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A SINGLE EUROPEAN RAIL TRAFFIC MANAGEMENT SYSTEM

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***Abstract*:** *Over time, each European country has developed its own technical specifications for its signalling system, estimate width, safety and electricity standards. This represents a significant barrier to trans-European interoperability and results in additional costs and technical constraints. In particular, there are around 30 train signalling systems across the European Union, which are not interoperable.*
The concept of a single EU signalling system to enhance interoperability dates back to 1989, Romanian revolution year, when the rail industry launched an analysis of rail signalling issues across the EU Member States, and, since then, it has constantly evolved.

***Key words*:** *rail network, signalling systems, communication system, European Rail Traffic Management System (ERTMS)*

1. Introduction

To run trains on a rail network, it is necessary to have a rail signalling system so that railway traffic can be managed safely and trains kept clear of each other at all times. These systems usually consist of equipment placed both on the tracks and on the locomotives or entire train sets [1].

However, each European country has developed its own technical specifications for such signalling systems, gauge width, safety and electricity standards. There are now around 30 different signalling systems across the EU managing railway traffic, which are not interoperable. As a result, locomotives or train sets running in several countries or even within a single country need to be equipped with different and multiple national signalling systems [2].

Among other operational obstacles the different signalling systems in place in the European Union rail network hinder interoperability. Interoperability is defined as the capability to operate on any stretch of the rail network without any difference. In other words, the focus is on making the different technical systems on the EU's railways work together.

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To overcome this and to help create a single European railway area, the European rail industry started developing a European control-command, signalling and communication system - ERTMS.

2. European Rail Traffic Management System (ERTMS)

The European Rail Traffic Management System (ERTMS) is a major European industrial project which aims to replace the different national train control and command systems. ERTMS' objective is to replace all existing signalling systems in Europe with a single system to foster interoperability of national rail networks and cross-border rail transport.

It has two basic components, the European Train Control System (ETCS) and a radio system for providing voice and data communication between the track and the train, based on standard GSM technology, but using frequencies specifically reserved for rail (GSM-R).

Over the year, different train control systems have been developed and operated by individual European Railways according to their national requirements on technical standards and operating rules. However, the diversity does not meet the long-term reliability and efficiency requirements. The automatic train protection (ATP) systems in use are non-compatible. Sometimes, it even requires changing locomotive or driver at frontiers as each country generally has its own signalling system for which the drivers have to be trained. A train must be equipped with different ATP systems as it travels along different lines across the country borders.

The additional ATP systems take up a lot of space on-board. It also adds to travel time, operational and maintenance costs. Unifying the multiple signalling systems will provide better interoperability of freight and passenger rail services, minimize technical and cultural problems of cross-border rail operations, reduce costs, improve the overall quality of rail transport and increase competitiveness.

ETCS is in fact an ATP system, based on cab signalling and intermittent and/or continuous track to train data transmission.

An automatic train protection system, ATP will replace the existing national ATP-systems; it provides an inherently safe operational environment for the movement of trains throughout the network, while facilitating a greater network carrying capacity. It does this through the real-time monitoring, capture and analysis of data relating to movement authorities, precise train location, train speed, braking curves and system integrity.

Based upon the analysis of this data, appropriate control orders are issued so that rail traffic operates with the shortest, most efficient, but safest headways.

ERTMS is composed of two software-based sub-systems: trackside and on-board, and both the infrastructure and the train must be equipped for the system to work. The trackside system and the system installed on the vehicles exchange information enabling continuous supervision of the maximum speed allowed for operation and give the driver all the information needed to operate with cab signalling.

Before being put into operation all the equipment must be tested and certified by notified bodies and authorized by national safety authorities or the European Union Agency for Railways (ERA) [3].

The trans-European transport network should be developed through a dual-layer structure consisting of a comprehensive network, which includes a core network, comprising in itself nine core network corridors. These guidelines envisaged that the core network and the comprehensive network should be equipped with ERTMS by 2030 and 2050 respectively.

Figure 1 shows the nine core trans-European transport network corridors.

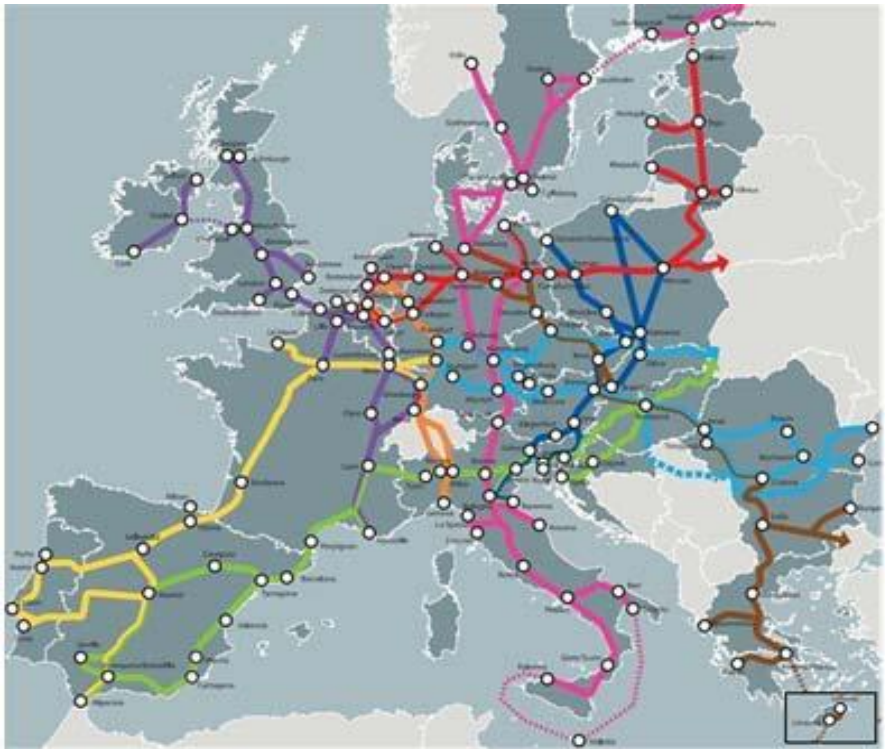

Fig.1 Map of the nine core European transport network corridors

3. Levels of ETCS

ETCS is divided up into different equipment and functional levels. The definition of the level depends on how the route is equipped and the way in which information is transmitted to the train. The scope and interface of ETCS at trackside level vary considerably for the three application levels [4].

3.1 ETCS – Level 1

ETCS Level 1 is a cab signalling system that can be overlay or used in conjunction with existing signalling systems. Line side signals are generally retained and block control is achieved in the conventional manner by the interlocking, based on the information

detected by track circuits or axle counters. It is a system based on intermittent track-to-train communication. Balise is a stable kernel in terms of system functionality performance and other non functional characteristics. Balises, which are linked to the signals or inter-locking via the Line side Electronic Unit (LEU), transmit route data as movement authority to the trains. The on-board computer continually monitors and calculates the maximum permitted speed and the braking curve.

To increase the capacity, additional infill balises between the remote and the main signal are installed. The new aspect status is updated more frequently via radio using GSM-R corresponding to a balise in advance of the train. As a consequence, a train approaching the application zone of a more restrictive condition can revoke braking as soon as the 'signal clears' without waiting to reach the balise itself.

3.2. ETCS – Level 2

At ETCS Level 2, the transmission of variable data between the Radio Block Center and the trains is based on continuous digital radio-based system, GSM-R, in the 900 MHz frequency band.

This system can be used with or without lineside signalling as a backup (subject to operating rules). It enables safe operation at higher speeds, and provides a near instantaneous update of the movement authority and display in the cab for the driver through Radio Block Centre, using GSM-R. All trains automatically report their exact position and direction of travel. The on-board computer continuously monitors the transferred data from balise including movement authorities, the status and characteristics of the track ahead and the distance to the next balise. Between two positioning balises, the train determines its position via sensors (axle transducers, accelerometer and radar). The positioning balise is used as a reference point to calibrate distance measurement errors.

The on-board computer also compares the train's actual speed to the permitted speed. It applies mandatory brake automatically to bring the train speed to below the permitted speed.

3.3. ETCS – Level 3

In Level 3, ETCS goes beyond the pure train protection functionality with the implementation of fully continuous radio-based train spacing.

ETCS replaces the line side signals as well as the trackside detection devices. The train driver views all speed and signalling information on in-cab displays and no signals are required along the line.

As in ETCS Level 2, trains find their position themselves by means of positioning balises and sensors (axle transducers, accelerometer and radar) and must also be capable of determining train integrity on-board to the very highest degree of reliability.

The location of the train is determined by the train odometer and reported to the trackside radio block centre via the GSM-R radio transmission. In this configuration, the

interlocking no longer controls train spacing. It enables the railway to operate at the highest possible capacity.

This configuration offers a great simplification with cost reduction of the equipment in the track and an independence from rigidly structured fixed block intervals. Train headways come close to the principle of operation with absolute braking distance spacing known as “moving block”.

4. Benefit of ERTMS

Compared with the traditional signalling systems, ERTMS is clearly more flexible and advanced with regard to conveying information. It provides interoperability cross-border railway traffic. There are also many other benefits of implementing the ERTMS such as:

- less trackside equipment and major equipment reduction the leads to fewer breakdowns/disruptions;
- increase capacity, provide quicker and more flexible train movements;
- higher operational throughput and lower operations and maintenance cost;
- possible to have line speeds of up to 500 km/h;
- ERTMS allows a more competitive rail sector, and this means a gradual shift to rail is expected instead of other methods of transport. This will benefit the environment and decarbonisation; the railway is one of the greenest transport methods.

5. ERTMS Implementation Status

The ERTMS trackside approval is part of the application file for an authorisation for placing in service trackside control-command and signalling subsystems, involving the European Train Control System (ETCS) and/or the Global System for Mobile Communications – Railway (GSM-R) equipment. [5]

After years of development and studies, ERTMS has rolled out successfully on both high speed and conventional lines. The EU has initiated six ERTMS corridors and some other trans-European transport network (TEN-T) and is now considering an EU-wide master plan on ERTMS migration. In order to ensure the harmonized implementation of ERTMS and interoperability at Union level, an ERTMS trackside approval is requested to check that the technical solutions envisaged are fully compliant with the relevant Technical Specifications for Interoperability and are therefore fully interoperable.

ERTMS is intended to guarantee a common standard that enables trains to travel uninterrupted across different countries and facilitate rail competitiveness.

ERTMS deployment in the EU is at a low level and represents a mix, despite the fact that the ERTMS concept and vision to enhance interoperability is not generally questioned by the rail sector. As of today, the level of ERTMS deployment across the EU is low.

Only 4 121 km of ERTMS were in operation in Europe as of the end of 2016. This only represents around 8 % of the core network corridors. The deadline of 31 December 2030 is established to equip the entire core network of 66 700 km with ERTMS (including

nine core network corridors accounting for approximately 51 000 km) and 31 December 2050 for all 123 000 km of the comprehensive network. Whole EU rail network is 217 000 km. [6]

At the end of 2017 more than 4000 km of lines was been in operation with magnitude of the ERTMS on the Core Network Corridors, and almost 7000 vehicles ware problem equipped or contracted in the EU.

The EU Member States have adopted different strategies for the deployment of ERTMS on their rail network [7,8].

6. Conclusions

The European Rail Traffic Management System (ERTMS) is gradually replacing the existing incompatible systems throughout Europe. This will bring substantial benefits to the railway sector in terms of maintenance cost savings, safety, reliability, punctuality and traffic capacity. It will definitely boost international cargo and passenger transport. The increasing implementation of ERTMS outside Europe demonstrates its success.

The ERTMS has been properly planned, organized and managed. ERTMS is designed to replace the diverse railway signalling systems around Europe with a single system that enables trains to travel uninterrupted across different countries and facilitates rail competitiveness. We also noted that the European Rail Traffic Management System (ERTMS) was being implemented slowly.

European Union Agency for Railways (ERA) should proactively engage in co-operation with the infrastructure managers and national safety authorities prior to the legal deadline in June 2019.

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