OPTIMIZATION OF FACILITY MANAGEMENT THROUGH THE IMPLEMENTATION OF BIM IN EXISTING BUILDINGS

Over time, the value of a building depends on its ability to function as efficiently as possible. Facility Management (FM) requires a large amount of information that comes from several sources and must be processed in a short amount of time. The application of BIM methodology to FM will be studied, what would be the 7D of BIM.

Currently, BIM is used in some new projects from the conception of the project and through the entire lifecycle of the building. This is not so with existing buildings, perhaps due to preconceived ideas about the difficulty of making informed 3D models or the actual possibility of combining BIM and FM to improve processes.

Most buildings from any city are not modelled in 3D (even less so with BIM), but do have to take care of their maintenance and exploitation operations with a multitude of dispersed and disconnected documentation.

This communication proposes a process and the software selection to implement BIM Facility Management in existing buildings, analysing the benefits and possible challenges. It is concretized with its application to a real case in the city of Montevideo (Uruguay), contextualizing the BIM moment in the region.

Keywords: BIM, Facility, Management, methodology.

Introduction

Context. The operational phase of a building, the amount of time the building is in use, may last between 30 to 50 years (Klein, Li & Becerik-Gerber, 2011). This turns any property into a long-term investment that ought to be treated as such. It is because of this that Facility Management (FM) must be optimized and a way of achieving that is through the inclusion of new techniques. While this has been happening for decades, particularly in places like Great Britain or the Nordic countries, the integration of BIM to FM is relatively recent.

The objective of this Paper is to explore ways of improving the Facility Management activities of an existing building that is already in use, through the integration of BIM.
It was understood that BIM characteristics such as, for example, its capability to centralize information and its focus on the cooperation between the different actors, were compatible with the needs and shortcomings of the current FM and, therefore, it was worth developing a way to apply the first to the second.

The result was the creation of a theoretical proposal, developed in such a way that it is applicable to any existing building, independent of its particular characteristics and the software used.

**Objectives.** In order to determine the best way to integrate BIM to FM, it was decided to make an analysis of the existing information in the subject, determine a theoretical proposal, corroborate if it is possible to apply it in reality and determine what its strengths and weaknesses are. At the same time, this involved an analysis of what the concepts of BIM and FM consist of, their benefits and problems, and an analysis of the existing bibliography regarding the integration of BIM with FM and BIM in existing buildings, in general and in Uruguay.

The latter was analysed as the theoretical proposal was applied to a real case in that country, a small-scale building with apartments for rent, a small-scale building consisting of apartments for rent. During the process, Autodesk Revit was used, not only for its worldwide use, but because its licence allows free use of other Autodesk programs.

**State of the Art**

**Analysed concepts.** The first step in the investigation was to determine what is meant by FM and BIM. One of the difficulties detected is that there are many definitions for these concepts. Given the complexity of the subject, it was understood that it was necessary to define them, starting with FM.

In order for a property to properly function, it is necessary to perform certain activities that cover the necessities of the building and the actors involved in its operations and use. Therefore, FM has always been needed, even if that name was not used (NIKAF et al., 2016).

Currently, there are many definitions of FM, which vary regarding content and scope, according to the source and time. A simple way to explain FM is by saying that it consists in taking care of a property and, therefore, the details of how to achieve that depend on the property itself (Magee, 1988). In addition, even if the relationship between activities and profit is not always understood, it is known that there is a direct relationship between poor management and monetary loses (TARANDI, 2011).

After evaluating several existing definitions, it was decided to make one. Here, FM is understood as a discipline through which all the activities needed
for the optimal function of a property and its associated services are coordinates and developed, with the main objective of satisfying the needs and interests of every actor involved. In order to achieve this, the integration of property, users and owners is sought (SABOL, L, 2013).

It should be noted that, over time, FM activities have change in quantity and nature. Even though daily operations and maintenance activities are still vital areas when it comes to keeping a building in optimal conditions, currently one of the most common goals in FM is achieving sustainable and/or smart buildings (SAPP, 2013), (KASSEM, 2015).

There is also a large number of BIM definitions that vary in their treatment of the concept. Currently, there are over 1000 publications dedicated to different aspects of BIM (Barlish, et al., 2012). After analyzing them, it was concluded that the way of understanding BIM depends on factors such as the sector or region in which the user works and that there is still no consensus on how to define BIM regarding topics such as its dimensions or reach.

The chosen definition is: “Building Information Modeling (BIM) is a digital representation of physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle; defined as existing from earliest conception to demolition. A basic premise of BIM is collaboration by different stakeholders at different phases of the life cycle of a facility to insert, extract, update or modify information in the BIM to support and reflect the roles of that stakeholder”. (National BIM Standard-United States, 2016).

Current situation. Its capability to coordinate information from different sources, its focus on teamwork and its capability to be applied to any stage of a building’s lifecycle makes BIM perfectly compatible with the activities of FM, However, the literature dedicated to the integration of both disciplines is limited.

This literature is divided, mainly, between theoretical articles and practical cases whose results are quite dependent on the particular characteristics of the analysed properties, that means to say, that they are difficult to repeat in other buildings. Among the articles, an investigation from the United States based on interviews and surveys with FM experts stands out (Becerik-Gerber et al., 2012).

When a BIM model is made after the construction of the building, it is called an as-built BIM model, which is why the current situation of that particular area of knowledge was analysed. It was concluded that the information is limited, with only about 80 publications dedicated to as-built BIM models. As with publications about BIM in general, there wasn’t much information and most of it was about practical cases. In addition, a common question among the
publications is whether the results found were circumstantial and, therefore, impossible to reproduce (VOLK, 2014).

In Uruguay, BIM in general is little known and the number of professionals that apply it is reduced. It is used in the stages of design and construction, but not during the operational stage and, thought this possibility has been mentioned, it has been in an abstract way.

**Proposed procedure**

**Recollection of information.** In order to apply BIM to the FM activities in existing buildings, a procedure was created, consisting of 3 parts: the recollection of necessary information, the creation of the as-built model and the application of the improvements in the FM activities. The first factor to take into consideration in the design of the procedure was that FM activities need information that goes beyond the physical characteristics of the building, that includes the materials used, the objects associated with it and every piece of information necessary for its proper functioning.

The first part of the process, the recollection of the information, was made with 2 clear objectives: the obtained information was necessary to achieve the specific improvements in the FM activities but, also, it would allow to know the exact state of the building. Therefore, it is not only necessary to create the as-built model, but also to be able to determine what problems and opportunities are present in the current performance of the building. This stage was divided in 3 parts: gather the existing documentation, survey the building – a complete description of its current status – and taking the measures necessary to incorporate the future data of the objects associated with the building (permanent or temporary objects, fixed or mobile).

The documentation that can be obtained will depend on the building itself but, usually, buildings do not have a 3D model and, if they are very old, their documents are not scanned either. This is the reason why the survey of the property will be one of the most important parts of the process.

Currently, there are several data capture techniques, quite varied in terms of method and scope. During the investigation, these techniques were analysed and divided between the categories of automated or manual. Automatic techniques are those that allow the capture of data through technology that automates parts of the process, decreasing the required time and effort. Some are useful for the capture of data related to the physical characteristics of the building, while others allow acquiring the objects’ future information (PARSANEZHAD, 2014).

These techniques include 3D laser scanning (scan-to-BIM) and photogrammetry, the main remote sensing techniques (Klein et al., 2011). In both
cases it is necessary that the data be processed by qualified personnel, though the advantages and problems of each method are different.

In the case of 3D laser scanning, the obtained data is detailed and accurate, as long as the environment allows it, especially when it comes to the reflection or texture of the objects (Klein et al., 2011). Another common problem is the equipment’s difficulty to capture edges or corners, though the equipment is already so sensitive that any adjustment can generate errors of accuracy in the final data.

Photogrammetry is, compared to the previous technique, less expensive but has less precision. The level of automation that can be achieved with this technique is not consistent and so, the results are not homogeneous. Even so, the higher the level of automation, the more data is obtained, but the amount of errors there will be is greater, especially regarding textures or points in similar images (Klein et al., 2011).

Thus, it was concluded that, even if both techniques have many benefits, they also have limitations and therefore, it is better to use more than one. Here, it is proposed to do a building survey using 3D laser scanning, with a manual verification of the data and using manual techniques for the survey of the objects.

For the third step in the data recollection, that is, the necessary measures regarding the objects’ future data, the use of tagging techniques is proposed. Although the use of both RFID and QR codes was analysed, it was concluded that the characteristics and the cost of QR codes made them easier to apply. After considering several ways of integrating tagging techniques into the process, it was decided that at that moment, the objects and places of strategic interest to FM that would get QR codes would only be identified.

It should be noted that, as different techniques imply different costs and time, the techniques available to a particular process will depend on the available resources and the particular situation of the building. Therefore, this is what will determine the time, cost and effort involved in the survey of the building, and the quantity and quality of the obtained information (Wook et al., 2015).

**As-built model.** After obtaining the existing documentation and the data from the survey, a BIM as-built model is created (Fig. 1). To achieve this, first the obtained information must be processed, that is to say, the data from different sources must be loaded into the Revit file and combined, and then continue with the model. Usually, these two tasks are so closely related that they must be done at the same time.

In order to model an element, several data must be loaded, such as the shape of the object, its identity and its relationship with the other elements of the model (Tang et al., 2010), (TEICHOLZ, 2013). As was previously men-
tioned, for any data capture technique, even the automated ones, data entry must be done manually. This makes the creation of the model the most complex and the longest part of the entire process (SUCCAR, 2009).

Once the modelling of the building is finished, physical characteristics and corresponding information included, the data from the objects associated with the building (installations, equipment and others) is loaded. Finally, it is here that the QR codes will be created, getting the relevant information from the model itself. They must be located both in the real object and its representation inside the model, so that they are easy to identify.

**Improvements in FM activities.** In order to complete the process, the improvements in the FM activities must be applied. This means making adjustments and adding more elements to the as-built BIM model, using Revit tools and other commercial software that belongs to Autodesk and whose functioning
is already associated to Revit. After determining which improvements were to be made and organizing the procedure to follow, those improvements were divided into 2 categories: those that are applicable to any FM activity and those that are applicable to particular activities.

During the investigation, Autodesk A360, Green Building Studio and Autodesk Insight were studied. Although an exact order of application of the adjustments to the model is not proposed here, it is recommended that these programs be used after using all the Revit tools. It is with this last part that the procedure to apply BIM to FM activities is considered finished. As was previously mentioned, it was determined during the investigation that many aspects of the process will depend on the characteristics of the building it will be applied to, which is why a workflow that includes all the possible steps was created (Fig. 2).

Fig. 2. Complete workflow of the process (authors, 2018)

Рис. 2. Полный алгоритм процесса (разработан авторами, 2018 г.)
**Case study**

**Modelling process.** Once the process was designed, its effectiveness was analysed by applying it to a real case in the city of Montevideo, Uruguay. The chosen property is a 3-level building, with 8 apartments destined for rent. The objective was to analyse the suitability of the theoretical proposal regarding its application to as many existing buildings as possible. Therefore, a small-scale building (900 m²) with a reduced budget was chosen, as the improvements achieved would not be dependent on the characteristics unique to the project and so, could be reproducible in other properties with the same or more resources.

First, the existing documentation was collected. This documentation was the one from the construction stage, but it was known that the building has not changed since then. In addition, the budget for both the FM activities of the building and the process was reduced. Once this was done, the workflow mentioned before was adjusted to the reality of the building. It was determined that, in order to acquire the rest of the data, it would be necessary to do a survey of the building with manual data capture techniques.

Once the information was obtained, it was loaded into a Revit file. The model was started with the configuration of the materials, the terrain and the physical elements (types of walls, windows, slabs and others). As the objective was to create a BIM model, the final product had to be the property plus its information, which is not just what was added before. Therefore, once the 3D model was made, the ‘Room’ tool, which allows to link information to specific areas, was used. Once the model of the building itself was done, the objects were modelled, located and identified, taking into account the fact that the goal was to make them ‘recognizable’, rather than exact depictions of the real objects. That means making a 3D model of a table and assigning it the real parameters of the actual table (Fig. 3). It was at this point in the process that it was determined for which objects would it be beneficial to have QR codes. The capacity of the QR code to support the FM activities carried out by personnel without access to the model was established as the criterion.

**Improvements achieved.** Once this point was reached in the model, the adjustments for the improvements to the FM were made. As mentioned before, the improvements achieved are divided between those that are applicable to any activity and those that affect specific areas. Regarding the second case, the use of Green Building Studio stands out. Green Building Studio creates an energetic model, analyses it and explains the energetic situation of a building in a format easy to understand, thus allowing to monitor the building’s energetic behaviour, without having to leave Revit.

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Among the improvements related to any activity, those regarding visualization and accessibility of the information stand out. For the visualization of the information, Revit tools such as Orient to View, Schedule and Parameters, whereas for accessibility the Autodesk A360 was used. This app allows access to the model from a computer, a Tablet or a phone, the addition of comments to the model or communication between the different actors who are given access permission. The main benefit of using this app is that, once a problem that requires information of the building itself arises, for example repairs, the information can be sent instantly, without having to go there or create physical copies.
When the achieved improvements were analysed, it became evident that most of them were made through the use of the same Revit tools. With Walkthrough and Animation, improvements were achieved in activities such as Emergency Management or Human Resources, by coordinating the existing information and creating documents that aid in the performance of the activities. With Colour Scheme there were improvements in Emergency Manage-
мент, Daily Operations and Maintenance, identifying areas by subjects or tasks to achieve. Another tool that was repeatedly used was the Parameter Identity Data, which allowed entering information of different elements of the building and creating a useful database for the daily FM activities. In the case of very extensive or detailed information, such as the maintenance history of the equipment, the tool URL Parameter, which allows to associate a website or a file path to the model, was used.

Finally, with all the information loaded into the model, the QR codes were created and installed. Thus, it was possible to implement the process to apply BIM to FM to a real case. The created model is capable of containing and coordinating all the information required to perform the FM tasks, with which the initial objective, that is, to verify that the theoretical procedure can be applied to real cases, was achieved (Fig. 4).

**Conclusions.** Currently, it is possible to optimize the FM of an existing building by integrating BIM. The main factors will be the available budget, as this will limit the resources that can be obtained, and the capacity of the technology used. In fact, the main limitation will be the gap between the needs of the process and current technological advances.

The main difficulty during the investigation was the creation of the model, a process that was long and complex. This is because, even when automated data capture techniques are used, much of the data loading process to the software is manual. Revit can store a lot of information, very varied, but the vast majority of it has to be manually loaded. As data entry was the longest part of the creation of the model, this is what determined the duration of the entire process. This fact is particularly important, as most buildings currently in use do not have a BIM model. In those cases, integrating BIM to FM would be a long process, which could dissuade the different actors from trying.

In turn, this means that the amount of people involved in the process must be a factor to take into account. The budget will determine the data capture techniques to be used and, therefore, the effort to dedicate. If the available budget is reduced, the available data capture techniques will be ones that require a lot of effort, with the adequate training of the intervening personnel so as to adjust the time consumed in the creation of the model.

Finally, it was concluded that, in order to maintain the achieved optimization of the FM activities over time, it is necessary that the model be updated regularly and that cooperation between the different actors be achieved. Therefore, the success will depend on the consistency of those involved in the process.
Future Research Directions. During the investigation, several points of interest emerged, the analysis of which would serve to advance the application of BIM in FM. The proposals presented here are about improvements in the technology that would facilitate the study and comparison of future case studies.

In the first place, it would be beneficial to study ways to standardize the process, even partially. As a starting point, it is proposed to create a standardized way to record the steps that had to be taken to achieve a model adjusted to improve the FM activities. If it were a part of Revit, as a new type of Schedule (the Revit tool) or add-on, records easy to share among users could be achieved. These records would be a source of information that would help determine which parts of the process are common to any project and which ones differ.

It is also proposed to standardize the way of dividing the data needed in large projects. The size of the model used during the investigation did not exceed the used computer’s capability, but the case of study was a small-scale building. For large-scale buildings, data has to be divided into several files and, if there is a common format, it would be easier to identify similarities between the processes. To options that are already in use are dividing by floor or dividing by discipline.

In addition, it is proposed to research ways to integrate tagging techniques to Revit. Although there are research papers that mention investigations where QR codes have been automatically connected to a model, there are no cases on a commercial level. The use of QR codes in the practical case created benefits, despite the fact that there was little interaction between them and the BIM model. Therefore, it is understood that, if there is greater connectivity between these technologies, the process would be improved.

Finally, the implementation of BIM in FM requires the constant optimization of the existing procedures and an emphasis on teamwork. Thus, it is proposed to research the integration of the Lean methodology to the process as a way to improve it.

References


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Вероника Вилас Гарсиа, Фернандо Лопез Кос-Гайон, Луис Иглесиас Палмеро

ОПТИМИЗАЦИЯ УПРАВЛЕНИЯ ОБЪЕКТОМ ЧЕРЕЗ ВНЕДРЕНИЕ МЕТОДОЛОГИИ ВИМ В СУЩЕСТВУЮЩИХ ЗДАНИЯХ

В процессе эксплуатации ценность здания зависит от его способности функционировать максимально эффективно. Управление объектом (англ. Facility Management, FM) требует большого количества информации, которая поступает из нескольких источников и должна обрабатываться в короткие сроки. В данной работе изучается применение методологии ВИМ к FM.

В настоящее время ВИМ используется в некоторых новых проектах – от разработки концепции проекта и на протяжении всего жизненного цикла здания. Однако ВИМ не применяют для уже существующих зданий, возможно, из-за предвзятых представлений о сложности создания 3D-моделей или реальной возможности объединения ВИМ и FM для улучшения процессов.

Большинство зданий любого города не смоделированы в 3D (для еще меньшего количества зданий используется методология ВИМ), однако и в этих зданиях необходимо управлять операциями по обслуживанию и эксплуатации, связанными с работой с большим количеством разрозненной и удаленной документации.
В данной статье предлагается процесс и выбор программного обеспечения для реализации управления объектом (FM) на основе методологии BIM в существующих зданиях с анализом преимуществ и возможных проблем. Этот подход конкретизирован на примере реального здания в городе Монтевидео (Уругвай).

Ключевые слова: BIM, объект, управление, методология.

Vilas García Verónica – Architect of ORT University (Uruguay), Master in Building Universitat Politècnica de València (Spain) (veronicagarcia234@gmail.com).

López Cos-Gayón Fernando – PhD. Architect & Engineer Building, Professor at the Technical School of Building Engineering, Department of Architectural Constructions, Universitat Politècnica de València (Spain) (fcosgay@csa.upv.es).

Palmero Luis Iglesias – PhD. Engineer Building, Professor at the Technical School of Building Engineering, Department of Architectural Constructions, Universitat Politècnica de València (Spain) (lpalmero@csa.upv.es).

Вероника Вилас Гарсиа (г. Валенсия, Испания) – архитектор, Университет ОРТ (Уругвай), магистр по направлению «Строительство», Политехнический университет Валенсия (46022, Испания, г. Валенсия, ул. Камино Вера, 6/н, e-mail: veronicagarcia234@gmail.com).

Фернандо Лопес Кос-Гайон (г. Валенсия, Испания) – канд. техн. наук, профессор, архитектор и инженер-строитель, кафедра «Архитектурное строительство», Политехнический университет Валенсия (46022, Испания, г. Валенсия, ул. Камино Вера, 6/н, e-mail: fcosgay@csa.upv.es).

Луис Иглесиас Палмеро (г. Валенсия, Испания) – канд. техн. наук, профессор, инженер-строитель, кафедра «Архитектурное строительство», Политехнический университет Валенсия (46022, Испания, г. Валенсия, ул. Камино Вера, 6/н, e-mail: lpalmero@csa.upv.es).