

Original article

## Changes in maintenance of railway vehicles as the sources of threats in the railway system

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### INFORMATIONS

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### ABSTRACT

Proper operation of railway vehicles is the basis for the functioning of a safe railway system. At the same time, it is not possible to talk about the safe use of a vehicle without adequately carried out maintenance processes. Due to legislative changes in August 2017, the maintenance system of railway vehicles has changed significantly. In most cases, it is the entities responsible for maintenance that are fully liable for the shape of the maintenance documentation, not the national security authority (in Poland the President of the Rail Transport Office) as has been the case so far. That is a big challenge for everyone involved in maintaining railway vehicles.

The article presents the system of maintenance of railway vehicles as critical for the railway system safety, with the division into those registered in the National Railway Register and the unregistered ones. National and EU requirements for maintenance systems as well as the conditions for the implementation of “changes” in these systems have been presented, based, among others, on the results of the risk assessment of the threats they generate.

### KEYWORDS

railway vehicles, sources of threats, maintenance system, railway system

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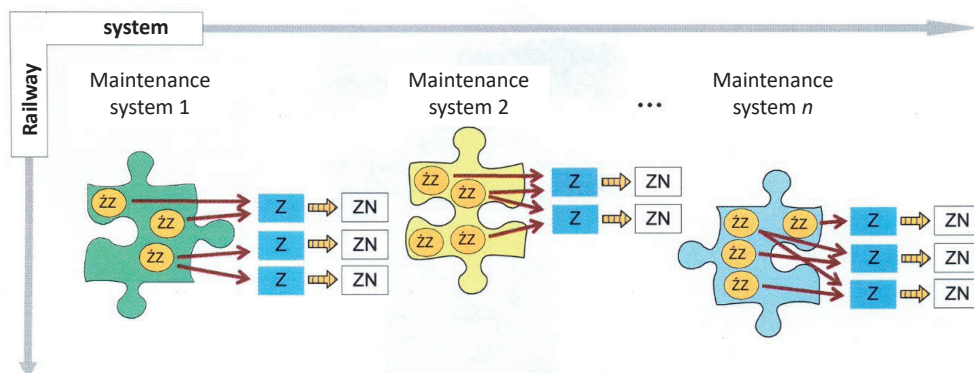


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## Introduction

The technical condition of railway vehicles depends on their correct exploitation – proper maintenance and use. Only a technically fit the vehicle, moving along the railway network, does not generate sources of threats in the railway system. Many undesirable events in the railway system still have their origins in the errors related to the maintenance of railway vehicles, including decisions on “changing” service activities (Fig. 1).

The creation of a uniform European railway system has obliged all European Union countries to harmonize legal provisions, including in the field of maintenance of railway vehicles. The main intention of this project was to place all responsibility for the upkeep of a railway



**Fig. 1.** Schematic diagram of occurrence of undesired events (ZN) in the railway system as a result of the activation of threats (Z), whose sources (ZZ) are “changes” in the systems of maintenance of railway vehicles

*Source: study based on [1, 2].*

vehicle on the entity responsible for maintenance, which was previously dispersed between a carrier, a dispatcher and a repair workshop.

The maintenance system of railway vehicles often requires “change”. In such cases, it is necessary to identify risks (e.g., according to the scheme presented in works [1-2]) and reliably carry out the remaining procedures of the risk assessment process (e.g., under the scheme presented in work [4]).

## 1. Systems of maintenance of railway vehicles used in Poland

### 1.1. Legal conditions

The railway vehicle maintenance systems in Poland are built based on detailed requirements contained in EU and Polish law. The fundamental Polish legal acts regulating the issues of railway vehicle maintenance include the Regulation of the Minister of Infrastructure of October 12, 2005, on general technical conditions for the operation of railway vehicles along with the Regulation of the Minister of Infrastructure and Construction of July 28, 2017, amending the Regulation on general technical conditions for the operation of railway vehicles [5, 6], which has been in effect in the modified form since August 25, 2017, and the Regulation of the Minister of Transport of March 19, 2007, on safety management systems in railway transport [3]. What is more, the following European Union legal acts are worth pointing out: the Directive on Railway Safety [7], the Regulation (EU) No 445/2011 [8], the Commission Regulation (EU) No 1158/2010 [9], the Commission Regulation (EU) No 1169/2010 [10].

The system of maintaining a specific railway vehicle depends on whether the vehicle travels on the railway network and is therefore subject to the obligation to register at the National Register of Railway Vehicles (KRPK) (a registered vehicle) or moves only within the closed infrastructure (an unregistered vehicle).

## 1.2. Registered Vehicles

The shape of the maintenance documentation regarding railway vehicles subject to registration at the KRPK is the competence of the entity responsible for maintenance, the so-called ECM (Entity in Charge of Maintenance). Before a railway vehicle is put into service, it must have a body responsible for its maintenance assigned in the KRPK. That means that every vehicle traveling along the railway network has its own ECM. Besides, ECM for freight wagons must go through the process of the Maintenance Management System (MMS) certification. In Poland, the only unit certifying entities responsible for maintenance is the President of the Rail Transport Office (UTK). However, ECM can pass the certification process in any EU country. A certificate issued for an ECM should be in accordance with the Regulation 445/2011 [8]. The ECM certificate is valid throughout the EU. It can be issued for a maximum of 5 years, however, in most cases it is the period of 3 years.

To receive an ECM certificate for freight wagons, the railway company must establish and implement its MMS and successfully undergo the certification audit. The characteristic feature of the MMS is that it performs the following four functions [11]:

- 1) management,
- 2) development of maintenance,
- 3) management of maintenance of the rolling stock,
- 4) carrying out maintenance.

The first function – management – must be performed by a certified ECM, while the other three ones may be outsourced to companies/external entities. Although some of the certified ECM may delegate a certified ECM bears part of tasks related to maintenance to other entities, the entire responsibility for the technical condition of railway vehicles (e.g., freight wagons). The list of procedures that make up individual functions can be found in the Regulation 445/2011 [8]. Any function can be certified, e.g., only the fourth one – maintenance. The so-called repair workshops use this possibility. Even though the President of the UTK for registered vehicles does not approve the maintenance system documentation (DSU), the requirements of the maintenance documentation still apply in Polish law. Documentation of the rail vehicle maintenance system should contain the following elements [5]:

- description of the maintenance organization,
- data identifying own organizational units and others performing maintenance work,
- a list of types of railway vehicles for which qualified employees are maintained and the necessary technical facilities,
- specification of the levels of maintenance for which qualified employees and the necessary technical facilities are required,
- a description of the technical facilities for maintaining railway vehicles,
- a description of performed technical acceptance.

Additionally, the maintenance documentation should include [5]: a maintenance plan, technical documentation, documentation of maintenance activities, and a description of document management.

### 1.3. Unregistered vehicles

For vehicles not subject to registration in the KRPK, the maintenance system has been defined in the requirements [5] for the Maintenance System Documentation (DSU), which is submitted to approval by the President of the UTK. This prerequisite applies to [12]:

- metro vehicles,
- vehicles moving only on railway sidings,
- vehicles moving on a track less than 1435 mm wide,
- antique vehicles used as stationary exhibits,
- historical vehicles not moving along the railway network,
- special vehicles moving only within a closed track or transported on other vehicles,
- vehicles moving only on railway networks that are functionally separated from the railway system and intended only for the needs of local passenger transport (e.g., Warsaw Commuter Rail), both urban or suburban ones,
- vehicles moving only on the infrastructure belonging to the managers of private railway infrastructure,
- vehicles moving on railway infrastructure intended exclusively for local, tourist or historical use.

The DSU is a set of rules according to which the maintenance of a railway vehicle should be carried out. The application for the DSU approval to the President of UTK may include ECM, railway vehicle manufacturers, railway carriers, infrastructure managers, disposers, entrepreneurs managing infrastructure and performing transport in the subway, users of railway sidings and entrepreneurs performing transport within the railway siding. One DSU can cover several types of railway vehicles of similar construction and purpose. A vehicle without a DSU approved by the President of UTK cannot be used. The DSU must be consistent with the technical documentation of the vehicle, national technical specifications and standardization documents, as well as provisions regarding the transport of dangerous goods. The DSU must contain the following components from [5]:

- functional description of the vehicle with a breakdown into its components relevant to the maintenance process,
- documentation containing: descriptions of review and repair activities; disassembly and assembly instructions; the structure of the review and repair cycle; the set-up of parameters measured during the review or repair process and descriptions of measurement methods; the specimen of measurement cards with a list of design values, as well as post-repair and boundary parameters for vehicle components; lists of specialist equipment and tools; lists of tests carried out during maintenance; requirements for the qualification of employees and special requirements for welding and non-destructive testing,
- constraints essential for safety and interoperability of vehicle components, setting limits that cannot be exceeded during exploitation, including operation in emergency mode,
- list of vehicle components under technical supervision.

## **2. Threats and changes in the system of maintaining railway vehicles**

### **2.1. Events generated by errors in the maintenance of railway vehicles**

The maintenance of railway vehicles causes a lot of problems for railway carriers, and the incorrect performance of inspection and repair works constitutes a source of threats to ensuring safety of the railway system. The Chairman of the National Railway Accident Investigation Commission pointed out in the 2015 Report that the technical condition of railway vehicles without a drive is insufficient [13]. However, in the Report for 2016, it was emphasized, among other things, that actions should be taken to reduce the number of events caused by train uncoupling, which is related to a large number of such events without runaway wagons (C68 category) on the railway network and low involvement of entities operating railway vehicles in analysis and elimination of causes of events [14]. The most frequent errors in the processes of maintenance of railway vehicles in 2015, which were one of the reasons for the events, include approvals for the use of railway vehicles with, among others [15] damage to bearings (including: cracking, contamination, caking, wearing, excessive looseness), damage to brake systems (including: leaks, wearing/heating-up/cracking of pads), damage to valve camshafts, and sudden unseaworthiness), damage to the suspension systems (including breaks, fractures of the leaf springs, wear, contamination of the bogie steering bearings, sudden defects).

### **2.2. The concept of “change” in the maintenance of railway vehicles**

In the subject literature, the following strategies for exploiting technical facilities are indicated according to:

- reliability,
- economic efficiency,
- the amount of work performed,
- technical condition.

It often takes place that for various reasons the previously adopted vehicle maintenance system should be changed. The shift of vehicle repairs, which every day transports hundreds of passengers, can be a source of threats and ought to be supported by detailed and reliable assessment of the risk of incurring losses resulting from such proceedings – “changes”. The process of introducing “change” under the safety management system and maintenance management system must be in line with the requirements of the Regulation 402/2013 [16]. This document refers to a common method for assessing safety in the field of risk analysis and valuation. This Regulation treats risk analysis as a systematic use of all available information to identify dangers and assess the probability of their occurrence. The risk valuation is understood as a check (by quantification, comparison, evaluation) to which risk category (class) the risk level of the assessed threat belongs to. Risk analysis and risk assessment procedures make up the risk assessment process. The Regulation 402/2013 applies when a change in a technical, organizational or operational nature is being introduced into the railway system.

If an entity wants to introduce a “change” in the maintenance of registered vehicles, the first step is to assess the impact of the proposed “change” on the safety status of the railway system. Unless there is such effect, no need to apply the provisions of the Regulation 402/2013

exists. However, full documentation must be kept, based on which it was found that “change” does not affect the railway system’s safety.

In the case when the entity decides that the “change” of the maintenance system has an impact on the railway system’s safety status, the next step is to specify whether the “change” is significant or insignificant. The Regulation 402/2013 [16] indicates the following criteria to be considered in such proceedings:

- consequences of a failure: a credible worst-case scenario in the event of failure of the assessed system, with due account taken of the existence of safety barriers outside the assessed system,
- innovation used when introducing “change”: this criterion includes innovations concerning both the entire railway sector and the organization introducing the “change”,
- monitoring: inability to monitor the proposed “change” during the entire life cycle of the system and to perform appropriate interventions,
- reversibility of “change”: inability to return to the system before “change”,
- additionality: assessment of the meaning of “change”, taking into account all the recent “changes” in the system under evaluation, which were related to safety and were not assessed as important.

In the case when “change” is assessed as insignificant, it can be implemented in the railway vehicle maintenance system. The situation is more complicated when the “change” is considered meaningful. Then it is necessary to consult the external evaluation unit, whose task is to test the correctness of risk assessment resulting from the proposal to implement the “change”. It is worth adding that the evaluation unit does not assess the recognition of “changes” as substantial or not.

In the case of unregistered vehicles, the process is different. An entity that wants to make a “change” in the DSU must submit such an intention to the President of the UTK. If the President of the UTK believes that the proposed “change” has an impact on security, within 30 days he/she may request submission of the “change” for approval. “Change” will then be introduced in the form of the so-called amending decision.

## Conclusions

- 1) Maintenance of railway vehicles is a critical process from the point of view of the safety of the entire railway system. The maintenance process causes various problems for railway companies. There is a shortage of qualified employees, especially for performing tasks in the field of welding and non-destructive testing.
- 2) Many railway incidents have their sources in improper maintenance of rail vehicles, including making wrong decisions about “changing” the way in which maintenance is carried out, for example the use of prohibited technology for regeneration of railway couplings by welding.
- 3) Maintenance documents often contain errors and are not adapted to the specifics of enterprises and operated railway vehicles.
- 4) It seems that for many users of railway vehicles the economic effects of their operations, not ensuring the safety of the railway system, are the most crucial.

5) The facts cited in this paper indicate the importance of the need to apply detailed regulations concerning the maintenance systems of railway vehicles and the possibility of introducing “changes” to them.

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### Conflict of interests

All authors declared no conflict of interests.

### Author contributions

All authors contributed to the interpretation of results and writing of the paper. All authors read and approved the final manuscript.

### Ethical statement

The research complies with all national and international ethical requirements.

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### Biographical note

**Magdalena Helak** – MA, PhD student at the Faculty of Transport Engineering at the Poznan University of Technology. A graduate of security studies at the National Defense University, as well as management of security systems in rail transport. In the 2015-2018, she was the Head of the Vehicle Maintenance Department at the Railway Safety Depot at the Railway Transport Office, where she dealt with issues related to the safe operation of railway vehicles. Currently, technical security specialist and RAMS in the Technical Security Department of Thales Polska Sp. z o.o. Experienced auditor of Maintenance Management Systems, trainer at the UTK Academy, lecturer at the conference devoted to the railway system safety issues.

**Adam Kadziński** – Dr. hab. inż., academic teacher at the Faculty of Transport Engineering at the Poznan University of Technology. He deals with research and reliability assessments of basic types of diesel locomotives, assessment of the operational condition of railway vehicles, assessment of the safety status in land transport areas, models of reliability and safety in land transport; analytical and computer models as well as simulation tests of land vehicle operation systems, models and optimization studies of systems for the use and maintenance of land vehicles, advanced reliability models of land transport vehicles, integration of risk management methods in transport, risk management at work-places in transport, industry and services, as well as design and deployment of computer program packages.

### Zmiany w utrzymaniu pojazdów kolejowych źródłami zagrożeń w systemie kolejowym

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#### STRESZCZENIE

Prawidłowa eksploatacja pojazdów kolejowych jest podstawą funkcjonowania bezpiecznego systemu kolejowego. Jednocześnie nie można mówić o bezpiecznym użytkowaniu pojazdu bez prawidłowego przeprowadzenia procesów utrzymaniowych. W związku ze zmianami legislacyjnymi w sierpniu 2017 r. system utrzymania pojazdów.



kolejowych uległ istotnym zmianom. W większości przypadków to na podmiotach odpowiedzialnych za utrzymanie spoczęła pełna odpowiedzialność za kształt dokumentacji utrzymaniowej, nie zaś na krajowej władzy bezpieczeństwa (w przypadku Polski na Prezisie Urzędu Transportu Kolejowego), jak było do tej pory. To duże wyzwanie dla wszystkich zajmujących się utrzymywaniem pojazdów kolejowych.

Artykuł przedstawia krytyczny dla bezpieczeństwa systemu kolejowego system utrzymania pojazdów kolejowych, z podziałem na pojazdy zarejestrowane w Krajowym Rejestrze Pojazdów Kolejowych i niezarejestrowane. Zaprezentowano wymagania krajowe i unijne dla systemów utrzymania, jak również warunki wdrażania „zmian” w tych systemach, oparte m.in. na wynikach oceny ryzyka generowanych przez nie zagrożenia.

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**SŁOWA KLUCZOWE** pojazdy kolejowe, źródła zagrożeń, system utrzymania, system kolejowy

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