Chapter 7
Impact of Electromagnetic Environment on Reliability Assessment for Railway Signalling Systems

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ABSTRACT

The electromagnetic interferences (EMI) are threats that affect the reliability of the railway signalling systems. Consequently, the identification of the reliability requirements dependent on environment conditions is a major issue for signalling systems designers, and therefore for evaluators, and testing and certification bodies. Signalling systems work in the complex and heterogeneous railway environment, where low power electronics have to work together with high voltages and currents from trains and railway infrastructure. This chapter presents the relationship between the railway electromagnetic interoperability and the reliability assessment by analyzing the signalling systems and the associated inter-dependencies with other components of the rolling stock. It is composed of two main sections; the first gathers an exhaustive state of the art approach to the issue of electromagnetic interoperability and railway industry. This subsection steers towards the combination of electromagnetic interferences and the signalling systems present in the rolling stock noise environment. That is the basis of the second section that finally sets how to establish the reliability requirement for a communication path in this environment. This requirement is established because of the electromagnetic noise environment, as well as the radiated and conducted fields, which are a combination of all the surrounding threats a focused railway system has to face. It also depends on the modulation of the communication signal under study.

DOI: 10.4018/978-1-4666-1643-1.ch007
INTRODUCTION

A wide range of definitions can be found for the term “reliability”, but the one proposed by the IEEE in 1990 is (IEEE Std 610.12, 1990):

“Reliability is the ability of a system or component to perform its required functions under stated conditions for a specific period of time”

The thesis of Vromans in 2005 (2005), based on that statement, discussed the improvement of railway reliability in the form of the development of tools and guidelines helpful in the construction of reliable timetables for railway traffic organization.

And even if the goal of the study of the reliability of service is not exactly in the line of the scope of this chapter, which is mainly focused on the reliability requirement extracted from the electromagnetic interoperability, it proposed an interesting list of definitions in direct correlation to the term “reliability”. The one which would be directly related to interoperability and reliability is “robustness”:

“The robustness of a railway system indicates the influenceability of a system by disturbances. A robust railway system can function quite well under difficult circumstances. When a railway system is not robust, small external influences cause large delays which propagate quickly throughout the system in place and time”.

In this definition, “disturbance” is the key term. Which are the disturbances of the railway systems in terms of interoperability? The railway electromagnetic noise environment. This is why this chapter collects and defines all these threats for the rolling stock environment. The first section of this chapter starts with the state of the art of the electromagnetic compatibility issue for the railway industry. To ensure compliance and to satisfy safety and reliability requirements, it is necessary that rail vehicles and railway on-board and track equipments are rigorously designed and EMC tested prior to service introduction. Nevertheless, the lack of an ultimate electromagnetic compatibility test setup and procedure with the consideration of the specific worst cases is a setback in terms of cost, time and, of course, reliability. The norms and standards that rule these issues are completed in this chapter with the scientific community contributions for a global understanding of the present situation.

Consequently, the threats for the rolling stock are presented. The railway noise environment is mainly composed by the following noise sources/EMIs:

- Thermal noise
- Spot signalling systems
- On-board communication systems
- Track communication systems
- Electromagnetic fields generated by traction systems
- Overhead lines noise and discontinuities in the contact between the catenaries and the pantograph
- Electrical substation noise

The combination of these threats establishes the magnetic field spectrum with the steady state and the transient conditions for the rolling stock. Obviously, depending on the threatened system studied in each case, a specific frequency band has to be considered and the signal and noise spectrum around that frequency delimits its reliability requirements. The spectrum characterization is also schematically presented in this chapter, in the second section, through an example of spot signalling system. A similar analysis would be applicable for any other signalling system for railway applications.

The last section of this chapter explains the relationship between the accomplishment of the reliability requirement of a signalling system and the noise received by this system. The procedure presented in that section leads to the quantification