Advances in Reliability, Safety and Security

ESREL 2024
Collection of Extended Abstracts

A BIM Methodology In Favor Of Railway Safety

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Keywords: safety, demonstration, process, railway, BIM

The safety demonstration processes of railway systems are complex, which makes it difficult to integrate new digital tools that are increasingly widespread in the field of construction and infrastructure.

The railway industry is one of the most mature and oldest industrial sectors, it represents a long tradition of excellence in engineering and safety standardization (Suchocki, 2017). The complexity of railway projects is partly justified by these traditional methods and the use of the safety file (Office documents) for several years. In addition, the regulatory and normative requirements (Helfrich. and Romestant, 2015) aimed at demonstrating a sufficient level of safety so as not to expose users to uncontrolled risks of participation in this complexity linked to the use of new solutions. These working methods, safety requirements and the regulations governing the profession constitute an obstacle to the deployment of new digital tools such as Building Information Modeling (BIM).

BIM was first introduced in 1970 by Professor Charles M. Eastman (Sacks, 2013). It is a working methodology that allows you to manage the design and data of a project in a virtual environment during the project life cycle. Even if BIM was initially developed for the building, it now extends to the scale of railway infrastructures (Vignali, 2021). The growing use of BIM in the railway industry presents significant opportunities to improve the design, construction, and management of infrastructure. (Bensalah, 2019) presents five projects in different continents for the application of BIM to railway, the objective is to improve the design integration process, communication, and collision detection. His study highlights that BIM helps with the ecological transition, while being a revolution in the process of project management, collaboration, design, etc.

Effective integration of BIM methodology into railway safety assessments remains a major challenge (Eydieux et al, 2018). It is starting to be the subject of several studies and research dealing with this theme. Digital twins are used for maintenance management and adaptation to climate change of railway bridges (Kaewunruen, 2023), collision prevention studies inside tunnels (Baek and Choi, 2018), RAM (Reliability, Availability, Maintainability) studies at BIM basis (Manuel et al, 2022). Several companies are currently looking for new technologies and solutions to manage the safety of railway projects. For example, companies like SNCF, Assystem and Egis, use BIM models to assist and prevent the construction of railway lines. ***SNCF Reseau*** states in its publication[1] (rail Network) being leader of the new industry 4.0 market with the fact they widely use 3D modeling and the digital twin for anticipating breakdowns and assisting in the operation of the rail network. Systra Group[2] offers a new tool called “safebybim” which makes it possible to identify and manage safety risks in order to guarantee a design safety of railway infrastructure. The CrossProduct [3] is also launching into safety studies with new automated technology to enable inspections and measurements and analyzes of railway infrastructure.

[1] https://numerique.sncf.com/actualites/sncf-reseau-leader-dans-le-bim-et-le-jumeau-numerique-du-systeme-ferroviaire/
[2] https://www.systra.com/safebybim/
[3] https://www.thecrossproduct.com/en/railway-solution

Although there are issues such as lack of BIM-based quality assurance and requirements for quality control and lack of a structured BIM methodology also hampers its implementation (Eastman et al, 2008) (Tan et al, 2010), establishing an innovative safety process is a major challenge to improve the 3D modeling of BIM models and their exploitation for railway safety. To do this, a methodical and systematic approach is proposed to explore the implications of Building Information Modeling (BIM) in the context of railway safety. Firstly, an in-depth literature review was undertaken to bring together existing information on the use of BIM worldwide and more specifically in the railway sector and its impact on safety. This step helped identify trends, gaps and research opportunities offered by this technology on several levels.

Subsequently, a qualitative analysis through semi-structured interviews with operational safety expert and analysis was developed. This analysis made it possible to define the methodologies currently used and to identify the issues linked to the practice of BIM for railway safety. Next, a quantitative analysis was conducted to analyze BIM practices and delve deeper into the risks associated with its use in safety demonstrations. Based on these results, a specific BIM methodology was developed for railway safety demonstrations. This methodology incorporates key elements such as detailed infrastructure modeling, inclusion of crucial geometry information, equipment, and 3D modeling procedures.

The development of a safety demonstration process adapted to BIM methodology in the context of railway safety demonstrations represents a significant advance in the field. The results of surveys among BIM professionals and safety experts have highlighted the issues and risks linked to the use of BIM in this specific context. The implementation of a specific methodology, integrating key steps such as data entry preparation, 3D modeling, coordination of different models and quality control, aims to address these challenges and ensure a level of safety optimal in railway projects.

Safety analyses, such as preliminary risk analysis, fault tree analysis, and failure modes and effects analysis, have been essential tools to identify potential risks at each stage of the BIM process. By deducing safety requirements from these analyses, we were able to establish clear guidelines to ensure the quality and reliability of the 3D models produced.

Ultimately, this safety demonstration process provides a systematic approach to instill confidence among using 3D models in the railway domain. These advancements are crucial to ensuring the safety and reliability of railway projects, paving the way for more widespread and successful implementation of BIM in the sector.

Acknowledgements

The authors would like to thank the various collaborators who help directly or indirectly to ensure the progress of the project, in particular Dr. Jérémy PATRIX (R&D Manager at the *Opal Research* laboratory) and Emmanuel ETHORE (Design Office Leader at *Ccamy Systems*).

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