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DOI: 10.35117/A_ENG_22_07_03

Intelligent video surveillance of containers in the view of electromagnetic compatibility tests

Abstract: The article presents the results of field tests of the intelligent video monitoring system of railway wagons, own name IMW. The IMW device was created as part of a project financed by the National Center for Research and Development, under Measure 4.1 of the Intelligent Development Operational Program 2014-2020 POIR.04.01.04-00-0157/17-00. The leader of the project is MobileMS, while the Railway Institute conducted various research works from 2019 to 2021 together with other institutions (consortium partners) i.e. STIPENDIUM Institute of Science and Technology and Kodegenix. The Automation and Telecommunications Laboratory of the Railway Institute realized part of the electromagnetic compatibility tests. The measurements were carried out in laboratory and field conditions in order to reduce as much as possible the level of generated interference from the IMW device. Tests were carried out on the IMW device mounted by means of metal clamps on the hydraulic distribution block of the WM-15A type motorized bogie. EMC and interference test specialists of the Railway Institute developed test templates according to which the planned measurements were carried out.

Keywords: Electromagnetic Compatibility; Diagnostics; Radiated emission

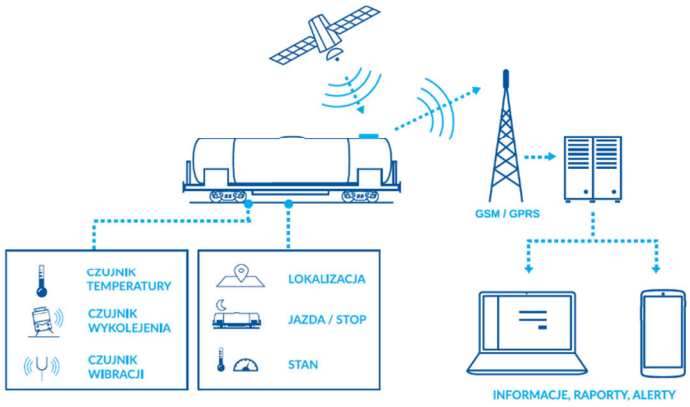
Introduction

The Railway Institute participates in many innovative and innovative national and international projects. Research and development, investment, and application projects financed by the National Center for Research and Development are being implemented. The Laboratory of Automation and Telecommunications participates in several research projects and participates in the implementation of investments in the project no. RPMA.01.01.00-14-9845/17-00 Purchase of modern research and laboratory equipment for the Railway Institute. The research works that will be presented in the article focus on the application project "Intelligent video monitoring of containers" financed by the National Center for Research and Development, under Measure 4.1 of the Smart Growth Operational Program 2014-2020 POIR.04.01.04-00-0157 / 17-00. The leader of the project is MobileMS, while the Railway Institute in the years 2019-2021 conducted various types of research and development works together with other institutions (consortium members), i.e. STIPENDIUM Instytut Naukowo-Technologiczny and Kodegenix.

1. Logotypes of all project consortium members and the financing unit

The project aimed to obtain the effectiveness and efficiency of the IMW product, enabling the provision of a package of monitoring services, including [5]:
- intelligent analysis of monitoring data allowing for risk estimation and forecasting of service costs, using real-time data on the technical condition of wagons and related geolocation data,
- detecting faults in freight wagons (flat wheel surfaces, stickers, build-up) through vibration diagnostics and a network of sensors (bearing temperature sensors, a gas pressure sensor in the tank car),
- forecasting failures and faults and carrying out preventive actions (so-called predictive maintenance).

An illustrative illustration showing the principles of operation of the IMW device is shown below - Fig.**2**.



2. The idea behind the operation of the intelligent video monitoring system for wagons **Błąd! Nie można odnaleźć źródła odwołania.**

Research method

Among many different types of environmental and functional tests of the target IMW product, the Automation and Telecommunications Laboratory of the Railway Institute carried out part of the electromagnetic compatibility tests. The measurements were carried out in laboratory and field conditions to maximally confirm the lack of impact of the IMW device on the immediate surroundings - the railway environment. Tests of the IMW device, i.e. the transmitter mounted with metal clamps on the distribution block of the hydraulics of the WM-15A motor trolley, were proposed - Fig.**3**. EMC and interference specialists at the Railway Research Institute developed test scenarios according to which the planned measurements were carried out.

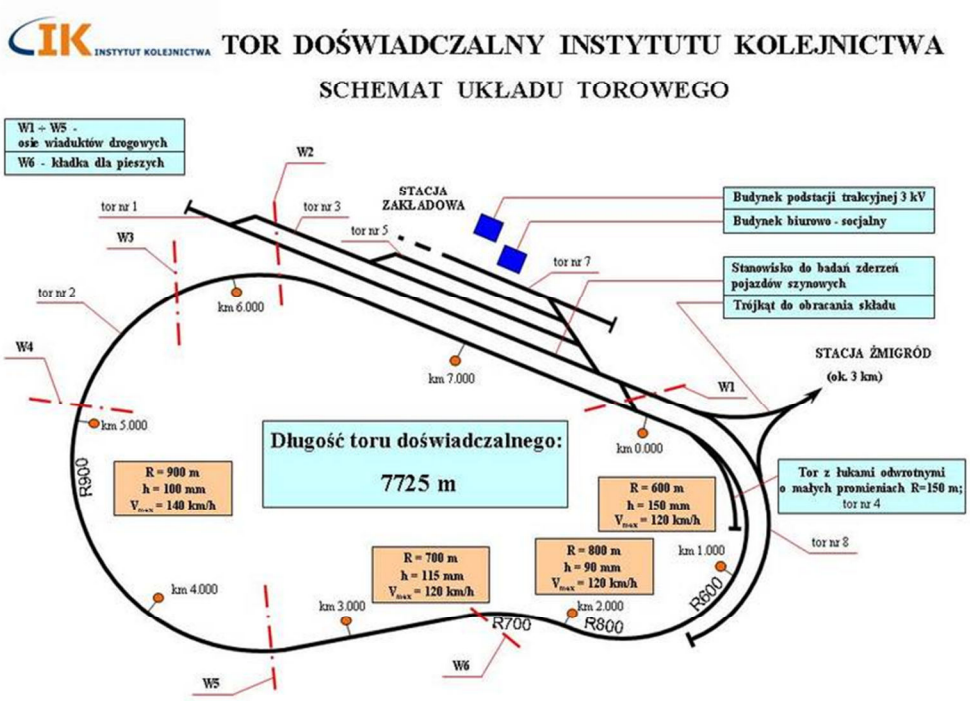
3. Mounting place of the transmitter on the WM-15A motor wagon

The measurements of the emission of radiated disturbances of the IMW rail car monitoring device mounted on the WM-15A motor trolley and the vehicle itself were carried out in accordance with PN-EN 50121-2 [2] and PN-EN 50121-3-1 [3] for the housing port, in the required frequency band of 150 kHz - 1 GHz in the following subranges and proposed operating modes (Table **1**).

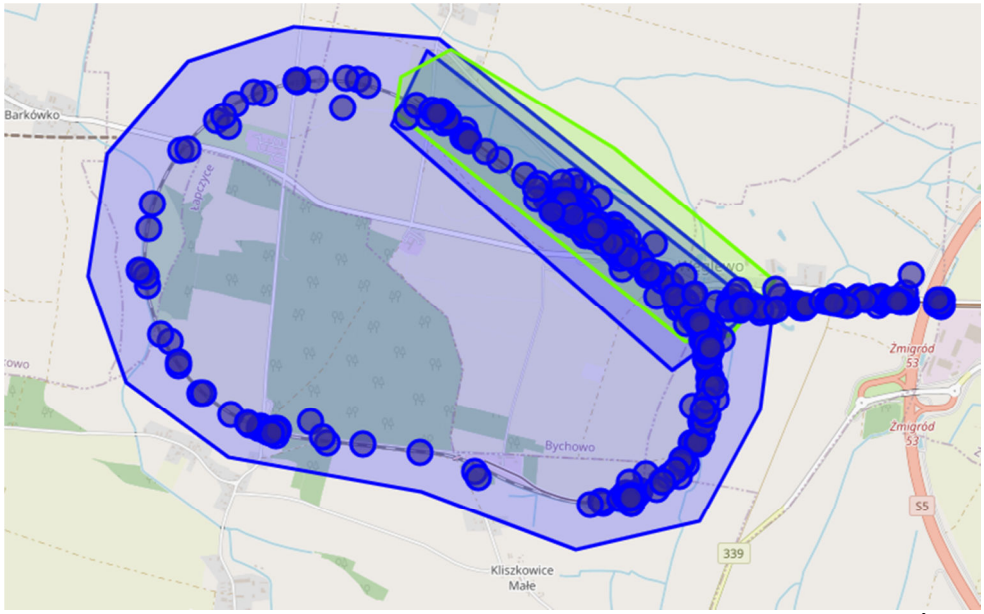
Tab. 1. The proposed test scenario for the IMW device

Frequency range	**Vehicle operating mode**					
150 kHz – 1,15 MHz	BACKGROUND	STOP with transmitter	STOP without transmitter	BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter
1 MHz – 11 MHz				BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter
10 MHz – 30 MHz				BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter
30 MHz – 230 MHz	BACKGROUND	STOP with transmitter	STOP without transmitter	BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter
200 MHz – 500 MHz	BACKGROUND	STOP with transmitter	STOP without transmitter	BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter
500 MHz – 1 GHz				BACKGROUND	DRIVING 50 km/h with transmitter	DRIVING 50 km/h without transmitter

The electromagnetic compatibility tests presented in the article were carried out on the Experimental Track of the Railway Institute located near Żmigród. The curvilinear, closed shape of the Experimental Circle, 7,725 m long, with a straight section of over one kilometer, enables testing of vehicles in terms of their dynamic behavior at the permissible speed Vmax = 160 km/h [3]. - Fig. **4.** The Experimental Track was also a place for various types of off-road driving, and functional tests, which were monitored using a dedicated IMW.Centrum system created in connection with the implementation of the NCBiR project - Fig. **5**.



4. IK Experimental Track, track layout scheme [1]

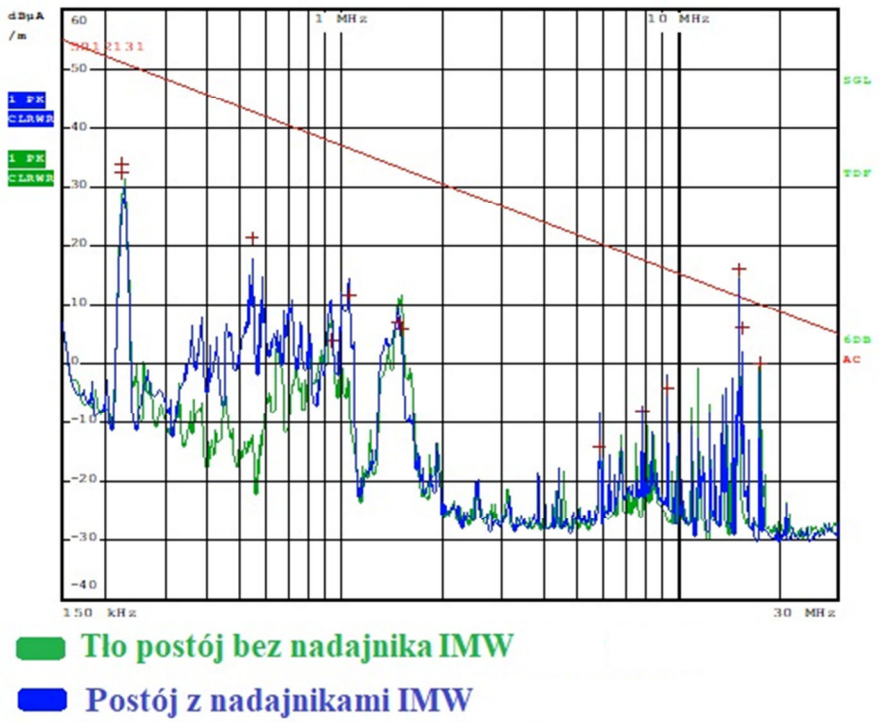


5. Location data from the IMW system. Center - functional tests at OETD Żmigród

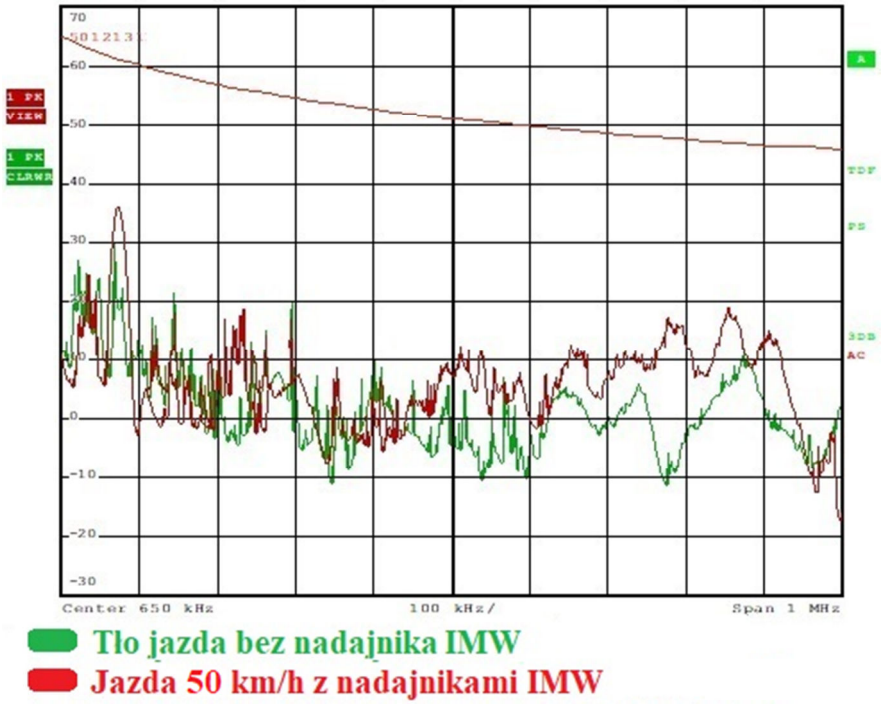
Measurements

Figures **6** - **9** show in three colors the spectral analysis of the emission of radiated disturbances in individual frequency sub-ranges for three operating modes:

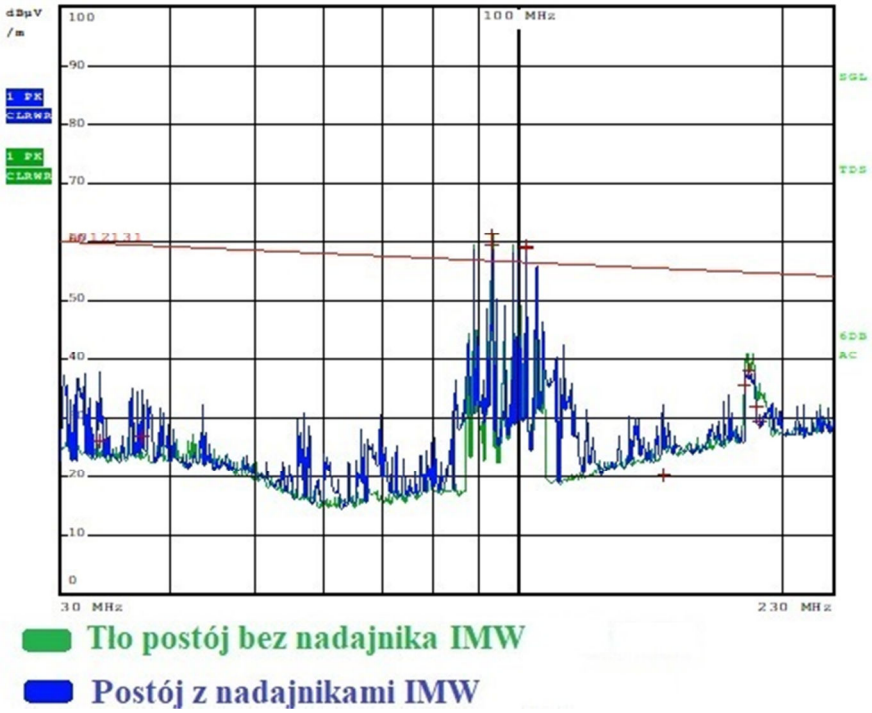
- Green color - DRIVING BACKGROUND and STOPPING BACKGROUND,
- Blue color - STOP with the transmitter installed,
- Red color - DRIVING 50 km/h with the transmitter installed.



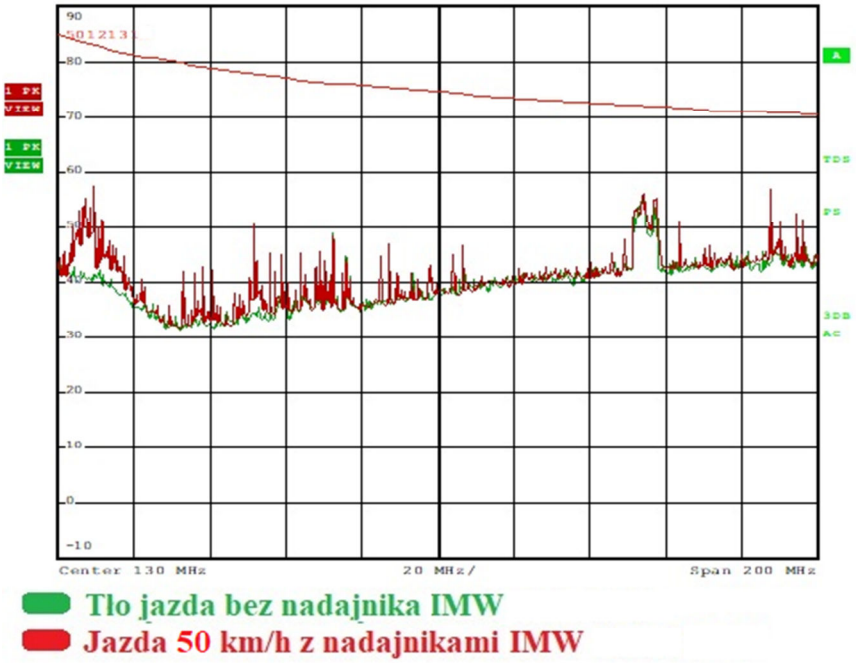
6. Emission level of radiated disturbances in the 150 kHz – 30 MHz frequency band



7. Emission level of radiated disturbances in the 150 kHz – 1.15 MHz frequency band



8. Emission level of radiated disturbances in the 30 MHz – 230 MHz frequency band



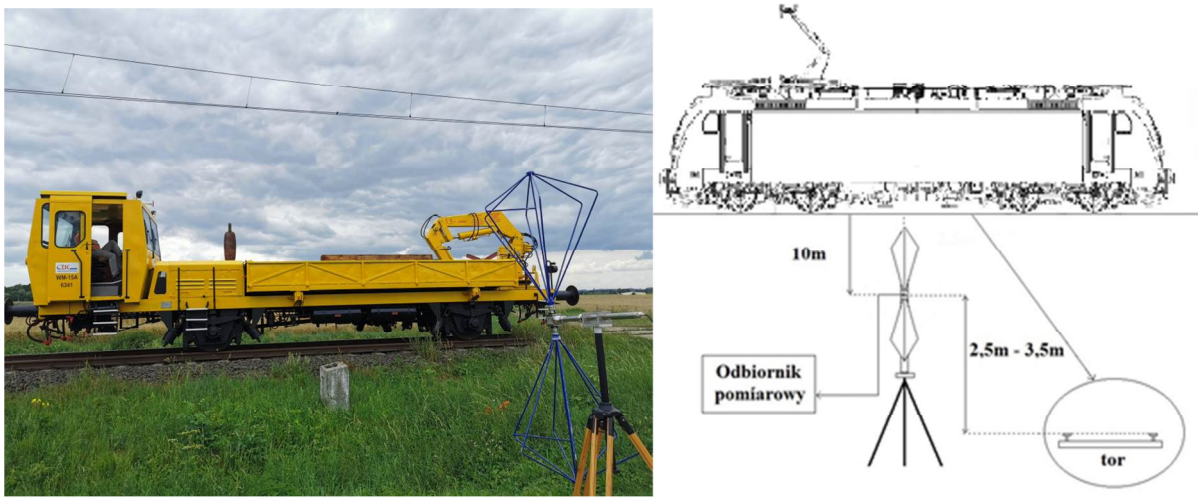
9. Emission level of radiated disturbances in the 30 MHz – 230 MHz frequency band

The measurements were carried out using calibrated measuring equipment, which confirms the reliability of the obtained results. The antennas were set according to Table **2**.

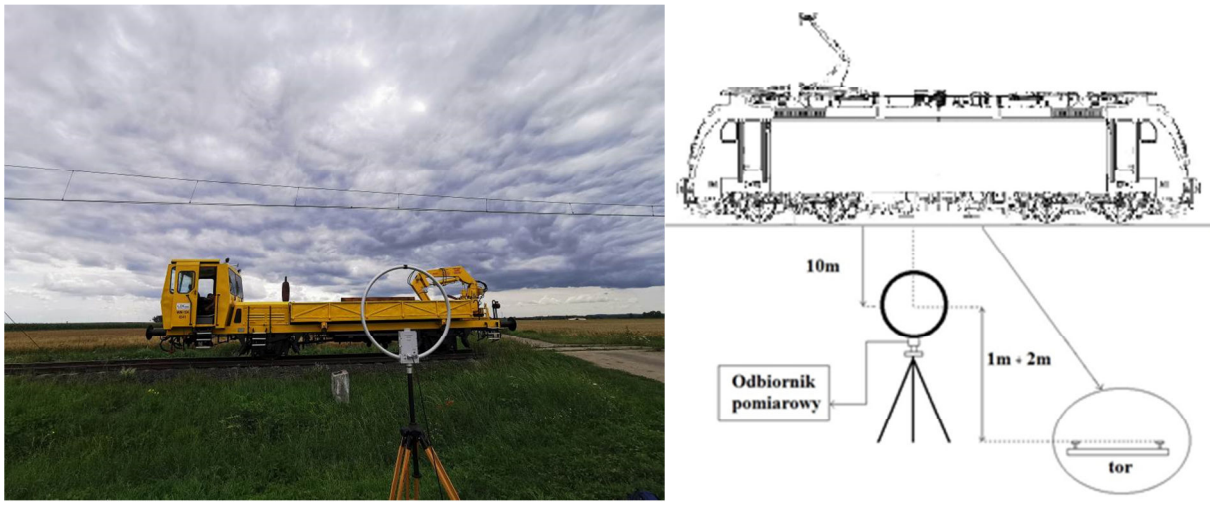
Tab. 2. Antenna setting parameters

Antenna type	Frequency band	Measuring distance	Antenna suspension height	Antenna alignment
FMZB 1513	150 kHz – 30 MHz	10 m	1,5 m	Parallel to the axis of the track
VBA 6106A	30 MHz – 230 MHz	10 m	2,5 m	Vertical (V) and horizontal (H) polarization
VUSLP 9111B	230 MHz – 1 GHz	10 m	2,5 m	

The actual position of the measuring antennas is shown in the pictures below and illustrative drawings showing the position relative to the vehicle.



10. Stand for measuring the emission of radiated disturbances in the 30 MHz - 230 MHz frequency band



11. Stand for measuring the emission of radiated disturbances in the frequency band 150 kHz - 11 MHz

Summary

The article presents the measurements of the emission of radiated disturbances generated by the IMW device for monitoring railway wagons mounted on a WM-15A motor trolley. Tests carried out in the frequency range from 150 kHz to 1 GHz have shown that the installed IMW device has no negative impact on the above measurements and can be used as intended. The permissible levels under the PN-EN 50121-3-1 standard [4] were not exceeded, the source of

which is the WM-15A motorized trolley with the IMW device. Due to the impact and propagation of the electromagnetic wave in the railway environment, individual frequency bands of interfering signals should be considered separately for the entire spectrum of interfering signals.

Source materials

[1] Fiedziuk M, Szulc M., *Możliwości badawcze i znaczenie toru doświadczalnego dla kolejnictwa*, PROBLEMY KOLEJNICTWA, zeszyt 185.
[2] PN-EN 50121-2:2017-06 Zastosowania kolejowe -- Kompatybilność elektromagnetyczna -- Część 2: Oddziaływanie systemu kolejowego na otoczenie,
[3] PN-EN 50121-3-1:2017-05 + A1:2019-07 Zastosowania kolejowe -- Kompatybilność elektromagnetyczna -- Część 3-1: Tabor -- Pociąg i kompletny pojazd,
[4] Stefański M., Prezentacja dotycząca projektu IMW, MobileMS,
[5] Toruń A., Białek K., Wetoszka P., *Field Tests of an Intelligent Video Monitoring System Installed on Freight Wagons*, Proceedings of 25th International Scientific Conference. Transport Means 2021,