ISSN: 0976-3031

Available Online at http://www.recentscientific.com

CODEN: IJRSFP (USA)

International Journal of Recent Scientific Research
Vol. 9, Issue, 1(H), pp. 23398-23403, January, 2018

International Journal of Recent Scientific Research

DOI: 10.24327/IJRSR

Review Article

INTEGRATING BIM IN RAILWAY PROJECTS: REVIEW & PERSPECTIVES FOR MOROCCO & MENA

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DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1460

ARTICLE INFO

Article History:

Received 15th October, 2017
Received in revised form 25th November, 2017
Accepted 28th December, 2017
Published online 28th January, 2018

Key Words:

Building Information Modeling, Railway infrastructures, design.

ABSTRACT

Rail infrastructure plays an important role in the development of economic activities and also makes it possible to connect the territories. Territorial development will require more and more rail infrastructure projects. There is no need to prove that rail is the most environmentally friendly means of transport

Building Information Modeling BIM allows to design, plan, track and save projects throughout the construction process. Its application to the railway sector is booming.

This paper aims to review the literature concerning the integration of BIM into railway projects and the enhancement of the benefits of this integration.

This paper will also be used to explore future directions for integrating BIM into railway projects to optimize collaboration and project planning.

INTRODUCTION

Methodology

Rail is an important infrastructure area for economic and regional development. This market today represents an annual growth of 2.3% until 2010 [1]. In Morocco, for example, the railway knows an important development with notably large projects: LGV, Tram, Regional lines.

The duration of a railway project takes several years and comprises several phases: opportunity / idea, initial design, APS (preliminary project summary), search for financing, APD (detailed project), execution studies, construction on site, DOE (As built documents), and maintenance.

During all phases of the project, thousands of 2D plans are exchanged in design, engineering and architecture (Suchocki, 2017) between the different skilled in the art, which complicates the process and makes collaboration difficult, incomprehensible and difficult, likely to cause errors.

"In recent years, many research and industry efforts have focused on the development of Building Information Modeling (BIM) and leveraging these models to support various aspects of architecture, engineering, the construction and facility management industry " (Nepal, 2008). " BIM allows participants to collaborate in a shared software-based environment to share information, enabling better decision-making throughout the project lifecycle" (Kurwi, 2017).

The BIM allows an optimization of collaborative work around a single database or digital model accessible to all those skilled in the art around a given project. It also offers better planning and in-depth knowledge of economic data.

We will give an overview of the history of rail in the North Africa region, in addition to giving a glimpse of future projects in Morocco as an example before listing some benefits of rail links in terms of development, ecology, security, space management, ... We will then give an overview of the development of BIM, its benefits, risks and issues. Then, we will review the literature concerning the integration of BIM in railway projects and we will highlight the benefits of this integration. This literature review will be reinforced by a practical case study of projects that have chosen the BIM integration approach. We will present the preliminary results of

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a research experiment carried out for the BIM modeling of a rail project in Morocco led by Colas Rail Maroc on behalf of the ONCF (railway infrastructure manager in Morocco). Finally, in conclusion, we will propose some lines of research for the successful integration of BIM in railway projects.

Railway projects

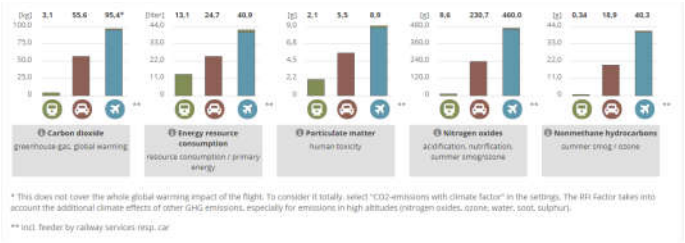
The growth of rail in developing countries has lagged behind industrialized countries. For example, the oldest railway on the African continent was opened in 1858 between Cairo and Alexandria (Egypt), the alpha line was opened in 1879 between Arzw and Saïda (Algeria), the phosphate line was opened in 1923 connecting Oued Zem and Sidi El Aïdi (Morocco). In Morocco, Spain had built a line in 1879 in the north for military reasons. It was not until 1933 that the transmaghrebin line was opened on 2869 km connecting Marrakech - Casablanca - Algiers to Tunis (Bavoux, 2000). Indeed, according to the work of Bavoux (2000), "with few exceptions, the railway is hardly able, for the moment, to contribute actively to the economic development of the States and to the balanced development of their territory" (Bavoux, 2000).
The railway market is expected to have large investments in developing countries. For example, Morocco plans to build 1500 km of high-speed line by 2035 (ONCF, 2009), not counting conventional lines (The current rail network has 3600km of line) (ONCF, 2017). The city of Casablanca is building a network of more than 80 km of Tramway (30 operational) by 2022 (Casa Transport, 2015), and the city of Rabat is building 29 km in addition to the 19 km operational (Kacimi, 2017). In addition, conventional lines, such as links between Khouribga é Beni Mellal, Safi & Essaouira, Tangier & Tetouan, Essaouira & Agadir, Kenitra & Mehdia port; the regional train of Casablanca; ... are under study. This is to say all the promises that the railway offers in this country. The same outlook is observed in other countries, which augurs well for rail.

Railway projects, in addition to their effects on development, are major consumers in terms of budget. Their implementation requires the intervention of the States as main actors. "Thanks to greater reliability with regard to uncertainties and climatic excesses, the train could reduce delivery times and mitigate stockouts, thus ensuring relative safety during harvest peaks and limiting wastage" according to Bavoux, which adds that "in the railway sector, choices and investments are particularly cumbersome and cumbersome, laborious implementation, profitability slow to assert themselves. Political will is crucial in this respect" (Bavoux, 2000).

It is undeniable today that the strengths of rail in Morocco are extremely important. To name only these:

- Safety: The bitter reality of the 3600 deaths per year in road accidents, the train represents a solution to reduce this deplorable human invoice.
- Space saving: Parking problems, congestion, rail is an asset. Also, it should be noted that a double rail track requires 14m against 40m for a Moroccan type highway.
- The environment: The reduction of greenhouse gas emissions, the reduction of energy pressure and dangerous goods transport solutions are important for decision-makers today.

On this last point, there is no need to prove that rail is the most environmentally friendly means of transport. The UIC data for a Paris-Lyon trip gives the following comparison:



Emission comparison of different means of transport (UIC, 2017).

Unlike most African countries, Morocco's rail network is one of the best maintained networks. The strengthening of security has been particularly well thought through the installation of computer signaling systems equipped with the most efficient equipment. The social aspect was one of the major axes that characterized the development of rail. The Pacific Railroad is an example of creating a social header between Americans. The latest example is the creation of a common line between the two Koreas. This line will allow more family, cultural and human exchanges between neighbors that the fate of ideologies and the law of the cold war have removed.

BIM development

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). Studies reported major benefits of BIM : Up to 40% elimination of unbudgeted change, Cost estimation accuracy within 3% as compared to traditional estimates, Up to 80% reduction in time taken to generate a cost estimate, A savings of up to 10% of the contract value through clash detections, and Up to 7% reduction in project time (Salman, 2011).

"BIM is now more than software it is a culture, collaboration, and Team working … BIM is 10 percent technology and 90 percent sociology" … BIM culture should be maintained in the project before adopting the cutting edge technology (Gamil, 2017).

As part of this literature review, we have estimated that BIM has several levels of maturity. They are the steps to move towards collaborative BIM.

- BIM level 1: The isolated BIM includes the realization of the Digital Model, the use by one or more actors, but does not include the exchanges between the models, each one updates its data individually.
- BIM level 2: Establishment of collaborative work between actors where several models linked and put in common and allows to combine all the models into a single or federated model. It includes: a graphic model or 3D digital mockup, non-graphical data (information for the use and maintenance of the work), structured data, documentation, a native file format (IFC).
- BIM Level 3: The ultimate goal of BIM (for many, only level of the BIM process), a unique model shared by all actors. It allows the possible intervention by all and at

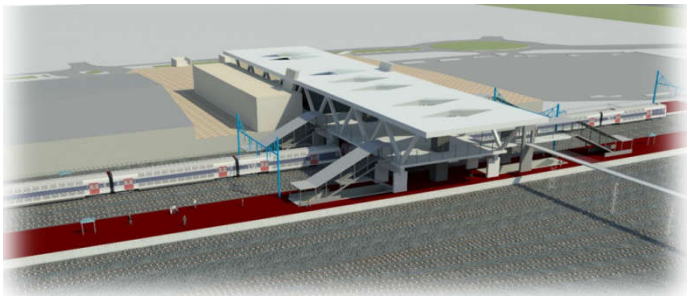
the same time. It includes "Level 2" + storage on a centralized server.

According to Gamil (Gamil, 2017), nobody could claim that BIM has become a key player in the construction industry. As the construction industry in recent years has noticed a sudden development in the way and the construction technique such as the use of prefabricated elements and more innovative materials such as carbon fiber or machinery. But meanwhile, the construction industry is still poor in the implementation of BIM and uses more of its features for the planning of construction and site planning. “It is important to note that BIM is not just software; it is a process and software; BIM means not only using three-dimensional intelligent models but also making significant changes in the workflow and project delivery processes” (Gamil, 2017).

At the same time, it must be considered that the integration of the BIM reveals some risks that must be considered to master. Azhar argues that “BIM risks can be divided into two broad categories: legal (or contractual) and technical” (Salman, 2011). As legal risks we can mention: Ownership of BIM data, license limit issue, mastery and mastering of the database with regard to the impacts of the modifications, etc., and as technical risks we can mention: the use of different software or different versions, the use of different planning or cost estimate, 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 steps of the implementation are not standardized either.. “Additionally, the industry will have to develop acceptable processes and policies that promote BIM use and govern today’s issues of ownership and risk management” (Salman, 2011).

BIM integration to railway projects

The new imperatives such as climate change, security, the opening up of territories and the construction of "smart territories" favor an important development of railway projects. Studying the opportunities of BIM in rail, Suchoki states that “the benefits from adopting technologies go beyond just time and also include better solutions, more engaged stakeholders, dramatically reduced errors during the capital phase of projects and significant improvements during asset use” (Suchocki, 2017).



Gare SNCF des Adroines*

The adoption of BIM in rail requires a high level decision and years of model building. Smith explains, for example, that in the United Kingdom, CROSSRAIL's project to adopt BIM started in 2007 and will only be effective in 2019! (Smith, 2014). He estimates that “the implementation of BIM on major civil projects in the UK is in its infancy but gaining rapid and significant momentum”. “By 2016, BIM use will be mandatory in all public sector projects. France is aiming for regulations and in 2017 BIM used will be require for all public buildings. No such BIM-regulation exists in Sweden however the large public actors have been inspired by the UK development when adopting BIM strategies, which is in line with the 2014 Mc GrawHill report that indicates many public properties and public clients require BIM for their projects” (Davies, 2015). German national BIM initiative (“Stufenplan” of the German Ministry of Transport and Digitalization), “defines Niveau 1 of BIM project execution which is expected to be realized in all construction projects in the infrastructure domain starting 2020”(Borrmann, 2016). This shows the importance of the role to be played by governments.

The integration of BIM into railway projects, in view of the above, has many advantages, among others:

- Decision support: allows you to make the right choices from the start through simulations, tests and representations (integration of the budget dimension for cost optimization, consistency of information, avoid repetition, detect contradictions and reduce delays).
- Mastery of the implementation phases: better planning of needs and supplies combined with anticipation of difficulties is one of the main advantages of BIM.
- Assistance for management, operation and maintenance: makes it possible to facilitate the future evolution of new works and to facilitate their adaptation to new needs or to the evolution of the environment

Case study

Project Mälarbanan, Sweden

Norberg analyzed in his thesis the case of the integration of BIM in Project Mälarbanan (Norberg, 2012). this study listed the main benefits of BIM integration, given its literature review, to this project for owner, designer, contractor, facility management : Concept, feasibility and design benefits; Increased building performance and quality; Improved collaboration using integrated project delivery (IPD); Cost estimates throughout the design phase; Discovery of design errors and CAWs before construction; Synchronization of design and construction planning; Better implementation of lean construction techniques; Integration with facility operation and management systems.

The same paper (Norberg, 2012) listed benefits for Vectura identified from the project: A better understanding for the railway facility since all CAD designers can see the common 3D model at an early stage in the project; better review of object placement, everything is in a 3D environment. A condition is that all technical areas work in the same model; design material in a digital environment can facilitate visualization, simulation, quantity take-off, time planning, cost calculations etc; 4D-modeling; re-use of data through different stages in the process; Better quality and timesaving through a more effective work method; Fulfillment of new industry standards for upcoming procurements.

In addition to these same benefits of integrating BIM into railway projects, Norberg's paper listed the same challenges

and risks that we identified in our literature review above. These include: the designer does not benefit most as the key adopter; collaboration challenges; legal status of the model; changes in practice and use of information.

TUC/INFRABEL experience, Belgium

A recent article (Nuttens, 2018) has described an experience of Infrabel (Belgian Railway Infrastructure Manager) in recent years with the implementation of a BIM methodology for the integration of 2D and 3D designs that has led to a number of factors which we consider important or even crucial for the successful implementation of BIM. The main purpose of using BIM is to improve the integration of design, internal project team communication and collision detection to avoid re-work during project and project execution. minimize delays on the site. These improvements translate into higher quality projects delivered on time and on budget. In this implementation of BIM, the focus is on its use for integrating designs from different technical disciplines for large railway infrastructure projects and on processing different levels of BIM maturity of each project unit of the project team.

There are a number of key factors, both at the company and project level, to contribute to a successful and progressive introduction of BIM into a large multidisciplinary design firm. At the enterprise level, these key factors focus on more organizational aspects, such as clear communication of the BIM vision to all colleagues in the company and taking into account the difference in maturity level of these colleagues. in all communications. In addition, during the implementation of BIM, all communications, manuals, training courses and workflows should remain "tailor made", focusing on the target audience.

Guiding the management of change and taking into account the specificity of the company is crucial when implementing the BIM. At the project level, clear decisions and guidelines at the beginning of the project are needed, describing the project needs for each technical discipline. Regular project team meetings, based on the BIM model as a tool to have a 3D view of the project, allow for an in-depth monitoring of the monitoring project. The minimum requirements for BIM data must be defined such as the status of the object, the accuracy and date of measurements of the existing situation, and the information to which the technical discipline of an object belongs. They allow all users to have an overview of the most important aspects of the data and they allow a BIM implementation step by step in the different design units, depending on their maturity. Units with a higher BIM maturity can already add additional information to their designs, allowing for more advanced BIM analysis, while maintaining integration with other technical disciplines.

Highlighting these factors can help increase the use of BIM in similar design firms and improve the success rate of BIM in the construction industry. "The implementation of BIM in our company has already led to a much closer collaboration between our design units, now working even more as a team to provide high quality design. Our other BIM developments will focus primarily on adding more uniformity and intelligence to the models, allowing more analysis and allowing our customers to use more asset management models for their infrastructure "says TUC, the engineering firm of Infrabel (Nuttens, 2018).

Bergen's Light-Rail, Norway

The goals Bergen Light Rail team set was: Ensure quality in designed solutions; Secure efficient communication throughout the project; Designing constructible solutions; Increase safety; Reduce total costs (Amdal, 2016).

BIM at SNCF maintenance department, France

For SNCF, the objective is mainly to look at the existing. This reverse engineering is possible today: all data is a mine of information to support the management of infrastructures. We must be able to improve the predictive maintenance of our network and the stakes are of size: the regularity of the traffic is to optimize while maintaining our requirement in terms of the safety of the users.

A first pilot project was launched at the end of 2015. The idea is to take advantage of the collaborative power of BIM as part of a program to implement European safety beacons. BIM is used for the lane and signaling trades. On this pilot, we are working with Dassault Systèmes and the regions of Metz and Strasbourg.

Two other pilot projects follow: one in connection with the catenaries in the framework of the Charles de Gaulle Express project for which the power supply must be modeled, we use Bentley's tools; the other with the station of Saint-Cloud, whose modernization is planned with Revit edited by Autodesk.

Even if we are only in the early stages of implementation, we are already reaping the support of our management who believes in the performance of BIM. And they are not alone: many tenders call for the use of BIM. It's up to us to go even further in this direction.

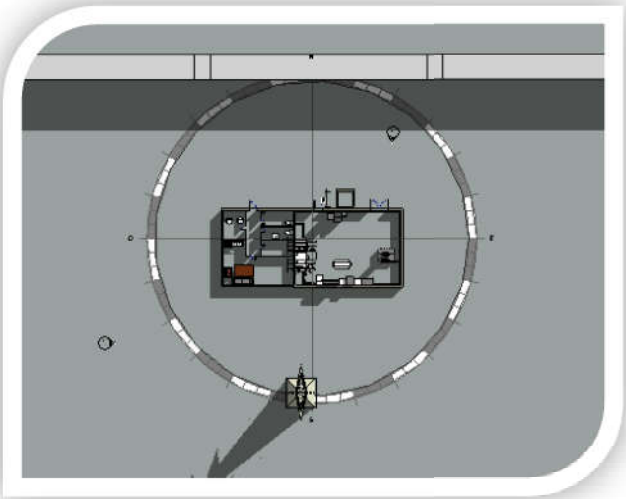
The digital mock-up will help us improve our knowledge of the network like no other tool. It is synonymous with economic performance, during studies, during renovation or construction work ... and during the maintenance of tracks or stations (Landes, 2016).

ONCF/COLAS RAIL MAROC Electrical substation, Morocco

As part of the realization of this paper, we proceeded to the implementation of an electrical sub-station as part of the project to build 36 electric traction substations built by Colas Rail on behalf of ONCF. This implementation made it possible to get as close as possible to the data collected in the literature. The resulting results (implementation in progress) will be used to study the lines of research generated by this paper. The following figure shows the first layouts of the 3D model.

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 way, the catenary and basic 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 (civil engineering, building, structural steel, supply and wiring of electrical equipment, testing and

commissioning). There was no contractual obligation to integrate the BIM into this project.



Colas Rail, following the recommendations of the group (Colas / Bouygues) and in a proactive approach has, in the framework of R & D, the modeling of an electrical substation following the BIM process.

The purpose of the experiment is to be able to experiment with 3D modeling in the railway context and to try to integrate planning and budget dimensions. This two-month work of Colas Rail's design teams, from different disciplines, after condensation sessions comments, gave the following preliminary observations:

- Working on a unique 3D model has allowed design teams from different disciplines to work together and better. The usual round trips and incomprehensions 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.
- Note that this project is still in progress.

CONCLUSIONS-PERSPECTIVES

In this paper, after having gone through the history of the birth of rail in North Africa, we have seen some cases of development of railway projects, especially in developing countries. The future of this sector is promising in countries like Morocco or Middle East & North Africa in general.

We explored the evolution and benefits of BIM technology, as an uneven tool for managing large projects in a collaborative way from idea / design to operation and maintenance phase. We have seen that this technology is in the development phase and has a promising future.

The integration of BIM into rail projects, we have exposed it, is in an embryonic phase, even in the most advanced countries, but it is gaining more and more ground. This integration requires government decisions and a maturation of technology and tools. Decision-makers in the developed countries studied (Sweden, UK, France, Germany) in rail, at different stages of implementation, adopt BIM in the process of setting up new rail project. Despite this experimental stage, these data point to an adoption between 2020 and 2030 of BIM in all / some railway projects in developed countries. Therefore, this trend will mark the future of rail in the world and push all countries of the world to adopt the BIM.

The case study of real projects incorporating BIM confirms the results of the literature review. Indeed, the advantages of integrating BIM into rail projects are multiple and proven: cost control, decision support, avoids additional work due to design errors, improves the detection of interface problems, improves vision planning, help with prefabrication, gives a complete view of maintenance and facility management, ...

Through this review of the literature, we can identify interesting lines of research in integrating BIM into railway projects:

- Standardization of the stages and phases of railway project management by integrating the BIM, comparative study of cases.
- Technological development and software tools to integrate railway libraries, special & normative constraints of large linear projects.

These themes, which are not very rich in literature, can make a major contribution to the successful integration of BIM in the railway sector, especially in developing countries.

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*Credit photo Gare SNCF des Adroines: http://villagebim.typepad.com/villagebim/data-management/page/10/ . accessed on November 1st, 2017.

How to cite this article:

Mounir BENSALAH *et al*.2018, Integrating Bim In Railway Projects: Review & Perspectives For Morocco & Mena. *Int J Recent Sci Res.* 9(1), pp. 23398-23403. DOI: http://dx.doi.org/10.24327/ijrsr.2018.0901.1460

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