Contemporary Engineering Sciences, Vol. 11, 2018, no. 44, 2181 - 2199
HIKARI Ltd, www.m-hikari.com
https://doi.org/10.12988/ces.2018.85217

BIM Integration into Railway Projects – Case Study

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Abstract

The technology of Building Information Modeling BIM is booming. More and more countries are introducing regulations to integrate BIM into new infrastructure projects. But this remains a tool designed initially for buildings, circumscribed geographically. Railway infrastructure projects are generally linear and extend over a line, with bifurcations. This article aims to confirm the theoretical results (benefits, limitations, risks) concerning the integration of BIM (Building Information Modeling) to railway projects through the study of a practical case with a real reel scale experiment.

The integration of Building Information Modeling into the rail project is a worldwide trend. The advantages of this integration are many: elimination of project collision risks, optimization of design, collaboration between disciplines and cost reduction. We will present the state of the art regarding BIM and its integration into the railway domain, and from there, we will list the benefits, limitations and risks. Then, we go through different experiments of integration of the BIM with the rail to reinforce the literature before presenting a real case of experimentation of study under BIM of a railway project in Morocco. Finally, we will draw conclusions and recommendations, comparing experiences with literature. Among the recommendations will naturally be an opening to future research that is needed.

Our research confirmed the results of the literature. The advantages of BIM in rail are multiple: conflict detection, time saving, integrated team, improved design visualized throughout the study and cost optimization. Certain limitations and risks mentioned by the literature are also confirmed: ownership of the database, need for support of BIM from the idea of the project and adoption of the collaborative spirit by team members.

It must be taken into account that the experimentation that we carried out is limited (in time, in interfaces and disciplines) and that it should lead to a greater experimentation taking charge of a railway project in its entirety. Nevertheless, these results open the door for more integration of BIM in the rail sector, especially in developing countries such as Morocco.

In Morocco, and in similar countries, BIM is starting to be a topic of interest for the project managers, the authorities and the industrialists. This article provides added value in the integration of BIM into the railway (which can be transposed to other areas) through case studies and confirmation of the state of the art.

Keywords: Building Information Modeling, Railway infrastructures, software, design, integration, ONCF, COLAS RAIL MAROC

Introduction & methodology

Introduction

Railway projects are structuring projects for a country that have a strong impact in terms of development and spatial management. Due to their size, these projects require considerable design, manufacturing and installation time, and require huge budgets. In these projects, tens of thousands of documents and 2D plans are exchanged between the various trades and the different phases. The document management proves tedious and does not prevent, in the majority of the cases, the collisions, the errors and the lack of coordination. We propose to explore a new approach to carry out these projects by integrating BIM from the idea phase. Decision-makers and project managers around the world are moving towards the integration of BIM modeling into large infrastructure projects. In this sense, the experiences of integration of Building Information Modeling BIM with railway projects show that the main objective of this approach lies in to improve design integration, internal project team communication and collision detection to avoid rework during project execution and minimize site delays, as was the case for instance at Infrabel (manager of the Belgian railway infrastructure) (Nuttens, 2018) [26]. These improvements translate into higher quality projects delivered on time and on budget. In this implementation, the focus is in particular on the use of BIM to integrate designs from different technical disciplines for major railway infrastructure projects.

Our current research aims to list, through a review of the literature, the data concerning the integration of BIM in railway infrastructure projects (advantages, risks, limitations), to compare them to the cases of use of BIM in

Rail projects around the world. These same data will be confirmed by a real-scale practical case study in a project in Morocco.

We will see in the first paragraph a review of the state of the art. This review concerns the literature on BIM, its advantages, its key success factors, the limitations of its implementation, and then presents some technical software before listing some case studies (examples of projects in Belgium, France, the United Kingdom, Sweden and Norway) extracted from the literature concerning the integration of BIM to the railway domain. We will try to draw the conclusions of these implementations in terms of difficulties, keys to success and organization.

In the second paragraph, we will comment on an experiment we are conducting: a rail project of Colas Rail Morocco for the ONCF (Railway Network Manager in Morocco). The exercise consists of listing the prerequisites, the keys to success and the steps for the integration of BIM through this implementation. Our experience will be to study a 20kv / 3kv electrical substation of the ONCF network built by Colas Rail Morocco. It will use the architecture, structure and electrical modules of the modeling software of the 3D model, then it will study the possibility of moving to the fourth dimension 4D (planning, adding time) and the fifth dimension (cost, incorporating the quantities and prices).

Finally, we will draw conclusions about the practical implementation of Building Information Modeling for a railway project. From these conclusions, we will draw the tracks of future research by defining the problem relating to the development of an implementation methodology to integrate the BIM in railway projects.

Methodology

This paper is part of our research project on the integration of BIM in railway, which is the result of a partnership between Colas Rail Maroc and the ENSAK of the Ibn Tofail University of Kenitra.

The objective of this paper is mainly to confirm that the integration of BIM with the railway, through a theoretical and practical study, can have positive impacts.

To do this, our methodology consists in studying briefly the development of the railway, the need to improve the budgets & schedules of the projects, to increase the productivity, before showing the advantages of the BIM in the sector of the AEC (Architecture, Engineering & Construction). The study of feedback from railway projects (chosen for their date of completion - beyond 2014, their size, their geographical situation in several countries and for the availability of literature in a new field) will confirm the initial hypotheses. The case studied again in this paper will, in addition to the confirmation of the elements of the literature review, provide a real-life experience of the advantages, limitations, and research and industrial tracks of the integration of BIM into railway.

In the discussion of the results, we will focus on the benefits, risks and limitations of integrating BIM into the railway. In conclusion, we are laying the groundwork for future research in the field.

Integrating BIM into railway projects: revue of experiences

Focus on BIM

Building Information Modeling (BIM) is a digital and graphical representation of the physical and functional characteristics of an installation. One of the main advantages of a BIM is that all the information about a project can now be contained or linked to the BIM. The BIM is a shared knowledge resource for facility information that provides a reliable basis for decisions during its life cycle (from design through to demolition). When using BIM, we do not just use new software to replicate the processes we used less effectively in CAD. When we use BIM, we dramatically alter workflows, relationships, and deliverables. This has an impact on a wide range of stakeholders in the construction industry and beyond. The type of change required, and the extent to which change is needed to facilitate BIM, is often unknown to senior management (Holzer, 2016 [17]; National BIM Standard – USA, 2014) [21].

Building Information Modeling (BIM): a literature review

Building Information Modeling simulates the construction project in a virtual environment. A simulation has the advantage of taking place in a computer thanks to the use of a software package. Virtual construction implies that it is possible to practice construction, experiment and make adjustments in the project before it is updated. Virtual errors usually have no serious consequences, provided that they are identified and processed early enough to be avoided "on the ground" (the actual construction of the project). When a project is planned and constructed virtually, most of its relevant aspects can be considered and communicated before finalizing construction instructions. The use of computer simulations in the field of building construction is revolutionary. Various manufacturing industries have successfully applied simulation techniques for decades. Many construction companies have now successfully applied similar techniques to their construction projects, although critics say that simulations will only benefit repetitive production processes and that construction is by definition unique (Kymmel, 2007) [20] A building information model can be used for the following purposes: Visualization 3D renderings, Fabrication/shop drawings, Code reviews, Cost estimating, Construction sequencing: A building, Conflict, interference, and collision detection, Forensic analysis, Facilities management (Salman, 2011) [31].

At the same time, it must be considered that the integration of the BIM reveals risks that must be considered. Literature estimates that BIM risks can be divided into two broad categories: legal (or contractual) and technical. Legal risks include: BIM data ownership, problem of license limit, control and control of the database in relation to the impacts of modifications, etc., and technical risks: the use of different software or different versions, use different planning or cost estimates. In addition, there is a need to standardize the BIM process and to define guidelines for its implementation. Software today does not make it possible to carry out all the steps of the BIM. The stages of implementation are not standardized either. In addition, industry will need to develop acceptable processes and policies that promote the use of BIM and govern current issues of ownership and risk management (Salman, 2011) [31].

There are three levels (in general) to evolve towards a collaborative BIM (Bensalah, 2018) [6]:

- BIM Level 1: Isolated BIM includes the realization of the Digital Model, use by one or more engineers, but does not include exchanges between models, each updates its data individually.
- BIM Level 2: Establishment of a collaborative work between actors where several models are linked and shared and allows to combine all the models into a federated model. It includes: a graphic model or 3D digital model, non-graphic data (information for the use and maintenance of the work), structured data (proprietary data, manufacturing data, cost and planning data), documentation, a native file format (IFC).
- BIM Level 3: The ultimate goal of BIM (for many, only level of the BIM process), a single model shared by all actors. It allows the possible intervention of all and at the same time. It includes "Level 2" + storage on a centralized server.

BIM software examples

In this subparagraph, we will see two examples of the most popular BIM software in the railway world: Autodesk Revit (Revit, 2017) [29] and Bentley Sweco (Bentley, 2017) [7]. The first is a wide-ranging software that can be suitable for several trades and disciplines, while the second is a specific software for the railway.

<u>Revit, Autocad.</u>
Revit is architecture software, from the company Autodesk, which allows creation of a 3D model of a building to generate various documents necessary for its construction, as in figure Fig.1. It is currently available in version 2017 since April 18, 2016. This CAD software is moving towards modeling BIM building data. The illustration of the Revit visualization is shown in Fig.1 below. Revit is a multi-business software for construction professionals (architects, engineers, technicians, designers and contractors). It integrates 3 trades:

- Revit Architecture, modeling tool for Architects;
- Revit Structure, allowing modeling the structure and then exporting it, for example: on Robot.
- Revit MEP (Mechanics, Electricity, Plumbing) for network design.

It also allows the exchange of data with a multitude of other software.

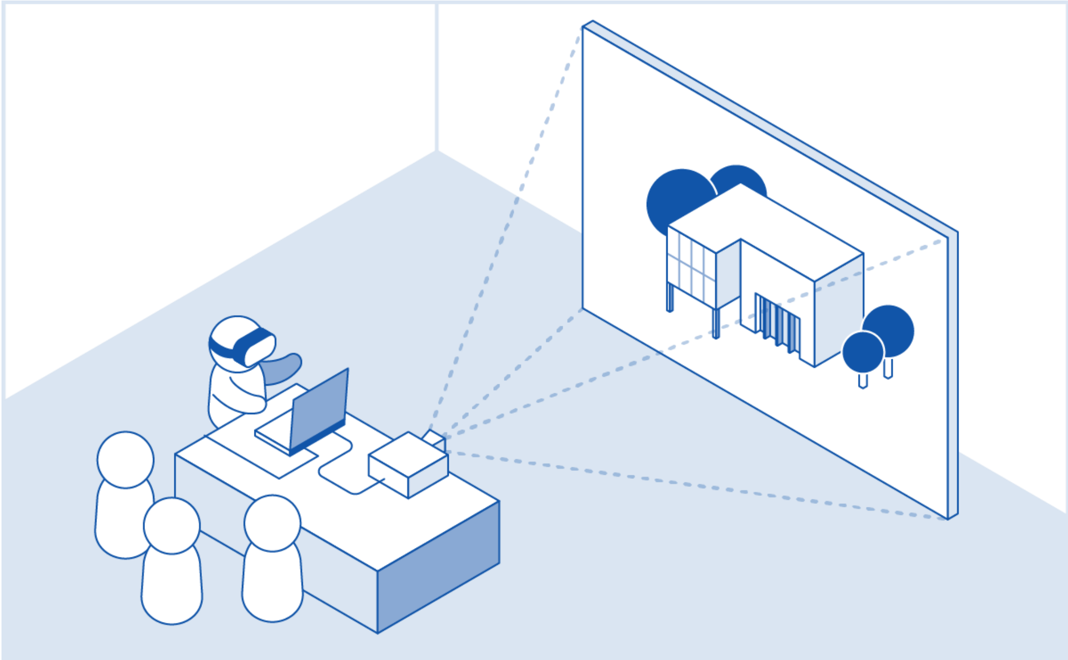

Fig.1: Revit Visualization (Revit, 2018) [30]

Revit architecture creates optimized and more accurate designs. This software helps to:

• Design and Documentation: Place smart elements such as walls, doors, and windows. Revit generates floor plans, elevations, slices, bills of materials, 3D views and renderings.

• Analysis: Optimize building performance upstream in the design process, make cost estimates, and monitor performance changes over the lifetime of the project and building.

• Visualization: Generate realistic photo renderings. Create your documentation with delineations and 3D views, as well as stereo panoramas to convert your design into virtual reality.

• Multidisciplinary Coordination: As Revit is a multidisciplinary BIM platform, you can share model data with engineers and contractors in Revit, reducing coordination tasks (Revit, 2017) [29].

Bentley offers a range of software (Sweco among others) for Rail Track Design and Analysis. These software dedicated to Rail trades and their different disciplines, have a large library of pre-defined elements and objects: sleepers, rail, poles, catenary elements and signaling (The figure Fig.2 illustrates an example of a railway line modeled by this software). In addition, the publisher also offers compatible tools for analysis, calculation and verification. The software allows:

• 3D modeling for improved analysis and visualization

• Performance of regression analysis, horizontal and vertical alignment, cant design, and turnout placement to international standards

- Improve asset quality and reduce rework with a fully localized application
- Decrease project errors and increase data re-use with built-in CAD, GIS, and multi-file format support

And all the creation, editing, visualization, and publishing capabilities of MicroStation in one application (Bentley, 2017) [7].

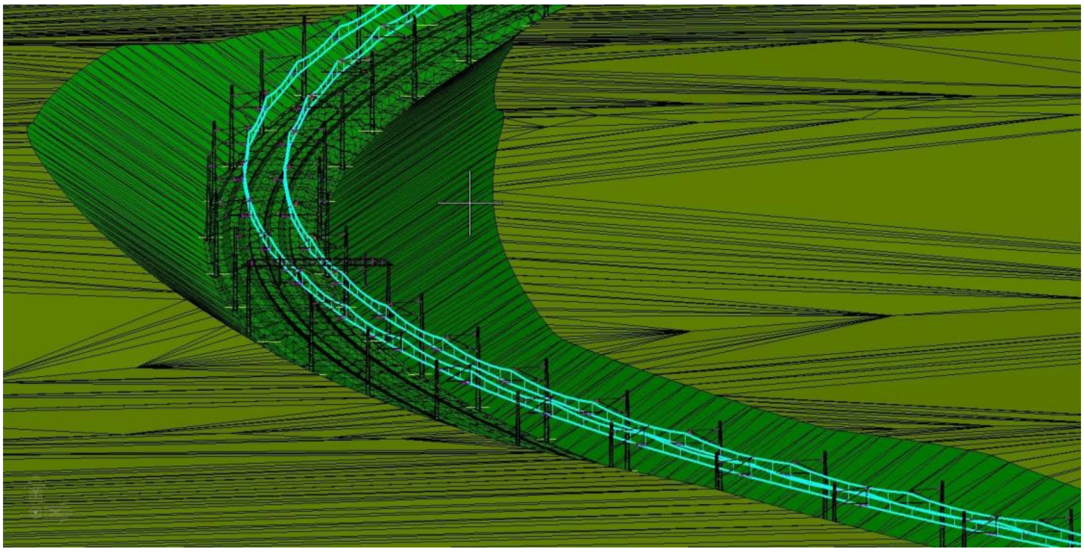

Fig.2: Bentley overhead line design (Bentley, 2018) [8]

Software choice

In this subparagraph, we saw two types of BIM software. Autodesk Revit which is a general-purpose, powerful, widely used, economical software, but which requires building up its own object libraries, and Bentley solutions dedicated to railway disciplines, with integrated object libraries, which is specific and little used. For economic and standardization reasons, we will use first software for our future experimentation.

Integrating BIM into railway projects: Review of experiences.

In this paragraph, we will discover experiences of integrating BIM into rail projects in several countries, assigned objectives, regulatory initiatives, milestones. The objective is to give an overview of the actual experiences before to consolidate the literature review, before moving on to our experimentation.

Crossrail, UK.

"In 2011 the UK GCS [Government Construction Strategy] called for a paradigm shift in the procurement and delivery of construction projects based on a whole-life 'built environment' approach" (Smith, 2014) [33]. The UK Government Construction Supplier Conference (UK Government, 2011) [36], held on April 2011, had assigned as goals on BIM integration, in its official presentation: 25%

reduction in waste and rework (25% of the 37% = 9%), Virtual elimination of design coordination error, Direct fabrication from BIM : 0 errors, 12-16 week savings, Increased investor/lender confidence, Verified Return on Investment (ROI) range = 3:1 to 12:1, 70% Claim reduction. According to Smith paper (Smith, 2014), since the publishing of the Government Construction Strategy (GCS) (UK Cabinet Office, 2011) the UK government has already started implementing BIM on a number of early adopter projects. Following this, and according to the same author, CROSSRAIL (the company that has been set up to operate the new railway line will become known as the London line when it opens in London in 2018 (Crossrail, 2014)) has reviewed its technical data strategy for harmonization with the implementation guides of the BIM. The following are Smith's main lessons from the CROSSRAIL experiment (Smith, 2014) [33]: Implement the BIM commercial framework at the start of the project; CIC (Construction Industry Council) BIM Protocol (or similar) should form part of the contract basis to provide governance around the use, liability and ownership of the BIM model; the whole project team needs to understand their role in BIM as it affects their work responsibilities and all phases of the project life cycle; Common Data Environment (CDE) foundation for collaborative design is essential, this should be enabled for the whole supply chain to foster innovation and maximize data reuse; design change needs to be carefully managed at model element level and preferably as a work process built into the CDE rather than an external additional process; intelligent (object-oriented) 3D models are an essential foundation for leveraging 4D, 5D, and design analysis; consistent application of standards is fundamental to the success of BIM; for example, schedule WBS needed for 4D modelling.

Infrabel, Belgium.

In Belgium, INFRABEL defines the main objective of implementing BIM in its railway projects is to improve the integration of design, internal communication of project stakeholders and the detection of collisions between sub-structures, in order to avoid rework during project implementation and minimize delays on the construction site (Nuttens, 2018) [26]. According to the Tuc’s (Design office working for Infrabel) story, the INFRABEL experience showed that the key factors are of an organizational nature, such as clear communication of the BIM vision to all colleagues of the company. In addition, during the implementation of BIM, all communications, manuals, training courses and workflows should remain "tailor made", focusing on the target audience. Key users can be useful to have an effective and seamless link between all user groups and the BIM support unit. Guiding the management of change and taking into account the specificity of the company is crucial when setting up the BIM.

STA, Sweden.

There is no regulation on BIM in Sweden, but some initiatives are underway, especially among public project owners. Sweden's largest transport project administration, the Swedish Transportation Administration, published a BIM strategy in 2013 with the aim of including BIM for all new investment projects from June 2015 (Davies, 2015) [14]. According to the same source, engineering companies in Sweden have pioneered the adoption of BIM. Engineering companies were open to new technologies and understood the benefits of BIM and the opportunities to develop services since 2007. All major design firms have begun to develop the use of BIM and its capabilities.

BIM France, France.

In 2013, "BIM France" (association of architects and engineers) later followed by the French government, public customers and professional organizations decided to actively support the development of BIM in France. In 2014, the Ministry of Housing and Construction declared that the use of BIM will be mandatory in public markets from 2017 (Davies, 2015) [14]. Believing that BIM will irreversibly revolutionize the practices of its sector in the coming years, Bouygues Immobilier has decided to accelerate its implementation. Indeed, at the end of 2016, François BERTIÈRE, the CEO, definitely anchored the company in this perspective by adopting the "Central BIM Policy". In this document, the construction company describes in a precise way its vision of the BIM and the way in which it will proceed to its generalization by 2020. The paper of reference, which institute a common lexicon and highlights the centrality of Collaboration also includes sustainable development and highlights the contractual issues to be taken into account. The ambitious goal remains "to ensure the design and implementation of all works under integrated BIM (the highest level of BIM) by 2020" (Bouygues, 2016) [11].

In the railway sector, SNCF Réseau (railway infrastructure manager in France) is working on its new projects (like CDG Express and Grand Paris) by integrating BIM. In addition to the creation of the BIM model, the goal is to also implement the 4D to simulate construction work (phasing) (Foeillet, 2016) [15].

NNRA, Norway.

The Norwegian Rail Administration has developed a unique approach to 3D design and BIM integration in the large InterCity rail project around Oslo, which focuses on innovation and best practices throughout the design and construction phase (Lysebo, 2016) [23]. “Based on very good experiences with the use of 3D models in our recent joint rail and road project E6-Dovrebanen together with the Road Administration, it was decided to use model-based design for all disciplines also in the planning of the new double-track InterCity stretches. We are therefore using our new “Manual for digital planning” in the InterCity project and we have also prepared a special contract document for the project, which all consultants must comply with” said Kristin Lysebo, from a Norwegian engineering firm.

Summary and discussions related to the review of experiences.

We have seen in this chapter the different phases of maturity of the integration of BIM in railway projects in several European countries. The general trend is towards the generalization of this integration between 2020 and 2030 for all railway projects. This review of experiments confirms the conclusions of the literature review on BIM integration that can be summarized as follows:

- Advantages: Collaboration, time saving, cost optimization, prevention of conflicts between networks, building before building, optimization of facility management, improvement of the quality of works, prefabrication.
- Risks: lack of internal communication, and common objectives, ownership of the BIM database, use of different versions or software, misunderstanding of schedule or cost estimates.
- Limitations: Lack of experience feedback in rail (requires a whole life cycle), software that is not well adapted to railway constraints, difficulty of approaches between disciplines.

ONCF/COLAS Rail Maroc Electrical Substation – Bim Integration

In this paragraph, we will study the modeling of an ONCF (rail network manager in Morocco) electric substation, carried out by the Colas Rail Maroc teams, according to the BIM process. The objective is to determine the key stages, the difficulties, the advantages and the tracks for better taking into account BIM in the rail projects in Morocco.

Context of the collaboration

ONCF, manager of the rail network in Morocco, has an ambitious investment program. It plans, for example, to build 1500 km of high-speed rail lines by 2035, 360 km of which will be delivered in 2018 and COLAS RAIL MAROC has contributed by realizing turnkey (design and realization) the track, the catenary and basis works.

From 2014 to 2018, ONCF also entrusted Colas Rail with the construction and renovation of approximately 40 substations throughout its network. Scope ranged from design to commissioning of facilities (civil, mechanical & electrical engineering; building; structural steel; supply and wiring of electrical equipment; testing and commissioning). There was no contractual obligation to integrate BIM into this project. Colas Rail, following the recommendations of the group (Colas / Bouygues) and in a proactive approach has, as part of its Research and Development strategy, the modeling of an electrical substation following the BIM process.

Methodology

To implement BIM integration, we proceeded by the following methodology:

- The design and execution studies having been realized, the 3D modeling was made on the basis of existing 2D plans.

- A BIM training was organized for the entire design office (different disciplines).

- Information meetings were held to share the objectives of the experiment.

- The 3D model was realized by Revit software, Architecture module. The structure and networks modules were then used to design the civil engineering, the metal structure, the electrical equipment and the various links.

- The client was not involved in the process. The final result was presented to him.

The Colas Rail Morocco team that led this project consisted of 15 designers and engineers: 3 civil engineering resources, 4 electrical engineering resources, 3 mechanical engineering resources, 1 quality / safety resource and 4 sub-project managers. This integrated team was based in the premises of Colas Rail Maroc in Casablanca.

The choice was made for the Skhirat power substation, which is a 60kv AC / 3kv DC substation, intended to power the catenary overhead line. We chose the Revit software, which is close to the software (2D) used by the team and which allows an optimal connectivity with other tools, especially for the calculation.

Key step and planning of realization

We have adopted the following schedule for the realization of the electrical substation modeling project according to the BIM scheme:

- Drafting and approval of a summary document describing the goals of the process, the objectives to be achieved and the expected results. 2 weeks.
- Launch meeting, presentation of the project. 1 day.
- Training in BIM software. 1 week.
- Phase 1 study: recovery of the 2D plans in the 3D model. 4 weeks.
- Mid-term meetings: design review. 1 week.
- Phase 2 study: resumption of studies. 2 weeks.
- Synthesis of the whole. 2 weeks.
- Meetings presenting the results, restitution workshops. 1 week.

Comments of the results.

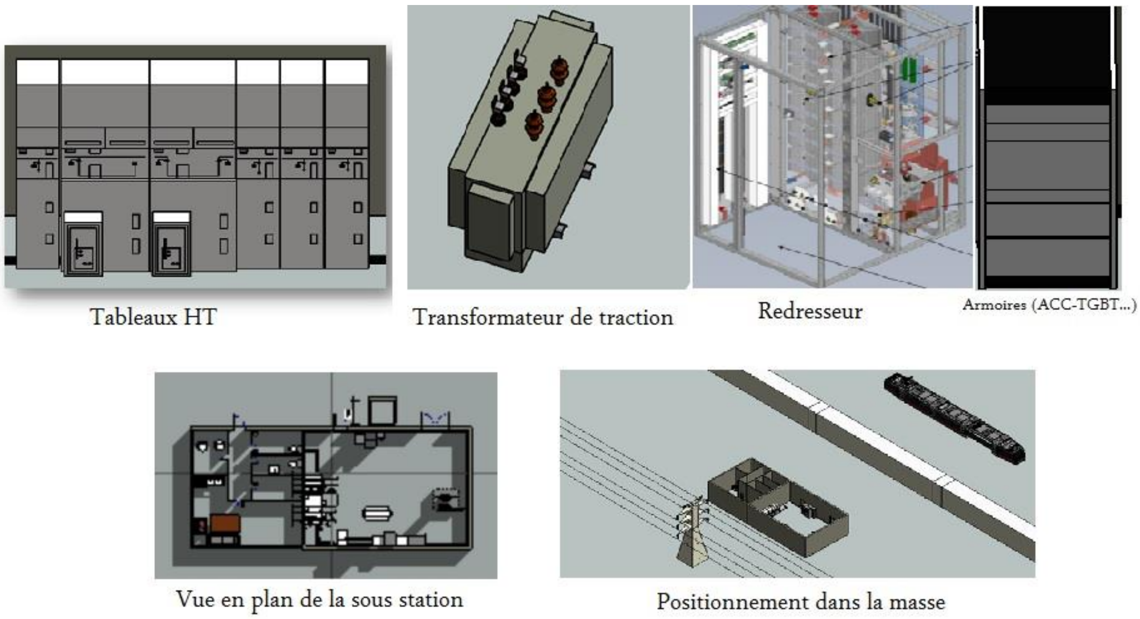

Fig.3: Model visualization of the Colas Rail/ONCF substation.

The purpose of the exercise (layout to see in Fig.3) is to be able to experiment with 3D modeling in the railway context and to try to integrate planning and budget dimensions. This three-months work of Colas Rail's design teams, from different disciplines, after condensation of sessions comments, gave rise to the following observations:

- Working on a unique 3D model has allowed design teams from different disciplines to work together and better. The usual round trips and incomprehension between disciplines have given way to more effective collaboration.
- Studies on the BIM model took longer as it required redrawing everything, including topographic acquisition. The advantage of integrating BIM in the sketching phase shows its relevance.
- One of the difficulties encountered was to redesign mechanical and electrical equipment. Not all equipment providers are on BIM logic. Hence the interest of integration when defining contractual obligations.
- In the absence of local standards, railway standards or object libraries, it was necessary to draw everything.
- The BIM integration speed differs from one discipline to another. While architectural and structural aspects were more likely to adopt the approach, other disciplines have encountered problems, especially related to interfaces with other dedicated software.
- The addition of the planning and budget dimensions has complicated the tasks in the studies. Objects must be drawn in such a way as to take these dimensions into account.

- The presentation of the result of the project to the client (ONCF) has been of great interest. He was especially attracted by the graphic power of the tool and the ability to visualize the project in 3D. His remarks and questions revolved around three main themes: cost of investment (software, learning, ...), experiences of other rail networks and the benefits of such a tool.
- The team members and the client are wondering about the implementation schedule and fear that the integration of the BIM will delay the progress of the project (because they did not understand firstly the investment of time to build the BIM modeling and secondly that this modeling started when the project had already started for months). This reflects the misunderstanding around BIM: It is not a simple 3D design process, but a management approach that should accompany the project from the idea and throughout the entire life cycle of the infrastructure.
- The completion of the measurements, and therefore the costs, was not an easy exercise. This data must be taken into account by the designer (who is not necessarily aware of the subject) from the beginning to be in conformity with the decomposition of the price of the infrastructure. Otherwise, iterations are necessary.

Recommendations

The main recommendations from the synthesis meetings for the above experience are:

- Integration of the BIM should begin as early as the sketch phase.
- Support for the BIM process must involve all players: equipment suppliers, subcontractors, different design units, purchasing departments, elementary project managers, etc.
- A scope definition must clearly define the property boundaries of the different models in the database.
- The project must refer to basic standards.
- The project must use software tools that allow maximum portability and interchangeability,
- The implementation should be supported by the highest hierarchies in order to guarantee the participation of all.
- An investment is to be made to build object libraries and blocks specific to railway disciplines, and also to realize trainings for all project teams.

Discussion of the results

The cases study discussed in this paper and previous research confirms the hypotheses of the literature. The integration of BIM into railway projects can have several advantages: Collaboration, time saving, cost optimization, prevention of conflicts between networks, construction before construction, optimization of facility management, improvement of the quality of works, prefabrication. They also allowed us to illustrate the risks (status and appropriation of the BIM model, lack of standardization of versions or software and lack of understanding of the basics of schedules and specifications) and limitations (lack of feedback, lack of adaptability and convergence of tools). These experiences have also shown that the use of BIM is not just a technological transition, but a revolution in the project management process, which requires several key success factors (participation of all, commitment, change management and adoption of the collaborative approach). Visualization, collaboration and conflict elimination are the three main chapters where the benefits of BIM can be organized. In fact, there is a lot of intersection between these chapters, but they have been chosen as the main ideas around which all the benefits can be better understood. Visualization primarily addresses the benefits to an individual and improving one's personal understanding as a result of using BIM. The collaboration refers to the cooperative action of several team members, which is encouraged and facilitated by BIM. Conflict elimination mainly concerns project-related benefits, such as conflict reduction, waste, risks, costs and time. For railway infrastructure projects, the main purpose of using BIM is to improve the design integration process, internal project team communication and collision detection to eliminate risk of rehabilitation.

General Discussion, Conclusions and Perspectives

In this paper, we reviewed the history (recent as technology is recent) of the development of BIM integration to rail projects in some European countries. We have seen that this integration is generally at the experimental stage, when some countries have already introduced the BIM standards in general and aim for its generalization within a few years. We quickly introduced the BIM software tool before moving on to a Level 1 BIM experiment. The case study explained in this paper and previous research (Bensalah, 2018 [5]; 2017 [4]) have confirmed the results of the literature. The integration of BIM in railway projects can bring out several advantages: Collaboration, time saving, cost optimization, prevention of conflicts between networks, building before building, optimization of facility management, improvement of the quality of works, prefabrication. They also allowed illustrating the risks (status and ownership of the BIM model, lack of standardization of versions or software and lack of understanding of the basics of schedules and cost estimates) and limitations (lack of feedback, lack of adaptability and convergence of tools). This experience has also shown that the use of BIM is not simply a technological transition, but it corresponds to a revolution in the process of project management, which requires several key factors for success (participation of all, commitment top management, change management and adoption of the collaborative approach). Visualization, collaboration and conflict elimination are the three main chapters where the benefits of BIM can be organized. In fact, there is a lot of intersection between these chapters, but they have been chosen as the main ideas around which all the benefits can be better understood. Visualization primarily addresses the benefits to an individual and the enhancement of his / her personal understanding as a result of using BIM. The collaboration refers to the cooperative action of several team members, which is encouraged and facilitated by BIM. Conflict elimination mainly concerns project-related benefits, such as conflict reduction, waste, risks, costs and time (Kymmel, 2007) [20]. For railway infrastructure projects, the primary purpose of using BIM is to improve the design integration process, internal project team communication, and collision detection to eliminate the risk of re-work when of project construction and minimize delays at the site.

In this paper, we reviewed the history (recent as technology is recent) of the development of BIM integration to rail projects in some European countries. We have seen that this integration is generally at the experimental stage, when some countries have already introduced the BIM standards in general and aim for its generalization within a few years. We quickly introduced the BIM software tool before moving on to a Level 1 BIM experiment. We reviewed different experiences of integrating BIM into rail projects in European countries, with several levels of maturity. The global trend is towards the generalization of this inequality in the coming years. This review identified the practical benefits, risks and milestones as outlined in the literature.

We also presented a real case study. The exercise we conducted consists of modeling in 3D a substation of the Moroccan railway network. The goal is to conduct the experiment on a real scale to overcome difficulties, observations and benefits. This practical case made recommendations for the integration of BIM. Overall, our case study confirms the results of the literature.

Current research opens the way for two major perspectives:

- Conduct a larger exercise with other railway disciplines (rail, catenary, signaling ...) in order to make the most recommendations.
- Work on a standardization of the BIM integration process for railway projects, especially in Morocco.

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Received: May 21, 2018; Published: June 15, 2018