The Hybrid ERTMS/ETCS Level 3 Case Study

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1 Introduction

The case study concerns the European Rail Traffic Management System (ERTMS)[3], the system of standards for management and interoperation of signalling for railways by the European Union (EU)[4]. The aim of ERTMS is to replace the different national train control and command systems in Europe with a seamless European railway system. The advantages of ERTMS include increased capacity, higher reliability rates, improved safety, and open supply market.

There are three signaling levels for ERTMS[5].

Level 1 Communication between trains and trackside equipment by means of transponders called Euro-balises. Trackside equipment is needed for detecting train location and train integrity[6] and lineside signals are required.

Level 2 Communication between trains and trackside equipment is provided by the Global System for Mobile Communications Railway (GSM-R). Trackside equipment is needed for determining train location and integrity while lineside signals are optional.

Level 3 The train determines its location using fixed positional transponders and supervises its integrity using the on-board Train Integrity Monitoring System (TIMS). This means that trackside detection equipment is not required.

The glossary of terms and abbreviations referenced here can be found in [2].

There are different options depending on levels of maturity in terms of definition and development, leading to several ERTMS *Level 3* types. Our case study focuses on *Level 3 Hybrid* which is the most mature and is developed using existing technology solution augmented for optimization [3]. In particular, it relies on the notion of fixed Virtual Sub-Sections (VSS) which we explain in the next Section.

[3] http://ertms.net.
[4] http://https://en.wikipedia.org/wiki/European_Rail_Traffic_Management_System.
[5] https://ec.europa.eu/transport/modes/rail/ertms/what-is-ertms/levels_and_modes_en.
[6] Train integrity means the train is complete and has not been accidentally split.

2 Level 3 Hybrid with Fixed Virtual Blocks

It is expensive and challenging to fit trains with ERTMS and the Train Integrity Monitoring System (TIMS) so *Level 3 Hybrid* copes with different train configurations (TIMS-equipped, ERTMS without TIMS, and non-ERTMS). *Level 3 Hybrid* uses a limited amount of trackside detection. In the case of TIMS-equipped trains, the capacity of the line can be increased using *fixed virtual blocks*. To achieve this, trackside detection sections are divided into several VSS. Depending on the train's equipment, the "occupied" and "free" status of the VSS is computed differently based on the train position information and the trackside detection information:

- A TIMS-equipped ERTMS train (an *integer* train) precisely occupies the relevant VSS in which it is located.
- A ERTMS train not fitted with TIMS also occupies the sections in the rear (until the end of the trackside detection section).
- A non-ERTMS train occupies the whole trackside detection section.

As a result, a non-TIMS train can follow an integer train on VSS sections, but other trains can only follow it on a separate trackside detection section. Capacity gain for *Level 3 Hybrid* can be achieved only for ERTMS trains and full gain is achieved only for TIMS fitted trains.

Due to the discrepency of the timing and spatial information of the trackside dection two addtional (internal) status of VSS are specified: "ambiguous" and "unknown". Status "ambigous" indicates that a train is present but its status is not known, whereas status "unknown" indicates that the occupancy sub-section is not proven.

3 Scope of the Case Study

The scope of of the case study is the management of the VSS (more detailed specification is in [1], a copy is available from the case study website). We will not consider the interlocking system, e.g., how train routes are set and unset. More specifically, we can consider that the trains travel on a straight line and in the same direction. We will not need to consider *how* the Movement Authorities (MAs) of the trains are computed or how they are related to routes. (A route is a contiguous sequence of connected sections.) The MA of a train defines (beside other information) a position on the track, called End of Authority (EoA), which must not be passed by the train. Depending on the type of the trains and their location within the track, the EoA can be defined in terms of the VSS or of the trackside sections. However, since VSS status depends on the trains MA, we will need to consider what has been set as the train MA with the assumption that the trains will be safe from collison if they respect the provided MAs.

Acknowledgements

The organisers would like to thank the EEIG ERTMS Users Group (EUG) for the Principles on "Hybrid ERTMS/ETCS Level 3" document [1] released on 14/07/2017.

References

1. EEIG ERTMS Users Group, Brussels, Belgium. *Hybrid ERTMS/ETCS Level 3: Principles*, July 2017. Ref. 16E042 Version 1A.
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3. Nicola Furness, Henri van Houten, Laura Arenas, and Maarten Bartholomeus. ERTMS Level 3: the game-changer. *IRSE News View 232*, 232, April 2017.