

From French National Signaling Systems to ERTMS: Considering the Evolution of Track-Side Systems

Dalay Israel de Almeida Pereira, Ouail Himrane, Philippe Bon, and Julie Beugin
COSYS-ESTAS, Univ Gustave Eiffel, IFSTTAR, Univ Lille F-59650 Villeneuve d'Ascq, France
Email: {dalay-israel.de-almeida-pereira, ouail.himrane, philippe.bon, julie.beugin}@univ-eiffel.fr

Abstract—In France, the railway lines are divided into the national and international lines. While the former has a proper implementation of the railway signalling systems as relay-based or computer-based systems, the latter follows the guidelines defined by the ERTMS standards, focusing on the interoperability throughout Europe. In a previous work we presented how the national legacy relay-based Railway Interlocking Systems (RIS) can evolve to use a computer-based technology in order to benefit from its advantages. In this present article, we present how these computer-based systems can be used in order to allow the evolution from a national line towards an ERTMS compliant international line. This proposition is based on the fact that the previous work provides the support for evolving the track-side technologies with, for instance, the use of GNSS for the train geo-localisation instead of electrical circuits-based train detection systems. Then, a discussion of the impact of this evolution over the system safety is presented.

Index Terms—railway interlocking systems, computer-based systems, French national railway lines, ERTMS

I. INTRODUCTION

Railway systems are being continuously studied with the aim of improving their safety and using trustful cost effective technologies. In France, the French National Railway Company (SNCF) works with two different lines: the national and the international. In the national lines, the signalling systems, responsible for detecting and controlling the trains in a safe manner, are implemented with relay-based (electrical circuits-based) or computer-based technologies, being this last one the most recent [1]. Regarding the international lines, these systems are implemented (or are about to be) accordingly to the European Rail Traffic Management System standards. ERTMS was developed to harmonise railway control and signalling systems to ensure railway interoperability throughout Europe [2].

The deployment of ERTMS is mandatory on railway infrastructure projects for new or upgraded rail subsystems receiving financial support from the European Union [3]. In this context, the ERTMS replaces the national conventional electrical systems where the train detection and control is built based on the electrical

circuits. Nowadays, especially in European research projects funded by Shift2rail, the ERTMS is being evolved to gain more advanced manners to detect the train position, control the trains movements and wirelessly communicate all this information with the on-board system, also known as the European Train Control System (ETCS). One example is the use of GNSS (Global Navigation Satellite Systems) [4] that allows the train can continuously and autonomously geo-localise over all the areas covered by these systems [2].

The Railway Interlocking System (RIS) is a track-side part of the signalling system and it is not yet standardized in ERTMS. It is responsible for the logic of the train control in specific areas such as junctions or crossings. In a previous work [5], we presented a safety-based approach to evolve the French RIS from relay-based to computer-based technologies in the national lines. Nonetheless, the possibility of adapting these RIS to international lines based on the improved maintainability resulted from the evolution to computer-based systems, is not yet addressed. By defining an appropriate interface to the RIS, one may evolve these track-side systems in order to suit with the defined ERTMS FIS and FFFIS (Form Fit Function Interface Specifications). However, new promising technologies for improving railway operations like GNSS, are recognized as game changer for signalling systems and introduce new challenging issues not addressed in ERTMS specifications. Hence, despite of the benefits of using such technologies as explained in [2] for GNSS, there are new risks that must be considered and analysed in an appropriate manner.

In this context, as the computer-based RIS generated in the previous work is safety proved, it is still necessary to analyse how the evolution of the track-side component technologies can impact the signalling safety. This article presents how the transformation from relay-based RIS to computer-based ones may support the evolution of the track-side components so the system can be adapted to conform to the ERTMS interface patterns. Then, we discuss the impact of the track-side system evolution over the system safety, focusing on the properties that must be met in a specific real industrial case study. The use of an approach for the transformation from national relay-based lines to international computer-based ERTMS lines is a new proposition. The benefits of using this computer-

based technology as well as the risks to the safety of the proposed system are detailed in this paper.

The next section focuses on presenting how the system may evolve from the legacy national relay-based technologies to have interfaces suitable to ERTMS. Then, the Section 3 is devoted to an analysis of the impact of this evolution to the system safety. The last section of this paper presents the conclusion and some perspectives.

II. RAILWAY SIGNALLING SYSTEMS EVOLUTION

Compared to the relay-based systems, computer-based RIS have a tendency to be easier to handle and maintain, cheaper and more flexible to extend function [6]. The transformation of the existing legacy relay-based RIS towards computer-based technology is under the interest of the industry, as long as the behaviour is preserved and the safety level of the existing systems are maintained or even improved. This is because the legacy systems safety have already been extensively tested throughout the years in a way that they have now a high level of confidence. In order to perform this transformation, in a previous work [5] we presented a methodology based on Formal Methods. By formal specifying the logic behind the electrical circuits diagrams in B-method [7], it is possible to benefit from the formal development process in order to verify the system safety and refine it until its implementation as a computer-based system.

In Ref. [5], an SNCF real case study is detailed and modelled: the Temporary Reversed Direction Installations (ITCS - *Installations Temporaires de Contre Sens*). In this case study, due to a problem on one of the tracks of a double-way train route, a train must pass through the opposite-way track. Because of the possibility of occurring a frontal collision, it is necessary to use the ITCS interlocking system in order to detect the trains presence and control the signals in a safe manner. A track plan of this example is presented in Fig. 1.

In ITCS, all the equipment necessary to detect and control the trains as well as the control logic are implemented based on electrical circuits. For instance, the train detection is made by pedals or buttons, which close electrical circuits that are directly linked to the system

logic. While Pedals indicate the presence of a train on a track, a button express the intent of entering in a portion of the track. On the other hand, the train control is made by track-side signals or by controlling the turnouts. All this equipment activation and deactivation are based on the electrification provided by the interlocking logic circuit. Regarding the ITCS case study, the left side of the Fig. 2 presents the electrical circuit responsible for controlling the Control Area A in the track plan presented in Fig. 1. The electrical components highlighted in yellow represent the inputs of the system, while the green components are the outputs that control the signals presented in the track plan.

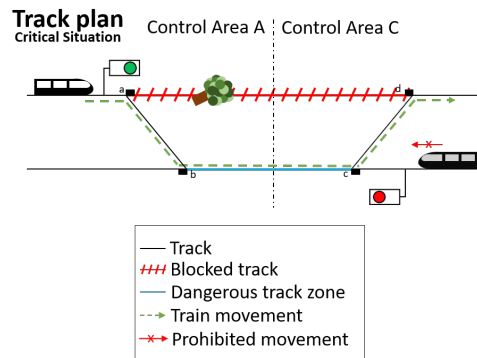


Figure 1. ITCS case study track plan.

After the specification, proof and transformation of the RIS into a computer-based system, the system logic can now be executed in a microprocessor, as abstracted in the right side of the Fig. 2. In this format, the system inputs and outputs, which were once part of the electrical circuit, can now be directly connected to the microprocessor, which is less expensive and more maintainable [6]. However, a contribution of this approach not discussed in previous work is the improvement of the maintainability and modularity of the system as a way to allow the track-side systems to evolve separately. One interesting benefit of this modularity is the possibility of using the ERTMS technologies together with the new computer-based RIS in such a way that the national system interact in an interoperable manner with ERTMS.

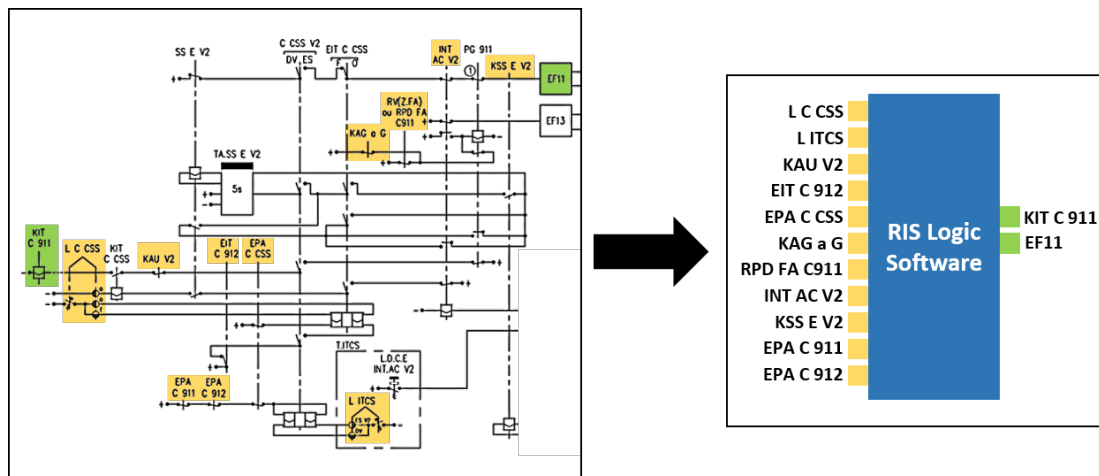


Figure 1. Abstraction representing the transformation of part of the ITCS system from electrical circuits to a computer-based system.

