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Introducing BIM into ACCIONA, an International Construction Company: Actual Real-Case Examples

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Abstract: This article is about the implementation process of BIM Methodology into ACCIONA, an international construction company, and the necessity to improve traditional flows in different departments, and the need to coordinate and manage corporately the company implementation. Real-case examples such as New Airport Terminal of Leon, Fine Arts University or The Penitentiary Center in Teruel, which are the first Spanish projects to be managed on site using BIM methodology, will be discussed. These first projects set up the basis for the implementation of the methodology at a global scale. Lessons-learnt and transfer of knowledge processes during the implementation will also be discussed. In addition, this paper shows several experiences adapting BIM methodology in departments like Design, Engineering, Quality or Tender. The main challenge was the necessity to adapt this methodology to local workflows or to create corporative Guidelines to improve the management of BIM models. Moreover, it was also necessary to create and change roles to adapt them to the new BIM workflows. Due to the necessity to improve the flow of information and decision making process, the teams worked on collaborative virtual reality rooms. The models included in the stereoscopic systems were obtained directly from BIM models. This involved the creation of exchange protocols to ensure interoperability of the both systems and the integration of BIM information into immersive environments. It was necessary to create different configurations of immersive portable systems for implementation on site. Conclusions and results of this case studio will be presented.

1 Introduction

BIM (Building Information Modeling) is a methodology based on the collaboration of all project participants on an integrated model and a combination of different processes and related technologies. This is a digital representation of physical and functional characteristics of a facility (National BIM Standard - United States). BIM facilitates sharing data (communication), exchanging opinions and experiences (collaboration), conducting pre-construction analysis (simulation) and using these results to improve design and execution (optimization).

Construction industry represents more than 13 % of the U.S economy (U.S. Bureau of statistics, 2000) and over 10 million people work in the construction field according to P. M. Goodrum, Haas, & Glover, (2002). These data show the importance of a good organization between participants and a correct interoperability between them. According to Gallagher, O'Connor, Dettbarn, Gilday (2004), between 0.86% and 1.24% of construction spending is directly related to inadequate interoperability, what represents \$36Billion per year. In order to improve the construction process and reduce the economic impact, BIM could be applied.

In Spain, the construction industry is much more fragmented. Besides, the lack of national guidelines and the unique process of Spanish construction make difficult the implementation of BIM. However, our company is a pioneer in the use of BIM during the construction phase of the projects in Spain.

2 Objective

The aim of the paper is to show that BIM is a very effective way to manage and deliver large, complex projects. This involved the necessity to adapt this methodology to local workflows and to create corporate Guidelines to improve the management of BIM models. In the next sections, different real-case projects will be used to describe the company evolution to adopt BIM. These are the first construction projects built in Spain where BIM applied to our works has been put into practice. The improvements in time and costs achieved with the application of BIM methodology in our three case studies are positive. In general, 87% of the projects managed with BIM have a positive ROI according to Norbert W. Young, (2009).

The main challenge was developing new communication flows in the internal processes of the company. With the implementation of BIM, every department may have access to the most updated project information, which it is stored in a central server and available to all the different departments working on a project. As a result of the international development of the company, the number of projects which require the implementation of the BIM methodology is three times the number one year ago.

3 Corporate Implementation

The implementation of BIM has been an inter-department cooperation process. The first step was a comprehensive study of BIM's state of the art carried out in 2008. This comprehensive studio was followed by a first knowledge-based application of BIM in one actual project: the New Airport Terminal of León

In parallel to this application, we carried out an intensive analysis about the current company procedures for every department which had a say in adopting BIM, the workflows between them and how BIM could fit in the work process. Based on the experience gained from the pilot application, together with the analysis of the departments, it was developed a guideline for BIM application. This guideline is necessary because it includes the internal company processes adapted to BIM; the workflows between departments, people and projects; the new roles of the personnel involved in the BIM tasks and groups and also the collaborators of other departments; the policies which implies new documentation and relations between partners; and the new hardware and software requirements.

The next step was the dissemination of the BIM guidelines procedures to the company. New roles, ICT, workflows and processes were explained on different informative sessions. A survey campaign was carried out among the different departments so the personnel involved could provide an insight of their needs and requirements, as well as how they would fit their daily job in the new BIM process.

The results of these surveys, made a year ago, were as follows: the use of BIM in the company is not homogeneous. Some areas have had a successful implementation while other ones have barely adopted it. The main areas that use BIM are related to international markets like tender's and proposals, international, R&D and engineering. 40% of the survey respondents already use BIM. 82% think BIM is critical for the company interests, and 90% think BIM helps to get new contracts. In fact, 64% of the clients recommend or require BIM in their tenders.

Nowadays our company counts with a specific area to coordinate the BIM-related projects, two projects have been completed using the BIM guidelines since the start of the works, more than 10 internal training courses have been carried out and the BIM also has been incorporated in more than 20 tenders. Besides, there has been an intensive communication campaign to spread the information and BIM Implementation Plan defined by BIM experts.

To sum up our journey since 2008, we have developed a comprehensive BIM methodology explained in the Guideline and Implementation Plan in order to increase the efficiency by means of interoperability between software, people, process and information for all company. Based on this, a scheme of the BIM activities which we can make is showed in figure 1:

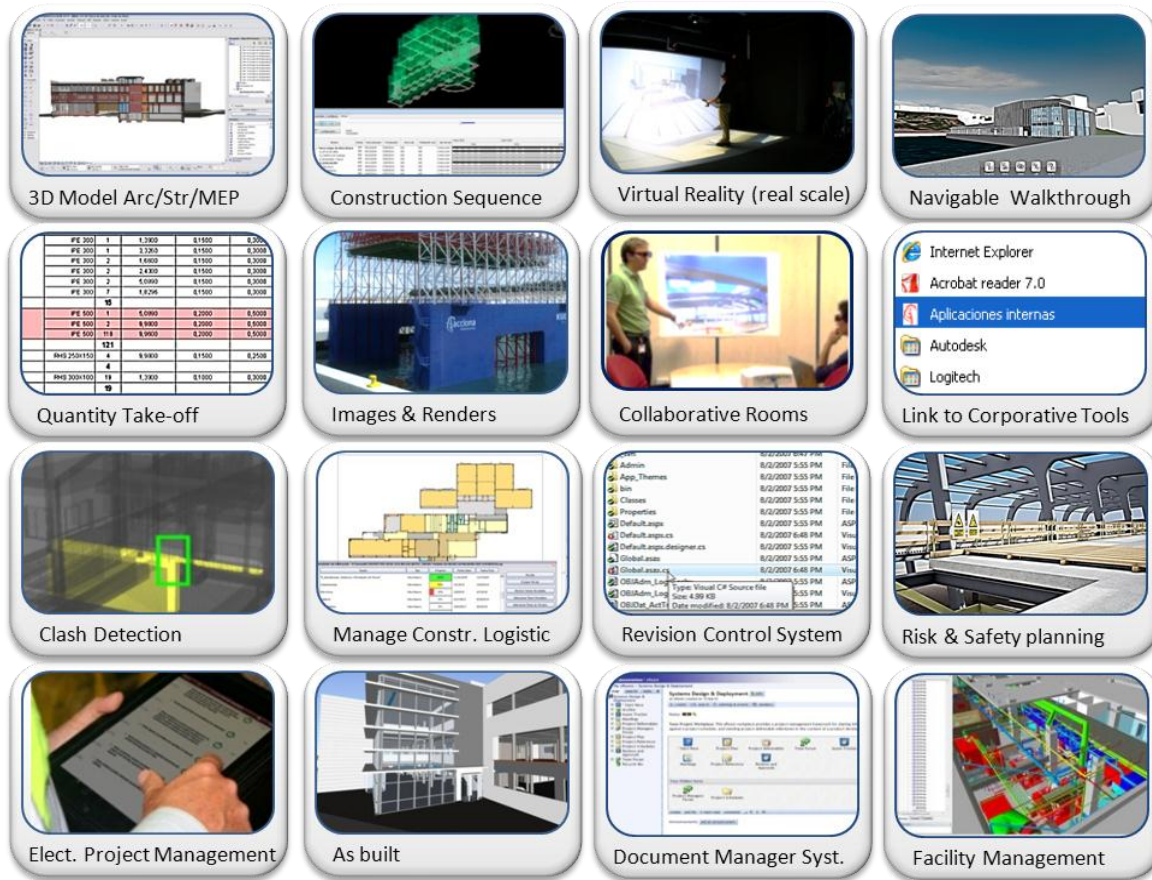


Figure 1: BIM Uses chart

4 Case Studies

In this section, three case studies are presented in chronological order of development. BIM has been gradually implemented from the first project, the New Airport Terminal of León, to the latest Teruel's University of Fine Arts and Teruel Prison, still under development. Each has represented new challenges in the BIM application, as the degree of inclusion of BIM in the model has significantly increased.

The methodology used to create and manage the case studies, is developed into the Guideline and the Implementation Plan of the company. As on-site works progressed, the Guidelines became improved and more completed.

4.1 New Airport Terminal (León – Spain)

This is our first project for and the first project ever in Spain, where BIM was applied. In this case the project was developed in parallel between the traditional way of construction and BIM methodology. This was our first approach to the BIM experience. In April 2009, we started the software courses for the people involved in the project. In June 2009 we visited the on-site works and started our collaboration

between BIM group and people involved in the work. The project was completed in September 2010. This project was pioneering in Spain using BIM from the bid phase to the implementation on-site.



Figure 2: New Terminal of León: Montage of BIM model (left) and real photograph (right)

The project consisted on the enlargement of Leon Airport Terminal. The New Terminal has 8.000 m² . approx. A summary of the tasks made in parallel during the works was:

- A BIM technician maintained the BIM model and exploited the results. Technical support was given from R&D BIM group. BIM technician was trained by the BIM group before and during the works.
- BIM technician and BIM group created together a BIM model that contained architectural, structural and MEP objects with high Level Of Detail (LOD 300-400 according to AIA E202-2008: Building Information Modeling Protocol Exhibit). This is the optimal LOD to show construction elements, fabrication and assembly. Figure 3 shows the frame structure created in the model. They were the base to obtain the exact drawings and real-time quantity take-offs. This frame was exactly measured. We found that the difference between original quantities and the new one extracted from the BIM model was 12%. Another important saving in budget was the dropped ceiling. 37% of them was not measured, so the model helped to quantify correctly and avoid a problem in the final budget.



Figure 3: Example of LOD 400 for structure, real picture of the works and the BIM model compared

- Thanks to the model, a set of errors was solved, anticipating problems on-site. Most of the errors were due to bad coordination between architectural, structural and MEP drawings. BIM model merges all, so it was easy to check the incompatibilities. For example, it was detected that the frame structure blocked the hidden gutter of the cover (Figure 4). The frame and the cover pieces were prefabricated. A minimum change could make them useless. So it was very important to check the model to resolve errors. The same as MEP systems. Installations were not adjusted to architectural and structural drawings and they were in conflict (Figure 5). The advantage of find those errors before on-site works allowed us labour savings of 27 %, and cost savings of 3.8%. The productivity of people involved in the work gained an improvement of 13%.

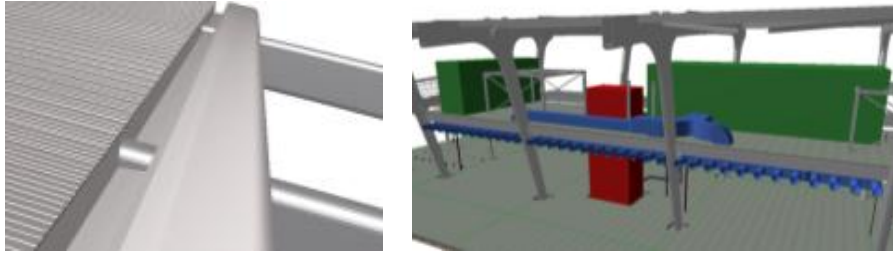


Figure 4 & 5: Gutter blocked by the frame and oversized MEP systems

- BIM model was used to check different MEP systems alternatives in order to find one that allowed a correct integration of them. Original MEP systems were oversized and their dimensions were bigger than the space available for them.
- A Virtual Reality model extracted from the BIM model was useful to check collisions and evaluate spaces and finishes. Also it allowed virtual walkthrough at real scale in order to show the project to the owner (see 5. Virtual Reality)

All the data extracted from Leon was gathered from the comparison between traditional way to develop on-site project and the new BIM-applied one (in this project both procedures was concurrent). All these estimations are based on the comparison between original and BIM developed budgets and programming.

Productivity data was not easy to measure. It was obtained according to the comparison of traditional assignation of roles and hours (extracted from our experience of our company) and the new BIM assignation plus some calculations to estimate the productivity loss (due to the BIM training and new adapted processes) and the productivity gain after these phase. Also, the change of roles, processes, software and methodology, has an influence in the estimation of hours and productivity percentage. All these information and measuring are included in our Implementation Plan.

4.2 Fine Arts College (Teruel – Spain)

Contrary to the first project, in the second one, BIM processes and workflows have been fully integrated as a working methodology, opposite to develop the works in parallel. The works started in January 2010. A training course was given by the BIM group to the people involved in the works.



Figure 6: Fine Arts College: montage of real building (left) and render image (right)

The project has 6.000 m². approx. A summary of the most important milestones is:

- At the beginning of the project, 3 error reports were presented to the on-site project team in order to show them how quickly and precise the BIM models are for the project development. The people involved were very impressed and decided to work with BIM. For this case we had all the experience acquired by our last project.
- In this project, BIM group offered technical support to the people involved in the works. A technical BIM Group (who was composed by members of the on-site project team) created the BIM model. This was the first time we had a technical BIM Group in the works that managed people, model and organized the works according to the Implementation Guidelines.
- Same as for the Airport Terminal, a comprehensive BIM model was created for this project. Level of Detail was LOD 300-400 -500 according to AIA E202-2008: Building Information Modeling Protocol Exhibit. Level 500 represents the projects as they have been constructed (the as-built conditions) for maintenance and operations of the facility. In Teruel's case, they need the as-built model in order to check every day the progress of the works. Therefore, they used two models: initial one, and the as-built one. In Spain it is mandatory to deliver as-built drawings. This is a difficult work because sometimes these drawings are not updated and generate confusion about what drawing is the latest. By means of the as-built BIM model, drawings are always updated, because they are extracted from the model. The work for the generation of as-built documents was reduced in 50% due to BIM model. It allows reducing the time in the generation of these documents by 30%. The productivity of people involved in the work gained an improvement of 21%.



Figure 7 & 8: Progress of the works for as-built: structure of the building (left) and render image (right)

- Simulation of construction details in the BIM model before their execution: BIM model helped the definition of the construction process, especially on: structural details (like beam joints, and positioning of columns), the distribution of the stepped Conference Room or the different finishing of curtain walls, walls and windows.
- Find errors and problems in the project in order to avoid them before the construction. One of the most critical was to find that the original structure was totally incompatible with the building's envelope. Architectural and structural drawings were not coincident. So it was necessary to change the envelope in order to adjust it to the structure. This change affected the brick walls. They increased their quantity take-off by 10% in relation to original measures.
- BIM model was used to show different solutions in materials and finishes to the client. For example the concrete prefabricated panels were changed for a traditional masonry with white plaster, more aesthetic, easy to build and more economic. This change represented savings of 13%. Other important changes were the structure of the curtain wall (that means an improvement of the system and savings of 6% and changes in the distribution and colours of the wood panels of the rooms (4%).

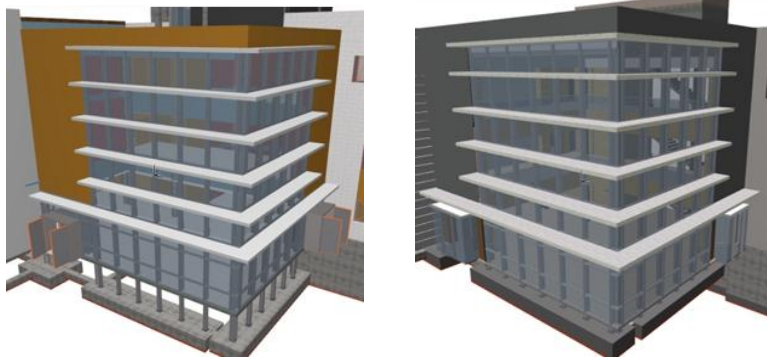


Figure 9 & 10: Different options of Curtain Wall Façade and materials

All the data extracted from Teruel was gathered from the comparison between traditional documentation generated by the architect and the new BIM documentation extracted from the model.

Productivity values are more precise due to the previous knowledge acquired in Leon. But methodology to obtain them is the same as Leon Airport Terminal.

4.3 Penitentiary Centre (Teruel – Spain)

Third case is at the moment on progress. It started in December 2011. The work team is the same as Fine Arts College, which clearly benefited the learning process and has proved to be useful to fast-track the project. However, the in-house learning process was advanced through courses of MEP, Clash Detection, and Regulations Check.



Figure 11 & 12: Penitentiary: photograph (left) and render picture (right)

The project has 19.000 m². approx. The BIM model was created for the same reasons as Fine Arts College. At the moment there are no important changes in the project except for a change related to the building services shaft. Thanks to BIM model, the project team found out that shafts are not wide enough to contain all the installations. This is a huge problem in this project due to the complex prefabricated concrete walls. They are impossible to move, modify or change so it is very critic to know exactly the distribution of them.

5 BIM-based Virtual Reality

Virtual Reality is an illusion of presence created or simulated by computer-based means that generates real time perceptions of environments without physical content. Virtual environment techniques can improve the design process by integrating human judgement at a far earlier stage of product design.

Inexpensive changes to the design and rapid prototyping using these environments should improve the quality and reduce the development time for new products (Ressler, 2004).

The knowledge of the building in its early stages by all the participants leads to greater design flexibility and optimizes solutions and cost. Changes in the production phase can be 36 times more costly in budget than those made in the design phase. (A. Valerio, 2004). Visualizing a project in real scale permits virtual preconstruction, and the ability to detect clashes as well as design problems in early phases reducing costs. The use of virtual reality techniques allows an immersive experience before construction takes place.

The industrial sector has been using virtual reality (VR) and simulations for decades. Until the development and implementation of the BIM methodology, it had never been thought to standardize the use of virtual environments for different applications (accessibility, risk prevention, acoustics etc.). Besides, BIM requires cooperative environments and information flows among the partners. This leads us to conclude that the use of virtual reality in construction will be a trend in the coming years.

BIM models were adapted to Virtual Reality in order to simulate models, check spaces, to visualize them in real scale (1:1) and to help owners to understand their buildings making walkthrough. Some of them were:

Monterrey Tower in Mexico. This was a complex skyscraper, very difficult to understand in drawings, so the owner asked us to visualize it in an easy way. Also he wanted to see the building divided in different zones and in construction phases. For this purpose, a new interface to improve the real-time navigation was created. It was possible to filter areas of the building and to look up the different construction stages.

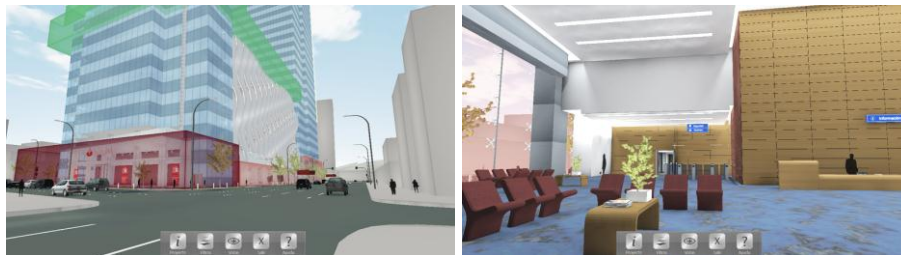


Figure 13 & 14: Exterior of the tower (left) and reception of the building (right)

Teruel Hospital. In the Hospital, the interface used was the same as Monterrey. It allows to navigate into the model in real scale, and to show alternatives of materials and distributions of the rooms. This allows owners to select combinations in real time and in a quicker and easier way than in drawings.

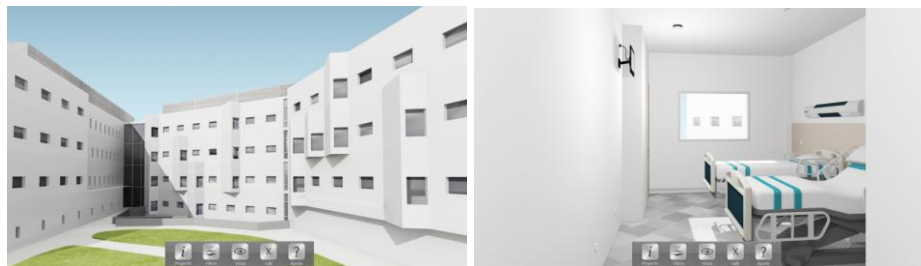


Figure 15 & 16: Exterior of the Hospital (left) and one of the rooms (right)

New Terminal in León. The VR model was extracted from BIM one. We use the VR model to check dropped ceiling spaces and how to optimize them; to check finishing and material of the different rooms and to check the structure assemblies of the frames. These visualizations were very useful for both technical project team and the owner of the building.

6 Conclusions

This paper has described the potential of using BIM methodology in on-site works and tenders. It was useful for people involved in Teruel and León case studies and it helps in time and cost savings. Every year increases the number of BIM projects, especially in international areas of the company and it is important to be prepared to offer our services.

We obtain significant profits in all our case studies. It demonstrates that our experience in these cases; show us, that projects managed with BIM methodology in our company; are more precise, economic and faster than projects managed in a traditional way. The reasons are: BIM allows a better comprehension of the project in order to avoid errors; BIM can manage and update the documents of the whole project; BIM improve the time and cost of the project and it can be used for visualization purposes by means of Virtual Reality tools.

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