XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J.R. Casas and V. Gibert (Eds)

A Maintenance Management Model. Upgrading and Experimentation

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Abstract. *The paper deals with the first results of the activities of BIG Building Innovative Governance srl, Academic Spin-Off and Innovative Start Up, which provides smart services for Building Maintenance and Facility Management also launching circular R&D actions in the relative reference areas. The contribution introduces some actions actually in progress geared to upgrading the Maintenance Management Model, M3, specifically aimed at managing the life cycle of buildings.*
The current stage of development corresponds to a TRL 4. TRL 8 is that expected by the end of 2020. Characterized by interconnectivity and scalability, the Maintenance Management Model is a dynamic, collaborative and implementable system, whose architecture consists of three separated but strongly interconnected devices: an information interface system, a collaborative platform, a remote cloud. An ICT network infrastructure able to activate using BIM models (IFC and COBie standards) circular information workflows between all operators and/or users involved in Maintenance and Facility Management processes. It allows the development and/or implementation of information management and sharing models based on Open Data and Semantic Web. Its use will also promote shared lexicons and the circulation of knowledge within a holistic process of managing information from and for Maintenance. The use of BIM models and the possibility of collecting and managing a large amount of data will be oriented to the structuring of information feedback databases according to ISO 15686 guidelines. In this way, available information can be usefully transferred in life cycle assessments and service life prediction of materials and components.

Keywords: *Facility Management, Information System, Maintenance Management Model, Operation&Maintenance, Service Life Planning.*

1 Introduction

BIG srl is a spin-off of the *Mediterranean* University of Reggio Calabria, as well as an enterprise registered in the list of innovative Startups.

It operates in the field of technological innovation exploiting, in line with the operational trend of Industry 4.0 and the potentials of Information Communication Technology, ICT; also provides Innovative Integrated Services characterized by technical-scientific nature and high technological value oriented to the construction market and in particular to the Facility Management, FM; develops R&D actions in the sectors focused on Smart Building and Smart Cities drivers. To implement its mission, it assumes as central the interactions between technological capital (infrastructure and technology), human capital (researchers, companies, professionals, users, etc.), administration (institutions, universities, managers, etc.) and real estate (public and/or private heritage).

BIG srl is currently engaged in the experimentation of an innovative governance system for real estate assets, *Maintenance Management Model*, M3.

The service offered through the proposed Maintenance Management Model answer for a primary need of the construction sector as well as of the research one: to increase the effectiveness, efficiency, circulation of information and communication between the operators involved in the management and operation & maintenance practices whose activities presuppose multidisciplinary approaches and great structured data availability.

This primary need is today perceived as immanent criticality for the construction sector. Its effects are felt with concern by technicians and workers, and at the same time, shape a crucial issue that manifests itself in all its severity due to the unexpectedly increasing costs - economic and social – connected with the lack of maintenance of infrastructures, buildings and plants. (World Economic Forum, 2016)

O&M operating and maintenance costs, which are generally neglected during the design phase, generally amount to more than half of the total costs of the building's life cycle (Becerik-Gerber *et al.*, 2012). However, more and more often they represent cost items linked to the inefficiency of choices in the design phase or to mistakes made during the construction phase.

The authors of the paper are among the founders of BIG srl and have been working on the issue for a long time in the scientific and academic field. (Lauria, 2003, Azzalin *et al*. 2005, Lauria and Azzalin, 2006, Azzalin, 2007, Lauria and Azzalin, 2007, Lauria *at al.* 2015, Lauria and Azzalin, 2019, Azzalin, 2019)

In addition to the skills of each founding members, BIG srl avails itself of the expertise recognized to the two industrial partners:

- ACCA software S.p.A. (Https://www.acca.it). Established in 1989, the company is today the Italian leader in the construction software market and a reference point for the sector. For BIG srl provides its expertise and its products with reference to the management of databases, information security, information systems through the implementation and use of collaborative platforms for maintenance and Facility Management purposes.
- BimCo (https://www.bim-co.com), an innovative Startup Enterprise specialized in the use of IT methods and tools for interoperability such as BIM, Building Information Modeling. For BIG srl, BimCo provides the skills related to the production, implementation and management of digital models.

2 Background

The service life and management of a building in its life cycle always combines the terms "costs", "efficiency", "maintainability" and "sustainability" with the planning activity. In this context, Facility Management is defined as an integrated approach oriented to the operation, maintenance, improvement and adaptation of real estate and infrastructure in order to meet the primary objectives of the occupants, owners and managers (Atkin and Brooks, 2009).

Its importance and relevance, assumed by BIG srl as a corporate policy, refers to and is framed, in numerous regulatory actions, scientific research, market trends, both internationally and nationally. The FM involves a relevant field of interest, requires numerous data and information and presupposes multidisciplinary approaches.

The available information and data, whether they concern new or existing construction, are almost never structured to be effectively used in the O&M activities, and not sufficient.

In practice, inefficiencies, disconnected processes and different degrees of dysfunction correspond to this gap.

In the recent past, and even today, data and information for FM are organized and managed by Computerized Maintenance Management System and Computer Aided Facility Management (CMMS and CAFM), Electronic Document Management Systems (EDMS), Building Automation Systems (BAS), etc.

However, these processes are subject to errors (Becerik-Gerber *et al*., 2012).

Today, in general, in the face of still limited use of open standards for structuring and transfer of information, the specific need for open systems and standardized data libraries and specifically declined is added (BIFM, 2012). The availability of open standards, Industrial Foundation Classes, IFC (ISO 16739-1:2018) and data specifications, Construction Operations Building information exchange (COBie-NBIMS-US-V3.4:2015), the diffusion of Building Information Modeling (BIM) methodologies and the adaptation of legacy systems represent the new frontier for the research and standardization challenges. (Kassem *et al.*, 2015a). Several countries, including the United Kingdom in the first place, have introduced and prescribed the use of interoperability tools based on open data, open standards (IFC) and data specifications (COBie) as formats and information exchange methods between the project delivery phases and the use phase of the building (Kassem et al., 2013).

As part of the aforementioned policies, in the United Kingdom the PAS 1192-3:2014 standard (BSI 2014a) is a reference for the structuring of data aimed at the management phase. It introduced an information management methodology based on openBIM standards and data specifications (COBie) connected with BS 8544:2013 (BSI 2013), relating to life cycle costs during the maintenance phase of buildings.

Currently, BuildingSMART deals with the open standards (BIM, IFC and COBie) with the aim of defining languages shared between the various operators and for each of the phases of the building process and the life cycle of the assets. (Atkin and Brooks, 2009).

Further research areas concern the COBie data exchange (Cabinet Office, 2012) for which the British industrial standard BS 1192-4:2014 (BSI 2014b) is the reference.

IFC and COBie are also employed in the context of standardization actions relating to Service Life Planning, ISO 15686 Series. In this sense ISO 15686-4:2014 is a specific reference. The standard proposes "IFC property sets" (IFC4) to support service life planning, including information on the durability of materials, semi-finished products and components. Moreover, the factors that affect durability as introduced in ISO 15686-2:2012, environmental impacts in ISO 15686-6:2004 (at now withdrawn), and Life Cycle Costing (LCC) according to the contents of ISO 15686-5:2017. This thus confirms a strong interrelationship between the LCC assessments, the costs in the usage phase of the building and the decision-making processes aimed at optimizing the Operation & Maintenance phase (Fu *et al.*, 2007, BSRIA, 2009). In other words, in a general context of life cycle management, the BIM based interoperability systems based on open data (IFC standards and COBie) can provide the information needed for planning, execution and management of maintenance actions allowing this information to be structured and kept in an organized management system (CIC, 2012). This system, which can be implemented and accessed over time, will be both a repository and a source of feedback information available at the design stage (Volk *et al.*, 2014).

In short, the essential background introduced above and, more specifically, OpenBIM for FM, the interactions between IFC and COBie and their applications for the management of FM processes and the service life planning (Maxwell, 2005, Kassem *et al.*, 2015b) configure the assumptions from which the R&D actions of BIG srl and the Upgrading of M3 start.

3 Upgrading M3

Currently the upgrade of the Maintenance Management Model, M3 specifically aimed at managing the life cycle of buildings is being implemented thanks to a public financing from the Calabria Region according to the Public Call of POR Calabria ERDF 2014/2020 Action 1.4.1 Support for the creation of innovative micro-enterprises Startup and Spinoff of research.

M3 is aimed at the assistance and smart accompaniment for building maintenance and real estate assets Facility Management activities.

Developed starting from a PhD research (Melchini, 2015), the subsequent definition and implementation of M3 has received significant validation resulting in being the winner and finalist of some contests for innovative business ideas (Coopstartup Calabria Ricomincio da T (r)E, 2016; StartcupCalabria, 2016, national finalist of Startup Europe Awards, 2017).

M3 is an ICT network infrastructure that will allow the development and/or implementation of information management and sharing models based on Open Data, as well as the definition and continuous verification of operational requirements (BSRIA, 2009) among the various operators involved in the whole cycle of life of a building. From the design phase (clients, designers, structural engineers, installers, etc.) and construction (companies and producers / suppliers of materials and components) to management (maintenance personnel, etc.) and disposal phases; and between all operators and the final users themselves (Figure 1).

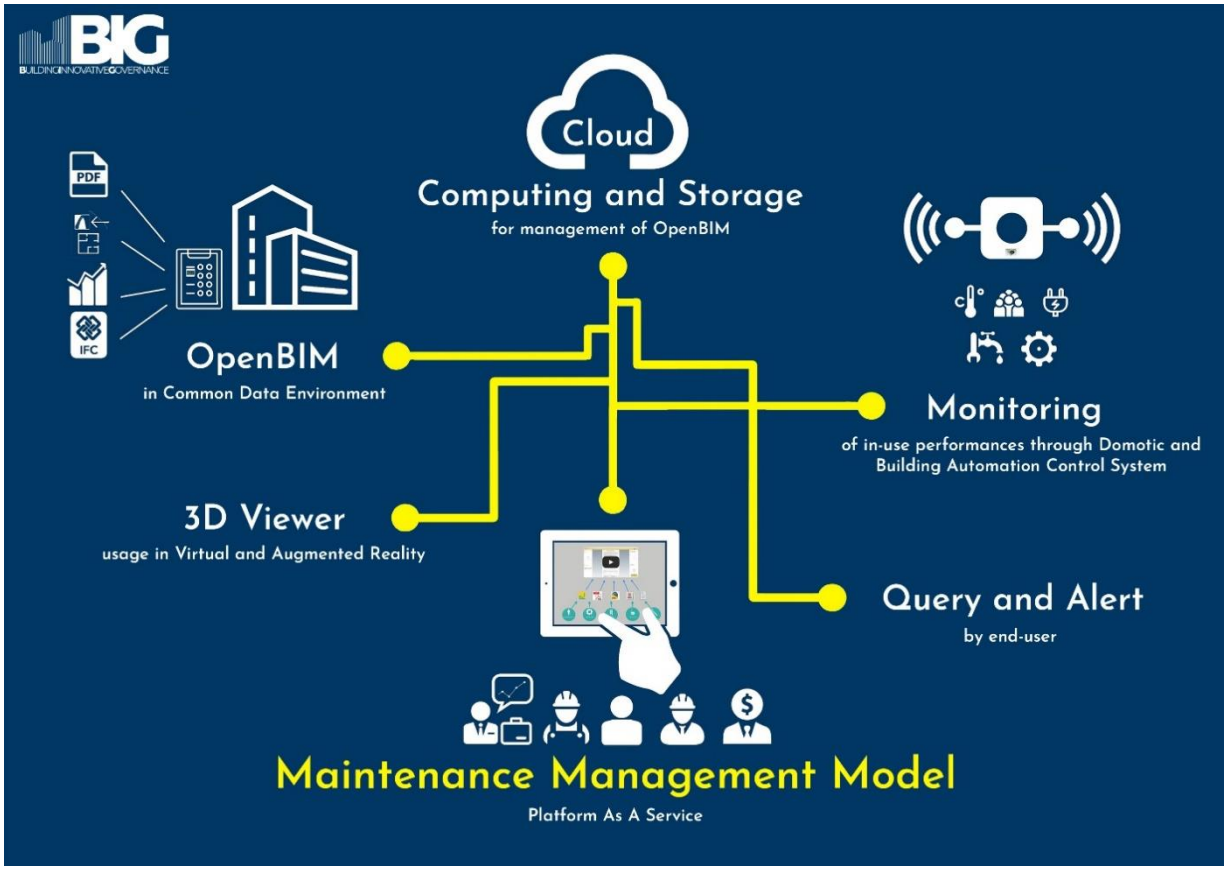

Figure 1. M3 Maintenance Management Model Architecture.

The objective is to support the decision-making process relating to the building management phase through an Information Modeling Asset (AIM) based on openBIM standards (IFC) and specifications on the data structure (COBie).

The structuring of the requirements that allow the definition of the AIM is based on the use of the ISO methodology, Information Delivery Manual (IDM) in ISO 29481-1:2016. A general methodology for defining the requirements of the FM format. In particular, IDM makes possible mapping and describing information processes throughout the life cycle of a building, maintaining links with each of the different phases in which information has been generated, exchanged, controlled and used.

Assumed as an initial development stage of the Management Model, a TRL 4 "low reliability prototype that can be built to demonstrate the technology and its function in the laboratory", a specific Business Development Plan and R&D is being implemented to allow:

- The realization of the engineering functioning model, corresponding to a TRL 6. In the specific case, the expected result is equivalent to an engineering prototype whose technology realizes a first connection level of the three apparatuses that make up the architecture of the Maintenance Management Model: an Information System (AIM); a collaborative platform (usBIM.platform by ACCA Software spa); a Cloud Computing.
- The upgrade to TRL 8 corresponding to a complete prototype system.
- Its experimentation, verification and validation (O.R.R., Operational Readness Review).
- Its marketing.

On a technical level, the availability of all the documentation, information and administrative management relating to the building/s appropriately collected and systematized in digital dossiers will allow, through an integrated system of alphanumeric and graphic databases (IFC and COBie format), the management of complex data concerning localization, use, security, accessibility, employment conditions, usability of spaces.

The availability of a digital twin in OpenBIM format will therefore allow, through a viewer and the interaction in Virtual and Augmented Reality modes, the following visualization:

- information on the current state of construction;
- the behavior of component and sistem transmitted by monitoring system (Building Automation home automation systems);
- the location and degree of severity of active fault and possible operational scenarios for the purpose of the intervention.

The partner ACCA spa, leader in the OpenBIM at national level, has made the usBIM.platform collaborative platform technology available for implementation in the direction described. With usBIM.platform is possible to manage the OpenBIM models (IFC standards and COBie specifications) of each type (architecture, plants, energy, structures, construction site and maintenance) in a single Data Sharing Environment (ACDat) or Common Data Environment (CDE). The related plug-in is being tested through a pilot application to the case study identified in a portion of the building asset of *Mediterranean* University of Reggio Calabria. In particular, the "usage scenario" of the system is the evaluation of IFC4 and COBie 2.4 and some of their enabling technologies.

The ongoing experimentation and the subsequent M3 implementation prefigure some main expected results. Evaluating IFC and COBie support in meeting the information requirements for the creation of the management activity register and proposing ways to implement and extract maintenance requirements respectively in and from BIM models.

The actions undertaken also promote shared lexicons and the circulation of knowledge within an interdisciplinary process of managing information from and for Maintenance.

The use of BIM models and the possibility of collecting and managing a large amount of data will be used as a source of information for service life planning. In particular, they will be oriented to the structuring of information feedback databases according to ISO 15686-7:2017 guidelines related to service life prediction of materials and components.

4 Conclusions

Although the results of the research in these areas refer to experiments that bring to the identification of some general OpenBIM requirements capable of supporting building maintenance activities (Hallberg and Tarandi, 2011, Becerik-Gerber *et al*., 2012, CIC, 2012, Motamedi *et al.*, 2014). To date, detailed studies and systematic evaluations of the IFC and COBie standards applied to FM are still lacking. In fact, it emerges from the literature that these, together with the available software support tools, are still inadequate for the management of the life cycle during the maintenance phase. (Kassem *et al.*, 2015a)

Furthermore, there are no widespread studies on the development of OpenBIM for FM and in particular research aimed at understanding "how" and "if" IFC and COBie can be effectively integrated to support FM processes.

Limits and criticalities that represent the areas of development and implementation of research in general and that related to the upgrade phase of M3 in particular but also of future commitments in the world of standardization and ICT.

In a perspective that embraces a holistic view of the life cycle of an artifact, which considers together: quality, duration, environmental, social and economic costs, the Maintenance Management Model, M3 takes on a dual meaning.

On the one hand, a tool to support the management of real estate assets through the activation of innovative information sharing processes (Open Data and Semantic Web).

On the other hand, it is evident that to effectively support decision-making processes in the development and execution of maintenance strategies, information on the useful life of building components is fundamental (Hovde and Moser, 2004) and should be taken into consideration from the earliest stages of planning (Marteinsson, 2005).

According to this vision M3 is beginning to look as a privileged "observatory" of the phenomena that characterize building systems over time, their operation and their use. Therefore, it appears functional for oriented collection of feedback data relating to the behavior of materials and components in specific contexts according to ISO 15686-7:2017 and as clearly expressed by the same ISO 15686-4:2014.

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