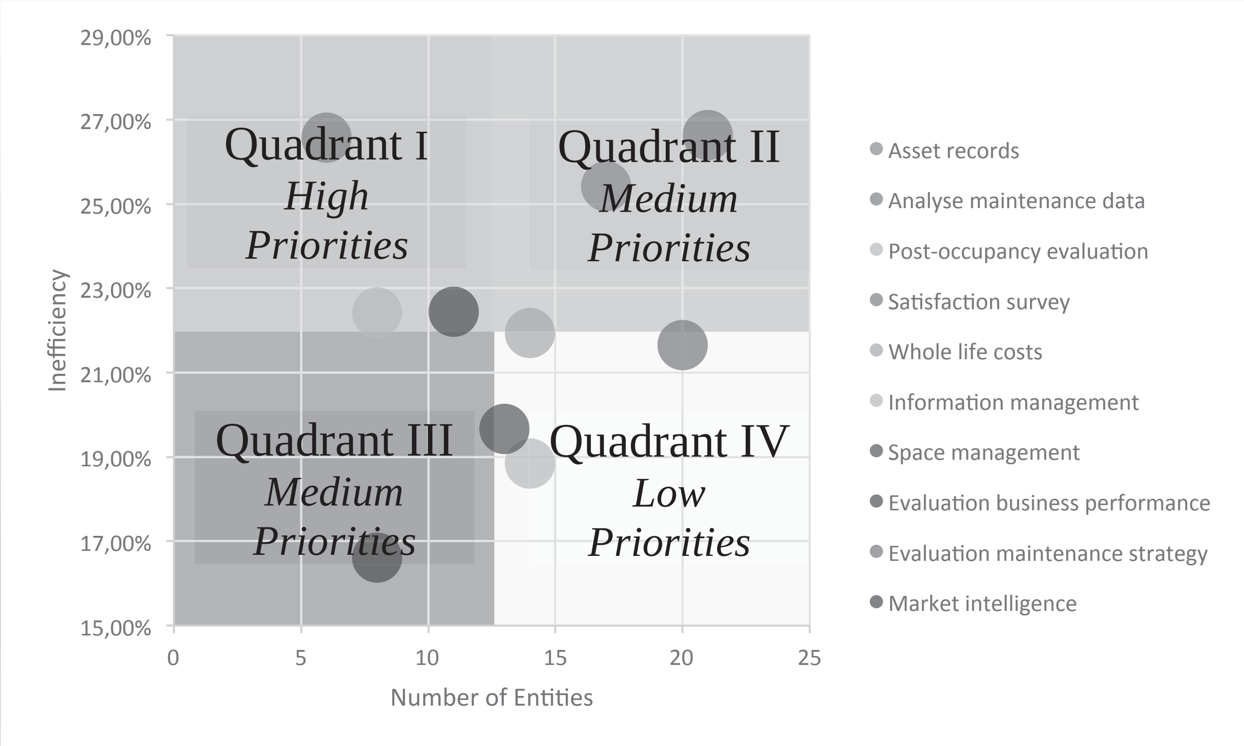


Figure 11 IFC map



By diving the tasks in four groups (Figure 6) it is possible to identify the BIM Implementation Priorities, in order to improve the efficiency. The tasks located in Quadrant I are defined as high priorities because they scored high value of inefficiency but they required a limited amount of information to be implemented. Quadrant II and III are both medium priorities: although the tasks located in quadrant II are more inefficient than the one in quadrant III, they require a higher volume of information. The decision to implement items from quadrant II and III can based on the opportunity to maximize the amount of tasks that can be improved by implementing the fewer number of information. In fact some of the task can be automatically covered by implementing information in the model for other tasks. Finally, the tasks in quadrant IV are low priorities because less inefficient than the other tasks and with a high number of information required.

Figure 12: BIM Priorities implementation



The tasks represented in Figure 6 are the most inefficient tasks identified through the questionnaire but the same process can be applied to all the FM tasks. The same methodology can be used by facilities managers to improve tasks' efficiency by implementing information models tailored on their needs. By evaluating the list of tasks used for the questionnaire, the FM can identify the high, medium and low priorities in terms on information that should be implemented within the BIM model.

8 CONCLUSION

Facilities Mangers should consider BIM as a tool for knowledge creation and support the improving of working tasks by developing strategic solutions. BIM should not be considered merely as a tool that could make facilities management tasks more efficient, but also an enabler for the interpretation and analysis of the information.

The evaluation criteria chosen for the study are based on the review of common FM tasks and then formulating them as a questionnaire, to capture the views of professionals. Although there are limitations linked with the subjective opinion provided by the respondents, the analysis presents important information for possible improvements of the tasks by implementing and using BIM. The research will continue with an in-depth analysis of each task and how the efficiency can be improved by using BIM.

The results from the questionnaire combined with the IFC map presented in the paper highlights some of the uses of BIM for FM. Even though some of the tasks are not directly linked with BIM and are not identified as possible application areas, the information that can be included in the model can still be used for informed decisions. Tasks such as market intelligence and satisfaction survey require the support of external information that are not included within the model but the analysis can still benefit from the use of the model. The methodology proposed for the identification of the priorities support FM in the implementation of information models based on their needs and current inefficiencies, without using costly and time consuming technologies.

REFERENCES

Antoniou, G. & van Harmelen, F. 2008. *A Semantic Web Primer,* Cambridge, MIT Press.

Barnes, P. 2013. *BIM in principle and in practice,* London, Ice Publishing.

Becerik-Gerber, B., Jazizadeh, F., Li, N. & Calis, G. 2012. Application areas and data requirements for BIM-enabled facilities management. *Journal of Construction Engineering and Management,* 138**,** 431-442.

Best, R., Langston, C. A. & de Valence, G. 2003. *Workplace strategies and facilities management,* Oxford, Butterworth-Heinemann.

Bosché, F., Guillemet, A., Turkan, Y., Hass, C. T. & Haas, R. 2014. Tracking the Built Status of MEP Works: Assessing the Value of a Scan-vs.BIM System. *Journal Computing in Civil Engineering,* 28.

BuildingSmart. n.d. *Industry Foundation Classes IFC4 Official Release* [Online]. Available: <span style="font-size:12.0ptAvailable: mso-bidi-language:AR-SA">http://www.buildingsmart-tech.org/ifc/IFC4/final/html/ [Accessed 19/01 2016].

Eadie, R., Odeyinka, H., Browne, M., McKwoen, C. & Yohanis, M. 2013. An analyses of drivers for adoption of Building information modeling. *Information technology in construction,* 18**,** 338-352.

Ebbesen, P. Information Technology in Facilities Management - A Literature Review. 14th EuroFM Research Symposium, 2015 Glasgow.

Fard, M. G., Bohn, J., Teizer, J., Savarese, S. & Mora, F. P. 2011. Evaluation of image modelling and laser scanning accuracy for emerging automated performance monitoring techniques. *Automation in construction,* 20**,** 1143-1155.

Force, C. T. 1998. Rethinking Construction. Available: http://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking_construction_report.pdf [Accessed 19/01/2016].

Government, H. 2013. Construction 2025. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/210099/bis-13-955-construction-2025-industrial-strategy.pdf [Accessed 23/01/2015].

Hadzaman, N. A. H., Takim, R. & Nawawi, A. H. 2015. Building Information Modelling (BIM): the impact of project attributes towards clients' demand in BIM-based project. *Building Information Modelling (BIM) in Design, Construction and Operations.* Southampton: WIT Press.

Hajian, H. & Becerik-Gerber, B. Scan to BIM: factors affecting operational and computational errors and productivity loss. 27th International Symposium on Automation and Robotics in Construction, 2010.

Kang, T. W. & Hong, C. H. 2015. A study on software architecture for effective BIM/GIS-based facility management data integration. *Automation in Construction,* 54**,** 25-38.

Kassem, M., Kelly, G., Dawood, N., Serginson, M. & Lockley, S. 2015. BIM in facilities management applications: a case study of a large university complex. *Built Environment Project and Asset Management,* 5**,** 261-277.

Laakso, M. & Kiviniemi, A. 2012. The IFC Standard - A review of history, development, and standardization. *ITcon*, 17**,** 134-161.

Lijing, B. & Zhengpeng, Z. Application of point clouds from terrestrial 3D laser scanner for deformation measurements. International Society for Photogrammetry and Remote Sensing, 2008. The International Society for Photogrammetry and Remote Sensing, 458-454.

Lucas, J. B., T.Thabet, W. 2013. An object-oriented model to support healthcare facility information management. *Automation in Construction,* 31**,** 281 - 291.

May, M. & Williams, G. (eds.) 2012. *The Facility Manager's Guide to Information Technology*: International Facility Management Association.

Mitchell, J. & Schevers, H. n.d. Building Information Modelling for FM using IFC. Available: https://www.researchgate.net/publication/229026874_Building_Information_Modelling_for_FM_using_IFC [Accessed 19/01/2016].

Mitropoulos, P. & Tatum, C. 2000. Forces driving adoption of new information technologies. *Construction Engineering & Management,* 126**,** 340-348.

Muñoz, V. & Arayici, Y. 2015. Using free tools to support the BIM coordination process into SMEs. *Building Information Modelling (BIM) in Design, Construction and Operations.* Southampton: WIT Press.

Oman, H. S. & Dulaimi, M. F. 2015. Using BIM to automate construction site activities. *Building Information Modelling (BIM) in Design, Construction and Operations.* Southampton: WIT Press.

RICS 2014. RICS Strategic Facilities Management. London: RICS.

Saidi, K. S., Choek, G., Franaszek, M., Brown, C., Swerdlow, J., Lipman, R., Katz, M. & Goodrum, P. 2011. Development and use of the NIST intelligent and automated construction job site testbed National Institute of Standards and Technology.

Sun, J., Liu, Y.-S., Gao, G. & Han, X.-G. 2015. IFCCompressor: A content-based compression algorithm for optimizing Industry Foundation Classes files. *Automation in Construction,* 50**,** 1-15.

Vanlande, R., Nicolle, C. & Cruz, C. 2008. IFC and building lifecycle management. *Automation in Construction,* 18**,** 70-78.

Volk, R., Stengel, J. & Schultmann, F. 2014. Building Information Modeling (BIM) for existing buildings — Literature review and future needs. *Automation in Construction,* 38**,** 109-127.