TECHNICAL RISK ANALYSIS OF RAILWAY VEHICLE

ANALIZA RYZYKA TECHNICZNEGO POJAZDÓW KOLEJOWYCH

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Abstract. *The first official document concerning technical risk assessment in railway transport was “Safety Directive” #49 released in 2004 by European Commission. It was particularized in commission regulation number 352 from 2009 on the adoption of a common safety method on risk evaluation and assessment. The actual requirement of technical risk assessment results from building and implementing IRIS, and from 2012 it will result from certification of maintenance facilities (Directive 110/2008/EC). In this article legal basics concerning technical risk assessment, and analysis of railway accidents were discussed.*

Keywords: *safety, technical risk assessment, railway vehicle*

Streszczenie: *Pierwszym oficjalnym dokumentem odnoszącym się do oceny ryzyka technicznego w transporcie kolejowym była wydana w 2004 roku Dyrektywa 49 WE. Znalazła ona swoje uszczegółowienie w Rozporządzeniu Komisji Europejskiej w sprawie wspólnych metod oceny ryzyka (352/2009). Faktyczny wymóg oceny ryzyka środków technicznych transportu kolejowego wynika na dzień dzisiejszy z budowy i wdrożenia standardu IRIS, a od 2012 roku będzie wynikał z certyfikacji zakładów naprawczych taboru kolejowego (Dyrektywa 110/2008/WE). W artykule omówiono podstawy prawne, oraz analizę zdarzeń, dotyczące oceny ryzyka technicznego w transporcie kolejowym*

Słowa kluczowe: *bezpieczeństwo, ocena ryzyka technicznego, pojazd kolejowy*

1. Introduction

At the beginning of the 90's first efforts were taken to unify European railway market. In 1991 The Council of the European Communities issued "COUNCIL DIRECTIVE of 29 July 1991 on the development of the Community's railways (91/440/EEC)", which main objective was liberalization of European rail carriage market. Following decisions were taken upon two paths, running close to each other and including:

- interoperability
- safety

The significance of interoperability of railway vehicles comes from variety of technological solutions around community. Interoperability of technical means of transport allows elimination of technological barriers between member countries. Regarding interoperability actions, at the begging, were divided between high speed railway and conventional railway. Eventually "DIRECTIVE 2008/57/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 17 June 2008 on the interoperability of the rail system within the Community" covered both theses aspects and updated them accordingly with the evolution of European since development in XXI century. Safety requirements for railway were written down in DIRECTIVE 2004/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 29 April 2004 on safety on the Community's railways. On the basis of this document all railway undertaking and infrastructure managers had to build their Safety Management Systems (SMS). The most important part of this system is risk assessment. SMS was to be approved by NSA (National Safety Authority – Urząd Transportu Kolejowego – in Poland), in case of railway undertaking (RU) by a safety certificate, and in case of infrastructure manager (IM) safety authorization. Member countries were also obliged to establish independent investigation bodies – NIB (National Investigation Bodies – Państwowa Komisja Badania Wypadków Kolejowych – in Poland). Safety Directive also points out the way to achieve CST (common safety targets) minimum safety levels for each countries, and market operators. All these actions are supposed to outline safety requirements, which all operators on liberalized market should comply with. It will limit the number of railway subjects functioning on the market, but will force them to be prepared for work. Railway operators will fulfill certain amount of requirements concluding under conceptions of interoperability and safety. Figure 1 shows predictions about the number of railway operators (not only RU and IM) throughout implementation of European directives.

Fig. 1 Evolution of EU railway market in context of EU legislation

In the context of technical risk currently most important documents are:

- DIRECTIVE 2008/110/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2008 amending Directive 2004/49/EC
- COMMISSION REGULATION (EC) No 352/2009 of 24 April 2009 on the adoption of a common safety method on risk evaluation and assessment

Commission regulation 352/2009/EC defines first CSM (common safety methods) on risk evaluation and assessment methods, and Directive 2008/110/EC expands the scope of subjects whom safety management systems concern – these are “entities in charge of maintenance”. Concurrently increases requirements for safety managements in their railway vehicle maintenance procedures. Accordingly its necessary to focus on technical risk assessment in current risk assessment modules.

2. Technical risk assessment system – requirements

2.1 European requirements

Directive 2008/110/EC speaks about the need to build safety management systems for entities who are responsible for maintenance. There is a wide scope of railway operators who can be responsible for maintenance , from owners of railway vehicles, users to specialized maintenance workshops (in polish realms they are called ZNTK – Zakłady Naprawcze Taboru

Kolejowego). Some of these entities, RU's and IM's are already obliged to build Safety Management Systems. [4] These subjects will have to improve their maintenance procedures, and risk assessment modules. Other entities, not specified in "Safety Directive 2004/49/EC" will have to build their systems and risk assessment modules from scratch. The methodology of risk assessment in railway context was build mainly in accordance with IRIS (International Railway Industry Standard), it is built on the requirements from PN-EN 50126 standard. Requirements which stem from European directives are in annex #1 to Commission Regulation 352/2009/EC at point 2.5.4. For technical systems where a functional failure has credible direct potential for a catastrophic consequence, the associated risk does not have to be reduced further if the rate of that failure is less than or equal to 10^{-9} per operating hour. [2]

This criterion was taken as a milestone in further considerations.

Quoted regulation also describes three methods of risk assessment for identified hazards:

- a) the application of codes of practice,
- b) a comparison with similar systems,
- c) an explicit risk estimation.

Procedures for risk evaluation and risk assessment where described in annex II to this Regulation.

2.2 Polish requirements

Poland, as a member country, has to implement statements of Directive 2008/110/EC to its law till 24 of December 2010. Currently there are no additive regulations in that matter, only requirements concerning risk assessment are in the "Bill on railway transport", but this document implemented "Safety Directive 2004/49/EC". Regulation 352/2009/EC is an act of direct appliance, and is valid from 1 of July 2012.

Currently only risk assessment modules which are used in the railway, descend from IRIS – voluntary standard for railways. It is true to say that nowadays there are no additive polish requirements.

2.3 Craft requirements

As it was mentioned before main requirements for railway conduct from IRIS. After many years railway industry worked out a standard of production and evaluation which is specific for this craft. It manages whole process of planning and production of railway vehicles and consisting

elements. This standard is an improved quality management system based on ISO 9001:2008, but this improvement in requirements is up to 70% of ISO QMS. [1]

IRIS sets the requirements for risk assessment from the concept level throughout the whole production, and comply with EN 50126, EN50128, EN 50129 standards. (fig. 3)

These requirements descend mainly from IRIS – approved PN-EN 50126 standard – Railway applications - The specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS).

The main goal of RAMS is to have a documented Procedure in place to cover all the aspects of RAMS activities, including:

- calculation and documentation,
- data collection, analysis and improvement action plan
- set up,
- implementation of defined tasks of the action plan.

Also it is crucial to manage the life cycle cost (LCC) regarding the reliability of the product (**R**), accessibility (**A**), maintainability (**M**), and safety (**S**).

Accordingly to the PN-EN 50126 standard during RAMS analysis you need to cover all the aspects and phases of life cycle enlisted below (fig. 3 i 4):

- A. concept
- B. definition of product
- C. risk analysis
- D. product requirements
- E. division of requirements concerning the product
- F. project and implementation (including staff training)
- G. production
- H. installation (assembly)
- I. validation
- J. acceptance of product
- K. operation of product (incl. service and supplies)
- L. disposal.

Main factors that influence RAMS concerning railway are:

- **system condition** – source of failure (breakdowns) coming from the interior of the system throughout whole lifecycle,
- **operation condition** – source of failure (breakdowns) coming from the operation of the system throughout whole lifecycle,
- **maintenance condition** (service) – source of failure (breakdowns) coming from the maintenance of the system throughout whole lifecycle.

These factors interact with each other, for example: reliability of product is linked with the interior sources of failures, which influences maintenance actions. So if you want to obtain a reliable system you need to identify all aspects concerning RAMS, a diagram shown on figure 4 represents division of factors influencing RAMS.

Reliability

Goals for reliability are defined throughout failure categories, and are shown in table 1

Fig. 3 Scheme of conducting a RAMS program

Fig. 4 Factors influencing RAMS [3]

Table 1 RAM Failure Categories [3]

Failure Category	Definition
Significant (Immobilizing failure)	A failure that prevents train movement or causes a delay to service greater than a specified time and/or generates a cost greater than a specified level.
Major (Service Failure)	A failure that must be rectified for the system to achieve its specified performance and does not cause a delay or cost greater than the minimum threshold specified for a significant failure.
Minor	A failure that does not prevent a system achieving its specified performance and does not meet criteria for Significant or Major failures.

Reliability parameters:

MTTF - mean time to failure;

MDTFP - mean distance to failure;

MTBF - mean time between failure;

MDBF - mean distance between failure.

Table 2 Failure assessment MTBF – reliability [3]

Failure Category	System Failure Mode	Effect on Operation	MTBF
Significant	Total failure	operation not possible	
Major	Critical functional failure	emergency operation 1	
Minor	non - critical functional failure	emergency operation 2	
Negligible	negligible functional failure	normal operation	

Table 3 Failure effect assessment – reliability [3]

Failure category	Effect on Operation	Performance %			Remarks
		Power %	Speed %	(*)	
Significant	operation not possible	0	0		
major	emergency operation 1				
Minor	emergency operation 2				
Negligible	normal operation	100	100		

(*) Define the technical and operational conditions in the application with respect to total failure, emergency operation 1, emergency operation 2, failures with no effect on operation.

3. Summary and conclusion

Literature analysis of guidelines from Regulation 352/2009/EC, in technical risk analysis context, didn't show up any practical solutions in that matter. There is no decomposition model of railway vehicle, which would be used on railway market, nor the identification of the element of vehicle which cause catastrophic consequence.

In further development of the technical risk analysis model for railway vehicles authors propose to use legal and technical requirements mentioned in point 2 and:

1. Modified IRIS certification criteria – for defining a decomposition model, which could be used in railway specification.
2. Analysis of data base from NSA – to exclude technical systems technical systems where a functional failure has credible direct potential for a catastrophic consequence
3. PN-EN 50126 standard – to conduct technical risk analysis of specified elements of railway vehicles.

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