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**ETCS (ESC) and GSM-R (RSC) compatibility tests in polish conditions**

**Abstract:** The process of verification of the installation of the ‘on-board control-command and signalling’ subsystem is complex and requires numerous and time-consuming checks of both the overall technical documentation for a given ETCS installation on a specific vehicle, as well as checks performed during in-service tests. The experience has shown that the tests carried out in laboratories in simulated conditions and the commissioning tests of the on-board and trackside subsystems do not provide sufficient certainty in terms of the correct integration of the ‘on-board control-command and signalling’ subsystem with ‘trackside control-command and signalling’ subsystem and other subsystems.

Therefore, additional tests of ETCS (European Train Control System) and GSM-R (GSM for Railways) on-board configurations with trackside ETCS and GSM-R installations on railway lines were introduced (hereinafter ESC / RSC compatibility tests). The premise of the ESC compatibility tests and RSC is to facilitate the operation of new subsystems, because their correct functioning in a given environment is fully verified at the stage of demonstrating compliance of ESC and RSC. In accordance with Polish requirements, from 1 July 2021, ESC / RSC tests are obligatory for all new, renewed and modernized projects in the field of the ‘on-board control-command and signalling’ subsystem. This obligation is a big challenge for vehicle manufacturers and users, because at that time these tests had not yet been carried out on the network managed by PKP PLK S.A.

Accordingly, this article aims to introduce the issues related to the ESC and RSC tests, as well as to describe the roles and responsibilities of the various parties involved in the implementation of the tests.

**Keywords:** ESC / RSC tests; Compatibility; ERTMS, ETCS

**Introduction**

Currently, many railway investments are being carried out in Poland, both in the area of railway infrastructure and rolling stock, consisting, among others, of the implementation of a modern and interoperable ERTMS (European Rail Traffic Management System), which includes the ETCS (European Train Control System) and GSM-R (GSM for Railways) [5]. In order to ensure the interoperability of these systems, it was necessary to develop detailed technical requirements and uniform procedures that would enable the assessment and verification of compliance with these requirements at the European level. However, practical

experience has revealed the existence of various types of inconsistencies when integrating and cooperation with various subsystems, despite their development in accordance with the applicable unified requirements. There are situations where interoperable rolling stock cannot run freely on an interoperable railway line due to some incompatibilities and differences in firmware versions installed in the components of the ETCS system. In connection with the above, ensuring the interoperability of the railway system in the European Union determines the achievement of full technical compatibility of infrastructure and vehicles. Following the provisions of the Commission Implementing Regulation EU 2016/919, as amended [16], [18], [17] (CCS TSI) technical compatibility covers functions, interfaces, and performance. The Control-Command and Signaling TSI specifies the need for mutual verification of the compatibility of the Control-Command and Signaling On-board and Trackside Subsystems. Depending on the specific project, both on-board and track-side devices are usually supplied by different manufacturers. In addition, individual hardware configurations may differ in software versions, interoperability component versions, or components used, because a given manufacturer may allow, for example, the use of 4 types of modems or 5 types of sensors for odometry devices. An important aspect is also the cooperation of the manufacturer of a given type of rolling stock with suppliers of on-board equipment, in particular when working on adapting the configuration parameters of the ETCS system that will be optimal for a specific type of vehicle (e.g. braking characteristics and time variables regarding the implementation of appropriate commands generated by the ETCS system) and location of the components on the vehicle. Experience has shown that tests carried out in simulated laboratory conditions and start-up tests of on-board and track-side subsystems performed at the stage of technical acceptance are not sufficient in terms of assessing the correct integration of on-board devices of the control-command subsystem with track-side devices and other subsystems. Therefore, there was a need to introduce additional checks to confirm the technical compatibility of the subsystems (trackside and onboard) and the safe and reliable operation of the ERTMS system.

Therefore, with the entry of the 4th railway package, changes were introduced to the Technical Specifications for Interoperability (TSI) [6]. In the TSI dedicated to the control-command subsystem, the procedures for verifying the compatibility of the track-side part of the subsystem with the onboard part have been unified. Compatibility tests are an additional check of the ETCS and GSM-R systems, necessary to achieve technical compatibility of on-board equipment with individual trackside implementations of the system. For the ETCS system, these are ESC tests aimed at demonstrating the compatibility of onboard equipment with the trackside part of the ETCS system. For the GSM-R system, these are RSC tests, which are to demonstrate the compatibility of the cabin radio and EDOR (ETCS Data Only Radio) with GSM-R trackside devices. From July 1, 2021, as part of the application for a vehicle type authorization, it is required to demonstrate compliance with at least one type of ESC/RSC selected by the applicant. If no type of ESC/RSC is confirmed, an appropriate restriction will be introduced in the permit stating that the vehicle cannot be operated on railway lines equipped with ETCS.

### **Regulatory documents for ESC and RSC compatibility tests**

With the entry of the fourth railway package, the first documents appeared that introduce the concept of ESC and RSC compatibility tests. The Interoperability Directive [1] introduced changes to the Technical Specifications for Interoperability (TSI) for the control-command subsystem [16] included in Regulations 2020/387 [18] and 2020/776 [17]. The requirement to perform ESC/RSC tests is defined in Regulation 2020/776 in points 6.1.2.4 and 6.1.2.5. Section 4.2.17 of this document defines a new basic parameter characterizing the control-command subsystems as: ETCS System Compatibility (ETCS System Compatibility) and Radio System Compatibility (RSC).

The compatibility of the ESC system should be understood as the verification of technical compatibility between onboard ETCS and track-side ETCS parts of the control command and signaling subsystems within a given area of use. On the other hand, the term ESC type defines the value assigned to record the technical compatibility between onboard ETCS equipment and a given section within the area of use.

RSC Radio System Compatibility is a technical compatibility check between onboard voice radio communication or radio data exchange systems and the trackside parts of the GSM-R system. The RSC type is therefore a value assigned to demonstrate this compliance for a specific section of the area of use.

Each type of ESC and RSC is characterized by tests assigned to it, developed specifically for its needs by a given infrastructure manager.

Infrastructure managers from various countries were obliged to develop test scenarios and send them to the European Union Agency for Railways, which published them in the so-called technical document [3]. This document presents the current test scenarios separately for ESC and RSC tests for voice communications and separately for RSC-data communications.

Another document that describes the basic assumptions to be adopted when carrying out compatibility tests and describes the roles and responsibilities of individual stakeholders is the guide for TSI Control issued by the EU Railway Agency [2]. This guide defines the concept of compatibility testing, describes its conduct, and indicates what should be included in the test report.

### **Characteristics of ESC and RSC tests**

The Polish infrastructure manager defined ESC types along with sets of related test sets, and as a consequence, on December 2, 2020, the ERA technical document on ESC/RSC tests was updated with a list of checks necessary to be carried out on the network of PKP Polskie Linie Kolejowe S.A. The following sets of tests are currently in force for Poland:

- Definition and scope of ESC tests for the ERTMS/ETCS level 1 system ESC-PL-01-L1 [7];
- Definition and scope of ESC tests for ERTMS/ETCS level 1 Limited Supervision ESC-PL-02-L1LS [8];
- Definition and scope of ESC tests for the ERTMS/ETCS level 2 system, E30 railway line, Legnica-Węglińiec section ESC-PL-03-L2 [10];
- Definition and scope of ESC tests for the ERTMS/ETCS level 2 system, E30 railway line, Legnica-Opole section ESC-PL-04-L2 [9];
- Definition and scope of ESC tests for the ERTMS/ETCS level 2 system, E65 railway line, section Warszawa Praga Transzycytowa - Prabuty (Szlak Prabuty - Susz) ESC-PL-05-L2 [12];
- Definition and scope of ESC tests for the ERTMS/ETCS level 2 system, E65 railway line, section Prabuty - Gdynia Chylonia ESC-PL-06-L2 [11].

However, as part of the RSC tests, a document applies:

- Test scenarios for the compatibility of the GSM-R radio system in the part: voice radio communication and radio data exchange for the purposes of ETCS2 [15].

As mentioned earlier, on the network managed by PKP PLK S.A. there are different configurations of the ETCS system to which the ESC types are assigned. Nevertheless, it is assumed that some of the tests can be considered the same (common) for different types of ESC, and their positive result can be considered for another type of ESC. This information is provided in individual test scenarios. As an example, the following table shows a list of tests, from which a positive test result can be considered for the ESC type: ESC-PL-05-L2 - E65 railway line, section Warszawa Praga Transzycytowa - Prabuty (Szlak Prabuty - Susz).

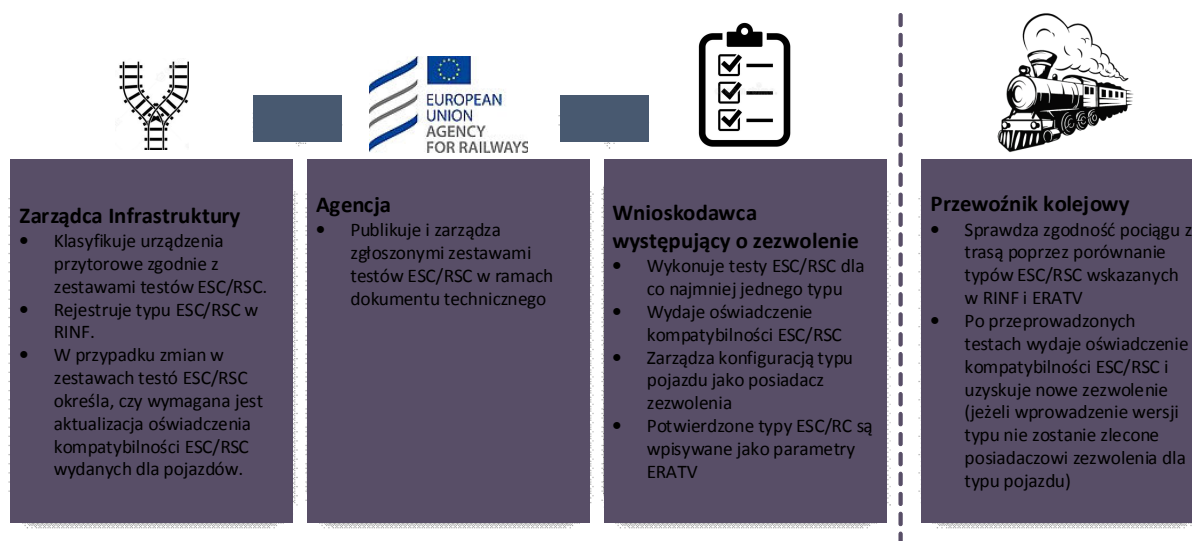
**Tab. 1.** List of tests from which a positive result of the test case check can be considered for the ESC type: ESC-PL-05-L2 *Source: [12]*

Nr testu	Typy ESC, z których pozytywny wynik sprawdzenia przypadku testowego może być uznany dla typu ESC będącego przedmiotem niniejszej specyfikacji:
3.1	ESC-PL-03-L2, ESC-PL-04-L2
3.2.2	ESC-PL-03-L2, ESC-PL-04-L2
3.3.2	ESC-PL-03-L2, ESC-PL-04-L2
3.6.1	ESC-PL-03-L2, ESC-PL-04-L2
3.7.1	ESC-PL-04-L2

In addition to the test sets, the infrastructure manager has published instructions on the rules for conducting ECS and RSC tests:

- Ie-128 Procedure for the ETCS system compatibility check (ESC) [13];
- Ie-129 Procedure for conducting compatibility tests of the GSM-R radio system (RSC) [14].

According to the TSI Control Guide [2], at least one ESC and RSC statement (voice and data) must be provided in the area of use to demonstrate technical compatibility with each network equipped with Class A CCS systems (ETCS and/or GSM-R) in the area of use to authorize a vehicle with Class A systems. Additional ESC/RSC can be done at a later stage for an already authorized area of use. No other checks are foreseen to demonstrate the technical conformity of the vehicle with the route. Figure 1 shows the general context of ESC/RSC testing in vehicle authorization and route compliance checks.



### 1. General ESC/RSC testing process

*Source: own study based on [2]*

It should be noted that, unlike the correct integration tests that are performed during the type-approval process, the ETCS compatibility check is carried out for certified onboard equipment or for vehicles on which onboard equipment with an EC verification certificate has been installed. Therefore, the basic criterion qualifying a given rolling stock for compatibility tests with the ESC type is that it has the appropriate EC verification certificates, and the tests themselves are usually carried out immediately before placing them on the market.

In accordance with the provisions of the above instructions and the guide [2], the

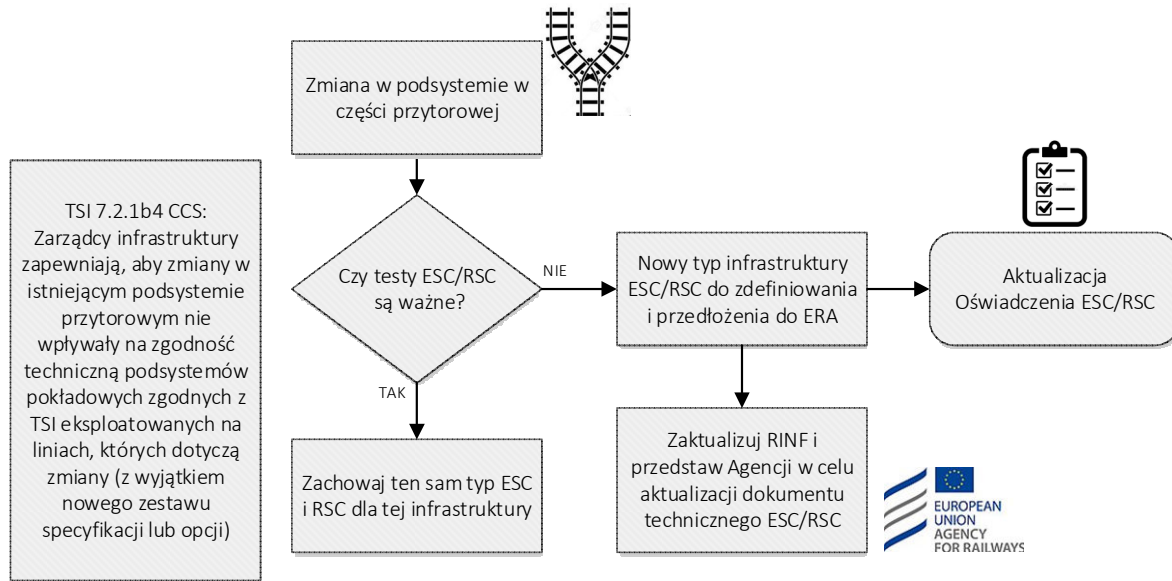
ERTMS system compatibility tests should be carried out by the Test Coordinator with the support of the supplier of trackside equipment and the supplier of on-board equipment of the ETCS/GSM-R system and the possible participation of the Infrastructure Manager. The ESC/RSC Test Coordinator must be an entity holding the Authorization of the President of UTK for the unit assessing conformity in the field of interoperability of the railway system in the EU, including the control-command subsystem. The list of entities along with their scope of authorization is available on the website of the Office of Rail Transport.

The results of the ETCS compatibility check should be described in the ETCS compatibility check report which should be included:

- information about the author of the report and entities involved in the ESC tests,
- indication of the type of ESC for which the tests were carried out,
- description of the railway vehicle (e.g. type of vehicle, type of vehicle, type of on-board equipment of the ETCS system) covered by the report,
- description of the checked configuration of the ETCS system,
- the result of the inspection (based on the analyzes and tests carried out),
- conditions of use resulting from the compatibility check (with an indication of restrictions, if any), which should be accepted by the Infrastructure Manager.

The results of the performed ESC/RSC tests are each time checked by a notified body. Based on the results of the ESC/RSC tests and the inspection of the notified body, the applicant issues the ESC/RSC declaration of compatibility, which is part of the subsystem's EC declaration of verification. Obtaining a vehicle type authorization without tests will still be possible, but it will imply additional restrictions that will be entered into the ERATV (European Register of Authorized Types of Vehicles) database. The lack of ESC tests (the case of ESC-EU-0 with uncoded restriction) is related to the inability to confirm compliance with the route on which the trackside ETCS system is implemented. In this case, it will not be possible to carry out transport with a vehicle equipped with ETCS without ESC compatibility tests for this route, despite the potential possibility of driving with the use of class B devices.

The ESC/RSC statements and the related ESC/RSC test report by the Test Coordinator, which is verified by the NoBo (Notified Body), should be included in the technical documentation accompanying the EC Declaration of Verification by the applicant (applicant) to place the vehicle on the market. Each time the ESC/RSC declarations in a vehicle type are updated, this should be reflected in the technical documentation accompanying the EC declaration of verification and therefore a new EC declaration of verification should be issued. Figure 2 shows the basic steps an infrastructure manager should follow when changes are made that affect technical compliance.

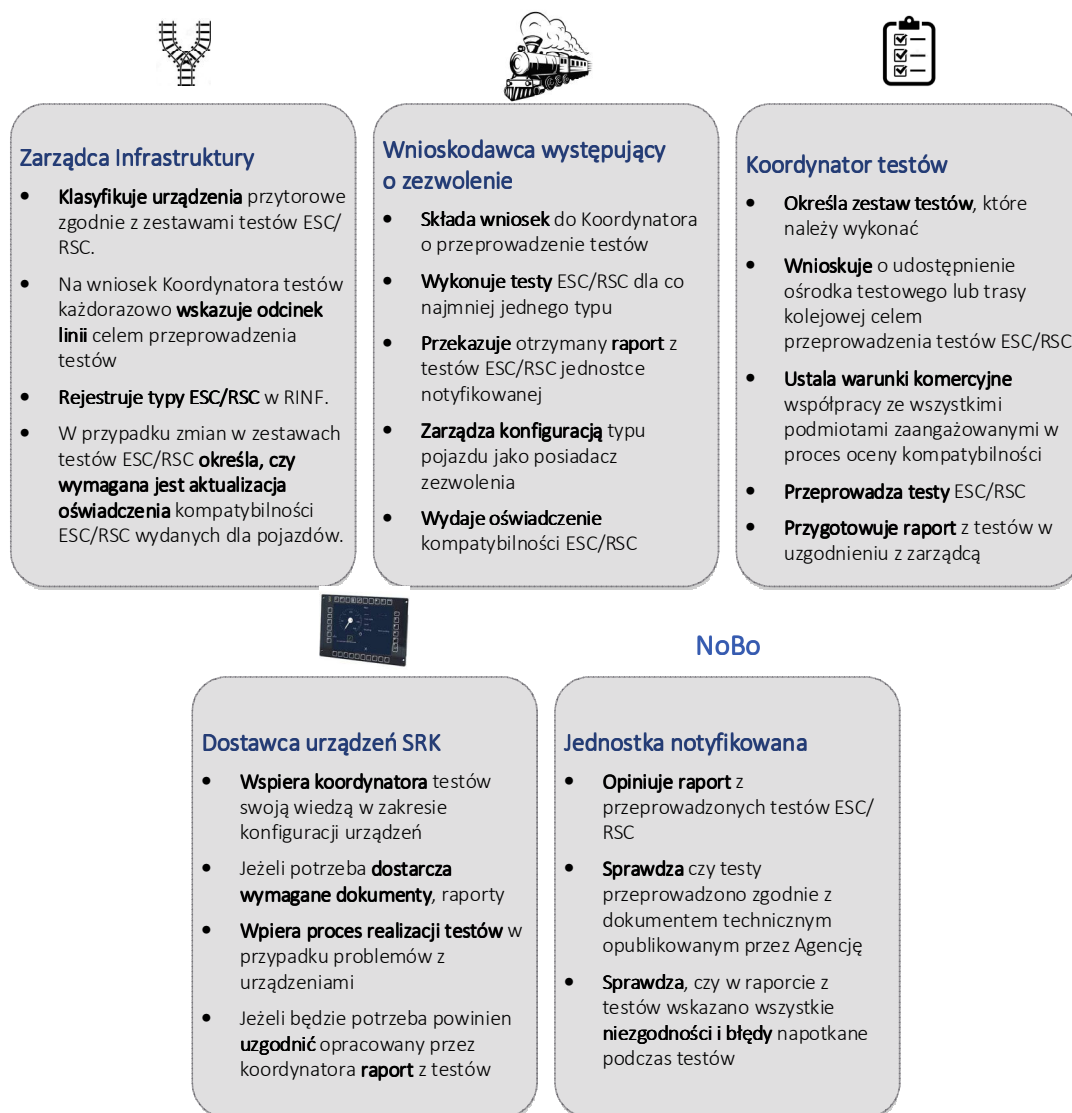


## 2. Trackside changes affecting ESC/RSC

Source: own study based on [2], [4]

### ESC and RSC tests in Poland

In Poland, compatibility tests must be carried out under the provisions of the procedures of the infrastructure manager PKP PLK S.A.[13], [14] and test scenarios that have been published in the technical documentation of the European Union Agency for Railways [3]. PKP PLK's procedures include, among others, provisions on the responsibility of entities participating in compatibility tests, which is presented in Figure 3. An important role is played by the Test Coordinator, who is mainly responsible for the implementation of the tests, as well as for the preparation of the test report. In addition, the Test Coordinator, if the test result is ambiguous or negative, is responsible for informing the applicant and the infrastructure manager about the failure of the tests, indicating the ESC test cases that failed. The currently existing procedures do not describe the procedure to be followed in the event of problems/incompatibilities on the side of trackside devices that affected the test result. If it is necessary to repeat the test campaign, the issue of which of the parties involved will bear the additional costs of testing and delays in obtaining a permit for the tested vehicle, resulting in contractual penalties, which is usually charged to the vehicle manufacturer, has not yet been regulated.



### 3. Roles and responsibilities in the ESC/RSC test implementation process

*Source: own study based on [13], [14]*

According to the requirements, from July 1, 2021, the ESC/RSC tests apply to all new, renewed, and modernized projects in the field of the "Command and Signaling - On-board Equipment" subsystem. However, from July 1, 2022, the ESC/RSC types that will be entered into RINF by the infrastructure manager will be valid to demonstrate compliance with a given route. Carriers who did not operate vehicles under ETCS supervision before 16 January 2020 must also demonstrate compliance with the relevant ESC/RSC types by that date. Therefore, many vehicles must be tested shortly, which is a very big organizational and technical challenge. The tests will be carried out on intensively used railway lines, access to which will be limited, which will significantly affect the works carried out and the time of their execution. In connection with the above, in the case of ESC tests for level 1, the high availability of the training ground at the Experimental Area of the Railway Research Institute, which will be classified as an ESC test center following the Ie-128 procedure, becomes a great advantage. This means that the Experimental Circle will reflect the actual configuration of the ETCS system (hardware and software) used on the section of the line defined by the given type of ESC (currently ESC-PL-01-L1).

As of today, in Poland, it is possible to perform only ESC tests because RSC tests in the field of voice communication cannot be carried out due to unsuitable infrastructure. For this reason, PKP PLK S.A. withdrew the published test scenarios for GSM-R voice communications.

### Summary

The ETCS (ESC) and Radio System (RSC) compatibility tests are intended to be an effective means to achieve full Europe-wide interoperability of train control systems. Their implementation will certainly be an important element in the process of approval of rail vehicles, and as a consequence, it will help to eliminate disturbances in train traffic caused by system errors occurring at the interface between the vehicle part and the trackside part of the ETCS system. The introduced requirements for the implementation of compatibility tests are a challenge for manufacturers, vehicle users, but also for the infrastructure manager, who will have to make railway lines available for research purposes.

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