Improving FM efficiency through BIM: a proposal for BIM implementation

ABSTRACT

Purpose: The purpose of the research presented was to investigate which tasks among the ones performed during a buildings' operational phase are perceived to be more inefficient and to investigate if the information within a Building Information Model (BIM) could help improve tasks efficiency.

Design/methodology/approach: 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 a buildings' occupancy phase is still limited. Current literature and research focusing on BIM and building management show only a marginal use of the technology, especially in terms of how BIM can be used beside maintenance.

Findings: The paper presents the results of an online questionnaire survey aimed to ascertain the level of perceived inefficiencies of operational tasks. Through the analysis of Industry Foundation Classes (IFC) data models, the research identifies the data set needed to improve the efficiency of the tasks and presents a structured implementation plan to identify which information should be prioritised in the model implementation.

Originality/value: The study presents part of a methodology developed by the author aimed to implement a BIM model for existing buildings including information that would support the management of the single facility/portfolio. While other studies have looked into BIM and operational phase, especially in relation to asset maintenance, this study has focused on understating how the information included in the model can improve the tasks efficiency.

Keywords: Building Information Modelling, Industry Foundation Classes, inefficiency, Operation Facilities Management

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 IT was first used for managing buildings, the impact of technology on the industry has been profound and caused many changes in the way the industry developed. Corporate Real Estate (CRE) is often considered only a cost factor, that does not go beyond "the bricks and mortar of physical assets" (Jalil Omar and A. Heywood, 2014) and where cost is the only driver for decision-making (Stadlhofer, 2010). In reality, the role of Corporate Real Estate Managers (CREM) is to add value to organisation and contribute to an organisation's success by integrating property management, facilities management and strategic real estate (Jalil Omar and A. Heywood, 2014). From building control systems to videoconferencing facilities, from Computer Aided Facility Management (CAFM) to Computerized Maintenance Management

Systems (CMMS), IT has allowed "to do more and accomplish many tasks faster" (May and Williams, 2012). Due to the nature of their work, real estate management (REM) deals with tremendous amount of data in heterogeneous formats, like text, spreadsheet and database. Although information is recognised as a critical success factor in REM (Palm, 2016), often most of the documents used to manage buildings are still paper based (Kassem et al., 2015) and resources are used to recreate incomplete and inaccurate information (Lucas, 2013). A variety of software tools allow 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) .

The two main objectives of CRE are to implement the corporate strategy and manage service delivery (Fisher, 2009). Nevertheless, poor communication, reliance on paper and manual processes, inadequate information tools (Schriefer and Ganesh, 2002) and information 'silos' (Fransson and Nelson, 2000) have impact the ability of CRE organisations to respond in a timely and decisive manner to changing business needs. The implementation of new technologies to support the business' needs during the occupancy phase of buildings has always been more laggard, compared to other fields in the construction industry. 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), building managers are showing limited interest in the process and technology, creating a vicious circle that inhibits BIM adoption in management 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 indeed be overcome by adopting new technologies, such as BIM (Oman and Dulaimi, 2015). CRE professionals could use BIM to access meaningful data and achieve, through an intelligent application of the technology, informed strategic planning (Fransson and Nelson, 2000).

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, literature confirms that research on BIM uses, benefits and opportunities for stakeholders such as CREM is still at early stage (Wilkinson and Jupp, 2016).

2 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 buildings (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.

The creation and implementation of information models for existing buildings is still a big issue (Volk et al., 2014), nevertheless the potential benefits of using BIM for the occupational phase seem to be significant. The model would act as unique source of data that can be used for multiple purposes while managing the building, as discussed by (Becerik-Gerber et al., 2012), such as:

- 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 the creation of 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 during buildings' operational phase.

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, 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.

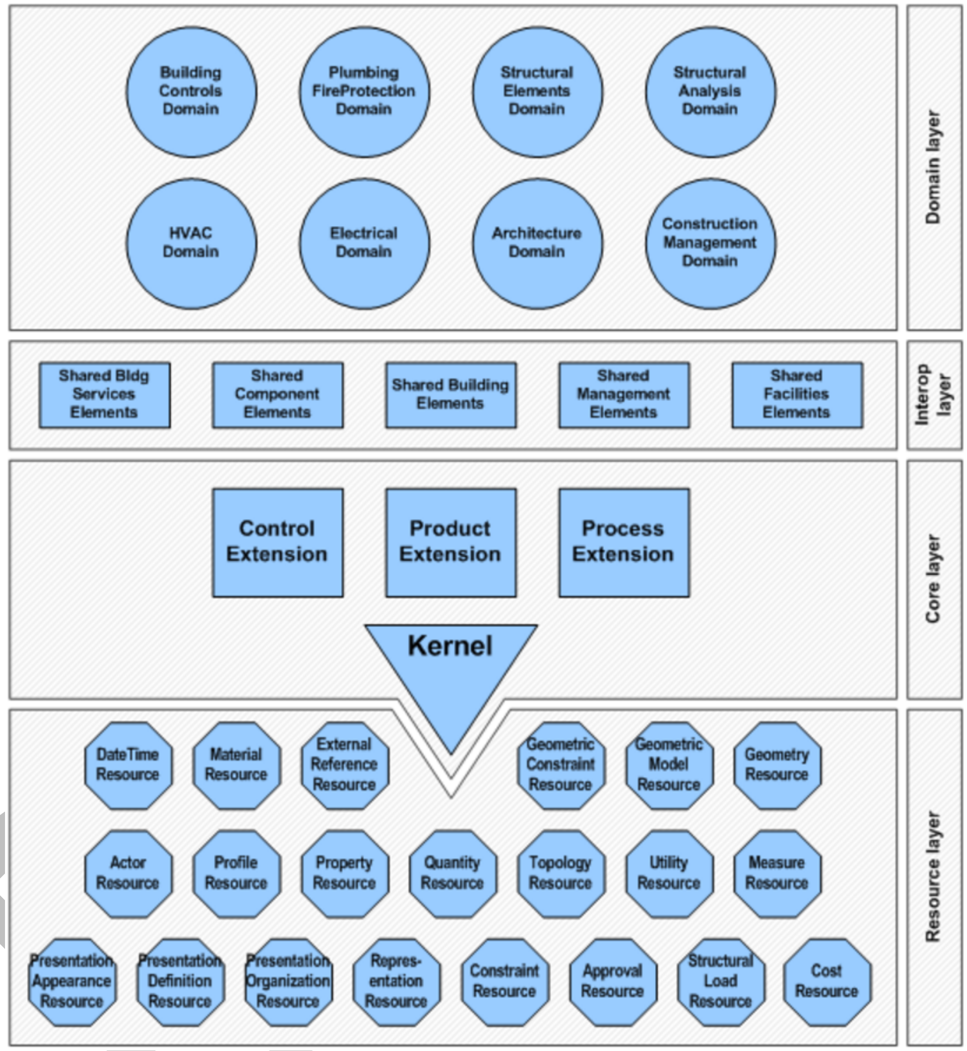

Figure 1: Data schema architecture with conceptual layers
Source: buildingSmart (n.d.)

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.

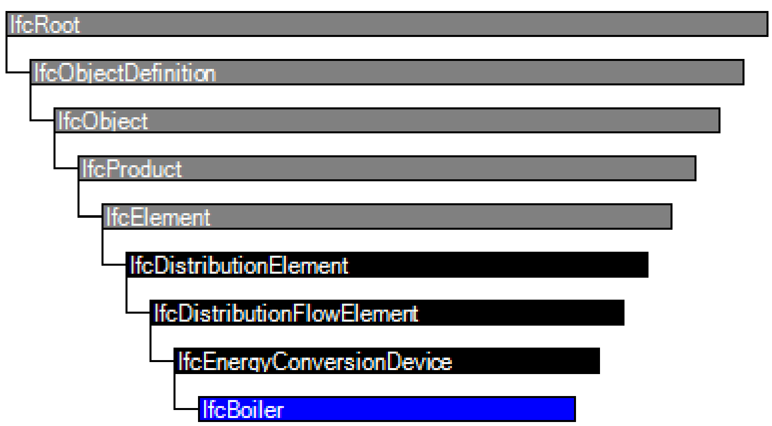

Figure 2: IfcBoiler
Source: buildingSmart (n.d.)

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.

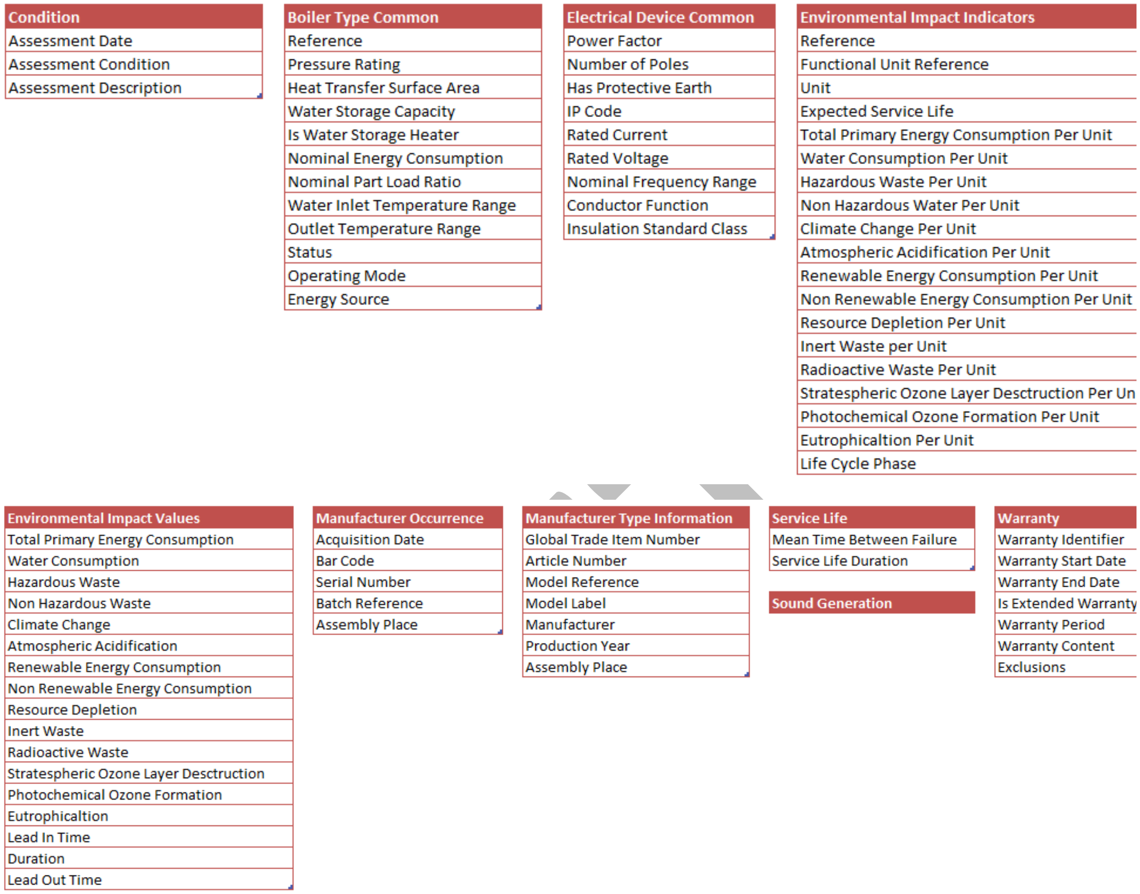

Figure 3: Boiler property sets

Since IFC is commonly used as data exchange standard for BIM (Gao et al., 2015) and ensures interoperability among AEC/FM software, the research presented in the paper is based on the IFC specification.

5 METHODOLOGY

In order to identify which tasks are the more inefficient when managing a building, a questionnaire survey was created. Based on a literature investigation and the analysis of over 300 job descriptions, the researcher identified 68 different tasks generally performed by facilities managers and 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 participants were asked to rate the efficiency of every task they are generally involved in, 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 was to understand, through the evaluation of the different tasks, the respondents' perception of efficient and inefficiency of the tasks they perform. The questionnaire was available online between October and November 2015 and the participants were invited directly by email in order to assure consistency in the population sample and not bias the results. 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 to support the specific task.

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

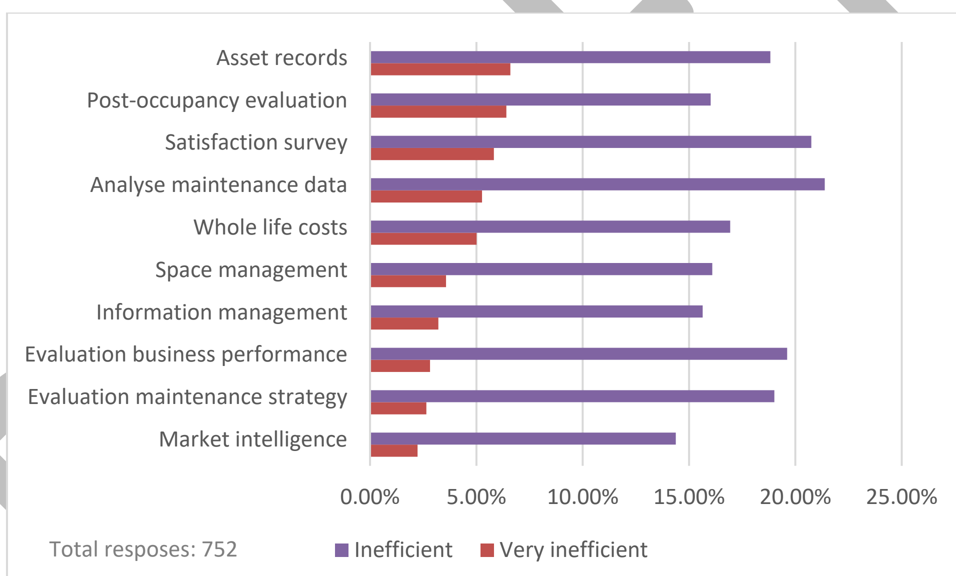

Figure 4: Tasks Inefficiencies

7 ANALYSIS

Some of the tasks identified as having the highest percentage of inefficiency, such as asset record and whole life costs, have a direct link with BIM and the information model can be used to improve the efficiency of the task whilst some other tasks perceived as more inefficient such as satisfaction survey and market intelligence might not have a direct link with information modelling. It is helpful to understand the amount of information that can be included in the information model to improve the inefficiencies of each of the tasks and in which order the information should be implemented, especially when the BIM model is not available as per the majority of existing buildings.

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 provides a summary of the results of the mapping and indicates the number of IFC entities that can support the improvement of efficiency of each of the tasks.

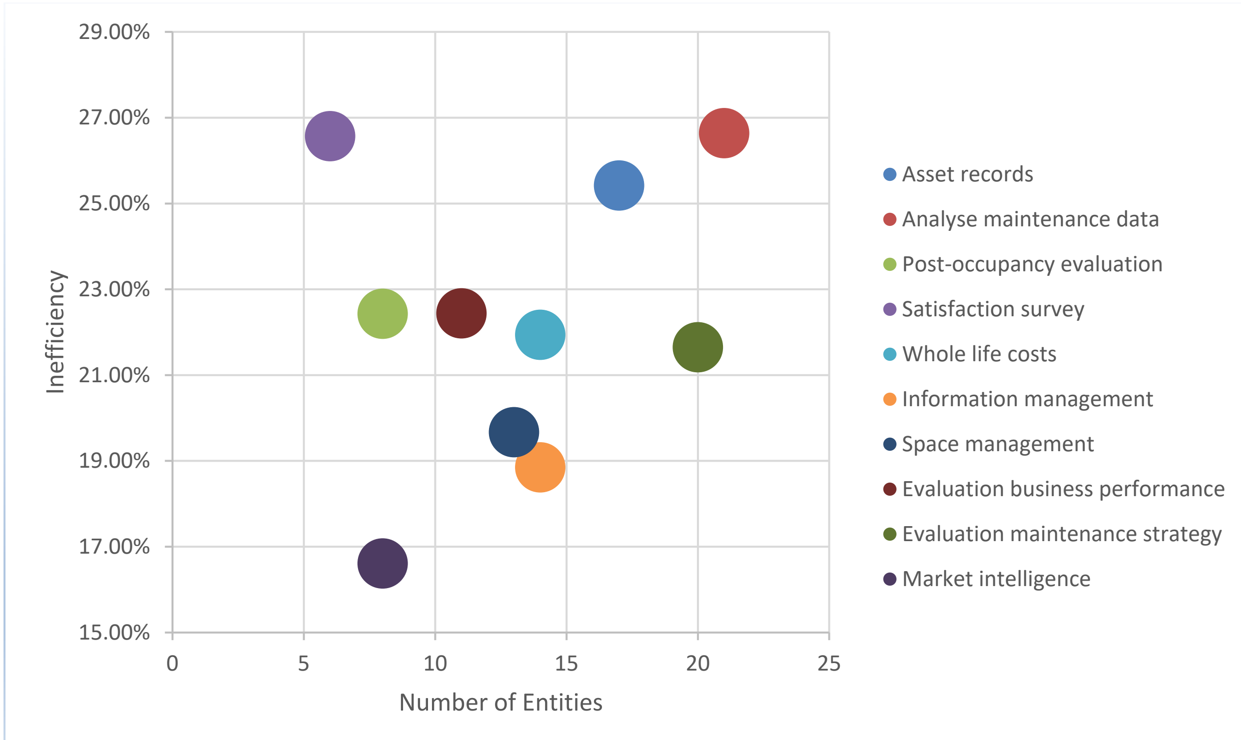

Figure 5: IFC map

By diving the tasks in four groups (Figure 6) it is possible to identify the BIM Implementation Priorities, a structural plan that shows in which order the information should be implemented in a model in order to improve tasks' 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 compared to other tasks. 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 should be based on the opportunity to maximize the amount of tasks that can be improved by implementing the least amount of information. In fact, some of the tasks can be automatically covered by implementing information in the model for other tasks. Finally, the tasks in quadrant IV are low priorities because they are less inefficient than the other tasks and with a high amount of information required.

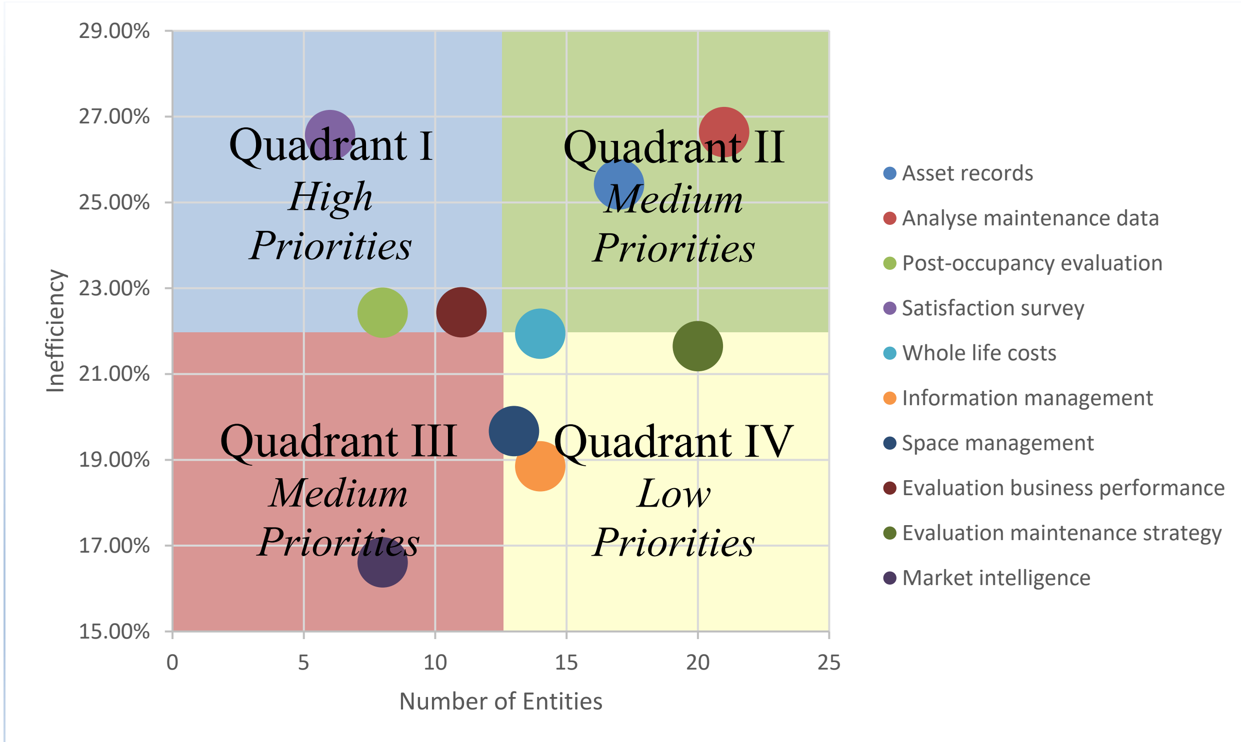

Figure 6: BIM Implementation Priorities

The inefficiency rating represented in Figure 6 was based on the results collected through the questionnaire but the same methodology can be applied at building/portfolio level to achieve improvements in inefficient tasks. The task rating and the identification of the BIM Implementation Priorities support the implementation of an information models tailored on corporate's needs and in line with the strategy.

8 CONCLUSION

The evaluation criteria chosen for the study are based on the review of operational tasks based on 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 results from the questionnaire combined with the IFC map presented in the paper highlights some of the uses of BIM for building occupancy phase. Even though some of the tasks are not directly linked with BIM and are not identified as possible application areas in the literature, the information included in the model can be used to analyse performance, inform decisions both at building and portfolio level, and support the definition of the strategy. Tasks such as market intelligence and satisfaction survey require the support of external information but these tasks can still benefit from the use of the information included in the model. The methodology proposed for the identification of the priorities supports the implementation of information models based on the corporate/building's needs and current inefficiencies, with a complete alignment with the business requirements.

Overall BIM should be considered as a tool for knowledge creation with the function of improving tasks and support the alignment with the strategy. The information implemented in a model can be used for interpretation an analysis, enabling a more efficient management of the building whilst adding value to all stakeholders (owner, users, investors, etc.). Although the management of building is only one of the aspects of CREM, a more efficient management of the occupancy stage would benefit greatly the overall business's bottom line and the methodology presented can support the implementation of an information model without using costly and time consuming technologies.

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