Advanced Rail Technologies

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News

Articles

Editor's

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As one of the key components of the transport system, rail transport is tasked with ensuring the safe and uninterrupted movement of passengers and freight. Therefore, from the point of view of fulfilling these tasks, an extremely important issue is the adaptation of command control and signalling systems to the challenges posed by changing market needs (increasing the speed of train traffic, optimisation of railway line capacity, centralisation of command control and signalling, implementation of systems in a distributed structure installed both on the railway infrastructure and on the rail vehicles, or finally, aiming at technical solutions of command control and signalling systems ensuring reduction of the human impact on the traffic control process, e.g. ATO class systems or autonomous rail vehicles).
Since its establishment, the Railway Research Institute has been carrying out work aimed at solving command control and signalling problems of safety in terms of what is known as technical and active safety of railway traffic control systems.
In the 1970s and 1980s, it was at the Railway Research Institute where technical solutions were developed that later implemented on Polish railways in connection with the automation of command control and signalling processes: the MS code block line system, the level crossing COB-83 system or the shunting control system awarded a silver medal in the „Eureka-86" innovation competition in Brussels. The late 20th century years and the beginning of the 21st century have seen the emergence of global and European safety standards for command control and signalling systems, technical specifications for interoperability, and the development of traffic control systems led by the wider railway industry. The needs of the market were changing and so did the nature of the research and development work carried out at the Railway Research Institute. Irrespective of commercial work aimed at confirming that certain safety parameters of newly implemented systems are met, or tests confirming the integration of vehicle-infrastructure systems (e.g. ESC tests described in this issue), the Institute's Traffic Control and Telecommunications Department's output includes conceptual work in the field of railway traffic safety e.g. the use of modern wireless data transmission technologies and spatial information systems for train localisation (the vehicle localisation method was presented at the 1st UIC Global Conference on Signalling in Milan in 2016) and its theoretical foundations were practically applied in the rmCBTC system tested in the Warsaw Metro.
Handing the current issue of the Newsletter to you, may we draw your attention to the fact that the evolving modern environmentally friendly railway using the latest technological achievements has always made safety for its users a primary objective.

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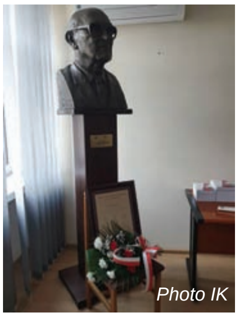
A meeting in memory of Prof. Henryk Bałuch (1932–2020)

A meeting in memory of Prof. Henryk Bałuch (1932–2020) was held on 20 June 2023 at the headquarters of the Railway Research Institute in Warsaw.

Prof. Henryk Bałuch was an outstanding scientist in the field of railways, a member of the Transport Committee of the Polish Academy of Sciences, a long-standing employee of the IK and its director, a member of the IK Scientific Council and editor-in-chief of „Railway Reports". He was the author of many publications, including fundamental monographs on the issues of construction and maintenance of railway superstructure, design of geometrical systems of tracks, reliability and safety of tracks.

The bust of the professor was founded on the initiative of the Association of Engineers and Technicians of Transportation of the Republic of Poland by the professor's students, persons associated with Professor H. Bałuch, as well as business entities benefiting from the results of his work.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XXXI Reporting Forum of Research Institutes

On 26 June 2023, the XXXI Reporting Forum of Research Institutes was held at the Institute of Physiology and Pathology of Hearing in Kajetany.

The Railway Research Institute, was represented by Director Andrzej Massel, DSC, PhD and Dr Renata Barcikowska, the Head of Project Coordination and International Cooperation Unit.

The meeting discussed and summarised the Science for Society Congress, which was co-organised by the General Council of Research Institutes (RGIB) under the chairmanship of Professor Henryk Skarżyński. In the later part of the meeting, the activities of the Council in 2022 were summarised. Dr Renata Barcikowska, as Chair of the RGIB Audit Committee, who presented the Committee's position on the activities of the RGIB for the period from June 2022 to June 2023. There was also a discussion on the future of research institutes in Poland. An expert report was presented entitled „Research institutes' performance in the evaluation of the quality of scientific activity conducted in 2011 and 2022 – analysis and comparison". The expert opinion was delivered by Leszek Stypułkowski from Index Copernicus – President of the Board, CEO, Head of Research and Development.

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Expected Performance of Paint Systems Used in Rail Transport

Marcin Garbacz
Senior Technical and Engineering Specialist, Materials and Structure Laboratory (LK)

Coating systems used for the protection of metal substrates in the railway industry, depending on the place of application in the train construction (car bodies, roof, undercarriages, axles and wheels, internal train equipment, etc.), should, in addition to their aesthetic and decorative functions, also provide a number of functional properties, such as:

- corrosion resistance (tightness of the system itself as well as corrosion resistance of the subsurface in the event of incidental exposure of the coating to the substrate and the first corrosion centre occurs);
- resistance to a variety of acidic and alkaline chemicals (in the context of subsequent cleaning agents, de-icing agents and bird droppings containing digestive acids);
- resistance of the coating to changing atmospheric conditions (temperature, humidity) and light, which causes chalking, changes in colour or gloss of the coatings;
- hardness of the coating / abrasion resistance – in the context of train washing;
- resistance to impacts – mostly from railway ballast;
- adhesion of the system and its interlayers – decals, pressure washing;
- elasticity of the coating – tensile/bending stresses during train operation;
- effectiveness of the protection against graffiti and the full multi-cycle washability of such agents from the coating;
- fire performance.

A coating may consist of a single paint, applied in one or more layers, but generally several different paints are used to form a multi-level protective coating system that complements and extends each other's protective and decorative properties. Properly selected and manufactured protective coatings applied to metal components enable a number of benefits to be obtained by increasing the reliability of train parts and reducing their failure rate. The application of coatings also has a direct impact on safety during train operation especially in terms of fire safety and the mechanical requirements for the protective coatings applied to the axles and wheels of trains.
In order to assess the quality and desirability of the applied paint system in the selected part of the train structure, appropriately selected laboratory tests are carried out against the expected properties of the paint system. Laboratory tests to assess their quality are conducted according to a wide range of available standardised and appropriately selected test methodologies. On the other hand, the overriding aim of laboratory testing is usually to evaluate the effect of ageing tests on the change of selected properties of the materials used. Therefore, the ageing processes in the laboratory are intensified in order to speed up the tests as much as possible, and also to reproduce the most characteristic ageing mechanisms, e.g. the effects of temperature, moisture, UV radiation or chemical agents such as sodium chloride (salt spray).

The Materials and Structure Laboratory has technical facilities and carries out its own tests covering quality assessment of paint systems used in the railways, where for this purpose it was developed document at the Railway Institute under the title DN 001/08/A2/16 „Paint products used in passenger rolling stock in locomotives, wagons and multiple units". The document containing a list of the necessary minimum tests required to be carried out and the expected acceptance criteria for the conducted quality assessment for coatings used in railway applications. The document is currently under review within the framework of the internal project „Adaptation of requirements for coating systems for rolling stock to European standards".

Photo 1. Materials and Structure Laboratory – Chemistry and Anticorrosion Section (source: M.Garbacz)

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Certification of interoperability constituents on the example of Eurobalise

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The Railway Research Institute as a Notified Body No. 1467 to the Directive of the European Parliament and of the Council (EU) 2016/797 of 11 May 2016 on the interoperability of the rail system in the European Union is authorized for the assessment of all interoperable structural subsystems, i.e. Infrastructure, Energy, Control-Command and Signalling Track-side and On-board subsystems, rolling stock and traffic operation and management subsystem. Those subsystems such as Control-Command and Signalling Track-side consist primarily of so-called interoperability constituents which must be certified in order to be implemented. Therefore each and every interoperability constituent has to be assessed in order to obtain so-called EC declaration of conformity. One of the most recently assessed interoperability constituent in the Railway Research Institute was Eurobalise.
Eurobalises are devices mounted along the track axis, transmitting data to on-board ETCS (European Train Control System) 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.

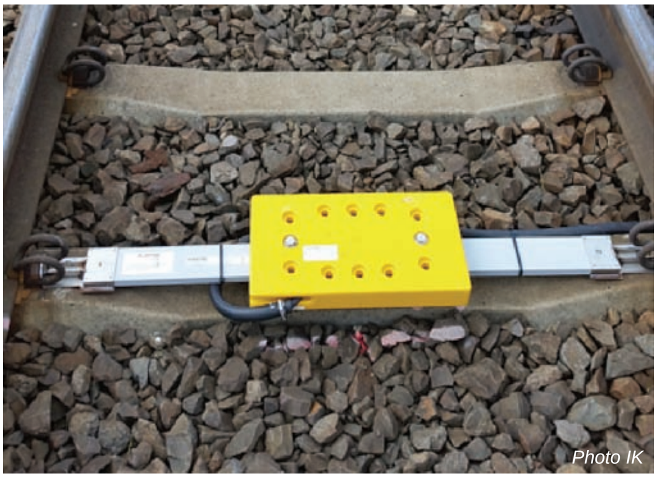

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Fig 1. Eurobalise mounted on the rails

Eurobalise as an interoperability constituent of the trackside control-command and signalling subsystem is assessed for compliance with the relevant regulations using the appropriate assessment procedure. The main document characterizing these procedures and defining the essential requirements for the eurobalise is Commission Regulation (EU) 2016/919 as amended (so-called TSI CCS). For each interoperability constituent certain technical requirements (so-called basic parameters) have to be checked as it is defined in Table 5.1.a of TSI CCS. Eurobalise has fallowing basic parameters assign to verify: 4.2.1 4.5.1 Reliability, Availability, Maintainability, Safety (RAMS), 4.2.5.2 ETCS and GSM-R air gap interfaces: only Euroloop communication with train, 4.2.7.4 Interfaces – LEU – Eurobalise and 4.2.16 Construction of equipment. After these specific requirements are fulfilled the next step can be performed. Therefore activities shown in Table 6.1 of TSI CCS shall be carried out when assessing the conformity of an interoperability constituent or a group of interoperability constituents. All verifications shall be carried out by reference to Table 5.1.a and the basic parameters indicated there.

Photo IK

Fig 2. EMU during functional tests of Eurobalises

When analysing the provisions of this document it can be noticed that an important aspect in the process of conformity assessment of trackside interoperability constituents is to check whether a given component works properly in the environmental conditions for which it was designed. Thus, this requirement determines the need to conduct tests for specific criteria on a selected test site. Test scope carried out on such test sites is often multidisciplinary and despite more and more efficient simulation methods many of them cannot be conducted on the computer or in a laboratory environment. Research possibilities of a given test site are determined, among others, by technical parameters (e.g. length, built-in railway traffic control systems, power supply systems, etc.) and logistic parameters. The Railway Research Institute has its own Test Track Centre, which due to its high availability and the infrastructure built on it, creates optimal conditions for performing a wide range of functional checks related to interoperability constituents such as Eurobalises.

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Adaptation of the ultrasonic test of the rails to the test with speed up to 120 km/h

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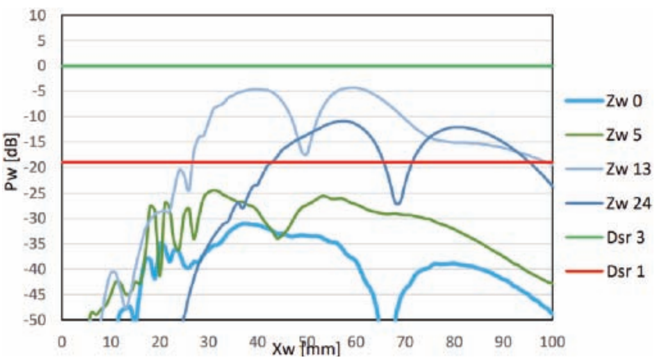
Diagnostics of railway superstructure is very important field of technology, which is an object whose focusing scientists in publications and industry conferences. Particular discussions are caused by the fact that in the time of many interesting industry solutions of ultrasonic rail diagnostics, the Railway Research Institute undertook to develop one of the world's fastest ultrasonic rail scanners together with its partners.

More and more railway lines with operating speeds of 200 km/h, 250 km/h are being under consideration in Poland. These are a very long sections of collision-free lines without possibilities of operating maintenance vehicles during ordinary operation. It is required to use a vehicle that can perform ultrasonic testing of rails at an operating speed up to 120 km/h and will be able to operate between scheduled trains.



Graph 1. Sample of the echo envelope

The realization of the project involves being on the border of physical barriers related to the mechanics of ultrasonic wave propagation in a shaped medium. In the extreme case an effective volumetric test of the rail cross-section requires covering approx. 0.5 m at a theoretical speed of transverse wave propagation of 3250 m/s. Thus, the time required for the acoustic wave to cross that distance is approx. 150 µs. During this time, a vehicle which operates at a speed of 120 km/h moves a distance approx. of 5 mm. That means the return wave never hit the transducer centrally, and it is constantly shifted also just in case when the reflector has ideal position. As a result, the amplitude of each received return echo is many decibels lower than derived from the quasi-static approach. That translates into a theoretical maximum test resolution at a speed of 120 km/h which is approx. 5 kHz of system repetition frequency. Numerical modeling of such a case requires the use of self-developed software which measures the echo envelope of a reference defect, taking into account the fact that the receiving transducer has permanent offset relative to the position pulse generation. The algorithm takes into account the phenomena of the diffraction effect of sound wave at the reflector edges during calculation of the acoustic pressure. The chart below presents an example of the echo envelope derived from a reference defect with a diameter of 8 mm, which is situated vertically in a rail head relative to the ultrasonic transducer position.

All numerical calculations are only an approximation in the case of such dynamic solutions because they never taking into account the influence of the fluctuations of the acoustic coupling. The possibilities of modeling the quality of properties of acoustic coupling during dynamic testing are unknown. As part of the project, it is planned to perform these measurements experimentally on a dedicated test stand. It allow to test the designed mechanical solutions for guiding the transducer on the rail head, measure the wear of the transducer block, measure the impact of the gap to the quality of acoustic coupling.

The quality of the test will be combined with the economy of solution because the system will be able to be fixed with the common type of the boggie frame. This will enable to assembly more copies of that system. For this purpose, the 3D model of the boogie frame have been created on the basis of 2D technical documentation.

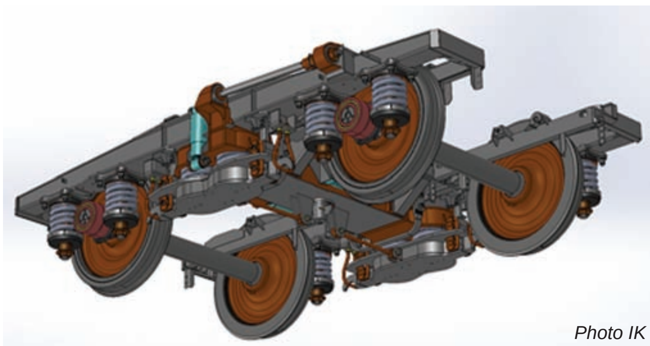


Fig. 1. 3D model of the boggie frame

The work is a result of the implementation of the research project No. POIR.04.01.01-00-0011/17 and its continuation No. BRIK-II/0013/2022 financed by the NCBR together with The PKP PLK S.A. as part of the BRIK Joint Undertaking.

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Research and Development in Rail Infrastructure – BRIK II

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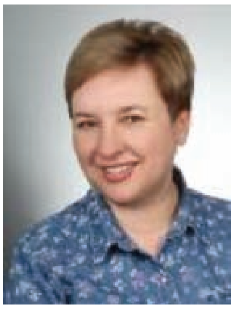

Since 2017, the National Centre for Research and Development (NCBR) and PKP PLK S.A have been implementing Joint Research and Development Undertaking with the acronym BRIK: „Research and Development in Railway Infrastructure". The main objective of the programme is to increase the innovation and competitiveness of rail transport. In December 2021, the NCBR announced the second BRIK call. As a result of the second competition, 45 applications were submitted for a total funding amount of 266,788,784.02 PLN. The minimum value of eligible costs was PLN 1 million. Eight projects received co-financing.

Fig. 1. Research areas in the 2nd BRIK competition

The formal requirements in both competitions were as follows: only consortia could enter the competition. A consortium consisted of: at least one research unit and at least one enterprise, or at least two research units. A consortium could consist of no more than five entities, and the leader of the consortium could be an academic unit only. No entities affiliated or partnered with PKP PLK S.A. could enter the competition. The level of co-financing depended on the status of the enterprise, for scientific units it was 100%. Funding from NCBR and remuneration paid by PKP PLK S.A. was intended for industrial research and experimental development work. The implementation of industrial research was not obligatory in the project. Scientific units carry out projects only as part of their non-economic activities.

In the 2nd BRIK competition, the Railway Research Institute submitted six applications for evaluation, three of which were awarded funding. The table below shows the proposals recommended for funding.

The aim of the project, entitled *'Energy-efficient electric turnout heating system with adaptive heating power distribution',* is to develop an innovative, high-efficiency electric turnout heating system with reduced power requirements at the point of connection to the 0.4 kV AC distribution network and reduced electricity consumption.

The project *"Innovative solution for rail defectoscopic testing at speeds from 60 km/h to 120 km/h"* aims to develop a new ultrasonic rail diagnostic system, enabling testing at speeds from 60 to 120 km/h.

Table 1.

Focus area	Name of project
2.2	Energy-efficient Electric Turnout Heating System with adaptive heating power distribution
4.2	An innovative solution that enables defectoscopic testing of rails at speeds ranging from 60 km/h to 120 km/h
4.3	Mobile system for radiographic (radiological) inspection of R60E1 or E2 profile rails on PKP PLK railway lines.

The project entitled *'Mobile system for radiographic (radiological) inspection of R60E1 or E2 profile rails on PKP PLK railway lines'* concerns developing a prototype of an innovative device (X-ray scanner) for field radiographic inspection of R60E1 or R60E2 rails on PKP PLK railway lines, taking into account aspects of maximum adaptation of the device's mobility to the requirements and specifics of work on railway lines.

The mission of the Railway Research Institute is to pursue scientific and research objectives that will increase the efficiency of rail transport operations, ensure its modernisation and lead to an increase in the competitiveness of rail transport. Significant support for the institution has come from participation in national and EU projects. The Institute is most actively involved in partnership projects with entrepreneurs. Based on the data presented and the Railway Research Institute's activity in BRIK projects, it can be concluded that programmes announced by NCBR dedicated to the railway sector are most advisable and necessary for the development of rail transport. Programmes supporting the financing of research in the area of rail transport require more resources and administrative improvements. Ultimately, in order to increase the competitiveness and innovativeness of the Polish economy, mechanisms should be put in place to expand the demand for marketable research results. This effect can be achieved by creating a system of effective incentives for entrepreneurs to invest in research and development work in the area of rail transport.

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Geometrical Measurements of Railway Infrastructure Facilities

Andrzej Aniszewicz
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The Metrology Laboratory of the Railway Research Institute is committed to improving and developing its range of activities. We are constantly extending our own measurement capabilities. In the core service area AP024 accredited by the Polish Centre for Accreditation (PCA), we calibrate several railway measuring instruments shown in Figure 1. The accredited activity is in accordance with the scope of accreditation No. AP024 and meets the requirements of PN-EN ISO/IEC 17025:2018-02.

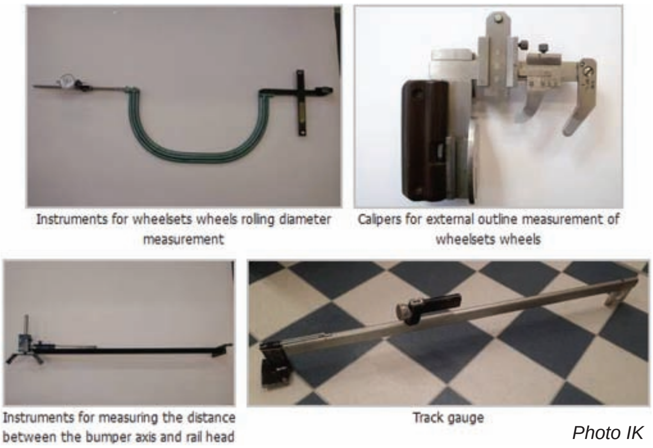

Fig. 1. Measuring instruments calibrated within accreditation scope AP024

Using the railway instruments and other equipment shown in Fig. 1, we make measurements of various railway infrastructure elements. These include new and damaged wheelsets (Fig. 2), brake discs, bogie frames and screw couplings (Fig. 3), wagon and locomotive underframes, pre-stressed concrete sleepers and rails (Fig. 4), spring clips, crossing plates, electricity poles, insulators, contact wires, etc. For measurements, we use modern specialised equipment, i.e. portable electronic instruments that successfully replace the old, mechanical, low-accuracy devices. These include the CALLIPRI laser instrument for measuring wheelset and rail parameters and the KREON universal measuring arm used for comprehensive spatial measurements.

Fig. 2. Measurement of a defective wheel set

Modern measuring equipment allows carrying out efficient and precise customised measurements of damaged components that are the subject of post-accident expertise, such as damaged wheel discs, broken axles, broken pivots and screw couplings.

Fig. 3. Measurement of bogie frame and screw coupling with measuring arm

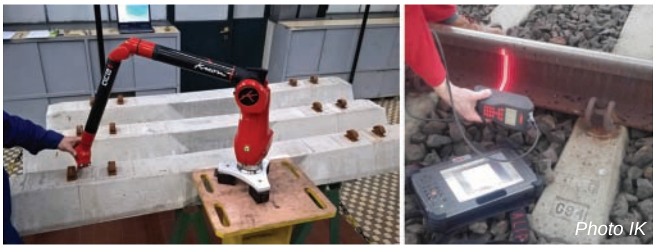

Fig. 4. Measurement of pre-stressed concrete sleepers and rail

We have the capability to measure dimensions and parameters such as, inter alia – wheel rolling profile contour and wear and Ow, Og, qr values, – wheel rolling circle diameter D, – wheel disc gauge Az, – rail rolling profiles and their wear, – brake disc wear, – surface roughness, – spatial distances and geometric dimensions of small and large objects such as frames and underframes, – important dimensions of prestressed concrete sleepers and other concrete elements, etc. Dedicated computer software installed on a portable computer allows precise non-contact measurements to be taken, controlled and analysed.

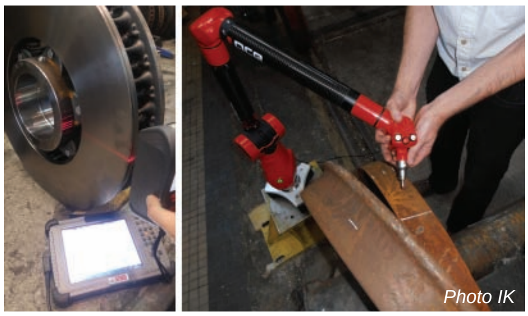

Fig. 5. Measurement of brake disc wear and defective wheel

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Implementation of ESC Tests in Poland

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ETS (ETCS System Compatibility) tests are intended, by definition, to demonstrate technical compatibility between the on-board ETCS and the trackside parts of the ETCS Control-Command and Signalling subsystems within a given area of use. However, it should be noted that, according to the current approach of the national authority in charge of rail transport safety and regulation in Poland – the Office of Railway Transport (UTK), these tests should not be used to identify problems in the interoperability between the on-board and trackside parts of ETCS, but should verify whether, for a given configuration of on-board and trackside equipment, there is a risk of specific threats to their interaction. This interpretation is intended to help clarify the mandatory specifications in the TSIs and also to limit the possibility of duplicating tests already performed and to minimise the costs of test campaigns.

Currently, the Polish infrastructure manager PKP PLK S.A. has defined 6 types of ESCs (areas of use with specific configurations of trackside equipment of the Control-Command and Signalling subsystem), for which the following sets of tests apply:

- Definition and scope of ESC tests for ERTMS/ETCS Level 1 ESC-PL-01-L1;
- Definition and scope of ESC tests for ERTMS/ETCS Level 1 Limited Supervision ESC-PL-02-L1LS;
- Definition and scope of ESC tests for ERTMS/ETCS Level 2, E30 railway line, Legnica–Węgliniec section ESC-PL-03-L2;
- Definition and scope of ESC tests for ERTMS/ETCS Level 2, E30 railway line, Legnica–Opole section ESC-PL-04-L2;
- Definition and scope of ESC tests for ERTMS/ETCS Level 2 system, E65 railway line, section Warsaw Praga Transit – Prabuty (Prabuty–Susz route) ESC-PL-05-L2;
- Definition and scope of ESC tests for ERTMS/ETCS Level 2, E65 railway line, Prabuty–Gdynia Chylonia section ESC-PL-06-L2.

The checks described in the individual test sets are carried out based on the „Procedure for carrying out ETCS compatibility checks (ESC) Ie-128", updated in October 2022, „Procedure for ETCS System Compatibility Checks (ESC) Ie-128", which details the process of carrying out ETCS system compatibility checks in Poland. While carrying out the tests it is essential to check how the tested vehicle behaves and responds to signals and information from the trackside infrastructure (e.g. balises, RBCs). During the individual tests, images from the vehicle's DMI monitor are registered by cameras and observations are made of the panel. Figure 1 shows an example of an image of the DMI monitor during the ongoing tests. After the completed ESC tests, the following documentation is created to confirm the conducted control:

- report of the ETCS compatibility check for a given set of tests, prepared by the Test Coordinator and agreed by PKP PLK S.A,
- assessment of the notified body in accordance with point 6.3.3.1 of the CCS TSI,
- statement by the applicant (entity applying for ETCS compatibility checks) according to the template set out in Annex 2 of Procedure Ie-128,
- updated EC declaration of verification of the Control-Command and Signalling On-board Subsystem.

From 1 July 2021, the obligation to carry out ESC tests on the network managed by PKP PLK S.A. is required for all railway vehicles, unless they were operated under ETCS supervision before 16 January 2020. Vehicles operated before 16 January 2020 under ETCS supervision are deemed to be compliant with the ESC types on which they were operated. It should be emphasised that in this case only, no additional checks are necessary. The due date for ESC testing in Poland is currently set on 10 December 2023 and this is already the third change to this deadline agreed with the Ministry of Infrastructure. The failure to test the compatibility of the ETCS system for existing vehicles will make it impossible to operate them on railway lines equipped with the system. At present, this is a major challenge for manufacturers and users of rolling stock, primarily due to: the limited availability of selected testing grounds, the costs associated with the implementation of test campaigns, making rolling stock available for testing, or sending appropriately trained drivers.

Figure 1. Example of DMI monitor imaging during ongoing tests [Photo: Author]

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