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New systems in management of railway traffic in Poland

Abstract: The new computer's solutions and microprocessor technology, microcomputers and the programmable controllers (PLC) for management of train traffic, which are implemented, contribute to the creation of modern rail traffic control systems. These systems provide high reliability, low power consumption, stability and safety of the trains' movement. One of the most important things for the boards of railway European countries is unification the systems of rail transport, in particular unification the signaling systems and control of the rail traffic. A good solution is as soon as possible implementation the European Rail Traffic Management System (ERTMS), which connect the system of safe operation of trains ETCS and the digital Global System for Mobile Communications – Railways GSM-R.

Keywords: Management of railway; Railway traffic

Introduction

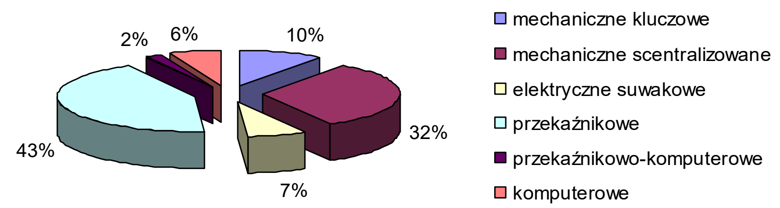
From the beginning of the existence of the railways, devices were used to safely drive traffic on the tracks. The development of these devices was growing every day, the needs and expectations of users grew, and the basic aims of using these devices, ie the safety and efficiency of rail traffic, remained unchanged. That is why rail traffic control devices (SRK) are necessary.

The implementation of the European Rail Traffic Management System (ERTMS) in Poland will meet the requirements of national and European law for the interoperability of rail transport and will increase the comfort and safety of travel. The idea of a single European train traffic control system was born in the early 1990s. On the basis of Directives 96/48 / EC, 2001/16 / EC and Consolidated Directive 2008/57 / EC requires the Member States of the European Union to ensure the interoperability of railways. This mainly concerns newly built and modernized conventional rail lines and high-speed lines, which are part of the trans-European rail network, through the implementation of the ERTMS system. In addition to the technical differences between railway systems used in different European countries, it is no less important to differentiate European railways in terms of organization, manifested by, for example, different motor regulations [12].

In the case of rail traffic control equipment, it is very important for the driver to provide information on how to operate the train. This can be done in a point-to-point manner, i.e. in a limited time when the train travels over appropriate devices installed in the track or continuously - with uninterrupted train communication with fixed devices. In addition to the old, technically uncomplicated point-of-impact systems, today train systems for automatic train control and high-speed binary data transmission systems are unlikely to be used and the probability of erroneous decision making is low. There are also access systems for precise localization of fixed and mobile objects by receiving and processing signals sent by satellite systems.

Support systems for operating a train

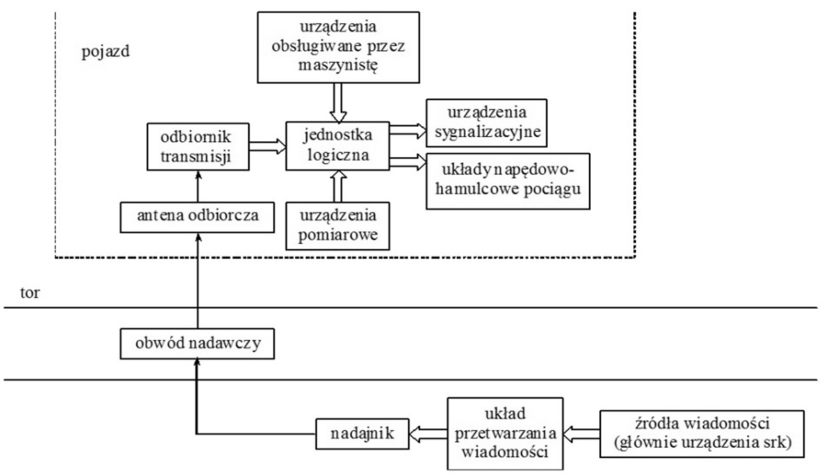
Rail traffic control devices, along with the development of railways, have improved their technical solutions with increasing needs, demands and expectations. Over the next few years, srk systems have been gradually evolving from mechanical, electromechanical, relay, to hybrid and computer [13].The latest generation of traffic control devices is computer systems that combine modernity, reliability and a very high level of traffic safety. As an example, the development of turnstiles used in srk adjustment systems can be used. According to PKP PLK, at present 6% of switches are computer-controlled devices, while another 2% are relay-computer (hybrid) devices. Most srk devices are relay technology (43%) and mechanical (42%), including mechanical centralized (32%) and mechanical key (10%) and electric slide (7%) – fig.**1** [15].



1. Percentage distribution of railway crossover used in setting systems in different technologies [15]

The train is operated by a driver who, based on the track-side signals, the timetable and parameters of the vehicle appropriately adjust the speed of the vehicle so that the ride is safe and according to the timetable and the applicable regulations. However, due to the unreliability of the human being (above 160 km / h, the perception of the human eye is uncertain), the driver must be assisted in his / her work by appropriate srk devices. Among the devices of full automation of train operation are distinguished two basic groups of srk systems, i.e. ATC and ATP.

The Automatic Train Control (ATC) system is designed to continuously control the speed of a train and to intervene in its ride by automatically limiting its speed when it is overrun, based on rolling stock, track or traffic conditions. ATC enable signaling in the driver's cab of the target speed and complement or replace the signaling trackside.



2. Diagram of a classic ATC class system [8]

The Automatic Train Protection (ATP) Automatic Train Protection system complements the track signaling and controls whether the driver responds properly to the signals signaled on the track signals. In the normal case, i.e. when the driver is operating properly, it does not trigger any reaction. In the case of erroneous operation of the driver a service or emergency brake is activated, which causes the train to stop (in front of the dangerous place) [6].

Methods for securing high safety levels on example of srk computer systems

The hardware and software used to create systems responsible for security must meet high quality and reliability requirements. Following the long-term work of the CENELEC (*European Committee for Electrotechnical Standardization*), the algorithms for creating, checking and commissioning secure rail applications have been developed and implemented,.

The basic methods of achieving the required level of safety of modern computerized traffic control systems are [5]:

– hardware redundancy - in the control system two independent operating channels can be extracted: power supplies, controllers, I / O circuits, etc. The devices installed on a given unit, regardless of their number and type, are allocated to both channels so that in the event of failure one of the control channels, the second channel provides sufficient passage protection;
– variety of control programs in both channels - Programs for the drivers in the channels are developed by independent teams of programmers. Most programs are written at the assembler level of the processor used and at the level of the ladder registers;
– synchronization of control channels - the PLCs of the two channels are usually connected by a serial interface through which information is exchanged between them to determine the compatibility of the decision-making layer of the system to enable or disable the srk system in one of the channels;
– real-time testing of the correctness of the modules and devices; - control programs also include procedures for testing the correctness of the power supplies, I / O devices, selected modules, as well as procedures and mechanisms for self-testing of control circuits;
– real-time test of the control program - the control program, in addition to the procedures implementing the various system functions, also includes procedures for checking the correct execution of each program cycle and procedures for validating the current values of parameters of the srk system (e.g. train counters).

3. Redundancy of the SOL-21 axis counter system structure (SRK Systems Laboratory in UTH Radom) [3]

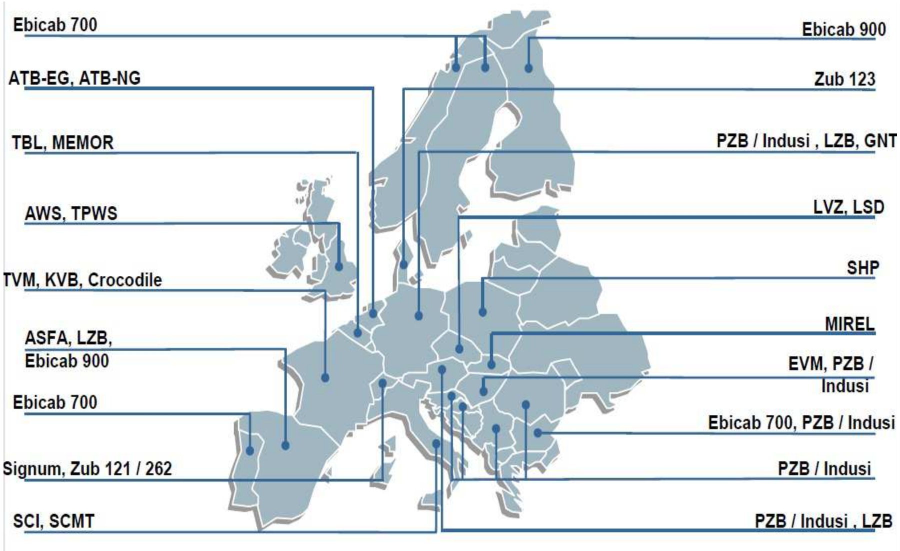
ERTMS system example of a new approach to rail traffic management

The European Union aims to create a single European rail system in which owners of interoperable rail infrastructure will introduce interoperable rolling stock of various carriers carrying passengers and goods [12]. Among the most important technical differences between the European railways, attention should be paid to three basic groups [12]:

- railway track (track width, gauge, permissible axle load),
- power supply system (3kV / 15kV / 25kV, alternating current / constant, various network constructions)
- control system (various signal images, different driver control systems - fig.4.

Equally important is the diversity of the European railways in terms of organization, which manifests itself in the differentiation of motor regulations. At present, there are more than twenty different developed systems in the national railway network. These systems differ in terms of performance (optimizing the distance between trains and railways) and safety [6].

The unified transport system in Europe is ERTMS (*European Rail Traffic Management System*), which is a secure system with continuous train control. The implementation of ERTMS in Poland will meet the requirements of national and European law regarding the interoperability of rail transport and will increase the comfort and safety of travel. The European Train Control System (ETCS), as the ERTMS subsystem, will provide cab signaling and continuous control of the driver, while the Global Mobile Radiocommunication System R will create and improve voice communication and data transmission.

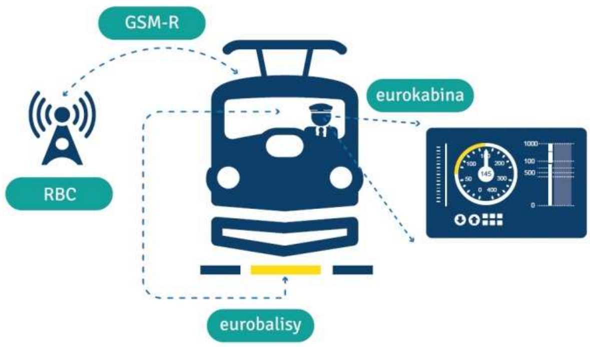


4. Arrangement of railway signaling systems in Europe [12]

The ERTMS system is primarily security. Thanks to it, the driver receives information on the location of other trains, speed limits, shutdowns, and any unforeseen obstacles on the route. All these data are displayed on the screen of the special monitor in the driver's cab. This makes it possible to react immediately and adjust the speed to the conditions prevailing on the route [16].

European Train Control System ETCS

The concept of the ETCS (European Train Control System) is based on the digital transmission of the track - vehicle. Transmissions can be made via balises, short, medium or long loops, digital radio channels or specialized transmission modules. Data describing the track and vehicle data are used to calculate static and dynamic speed profiles. The calculated profile is currently compared to the current speed in the position function. The location function is based on unambiguously distinguishable (by unique number) and precisely localized point transmitters (balises or loop terminals) [6].



5. ERTMS / ETCS operating principle [16]

ETCS is a system designed to control the movement of trains. As the need for control depends on the type of line, the specifications provide for three levels of ETCS implementation, with different levels for different hardware configurations.

Level 1 is based on transmission through balises of traffic permits issued by light signals. The signaling device via the encoder is provided with a switchable eurobalis that transmits a travel permit according to the siren indication to the onboard ETCS, which, based on the received information, controls whether the driver drives the vehicle according to the siren indication. Therefore, the introduction of ETCS at this level is particularly suitable for segments with already existing stationary signaling [12].

Level 2 is based on GSM-R radio traffic licensing and conventional track occupancy monitoring technology for the preparation of driving permits based on existing base-layer drive devices.

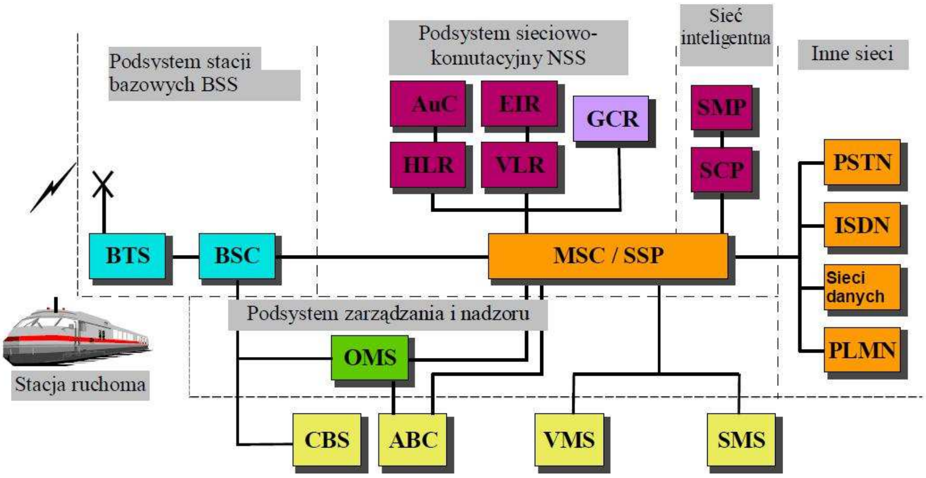
6. ERTMS / ETCS Control Center [2]

Level 3 is based on GSM-R radio communications for the issuance of driving permits and the replacement of conventional track occupancy control by a combination of train position monitoring and continuity control. This gives you the opportunity to prepare driving permits based on the principle of moving block spacing.

GSM-R Mobile Radiocommunication System

The GSM-R (Global System for Mobile Communications - Railway) system operates in the 900 MHz band and corresponds to the GSM 2+ version. In addition to conducting interviews also allows the transmission of data, group calls, priority calls, functional addressing (e.g. number of trains), and other specialized features for railways. GSM-R is the channel to which traffic permits are issued by the Radio Block Center (RBC) to individual trains located in the area of the center. For security, the GSM-R system allocates two 25 MHz bandwidth bands each: 890-915 MHz used for mobile station transmissions to the base station and 935-960 MHz for reverse transmission [6].

The GSM-R system architecture (Figure 7) is a typical GSM cellular network and consists of a Network Switching Subsystem (NSS) and a Network Management and Surveillance Subsystem (OMS) at the main level and a Base Station Subsystem (BSS) consisting of peripheral Base Station Controllers (BSC) and Peripheral Radio Base Station Groups (BTS).Unlike most European train-to-board systems, the GSM-R system does not only include voice communication but also RADIOSTOP. This feature is to be included in SHP's Specific Transmission Module (SHP) for SHP, although it is not an integral part of this system [14].



7. The GSM-R system architecture, where according to the markings we have: [1]

ABC	Centrum administracyjno - bilingowe	EIR	Baza identyfikacji sprzętu	SMP	Zarządzanie usługami
AuC	Centrum identyfikacji	HLR	Rejestr abonentów własnych	SMS	Obsługa SMS-ów
BSC	Sterownik stacji bazowej	MSC	Centrala radiowa	SSP	Przełączanie usług
BTS	Stacja bazowa	GCR	Rejestr wywołań grupowych	VLR	Rejestr abonentów obcych
CBS	Obsługa rozgłoszeniowa	SCP	Sterowanie usługami	VMS	Poczta głosowa

ETCS Onboard Equipment

For a train driver to be safe, the train must have access to the same information that is provided to the onboard ETCS and is used to control the train driver's correct operation. To this end, the onboard units are equipped with an "imaging device" commonly known as the MMI (Man Machine Interface). The proposed solution is based on touchscreen technology. Information is conveyed by means of icons, which always appear in the same predetermined position of the screen (middle part fig.8).

8. ERTMS / ETCS cab signaling systems [7]

The MMI has been standardized by the International UIC Railways Association. The clock on the left of the imaging device indicates the speed: current, permissible and allowed on the next segment, while the indicator on the right - current, recommended and maximum braking power - locomotives and train. Event icons and control buttons are located on the edge of the case i.e. communication via GSM-R [12].

Research infrastructure at the faculty of automation rail transport and electrical uth radom

The Faculty of Transport and Electrical Engineering is one of the most numerous faculty in Poland, educating engineers and engineers for transport. It is a significant academic center among faculties teaching electrotechnology and the largest number of students in the Faculty of Technology and Humanities. K. Pulaski in Radom. The Faculty has the right to award the degree of Doctor of Technical Sciences in the discipline of Transport and Electrical Engineering and the right to confer the academic degree of Doctor of Habilitation in the discipline of Transport.

In 2009, the Faculty of Transport and Electrical Engineering has enriched its research and laboratory base with the modern Laboratory of Rail Traffic Control Systems, equipped with solutions and systems of Bombardier Transportation (ZWUS) Poland and Z.A. KOMBUD Radom, and in 2016 a new railway automation laboratory was built by Scheidt & Bachmann Polska Company in the models of modern German railway automation systems adapted to the requirements of traffic control in the Polish railway. These laboratories are designed for the technical and functional research of railway traffic control systems and devices and for conducting didactics [4].

All laboratory stations are innovative, correspond to real computer and hybrid (relay-computer) systems of various manufacturers operated on Polish railway. In laboratory classes, it is possible to conduct both technical and functional tests of whole systems as well as selected subassemblies.

9. View of sample laboratories designed to: a) study the EbiLock 950 adjustment system of the Transportation Bombardier (ZWUS) Poland; b) execution of the trains on the ZSB 2000 configuration panel of Scheidt & Bachmann Polska; c) control of unchecked SKZR tracks manufactured by Z.A. KOMBUD Radom [4].

Conclusions

The efficiency and technological progress of the rail traffic control systems have a direct bearing on the safety of rail vehicles. The SRK is a complex and interrelated system in which the malfunction of even a small component leads to the inability of the trains to operate in a structured way, after having established and secured the runways.

The development of rail transport would not be possible without many new solutions in the field of telecommunication and railway signaling. Among the transport systems appeared. Intelligent Transport Systems (ITS), a comprehensive set of tools based on information technology, wireless communications, and vehicle electronics. They serve to increase safety and fluidity of traffic and reduce environmental pollution [11]. They enable efficient management of transport infrastructure as well as efficient handling of travelers. In ITS systems, transportation is largely supported by integrated measurement solutions (sensors), telecommunications, information and information technology, as well as automatic control. In the case of srk may refer, among others to adjust the distance between them and speed and to protect against the entry of other vehicles.

The European Rail Traffic Management System provides new opportunities for rail traffic management in Poland and seems to be the most efficient train traffic control system in the world. It brings significant benefits in terms of interoperability, maintenance costs, security, reliability, timeliness, and throughput. The implementation of modern ETCS and GSM-R systems in Poland and in European countries will contribute to the significant development of rail transport, increase of its safety and increase of railway efficiency. Not only will it enable better integration of the Polish rail network with Europe but will, above all, enable it to travel at 200 km / h and increase the safety of train traffic.

The use of modern satellite systems is slowly beginning to enter the traffic control area. However, for security reasons, the GPS system currently meets an auxiliary purpose in Poland, e..g it is used to locate emergency service vehicles, emergency draisines or rescue salvage trains. The use of satellite communication will allow remote transfer of location information and vehicle status to the relevant databases and entities directly interested in this information. It will also enable the implementation of many functions that will help the driver and technical crew.

Modern srk systems affecting new railway management and management methods are a key element in increasing the safety and viability of railway lines and the more efficient use of infrastructure and rolling stock..

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