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SRK, ERTMS, ETCS,GSM-R

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ERTMS – EUROPEAN RAILWAY TRAFFIC MANAGEMENT SYSTEM

The paper presents the general overview of ERTMS system. Subsystems are described: ETML, GSM-R with particular attention to ETCS.

ERTMS - EUROPEJSKI SYSTEM ZARZĄDZANIA RUCHEM KOLEJOWYM

W referacie przedstawiono ogólny opis Europejskiego Systemu Zarządzania Ruchem Kolejowym. Przybliżono pojęcie interoperacyjności kolejowej. Omówiono ogólnie główne założenia Europejskiego Systemu Sterowania Pociągiem (ETCS) i Europejskiej Warstwy Zarządzania Pociągami (ETML). Szczegółowo pokazano poziomy i konfiguracje ETCS, a także system zobrazowania dla maszynisty (MMI).

1. INTRODUCTION

European Railway Traffic Management System (ERTMS) in accordance with the Decision of European Committee 2001/260/EC should ensure railway interoperability.

Railway interoperability means the broadly understood compatibility of:

- infrastructure
- power supply
- maintenance
- control
- rolling stock
- traffic

Railway interoperability applies both to existing and newly constructed lines, the existing signalling systems and ERTMS.

Operational interoperability of control ensures international safe train travel within various European networks and in particular:

1. the train passage through the border without necessity to stop the train
2. without change of locomotives
3. without change of driver
4. using exclusively standard tasks compliant with ERTMS

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If on both sides of the border exist various signalling systems and the vehicle is provided with an onboard ERTMS device, requiring from the driver knowledge about more than one signalling system, then the vehicle is technically interoperable and not operationally, because item 4 is not fulfilled.

Technical interoperability is a component of operational interoperability.

2. GENERAL DESCRIPTION OF ERTMS SYSTEM

European Railway Traffic Management System (ERTMS) consists of:

- European Train Control System (ETCS),.
- Radio transmission system GSM-R,
- European Train Management Layer ETML.

2.1. DESCRIPTION OF ETCS SYSTEM

2.1.1. GENERAL ASSUMPTIONS OF ETCS

ETCS is bound to supplement and in the future even suppress the variety of AKJP systems (Automatic Train Travel Control) by one common system. Thus, it has to be fully accepted by all European, and in the future also non-European railway managements. This means that it has to fulfil all functions performed by the presently used system, while certain basic functions will be obligatory for all lines equipped with ETCS, and other will be used on an as needed basis.

At the same time for economical reasons this system will have to ensure a possibility of cooperation with various structures, both on the vehicle and on the infrastructure side. Moreover, the system has to enable management of traffic in accordance with requirements and provisions of all specific railway managements and ensure safety at the high level, but not lower than now.

It is necessary to make possible smooth transition of railway management borders without longer standstills for replacement of locomotive and reduction of investment and operational costs by expansion of market and implementation of market competition principles between control system manufacturers on the railways by making available full documentation of interfaces and functional and system requirements of each module to the potential manufactures.

Thus set, these objectives are reached through a far-reaching modularity of functions and structure of the system, open hardware and software architecture and mechanisms taking into account national and local traffic regulations.

ETCS based is on digital track-car transmission. This transmission may be made by balises, short, average or long loops, digital radio channel or specialized transmission modules. The data describing the track and data describing the vehicle serve the purpose of static and dynamic speed profile calculations. The calculated profile is continuously compared with the present speed in function of a location. Location function, necessary for this purpose is based upon uniquely identifiable (by an unique number) and precisely located devices for pinpoint transmission (balises or loop end marks).

Functions of control and supervision always operate along the same principles, independently from the channel receiving the information from the track. The basic functions fulfilled by the vehicle and track devices are presented on Fig.1.

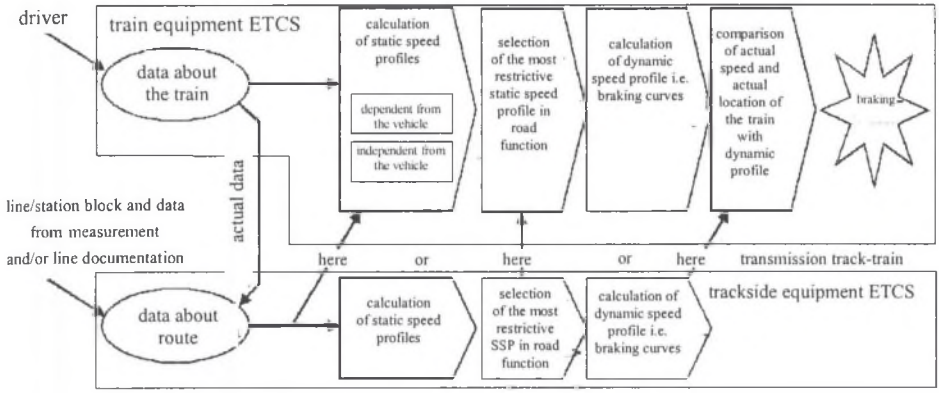

Fig.1. Basic functions of vehicle and track devices ETCS

This drawing shows clearly trackside equipment, transmission track-train and train devices. This division is always appearing in AKJP systems based on train-track transmission. We have to draw attention to the fact that in the case of ETCS system the majority of functions may be realized by both trackside and onboard train devices.

Each train provided with ETCS devices is able to realize all functions shown at the side of ETCS train on-board equipment as shown on Fig.1. Use or not of each function depends on information received from the track i.e. of level of ETCS application or configuration of trackside devices. This does not mean, however, that each vehicle equipped by ETCS is able to move on any line equipped with ETCS (for example, a vehicle equipped with Level 2 devices surely is able to move along the line equipped with Level 1, whereas reversed situation is practically impossible).

Trackside equipment, depending application level and configuration is ready to perform only a predetermined range of functions. This range is determined during designing of line equipping with ETCS taking into account, among others, needs of the line (expressed by, for example, required throughput of the line, speed of the line, required comfort of passengers) as well as cost of investment and operation. The designing begins with determination of level of line equipment, subsequently the ETCS configuration is determined, and then the detailed project is performed.

ETCS is divided into three levels, first, second and third. Equipment of railway lines and track vehicles in ETCS may be realized gradually, by installing equipment for subsequent levels.

We have to make a clear discernment between track equipment level and locomotive equipment level. For instance, the locomotive equipped with third level devices may move along lines equipped with devices for first, second or third level of ETCS, but the locomotive equipped with only first level of ETCS may move only along the lines equipped to first level of ETCS, whereas on the line equipped to second or third level of ETCS it will not be able to travel, as it will receive a STOP signal from the first encountered balise.

2.1.2. LEVELS AND CONFIGURATIONS OF ERTMS/ETCS SYSTEM

Levels and configurations possible within each of them may be presented using the afore mentioned functions, We may discern three basic levels of ERTMS/ETCS:

First level is a preliminary level and ensures protection of train drive. It ensures that the train will not pass beyond the place limiting the preset and acknowledged travel route, and that it will not exceed the acceptable speed on any section of its route.

The locomotive is equipped with first level ETCS equipment and has the following European Vital Computer – EVC, Maintenance Computer, Man Machine Interface – MMI, recorder, travel and time measuring unit (odometer) and antenna for receipt of information from the transponders (balises) laid in the track. All these hardware elements are connected between themselves with a normalized connection called ETCS-bus where also other additional equipment may be connected.

Locomotive of the first level may but not has to be equipped with devices for readout of information from the loop EUROLOOP and with digital radio equipment EURORADIO or specialized transmission modules.

The track equipped with first level of equipment has switcheable balises controlled by the logic of block protection devices for transfer of information displayed on the light signals to the driver's cabin.

Additionally the track may be provided with loops or radio used for the update of information transmitted by the balises or to the bidirectional communication track-train in order to carry out the preliminary information by the trackside equipment.

Level 1 ERTMS may be realized without update or with update of information, Such version of the system is inexpensive but limits the throughput of the line and requires from the driver knowledge of signals in force for the railway in question. Its application is provided in particular for secondary and less loaded lines where no international and high speed trains and no problems with line throughput are expected.

Level 1 with update may be realized in various hardware configurations, whereas update may be of pinpoint character (such as update through additional balises) or sectional (such as update through EUROLOOP). It is also possible to update the information by a Specific Transmission Module to the national system. For example, for PKP purposes, when developing a study for ERTMS application to the E-20 line Warsaw-Kunowice it was considered to use transmission applied for the KHP system for update of information in Level 1 ETCS

Second Level of ETCS is traffic control based upon a continuous digital bidirectional radio transmission.

Thus, the second-level locomotive, besides first level of locomotive equipment has to be provided in addition with devices for handling the digital radio channel (EURORADIO).

Besides balises, the track is equipped with Radio Block Centres – RBC). At the same time, light signals may be removed from the track, as their function is taken over by a continuous digital transmission. Balises has not to be switcheable anymore, as the changing information may be easily supplied through the radio channel. They may not be removed, however, because they constitute a basis for location of vehicles.

Level 2 does not restrict the line throughput and does not require from the driver a knowledge about signals in force for the railways in question. It is expected to use it, above all, for international lines, high speed lines and other lines of primary meaning.

Third level constitutes a development of second level through transposition of track occupancy control from trackside to onboard devices. This enables the drive with moving block

section (independence of block sections) and enables resignation from track circuits and axle counters.

The third level locomotive besides second level locomotive equipment has also to be equipped with safe and reliable system of the entire train set control (Train Integrity Unit).

The main track equipment, besides balises, remain Radio Bloc Centres although the functions of track occupancy are realized in a somewhat different way.

Level 3 is based on radio connection GSM-R for the issue of drive permits and replacement of conventional technique of track occupancy by a combination of train location control and set continuity control. This gives a possibility of preparing drive clearances based upon the principle of a moving block section. Such configuration gives a possibility to use the line throughput to the maximum, renders impossible, however, handling the mixed traffic understood as use of the line for travel of trains equipped or not equipped with onboard ETCS equipment.

In the case of level 1 the entire data processing takes place in the onboard device, whereas for configuration of level 2 and 3 the information processing takes place partially in the onboard equipment, and partially in the trackside equipment i.e. in the Radio Block Centre – RBC. For level 2 and 3, certain steps of data processing may take place in the onboard equipment or in RBC. This is not taken into account on the diagrams in order to make them more clear.

2.2. GSM-R

GSM-R is a railway version of GSM (R – Railway) operating in the band of 900 MHz. GSM-R functionally corresponds to GSM 2+ making available to the users, besides talk channel, also a radio channel for data transmission, group calls, determination of call priorities, functional addressing (using for example train numbers) and other specialized functions designed for such services as railways or police. GSM-R constitutes then a transmission carrier whereby drive clearances are sent, issued by Radio Block Centre – RBC to specific trains located within one RBC area. Place of GSM in the ERTMS/ETCS system is shown on Fig 2.

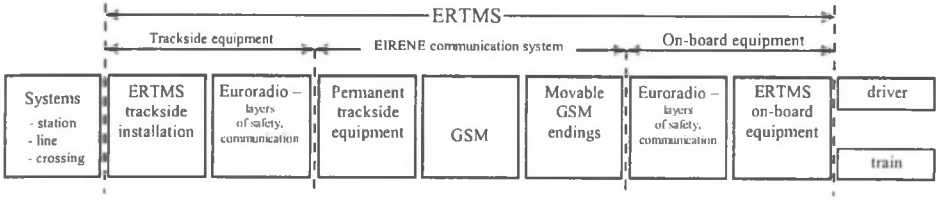

Fig.2. Place of GSM in the ERTMS/ETCS system

Architecture of GSM-R system is a typical GSM cellular network and consists of a main Network Switching Subsystem – NSS and Network Management Subsystem – NMS on the main level and Base Station Subsystem – BSS consisting of peripheral groups of Base Station Controllers – BSC and peripheral groups of Base Transceiver Stations – BTS.

GSM-R constitutes the transmission medium not only for ETCS but also for train radio-communication, as it makes available also talk channels. At the same time, spreading of

GSM-R gives medium for all other applications, related with information transmission for the purposes of maintenance, statistics, travellers' information etc.

2.3. VISUALIZATION INTERFACE FOR THE DRIVER – MMI

For the systems ETCS and GSM-R the international railway association UIC proposes an unified visualization interface for the driver **M**an **M**achine **I**nterface – MMI.

The proposed visualization device is based on a touch-on screen divided into areas with icons displayed. The main MMI areas are presented on Fig.3. Each icon is located in a determined place on the screen and in a colour corresponding to the situation. White icon means normal situation and lack of deriver's reaction requirements. Yellow icon means still a normal situation but with need for driver's intervention. Orange icon means exceptional situation indicating urgent need for driver's reaction. However, if the icon becomes red, this means that the system intervention took place and the system is replacing the driver who has not driven the vehicle in accordance with the information provided. The colours are applied for both classically understood icons and the arrow and bar of the speed meter.

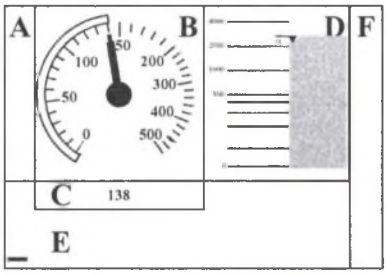

Fig.3. Main areas of MMI that is common for ETCS and GSM-R

Areas of MMI: A (data concerning braking), B (speed meter) and C (speed values) apply to the ETCS system, whereas areas D (planning), E (supervision) and F (driver's keyboard) are used by both ETCS and GSM-R systems. For instance, area F located at the right side of the display constitutes the driver's keyboard. It contains ETCS pushbuttons such as „locomotive operation mode", „passing the signal with a STOP aspect" or „go to introduction of data about the train", and EIRENE pushbuttons such as „onboard radio function", „connect to the first operator", „connect to the second operator", „ connect to the power supply supervision" and „urgent warning for all trains within this area". Whereas this last pushbutton may be interpreted as being on the borderline of ETCS and GSM-R.

2.4. TRAIN MANAGEMENT LEVEL – ETML

Even in 1998 it was expected that within the ERTMS system the railway management layer will be introduced. Railways however could not agree upon which functions should have been introduced to the management system and in the meantime the railway managements were creating their own systems. Telematic railway management systems in the specific railway managements developed to such degree that any standardization of the entire

management system became impossible. For this reason, at the level of European Committee, a decision was taken that ERTMS should contain an interface enabling the national telematic railway management systems to exchange information using standard connections and standard messages.

The fact, that within the ERTMS only an interface between telematic railway management systems will be developed, means that specific railways need their own railway management systems and should not expect in this respect standardized European solutions.

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Reviewer: Ph. D. Jerzy Mikulski