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Editor's

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Acting Director of the Railway Research Institute

The development of railway technology has been continuing for almost 200 years and is largely the result of successively introduced innovations. They concern both the infrastructure in the broadest sense of the term, including the railway track structure, control-command and signalling and power supply systems, as well as vehicles running on this infrastructure. The process of new technical solutions' implementation involves a number of stages and, by its nature, is spread over time. It comprises a search phase for new forward-looking and innovative solutions, a design phase, a laboratory testing phase and finally operational tests. All these phases are necessary so as to ensure operational safety and also to avoid faults, especially during the initial period.

In order to accelerate the implementation of innovative solutions in rail transport, while ensuring their required quality, dedicated testing grounds are used in some European countries and in the world. Such testing grounds include, in particular, test tracks, and one of their groups is the test loop. The advantages of using such specialised infrastructure for testing are primarily the possibility of obtaining conditions analogous to those prevailing on railway lines without the negative impact of tests on the performance of transport tasks, ensuring the same conditions for comparative tests, guaranteeing continuous testing, shortening the duration of tests and speeding up the results acquisition. Thus, test tracks are testing grounds for comprehensive testing of rolling stock and infrastructure in various fields of railway engineering.

September 2021 marked 25 years since the IK test track in Żmigród entered into service. It is worth noting that this track was planned mainly as a testing ground for endurance tests of railway superstructure, as well as bridge structures. It is a paradox that for many years the test track loop has been used primarily for testing rolling stock. The majority of vehicle tests carried out by the Railway Research Institute in Żmigród are conducted for practically all rolling stock manufacturers in Europe. An increase in its testing capacity is planned in the coming years and will include the modernisation of the power supply (supply to all AC and DC systems used by European railways), the installation of equipment for the ETCS Level 2 system and the GSM-R system, as well as the construction of a hall for rail vehicles.

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Tests in Brakes Unit in Cracow

The third quarter of 2021 at the Brakes Unit in Crakow was divided into tests for various rail vehicles.
The research work on braking systems started with a "polonised" track tamping machine type 08-475/4S, which took place in Rybnik.
Next tests were carried out by the Brakes Unit at the IK Test Track in Żmigród for selected brake tests for PKP Intercity of the Flirt 3 vehicle manufactured by Stadler Polska Sp. z o.o. The tests are very extensive due to the interaction of new vehicles from Stadler in multiple operation with FLIRT vehicles of the previous generation.
Another challenge for the Brakes Unit in Kraków was a tank car GATX 5465/MN474 manufactured by Wagon Service in Ostróda. Stationary tests of the brake were carried out in Crakow and running tests were continued at the Test Track in Żmigród for different masses of the vehicle.
Tests on another vehicle started in Crakow in the Brakes Unit and concerned 45WEa vehicle produced by NEWAG S.A. for SKM Warszawa. The test continuation was conducted by the team from the Brakes Unit on the Test Track in Żmigród. At the same time, stationary and running tests of the EUHL track grinder were conducted in various load states. An interesting part of the research was the delivery of the grinder to the Test Track Żmigród by means of an oversized road transport. All tests carried out at the Railway Research Institute are performed under the COVID 19 sanitary regime.

25th International Scientific Conference TRANSPORT MEANS 2021

The 25th International Scientific Conference TRANSPORT MEANS 2021 was held remotely on 6–8 October, 2021. Its topics included, inter alia, Railway, Intelligent Transport Systems, Traffic, Transport Infrastructure and Logistics, Fuels and Combustion.
The IK participants prepared 10 papers:

1. Assessment of Railway Infrastructure Development in Central-Eastern Europe Using Taxonomic Method - A. Massel,
2. Rational Integration Level of Solar Generation in Traction Power Supply Substations for Supplying Auxiliary Consumers - Kuznietsov M., Kuznetsov V., Ostapchuk O., Kuznetsov Vit., Hubskyi P.
3. Setting Dynamic Problem of Logistic Support of Building Objects by Material Resources Taking into account Random Factors Affecting Transportation Timing - I. Arutiunian, A. Radkevich, V. Kuznetsov, M. Kovalenko, M. Skrzyniarz
4. HYPERNEX: Ignition of the European Hyperloop Ecosystem Project Within Horizon 2020 -E. Wawrzyn, K. Polak
5. Infrastructural and Organizational Problems of Suburban Trams in Łódź after 1989 - A. Soczówka, Railway Research Institute, M. Pająk
6. Hard and Soft Telematics Systems - M. Sumiła
7. Impact the tarin Wi-Fi systems on the GSM-R network service availibity - M. Sumiła
8. Field Tests of an Intelligent Video Monitoring System Installed on Freight Wagons - A. Toruń, K. Białek, P. Wetoszka
9. All-purpose Interface Model Between Interlocking System and Line Block System - A. Toruń, L. Sokołowska
10. Simulation Research of All-purpose Interface Model Between Interlocking System and Block System - L. Sokołowska

Hypermotion exhibition, Frankfurt 16 September 2021

On the 16 September 2021, Railway Research Institute (IK) was present on the Hyperloop Conference 2021 organised at, represented by director Marek Pawlik, the occasion of the Hypermotion exhibition which took place in Frankfurt parallel to the Automotive Fair. IK is following hyperloop related events being involved in hyperloop related projects (e.g. Hypernex) and joined CEN and CENELEC standardisation works in which IK is representing PKN Polish Standardisation Committee.

Conference on communication and IT for railways, Wisła 11–13 October 2021

Railway Research Institute was presenting challenges regarding keeping Radiostop functionality during migration from analogue 150 MHz VHF radio communication to digital 900 MHz GSM-R radio communication. Keeping Radiostop functionality is possible, however, it requires some development works and investments both on infrastructure and rolling stock side. Mr. Marek Pawlik, Deputy Director for Railway Interoperability represented IK at the event.

Conference on railway safety, Jastrzębia Góra 6–7 December 2021

An overview of the holistic approaches to railway safety was presented by the Railway Research Institute as an add on to discussions regarding safety related contemporary challenges. Special attention was paid to cyber threats. Railway Research Institut was represented by Mr. Marek Pawlik, Deputy Director for Railway Interoperability.

IK Participation in 24th Scientific Railway Vehicles Conference 2020

Sławomir Walczak
Head of Rolling Stock Testing Laboratory and Rail Vehicles Department, Railway Research Institute

Periodic Railway Vehicles Scientific Conference 2020 was held in Arłamów on 13 - 16 September 2021. The conference was scheduled for 2020, but due to the Covid pandemic was postponed for a year. The conference was organized in a stationary manner with the possibility of participation online. The organizers of this edition were Crakow University of Technology, Department of Rail Vehicles and Transport, and vehicle manufacturer NEWAG S.A. The conference was organised under the auspices of the Ministry of Infrastructure and the Office of Rail Transport. The scientific patronage was held by the Polish Scientific and Technical Society for Operation. The Railway Vehicles Conferences are biannual and are organised by individual technical universities and the industry. The conferences are a celebration for the whole railway vehicle community. Technical universities, research institutes, industry and railway operators from Poland and Europe present their achievements. It is a place for exchanging experiences and views, presenting current topics of scientific work and research problems.

Photo 1. Session IV Infrastructure elements

Speakers at the conference included a distinguished group of specialists from Poland and Europe.

At two parallel thematic panels, among a large number of papers elaborated by Polish and European scientists, manufacturers and operators, 11 papers prepared by 18 co-authors, who are employees of the Railway Research Institute, were presented.

Employees of the Railway Research Institute gave lectures on the environmental impact of railways, the dynamics and driving safety of vehicles, reliability, availability, maintainability in the rolling stock procurement and production processes, requirements for high-speed circuit breakers, noise reduction, brake efficiency, the INNORAIL project, heat transfer in brake discs, i.e.:

1. K. Białek, P. Wetoszka - The impact of rail vehicles on the railway environment – electromagnetic disturbances,
2. A. Chojnacki, G. Wysocki, R. Konowrocki - Longitudinal dynamics of freight trains – experimental and theoretical investigations,
3. W. Groll, B. Sowiński, S. Walczak - Statistical analysis of acceleration based measurements as approach for determination of rail track defects,
4. A. Massel - Implementation of ERTMS in Central-Eastern Europe railways,
5. M. Pawlik - Reliability, availability, maintainability and safety in the railway rolling stock procurement and production processes,
6. A. Rojek - Main circuit breaker of traction vehicles in the dc system – parameters,
7. P. Tokaj - Rail noise reduction in Europe,
8. P. Urbańczyk - The brake performance of railway vehicles. Operating and research issues,
9. E. Wawrzyn, K. Ochociński - Innovative and standardized development model for the purchase of passenger rolling stock – INNORAIL,
10. A. Wolff, J. Kukulski, Z. Jeleśniański - Selected cases of numerical and experimental analysis of the heat transfer process in a railway disc brake,
11. J. Korzeb, K. Polak – Acoustic effect occurring within the exploitation of high-speed trains class 2.

Photo 2. Session I Fire safety

As part of the conference, a meeting of the Transport Committee of the Polish Academy of Sciences and a meeting of the Polish Scientific and Technical Society for Operation were held.

Full versions of the papers have been published in the Monograph "Challenges for the market of production, operation and maintenance of rail vehicles" prepared by the Publishing House of the Cracow University of Technology.

It was agreed that the next, 25th Railway Vehicles Conference will take place in 2023 and will be organised by the Wroclaw University of Science and Technology.

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Railway Research Institute - Author of Technical Standards: Detailed Technical Conditions for Construction of Railway Infrastructure of Central Transport Hub (CPK)

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According to the agreement concluded between the Railway Research Institute and the company Centralny Port Komunikacyjny Sp. z o.o., the Institute is the contractor of the project entitled: Technical standards for the construction of the railway infrastructure of the Central Transport Hub - design guidelines. The development of technical standards was a complex and interdisciplinary research issue. The complexity of this issue results from the fact that the railway lines to be built together with the stations and junctions located on them are to provide:

- the possibility of running trains at speeds that have not yet been achieved on Polish railways,
- very high capacity, especially on sections leading directly to the CPK,
- interoperability, as part of the railway system in Europe, and at the same time technical compatibility with the existing railway infrastructure in Poland.
- the newly constructed railway lines are to be powered by the 25 kV AC traction system, which has not been used in Poland to date.

The developed Standards are intended to ensure maintaining uniform technical parameters for lines designed at different times by different entities, including the CPK company (feasibility study), external design companies (programme and spatial concept, construction designs) and construction companies (implementation projects). They will be also for institutions related to the transport industry, PKP Group companies and works contractors, and will provide technical information to manufacturers of materials and equipment used in the construction of railway lines and potential users of the railway lines, i.e. operators, at the stage of making purchase decisions (e.g. regarding rolling stock parameters). As a result, a wide range of institutions and companies from the railway industry are the beneficiaries of the Standards.

The whole task of developing technical standards for the CPK, which is being carried out at the Railway Research Institute, consists of three main stages: Stage I is a detailed analysis and study of technical standards of selected HSR infrastructure managers, Stage II is the development of appropriate standards for the implementation of the railway component of the CPK, and Stage III provides for supervision of the standards.

During Stage I, Railway Research Institute's specialists collected and comprehensively analysed requirements and good practices of foreign railway infrastructure managers with experience in HSR standard design, execution and use. The opportunities to apply technical solutions of other railway infrastructure managers operating in the HSR system in Poland were verified. Solutions for their design, as well as their construction and operation, which can be applied in Polish conditions and those whose application is not recommended, were specified. Stage I focused in particular on high-speed rail solutions of railway managers in Germany, Italy and Spain. There are also indicated areas where changes in national law should be considered due to new solutions and technologies not yet applied in Polish conditions. Stage I was completed and handed over to the company Centralny Port Komunikacyjny in February 2021.

The basic scope of work in Stage II included research and development work, which resulted in the development of technical standards for the railway infrastructure of the Central Transport Hub. As part of the implementation of research and development work, a number of studies have been carried out, the most important of which is the analysis and research in the field of AC traction power systems in the 2 x 25 kV system, including interference of DC and AC traction systems, the influence of AC power supply on the elements of command-control and signalling systems and simulation tests to select optimal solutions in terms of energy efficiency and minimisation of losses. Simulation tests of the influence of track systems at traffic stations (in particular, the selection of turnout parameters) on the capacity of railway lines and track nodes were also important research areas. Extensive analysis and research has also been conducted in the field of cybersecurity. The standards include all technical areas for proper functioning of modern high-speed rail infrastructure. The development of technical standards is to enable trains to run on the future main lines of the CPK, the so-called spokes, at speeds of up to 350 km/h, and the infrastructure is to ensure high capacity on sections leading directly to the airport, interoperability and technical compatibility with the existing conventional railway infrastructure in Poland. It is therefore a complex and interdisciplinary task for the scientific and technical staff of the Railway Research Institute of all specialities. Stage II was completed and handed over to the Centralny Port Komunikacyjny company in August 2021. Stage II consists of a total of 31 volumes which comprehensively describe the requirements for modern high-speed rail infrastructure and studies containing the results of research work carried out within the standards.

The layout of each volume included in the introduction part: the technical scope, relations with other volumes and definitions of used terms, then connections (correlations of relations) of detailed technical conditions with essential requirements according to the directive on railway interoperability and with basic and general requirements for the CPK railway infrastructure. The final part lists the reference documents referred to in the content of each volume, relating to EU regulations, Polish national law and applicable standards.

Stage III is currently in progress, with experts and specialists from the Railway Research Institute carrying out authors' supervision over possible revisions to the standards. In this stage, a series of trainings are also planned to carry out, intended mainly for designers of the railway infrastructure of the CPK, within the scope of the developed requirements included in volumes I - XVIII.

The planned railway investments connected with the construction of the Central Transport Hub include a total of almost 1,800 km of new lines to be constructed by the end of 2034. The first construction works are to begin in 2023. The railway component of the CPK consists of a total of 12 railway routes, including 10 so-called spokes leading from Warsaw and the Central Transport Hub to various regions of Poland. In total, there are 30 investment tasks and 1,789 km of new railway lines, whose investor is the company Centralny Port Komunikacyjny.

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Project Entitled Simulation Training System for Shunting Locomotive Drivers and Workers of Sidings and Marshalling Yards Involved in Shunting Processes, Increasing Efficiency and Safety of Their Operations

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Adam Dąbrowski, *research and technical specialist, Track and Operations Department*

In 2019-2020, the Railway Research Institute together with SimFactor sp. z o.o. (Consortium Leader) participated in the project "Simulation training system for shunting locomotive drivers and workers of sidings and marshalling yards involved in shunting processes, increasing the efficiency and safety of their operation". This project was co-financed by the National Centre for Research and Development (NCBiR) under the Operational Programme "Intelligent Development 2014-2020", in the priority axis "Increasing scientific and research potential", in the action "Scientific research and development works".

The aim of the project was to carry out research and development work in order to prepare a simulation training system for shunting locomotive drivers and other workers involved in rail transport shunting. The training system consisted of a shunting engine driver's station, a shunting manager's station and an instructor's station. The driver's cab of the 6Dg shunting locomotive was reproduced for the project. This cabin has two control panels which enable the vehicle to be driven in both directions and can be seen through all the available windows (i.e. a 360-degree view). In addition, the position of the shunting manager has been reproduced, equipped with virtual reality goggles (VR goggles) and tracking and motion recognition sensors. Through the virtual reality goggles, the trainee actively participates in the implementation of real shunting processes. Both stations are supervised by the instructor's station, from which it is also possible to initiate training scenarios taking into account an unforeseen event and a change in the conditions of the manoeuvring work (e.g. a change in weather conditions).

The whole project work was divided into 5 stages:

- Stage I - business analysis concerning the operation at sidings, marshalling yards and reloading facilities, and technical analysis verifying the technical feasibility of individual technologies for the project,
- Stage II - technical project of individual elements of the system, i.e. software, training stands, driver's cab and mobile platform; on the basis of the technical projects the production of a training system prototype including all the stands along with generating the virtual environment (including infrastructure of the siding and its environment) and construction of the mobile platform taking into consideration the physics of the rolling stock movement,
- Stage III - development of a set of test cases and carrying out functional tests including verification of correct reproduction of mechanics and physics of the prototype and quality of key shunting work processes, as well as the development of training scenarios and their verification during tests of simulation system operation,
- Stage IV - functional, integration, performance and quality tests together with of the prototype adaptation to the result of tests conducted in Stage III,

- Stage V - adaptation of the training system prototype to market conditions, promotion of the product, i.e. through participation in trade fairs and conferences.

The Railway Research Institute's participation in the project primarily concerned the implementation of work under Stage III. The scope of this work included:

- development of test cases including functional tests aimed at verifying if the sensory impressions reproduced in the simulation system at individual stations during the execution of activities correspond to the real ones,
- development of test cases verifying correct execution and quality of key shunting processes,
- conducting tests according to the cases mentioned in item 1, whose aim was to verify the correct reproduction of the mechanics and physics of the prototype together with the indication of elements to be improved and enhanced,
- verification of the of training scenarios implementation using the prototype, according to the cases developed in item 2 in order to check if the prepared scenarios are in accordance with the training needs, regulations and procedures binding in reality,
- identification of key aspects required to be introduced in the training scenarios,
- researching and analysing the effects of training, preparing sets and materials for conclusions, aiming at developing a training methodology to maximize the effectiveness of training with the use of a simulation system.

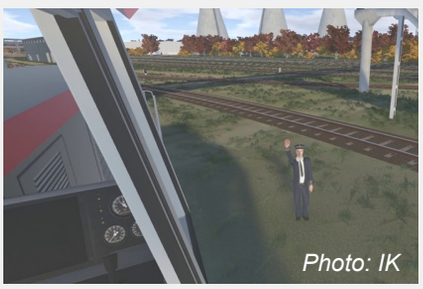

Fig. 1. View from the driver's cab of the training system on the shunting worker's avatar

The project entitled 'Simulation training system for shunting locomotive drivers and workers of sidings and marshalling yards involved in shunting processes, increasing the efficiency and safety of their operation' (POIR.04.01.04-00-0084/17) was co-financed from the funds of the National Centre for Research and Development and was selected for co-financing under competition No. 1/4.1.4/2017 in Sub-action 4.1.4 "Application projects".

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25 years of Testing and Research at IK Test Track Centre in Żmigród

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The development of railway systems has always been linked to the use of modern technological developments and to ensuring the safety of users, both passengers and staff. The wide range of issues associated with progress and safety requires not only the use of increasingly effective technical solutions, but also the testing of their suitability in operating conditions. The many advantages of the research conducted on the test track include the following:

- test conditions similar to normal rail operation but without any mutual interference,
- constant operational conditions during the whole test process,
- the possibility of carrying out the work without interruption (delivering results faster),
- possibility of carrying out comparative tests under the same conditions,
- carrying out tests impossible to undertake under operational conditions,
- greater safety and better social conditions for research staff.

The Railway Institute's Centre of Experimental Track Operations is located in Lower Silesia, approximately 4 km west of the town of Żmigród. Access to the track from the railway network is provided by a junction leading to Żmigród station located on the railway line E59 Wrocław - Poznań.
Completed and operational in 1996, the test track is an example of a unique research infrastructure for conducting tests on railway vehicles and selected infrastructure elements. During the period of the Centre's operation, research has been carried out in the areas listed below:

- tests on railway vehicles:
  - dynamic,
  - braking systems,
  - crashworthiness,
  - shunting through reverse curves,
  - noise;
- tests on traffic control-control and signalling equipment:
  - impact of rolling stock on control-command and signalling equipment,
  - electromagnetic compatibility of rolling stock,
  - rolling stock interference on control-command and signalling equipment;
- tests on new construction of overhead contact line (OCL):
  - OCL equipment,
  - dynamic interaction of pantograph with the OCL;
- testing of track superstructure and turnouts elements:
  - the switch locking,
  - ballast stabilisation with binder resin,
  - ballast dilution.

During the 25 years of the Centre's operation, i.e. between 12.09.1996 and 31.12.2021, nearly 600 research projects were carried out, the largest proportion of which involved research into rolling stock. Detailed information is provided in Fig. 1 and 2 elaborated by M. Poprawa.
From the perspective of the 25 years of the Centre's work, it can be admitted that the decision to build it was rational and brought considerable benefits to the development of the railway sector.

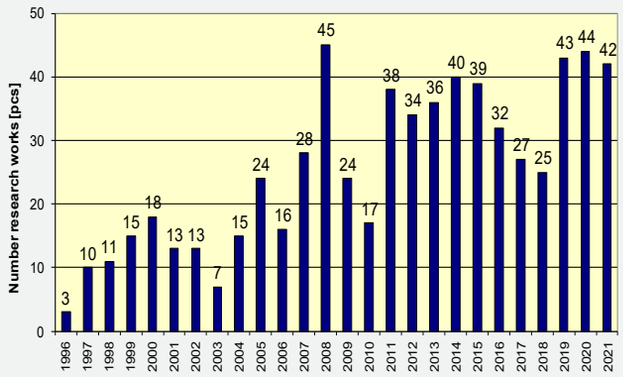

Fig. 1. Number of research works carried out 1996-2021

The need for an efficient and ecologically sustainable transport system results in the necessity to carry out work to improve transport processes and reduce the negative impact on the surroundings. The planned development of the Centre in Żmigród concerns the following areas:

- command-control and signalling and radio-communications, including: testing of on-board and track-side equipment (for ERTMS/GSM-R, ERTMS/ETCS), wireless communication systems (GSM-R, LTE, 5G, FRMCS),
- road infrastructure including: rails, switches and other track components,
- Electric power including multi-voltage supply (25 kV 50 Hz, 16.7 HZ, 3kV DC, 1.5 kV DC, 600 V DC, 750 V DC.

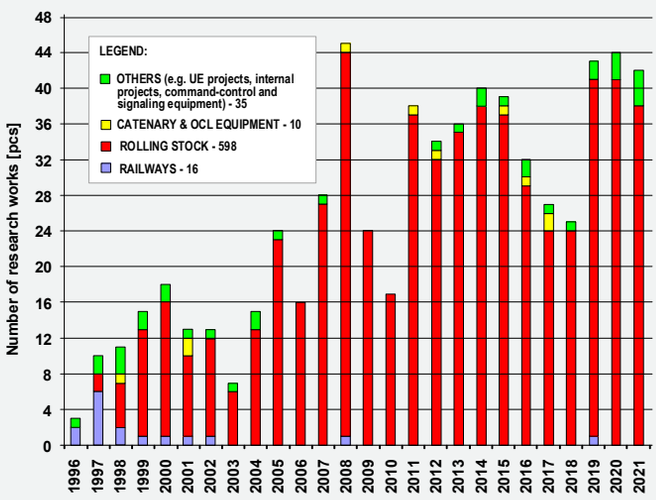

Fig. 2. Distribution of research works according to research area, in period 1996 – 2021

The development of the Centre's research infrastructure will allow the Railway Research Institute to extend its offer to include urban rail transport issues. Increasing the research potential will also serve to improve the position of the Polish industry in the market for rolling stock and infrastructure elements.

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ESC and RSC Compatibility Test on the Polish Railway Network

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Commission regulation (EU) 2019/776 introduced additional basic parameters characterizing the control-command subsystems. Compatibility of the European Train Control system and the Radio System have been defined in point 4.2.17. ETCS System Compatibility means the technical compatibility between the ETCS system installed on the rolling stock (on-board ETCS) and the ETCS system installed on the railway infrastructure (trackside ETCS) in a given area of service (i.e. a section of a railway line). On the other hand, the Radio System Compatibility is the technical compatibility between the on-board voice radio communication systems or radio data exchange and the trackside GSM-R system equipment in a specific area of vehicle operation.

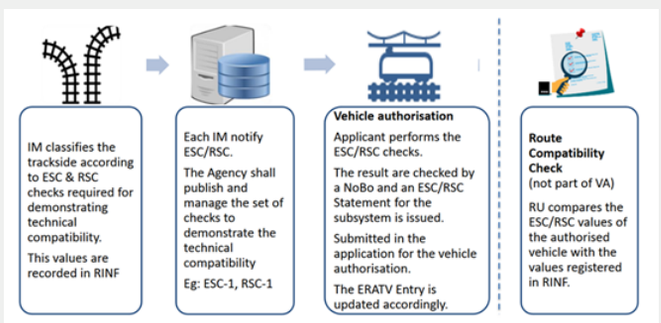

Fig. 1. ESC/RSC General process [1]

The main purpose of introducing these parameters was to minimize the impact of improper interaction at the level: "Infrastructure - Vehicle" in the conditions of commercial operation. Figure 1 shows the responsibilities of individual entities in the rail sector under ESC / RSC tests.

Fig. 2. ESC test sets on the Polish railway network

On the Polish railway network managed by PKP PLK S.A. six ESC test sets (See Figure 2) and one RSC test set (See Figure 3) have been published on the website of the European Union Agency for Railways [3].

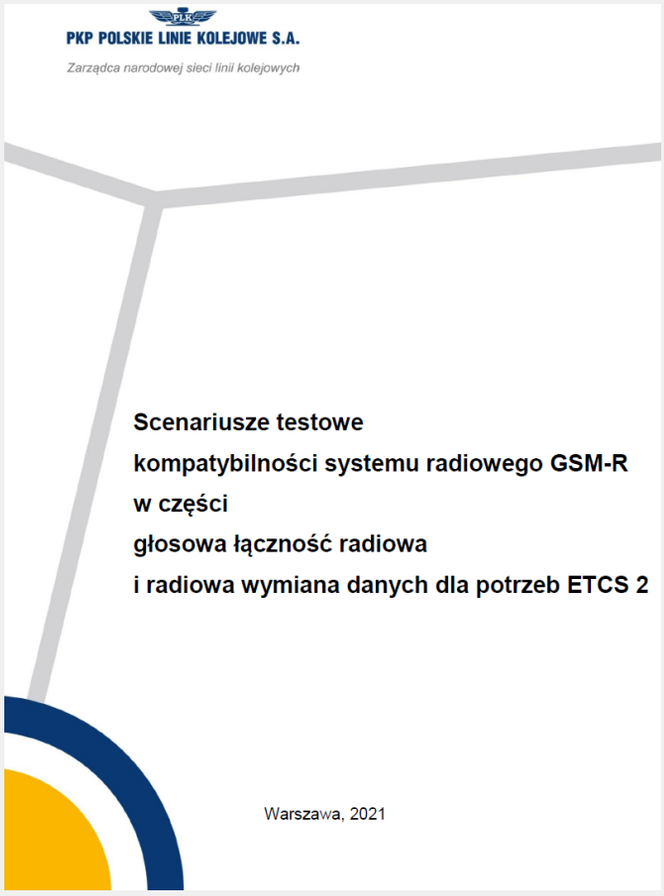

Fig. 3. RSC test sets on the Polish railway network

Particular tests described in individual sets are conducted on the basis of the "Procedure for performing ETCS compatibility control (ESC) - Ie-128" [2], which presents in detail the process of ETCS compatibility control.

It needs to be highlighted that the ESC tests are carried out for on-board units or vehicles which have been already certified by a notified body. The obligation to perform ESC / RSC tests applies to all new, renewed and modernized vehicles in the field of ETCS on-board equipment.

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3. www.era.europa.eu/content/ertms.

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Functional Tests of New Types of Eurobalises on Test Track Centre in Żmigród

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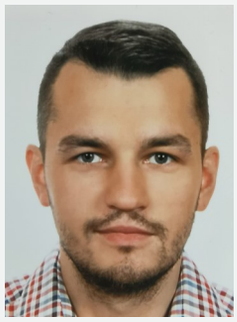

The Railway Research Institute has got a European Train Control System (ETCS) Level 1 installation on its Test Track Centre near Żmigród which at the beginning of 2019 was updated with the first in Poland ETCS L1 baseline 3.4.0 system version. The system has a centralized structure (i.e. LEU encoders and specially designed simulator are located in one place). During tests ETCS telegrams are sent to vehicles via 13 eurobalise groups which are situated in specified locations of the track. For over 6 years the Railway Research Institute measuring team has tested on the above mentioned test facility more than 30 rolling stock types in field of proper cooperation between ETCS onboard subsystems and ETCS trackside infrastructure.

Regardless of this, the track's research capabilities do not end only with vehicle tests, but go far beyond this range. An interesting example of this may be the functional tests of new types of eurobalises which were carried out in order to verify proper operation of the prototypes in field. Eurobalises are devices mounted along the track axis, transmitting data to onboard ETCS devices in the form of telegrams compliant with specific requirements. There are two types of eurobalises: non-switchable eurobalises - transmitting fixed telegrams and switchable eurobalises, which also transmit variable telegrams coming from railway traffic control devices (e.g. station semaphore) via the LEU (Lineside Electronic Unit) encoder. Both types of devices have been tested during test campaign Railway Research Institute Test Track Centre.

The tests consisted of selecting eurobalises groups from an existing installation and then replacing them with the prototypes.

Fig. 1. Eurobalise prototype on the Test Track Centre

Contents of the packages of exchanged eurobalises were copied and uploaded to the tested devices. Then newly programmed eurobalises were installed in indicated locations on track. The next step was to verify the correct upload of telegrams using a specially designed mobile device to check all required parameters.

Fig. 2. EMU during test of new type of eurobalises

On this stage the functional tests started and a train equipped with ETCS onboard was introduced on the test track. Many ETCS L1 movement scenarios were conducted in different conditions.

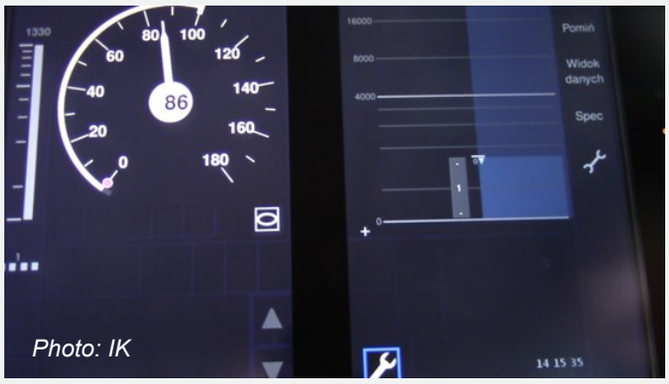

Fig. 3. Driver Machine Interface screen

During tests indications from the Driver Machine Interface (DMI) were recorded using video cameras (See Figure 3). Moreover, data from Juridical Recording Unit (JRU) were analyzed afterwards.

To sum up, tested eurobalise prototypes correctly transferred telegrams to the train what may be a good start to further development of this type of products on the market.

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