

# Asset Management in a BIM Environment

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## Abstract:

Nowadays construction projects are more and more delivered by Building Information Models instead of traditional 2D drawings. This allows for information rich projects but this information is, in many cases, accessible only for those who are able to use a BIM authoring software. In the current market, both the top levels (CEO and executives) and the low levels (on site and off site operators) of an asset or a facility management company are not able to use a BIM authoring tool, thus to use the valuable information stored in the model. Moreover, BIM models that work fine for the design stage will be of no use during the operational stage if not correctly created. A research has been carried on to cope with these problems and the preliminary results are shown in this paper.

Asset managers' work procedures and needs have been analyzed to identify what information is needed and when in the operational stage and then an IFC compliant standard has been adopted to store data. Once useful data are stored in the model, these must be made accessible for everyone who need them. To do this, web tools have been developed to provide an easy connection with the BIM model so to promptly highlight asset performances or problems and to act consequently. The tools, reading and saving data in the BIM model, are not only a way to visualize asset information and Key Performance Indicators (KPIs), but also an instrument for field operators to update the BIM model of the asset without using complicated BIM authoring software.

Both tools and KPIs are developed by the authors as part of a bigger research project with the aim of improving the current way to manage assets and portfolios.

**Keywords:** BIM, Asset Management, Maintenance, Real Estate, Web Services.

## 1. INTRODUCTION

Asset management is the coordinated activity of an organization to realize value from assets; the constitution of this value depends on the nature and the purpose of the organization, its objectives and on its stakeholders' needs and expectations (ISO 55000, 2014).

Assets, consisting of the physical building, systems, surrounding environment and equipment, must be maintained, upgraded, and operated at a level which satisfies both the owner and users in the most cost effective manner.

Asset management utilizes the data contained in a record model to populate an asset management system. This system is then used to determine cost implications of changing or upgrading building assets, to segregate costs of assets for financial tax purposes and to maintain a current comprehensive database that can produce the value of a company's assets. A bidirectional link between the asset management system and the record model can produce many possible values (Williams et al., 2014):

- store operations, and equipment specifications for faster access;
- perform and analyze facility and equipment condition assessments;
- maintain up-to-date facility and equipment data including but not limited to maintenance schedules, warranties, cost data, upgrades, replacements, damages/deterioration, maintenance records, manufacturer's data, and equipment functionality;
- provide one comprehensive source for tracking the use, performance, and maintenance of a building's assets for the owner, maintenance team, and financial department;
- produce accurate quantity takeoffs of current company assets which aids in financial reporting, bidding, and estimating the future cost implications of upgrades or replacements of a particular asset;
- allow for future updates of record model to show current building asset information after upgrades, replacements, or maintenance by tracking changes and importing new information into model;
- aid financial department in efficiently analyzing different types of assets through an increased level of visualization;
- increase the opportunity for measurement and verification of systems during building occupation;

- automatically generate scheduled work orders for maintenance staff.

A BIM model can be effectively used as a record model for asset management purposes once the level of information of BIM objects is correctly defined, but it cannot be the only access road to assets data because information stored in the model are used by people that: a) may not have access to BIM authoring tools; b) are unable to use BIM authoring tools; c) need elaborated information that cannot be provided by BIM authoring tools (Figure 1).

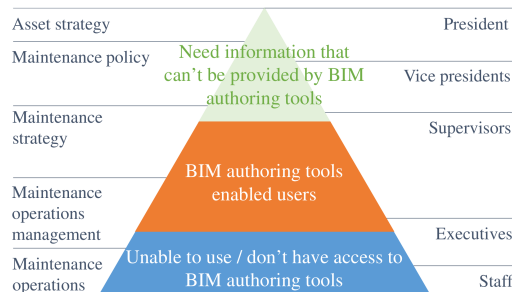


Figure 1. Information uses and users vs. Building Information Modelling in Facility Management

Among all the relevant asset management subject areas addressed by international, regional or national standards, Facility Management (FM) is one of the most affected by the introduction of Building Information Modelling. According to Becerik-Gerber et al. (2012), the information collected through a BIM process and stored in a BIM-compliant database could be beneficial for a variety of FM practices, such as commissioning and closeout, quality control and assurance, energy management, maintenance and repair, and space management.

## 2. STATE OF THE ART

This paragraph contains some key information to contextualize the research, so to properly address the right stakeholders and to use the proposed procedures and tools to improve the current way of dealing with BIM models and asset management: many times these two topics are faced in parallel but without any useful integration.

### 2.1 BIM and Facility Management (FM)

BIM is defined as “the process of designing, constructing or operating a building or infrastructure asset using electronic object orientated information” (BS PAS 1192-2, 2013). Jung and Joo (2011) provided further reasoning, stating that the future main areas of BIM will be “knowledge (in property level variable) and reasoning (in ontology variable)”. This means that BIM is enlarging its horizons, being used not only by designers, but also by decision makers and managers (e.g. Lu et al., 2016). In addition to this, BIM importance is growing; this positive trend is confirmed by the Global Building Information Modelling Market 2014-2019 report (Market Research Reports Inc., 2015), affirming that the BIM market will grow at a CAGR of 16.73%.

Despite the fact that BIM is generally considered as the future instrument to be used in the AEC sector, there is a great need of improving the adoption processes, also with tools and procedures, not only addressing technical issues, but also looking at the entire decision framework (Gu & London, 2010). Within the BIM Task Group, the BIM4FM group (2013) carried out a survey (by interviewing facility managers, owners and occupiers) about BIM and FM to understand the general level of knowledge about this “new” technology. In Figure 2 main concerns about BIM adoption in the Facility Management sector are collected.

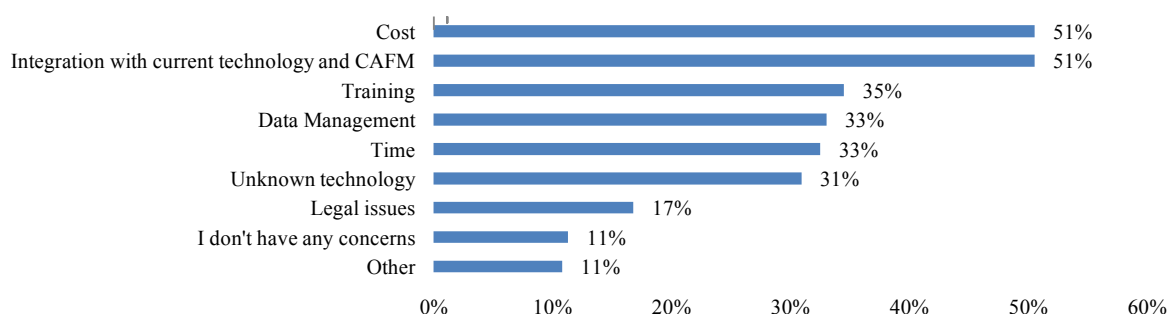


Figure 2. What are your concerns about BIM? (BIM4FM group, 2013)

Cost is, obviously, the first issue, but the second is “*integration with current technology and CAFM*” (Computer Aided Facility Management): facility/asset/building/portfolio managers, not depending on their precise roles, do not have the expertise to use properly (or at all) BIM authoring software. Facility Management software are more or less complex and usually consist in a database with multiple interfaces and 2D drawings associated to layers and attributes (e.g. Archibus, 2015); this allows to make queries and manage several activities: cleaning, spaces uses, maintenance, consumptions, rent, etc.. There are some attempts of direct connection between CAFM software and BIM models because Building Information Modelling has just begun growing in the FM market (BIM4FM group, 2013). The aim of this work is not to provide a software like the ones developed by Autodesk, Onuma, Ecodomus or Archibus, which are able to handle many more data and issues regarding BIM and FM. Objective of this paper is to demonstrate the possibility to implement existing KPIs and procedures (already used in non-BIM software) in a BIM environment. Despite the fact that tools from the industry have not been included in this study, current main research works on BIM and FM have been checked, so to align this research to the current trend. Among these works, Yang and Ergun (2016) provided a wide state of the art on the computerized approach to BIM for FM, especially regarding IFC; Arayici et al. (2012) provided a series of conceptual maps that connect BIM with main buildings operation themes and a list of soft and hard FM activities that can be supported by BIM (i.e. space management, cleaning, maintenance). In addition to academic works, some guidelines and books (i.e. GSA, 2012 and Teicholz, 2013) about BIM and FM have been checked, so to have a wider view on the topic. Maintenance operators and staff do not have access to BIM authoring tools or are unable to use them to gather the information they need for their work or to update assets data when they have to. On the other side of the operational chart of a FM company, top managers often need data that cannot be directly obtained from the BIM model; most of the time data contained in BIM models are only the source of KPIs used in the FM practice. Nonetheless a BIM model contains a lot of useful information gathered during design and construction that may ease operation and maintenance stages (e.g. McArthur, 2015). This is why this research aims to provide a link between BIM models and people that cannot use BIM authoring software, regardless of the reasons.

## **2.2 BIM and Just-In-Time (JIT) information**

Several attempts have been made in order to share, visualize and manipulate building-related information to overcome time and distance limitations of involved stakeholders (Chuang et al., 2011). Indeed, it is essential to facilitate anytime and anywhere real time communication and information exchange between project participants. Moreover, it is important to allow project managers to easily access required information to manage their projects effectively and efficiently (Lee et al., 2011).

In this context, web technology can be used for accessing and delivering building information in support of facility operations. For instance, a just-in-time approach has been developed to fulfill task-specific requests, by collecting, filtering and customizing distributed facility data and information (Song et al., 2002). Different stakeholders (as architects, consultants, and facility operators) could easily access a great amount of information through dynamic HTML pages. This process is enhanced by: 1) collecting and standardizing information; 2) storing and filtering information; 3) linking information; 4) creating and delivering documents; 5) monitoring documents; and 6) updating and managing documents. The integration of BIM and web-based interface may be considered a great opportunity to enable real-time information update and interactive visualization of information not only in the design and construction stage (Jeong & Yan, 2013) but in the operational stage too.

Moreover, also cloud-BIM systems provide easy-to-use web services for the various project participants, including construction companies, business owners and architectural companies, to access and view project information via the web (Chuang et al., 2011).

For this reason, the presented research aims to develop a framework based on the integration of BIM and web interface in order to facilitate asset management.

## **3. METHOD/APPROACH**

The research has been carried out starting from the analysis of asset managers’ work procedures in order to identify their needs and translate them into requirements for the development of suitable methods and tools, by which buildings-related information can be accessed by different stakeholders during the operational stage. Given the impossibility of many stakeholder involved in the building process to use BIM authoring tools (Figure 1), the research aims to provide a method by which assets information stored in a BIM model (often called Asset Information Model, AIM) can be queried and modified using specialized web applications. The main barrier to this is the fact that many BIM authoring tools store information in files with a proprietary format. To overcome this barrier part of the BIM (or AIM), information must be transferred to a more common format.

The method used to carry out the research is based on the following steps: a) to define a standard for creating BIM models to share harmonized information; b) to create a bi-directional link to transfer useful non-graphical information from BIM models to a database; c) to develop web services and web apps to exchange and update

information in real time; and d) to test the prototype with some case studies.

### 3.1 Standard for creating Building Information Models

Building information models are sources and repositories of geometric and non-graphical information stored in an underlying database, which may be exported and queried by external applications. The way information is stored in the BIM model has a great impact on its possible use: if a convention for name and measurement unit of each parameter of BIM objects is not drafted, it is impossible to use the data outside the BIM authoring tool. Therefore, Industry Foundation Classes (ISO 16739, 2013) and BuildingSMART Data Dictionary (BuildingSMART, 2015) have been chosen as naming convention for BIM objects in this research work.

BIM models for the case studies of this research have been realized using Autodesk Revit as authoring tool; shared parameters, mostly derived from IFC, have been created for facility management purposes, like space management (left in Figure 3) and mechanical equipment management.

The building under analysis is an office building of Politecnico di Milano. It has been built in the sixties as a steel warehouse and then converted into an office around 25 years ago. It has three storeys above ground and one under ground. Spaces are mainly dedicated to offices (for both researchers and administration), meeting rooms, rest rooms and connections (corridors, stairwells and lifts).

Parametri IFC	
AirConditioningCentral	<input checked="" type="checkbox"/>
AirConditioning	<input checked="" type="checkbox"/>
DiscontinuedHeating	<input checked="" type="checkbox"/>
Illuminance	
ArtificialLighting	<input checked="" type="checkbox"/>
AirPressurization	<input checked="" type="checkbox"/>
FlammableStorage	<input checked="" type="checkbox"/>
AncillaryFireUse	
Concealed	<input checked="" type="checkbox"/>
OccupancyNumber	2.000000
OccupancyType	
GrossAreaPlanned	
HandicapAccessible	<input checked="" type="checkbox"/>
ZoneName	
ZoneObjectType	
ZoneDescription	
AreaPerOccupant	8.424 m <sup>2</sup>

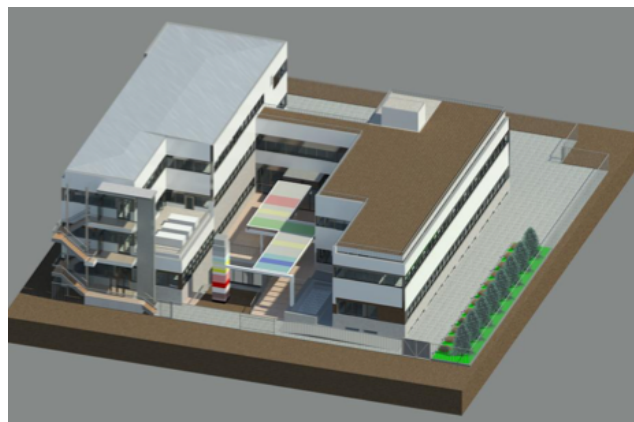


Figure 3: Extract of IFC parameters (left) associated to the objects “room” in the BIM model (right)

### 3.2 Design of Web services and Apps

Non-graphical data of the BIM model may be exported to a database via commercial plugin; DB Link is one of the available plugins to connect a Revit model to a database. The exported database has been published on web using REST web services that: a) produce JSON data to be consumed by web applications; or b) change information stored in the database according to users’ inputs. Web services are Java servlet contained in a Tomcat server called by HTML5 / JavaScript web applications (Figure 4). These provide the Graphical User Interface (GUI) for accessing information stored in the database and related to specific duties of the Facility Management so to have small web apps for each task of the Facility Management.

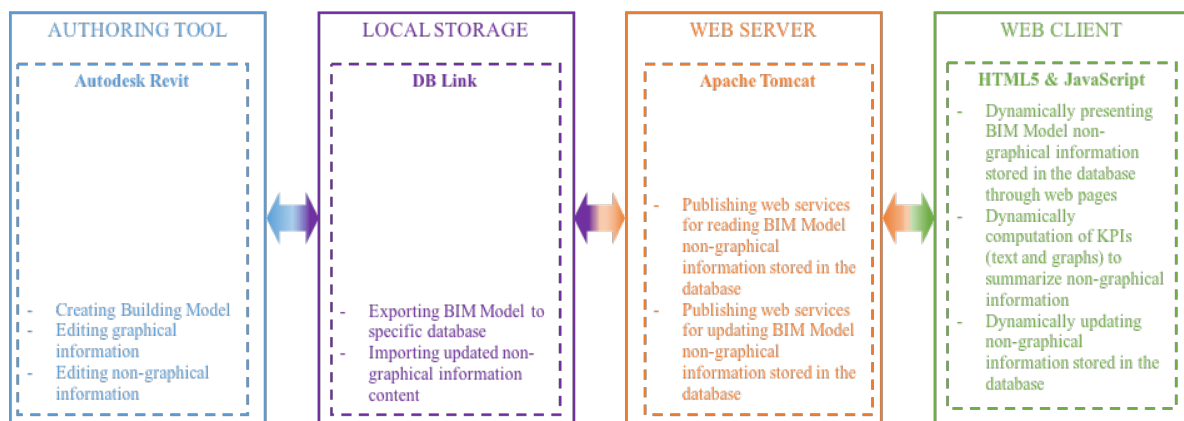


Figure 4. Workflow of the tool

Two of the developed software tools are presented in the following. A first one computes KPIs for space management of buildings from information stored in a BIM model. Particularly, it provides real-time information related to the occupational state of rooms, as:

- occupied area and number of occupied rooms;
- empty area and number of empty rooms;
- occupational ratio, both as person/room and person/square meters.

This tool is useful in order to provide information (also expressed in a graphical way through donut charts) related to occupied area, occupied rooms and available work desks. Then, it is also possible to obtain the list of rooms according to a selected level and change their occupancy parameters, without accessing any BIM authoring tool.

A second tool is available for the management of mechanical equipment. Thanks to this tool, it is possible to obtain information related to:

- number of mechanical appliances and their maintenance status;
- identity of mechanical equipment (ID and room hosting the equipment).

Even in this case, it is possible to read and update information in a simple way.

### 3.3 Case Studies

Case studies have been useful for testing the feasibility, usability and accuracy of developed tools. BIM models have been used both as test-bed for the development of web interfaces and as repository of data related to building operation.

After creating BIM models and adding shared parameters, the database associated to the model can be queried through both authoring tools and apps. Therefore, according to the values of shared parameters (whether or not they are changed through authoring tools or apps), the graphical representation of the model is updated. Considering the space management, thematic plans (Figure 5) have been realized in relation to different occupancy scenarios. In this way, it is easy to identify spaces with values of area per occupant lesser than a fixed threshold (left in Figure 5) or with available work desks (rooms turn to green if occupancy ratio is lower than 1, while overcrowded rooms are highlighted in red – right in Figure 5).

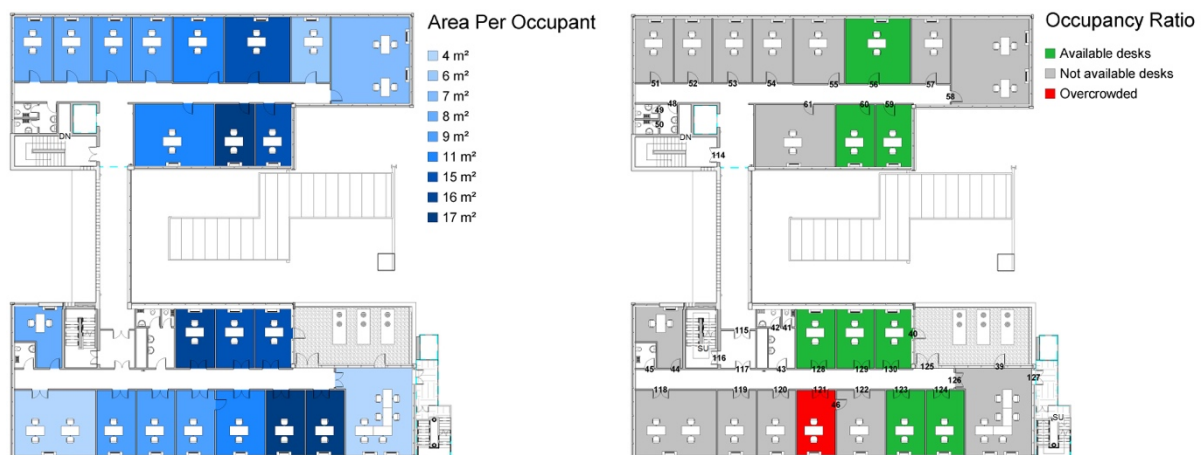


Figure 5. Examples of thematic plans

Area per occupant is the number of occupants divided by the net area of each room. Occupancy ratio is the ratio between the current number of occupants and the maximum allowed in each room.

In relation to the mechanical equipment management, appliances can be marked with different colors: green if working, red if not working or grey if unknown (left in Figure 7).

## 4. RESULTS

In this paragraph, the two main results are presented: an interface to manage spaces and another one to trigger mechanical equipment working condition. The former can be used by both managers and executives, while the latter could be efficiently adopted by the staff during surveys and daily tasks.

### 4.1 Space management

Current FM software usually adopts 2D drawings in combination with polylines; these polylines are converted

into analytic data (e.g. room surface) and then associated to other parameters (e.g. occupancy, condition, function, etc.). This workflow has a low and inefficient interaction with BIM models and it also requires a proprietary software. The solution presented here contains all the main data to be checked by the executives in a user-friendly web-based interface; this allows to control and update these key data directly on the BIM model, without any additional workaround, effort and possibility of error.

In order to provide a synthetic representation of parameters to control space usage, donut charts have been selected to represent used surface, used rooms and used work desks. In this way, users can immediately compare whether a surface/room/work desk is occupied or available. Moreover, users are allowed to update number of occupants for each room; consequently, IFC parameters in the BIM model are updated too. Users can also obtain a detailed list of all the rooms, filtered by levels (Figure 6).

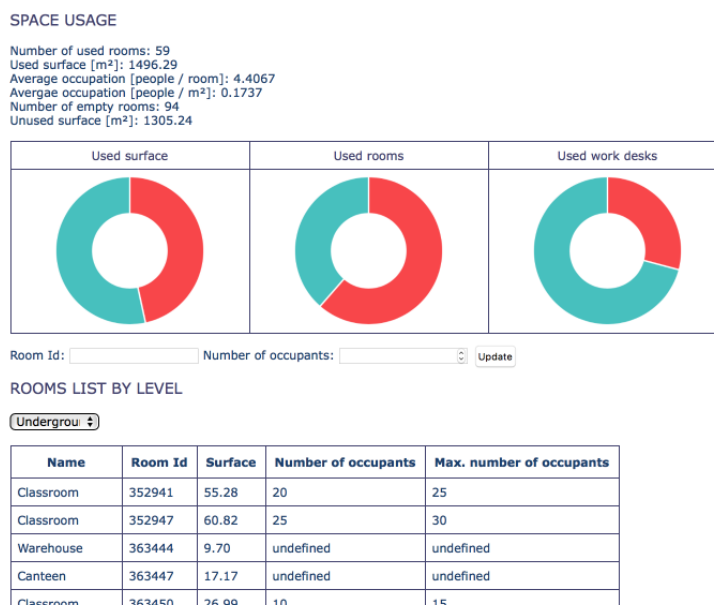


Figure 6. Web interface for space management

## 4.2 Mechanical equipment management

The second tool developed is made to ease operators work during buildings survey: there are many interesting FM-related tools able to ease surveyors work, but most of them are connected to a database or to proprietary software. This tool (Figure 8) is directly interfaced with the BIM model, allowing to update and control key parameters directly on it (right in Figure 7).

Also for this second tool, a web page has been created using HTML5 and JavaScript; this can be used both by operators during surveys and by executives in their offices. Fan-coils are divided by level and by room and, to avoid any ambiguity, they are associated to an unequivocal code. Information about working/failure condition can be highlighted in many ways, according to users' ability and needs: in an external database, in the model (graphical – Figure 7) and in the schedules (analytic data).

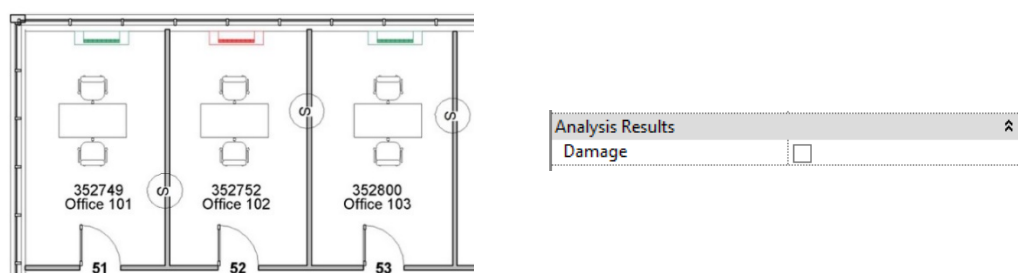


Figure 7. Thematic plan for mechanical equipment condition triggering (left) and connected parameter (right)



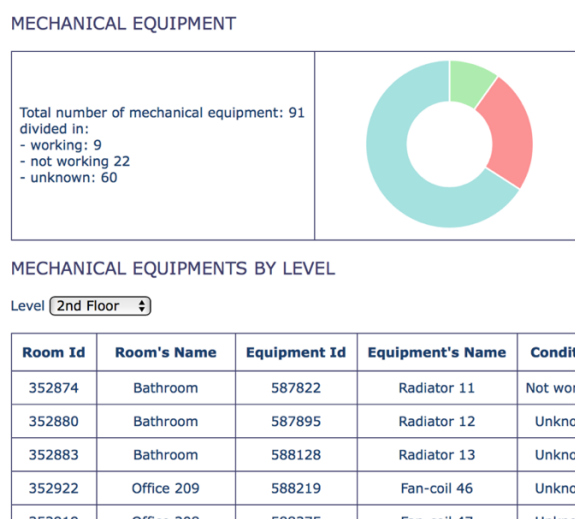


Figure 8. GUI for mechanical equipment condition triggering

These two tools are only preliminary results of a wider project, which aims to provide a better connection among BIM models, FM software and asset information management. Fan-coils working condition is just an example of many possible data (consumption, working schedule, maintenance performed, pictures, etc.) that can be efficiently entered and controlled. The web-interface is a great example of integration of BIM technologies in the every-day management of an asset.

One of the issues encountered during the development is related to the Access file connected to the BIM model with DB link: there is always the need to manually import/export the database with the plugin and an inattention could cause data losses; authors are currently working on a way to overcome this issue. Despite the complexity of the creation of web apps and web services, the final tool is really user-friendly and easy to use; these characteristics have been confirmed by some facility managers that tried to use it, even if without testing an intensive use. Eventually, now that the connection is defined, there is the possibility to provide many more applications.

## 5. DISCUSSION

The achieved results enable a bi-directional link to transfer non-graphical information from BIM model to database. Moreover, thanks to the development of web services and web apps, information can be exchanged and updated in real time and it can be accessed and reviewed from different model views among several stakeholders.

Future works will aim to exchange information through an open source IFC model server (Beetz et al., 2010). For this reason, the research group chose Java for server side programming and HTML5 with JavaScript for client side as well as IFC as exchange standard, in order to carry on the research by using bimserver.org. BIM Server (BIM Server, 2016) is an open source server in which “*data are interpreted and stored as objects in an underlying database. The main advantage of this approach is the possibility to query, merge and filter the BIM data*”.

## 6. CONCLUSIONS

In conclusion, developed tools can be considered as a preliminary result of a wider work, aiming to improve the current way in which assets are conducted and managed. These tools are not meant to be overlapping with existing FM software and procedures, but additional instruments that can be used to control and trigger assets KPIs.

The connection of these tools with BIM models (and their related database) is one of the major strength points of this work, as it allows to automatically update the central model without additional workaround.

These tools are meant to be used by people not familiar with BIM authoring software (because of their backgrounds and their tasks to fulfill): GUIs and web-interfaces help users in quickly addressing the objects (rooms and fan-coils in this case), without distractions and potentially with any device (from computers to tablets and smartphones) wherever they are (in the office, on site, etc.).

The provided examples demonstrate the feasibility of a system like this, allowing people to easily manage data directly on site or without a BIM authoring software. This work has many possible developments, among them: main services components condition assessment, space allocation, maintenance operations and inspections scheduling.

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