

Security Risk Assessment at Transport Infrastructure Facilities

O. Yanhulova¹, R. Keršys², L. Neduzha³

¹Ukrainian State University of Science and Technologies, Lazaryan 2, 49010, Dnipro, Ukraine, E-mail: yanhulova.olga@gmail.com

²Kaunas University of Technology, Studentu 56, 51424, Kaunas, Lithuania, E-mail: robertas.kersys@ktu.lt

³Ukrainian State University of Science and Technologies, Lazaryan 2, 49010, Dnipro, Ukraine, E-mail: nlorhen@i.ua

Abstract

To effectively analyze the variety of risks in transport, it is necessary to apply a set of methods. Which, in turn, confirms the relevance of a comprehensive risk management mechanism. The use of the considered methodology will increase the objectivity of the assessment of both the expenses associated with ensuring security and the effects of its increase. Thus, the proposed approach can be adapted to optimize transport facilities by assessing functional safety at the stage of their modeling/operation.

KEY WORDS: *risks, transport infrastructure, functional safety*

1. Introduction

For all modes of transport, "safety" implies the absence of unacceptable risk, which is associated (unfortunately) with personal injury, property damage, environmental damage, etc [1-3]. "Traffic safety" is a set of organizational and technical measures aimed at ensuring:

- a professional approach to the management of transport processes, increasing the availability and quality of services [4-6];
- high-quality, timely, mobile movement of goods flows/population [7-9];
- a high level of reliability of the vehicle, its trouble-free operation (maintenance of equipment, mechanisms, and devices in a constant working condition) [10-12] when applying modern technologies [13-17] for the renewal/modernization of rolling stock and its elements [18, 19], re-equipment of infrastructure facilities [20-22], compliance with environmental [23, 24] and energy efficiency standards of transport processes [25-27].

2. Basic Material

To increase the reliability of a safe, material-saving, environmentally friendly, energy-efficient rolling stock, it is necessary to "go through" three stages: structural, technological and operational, during which the tasks of design, manufacture, and operation are solved. The development of the reliability theory led to the setting of tasks that require taking into account the efficiency and functional safety of technical transport facilities throughout the life cycle [3, 12].

The experience of transport companies shows that it is necessary to constantly maintain a sufficient level of reliability of structures and their elements for safe operation. A minimal increase in reliability (even the smallest detail) requires significant scientific research, new technological developments, and financial investments. In modern conditions, most companies strive to reduce non-production losses by implementing effective management systems. They are aimed at reducing the risks of product shortages, incidents, emergency situations, etc.

Transport events that lead to cases of traffic safety violations require priority attention and research. Among many factors, the ability to assess risks is important for improving transport safety. At the same time, the study of factors affecting traffic safety provides additional tools for managing transport processes. One such tool is risk understanding and management. The main task of which is to achieve and support the management/operation of railway transport. Risk is a combination of the probability of an event and its consequences; it is a quantitative characteristic of the action of hazards formed by natural factors and specific human activities. That is, the ratio of the number of adverse manifestations of the danger to their possible number for a certain period of time (the frequency in the awareness of danger) [28]. For example, the ability to assess the functional safety risks of railway tracks makes it possible to harmonize characteristics of track elements under certain conditions of operation and certain maintenance for the effective use of the track structure throughout its life cycle [3, 12].

To assess risks, the following activities are carried out: qualitative and quantitative analysis of the level of probability and frequency of its occurrence; assessment of all consequences of the event; risk identification procedure (Fig. 1). After the risk analysis, the obtained results should be compared with the acceptable criteria (with acceptable norms). At the stage of risk identification, a list of adverse events is revealed, which can, in particular: deteriorate the quality of rolling stock, track superstructure; harm a person; cause irreparable damage to the environment. In such complex systems as railway transport, the manifestations of most undesirable events are not limited to any one type of risk. For example, the following factors can affect the bogie derailment:

- violation/non-compliance with operational standards for the maintenance of rolling stock and its structural elements, operating standards for the content of the track superstructure;
- exceeding the permissible speeds on different sections of the track;
- errors in regulatory documents.

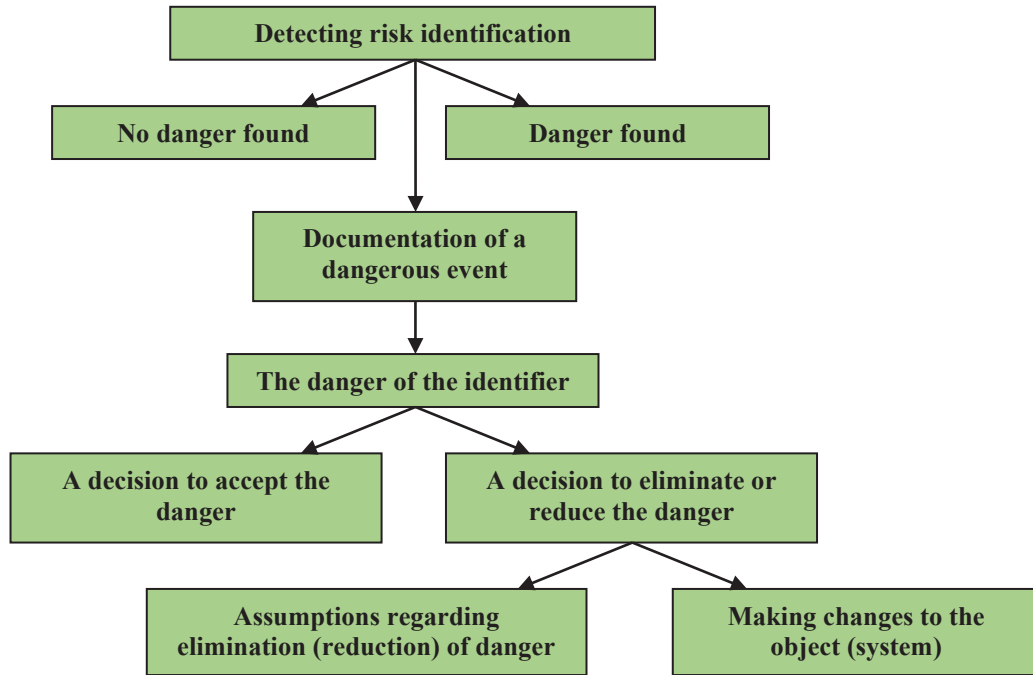


Fig. 1 Risk identification procedure

To manage risks in railway transport, a methodology should be used aimed at: risk identification and estimative probability of its realization; determining the maximum loss; selection of methods and tools for managing the identified risks; development of risk management strategies in order to reduce the probability of risk realization and minimize the possibility of negative consequences. Risks affecting traffic safety have been identified in railway transport (Fig. 2). Non-compliance with their norms can cause significant damage to the economy of the country.

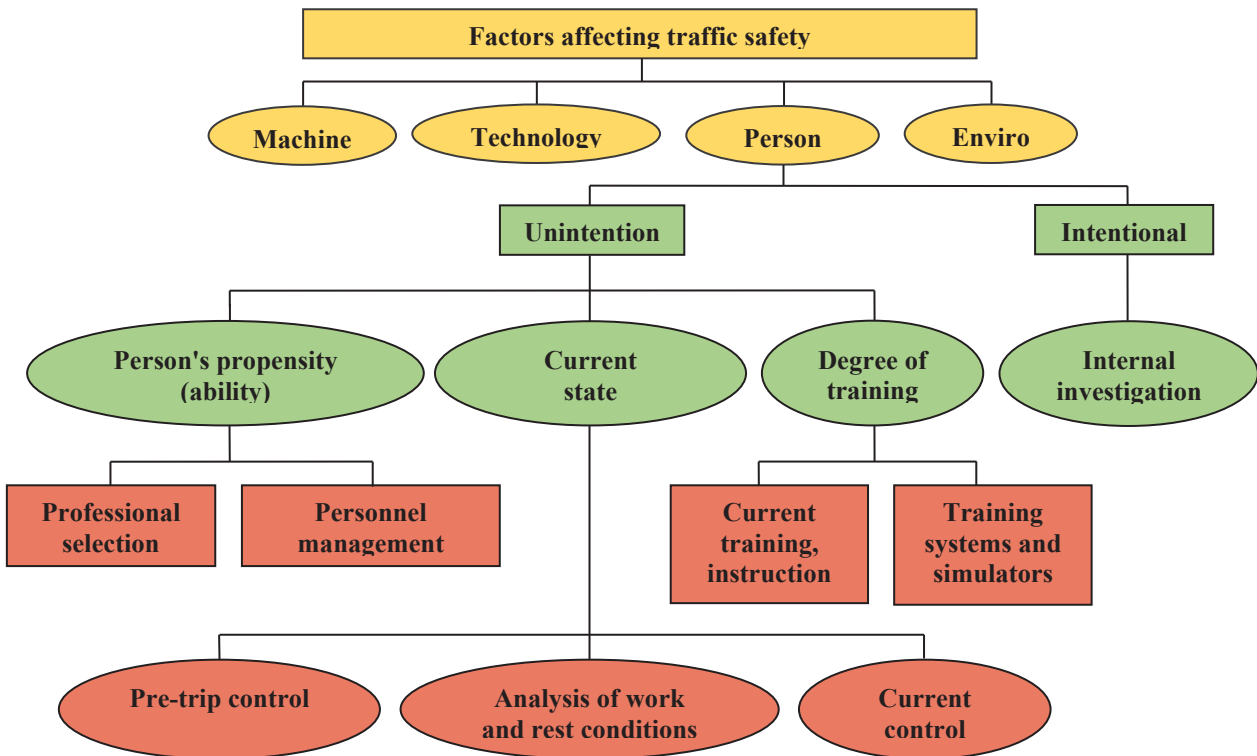


Fig. 2 Risks affecting traffic safety

All factors are interconnected and the level of traffic safety is affected by the actions of each in the group of factors. Thus, railway transport must be considered as the interaction of a large number of people – machine systems.

There are many methods for determining risk. Recommendations for the application of some methods of risk analysis for various activities of the life cycle for infrastructure objects and rolling stock are presented in Table, where:

"LA" – the method is not applied (the least appropriate method of analysis);

"A" – method is used (recommended method);

"WA" – the method is widely used (the most suitable method).

Table
Various activities of the life cycle for infrastructure objects and rolling stock

Method	Type of activity				
	Project works	Designing	Input/output from the operation	Operation	Reconstruction
"What happens if...?"	LA	A	WA	WA	A
"Check sheet"	LA	A	A	WA	A
Danger and operability analysis	LA	WA	A	A	WA
Failure modes and consequences analysis	LA	WA	A	A	WA
"Fault tree"/"event tree" analysis	LA	WA	A	A	WA
Quantitative risk analysis	WA	WA	LA	A	WA

Methods can be applied stand-alone or as a supplement to each other. At the same time, qualitative analysis methods may contain quantitative risk criteria. If possible, a full quantitative risk analysis should use the results of the qualitative analysis. In particular, to determine the frequency of occurrence of risks, one can use statistical methods. Data for the analysis of which can be taken from the statistical data of dangerous incidents on the roads. A deterministic method based on the development of the "vehicle-track" mathematical model can be used to assess the derailment of the wheelset; to assess the magnitude of horizontal transverse and vertical forces.

One of the most common methods is the PAD (Prevention, Assessment, Defects) model, which can also be used to account for security costs. The safety of any product (including transport) can be considered as a private indicator of its quality (Fig. 3).

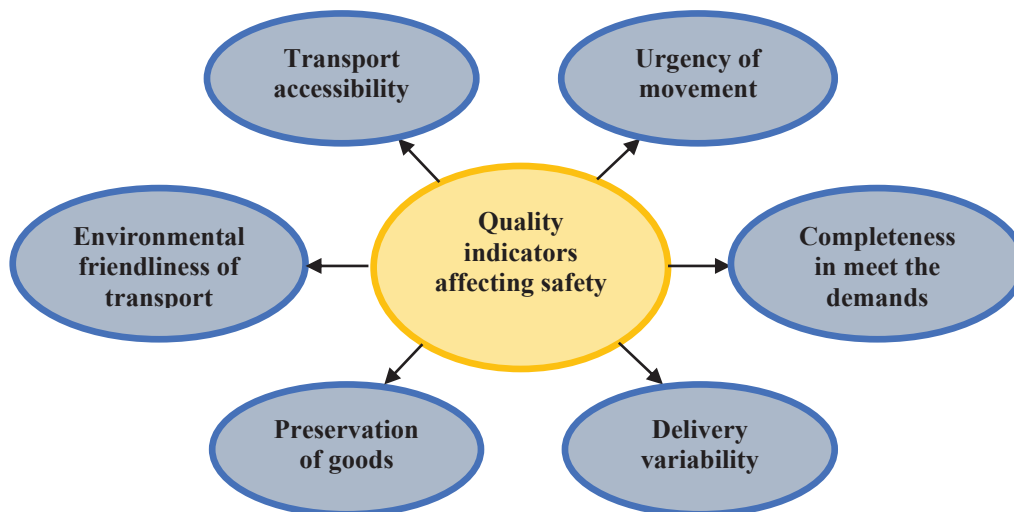


Fig. 3 Quality indicators affecting safety

Let us characterize the elements for the total cost of product quality (expenses on quality):

1. Expenses on prevention (for preventive actions, *P*) are the manufacturer's expenses on all actions to prevent the emergence of non-conformities and defects. They include expenses on the development, creation and maintenance of the security system, for research and preventive measures that ensure the reduction of risks and the occurrence of emergency situations.

2. Expenses on assessment or control (audit, inspection) of safety (*A*) are the manufacturer's expenses on detecting defects and non-conformities that arise in the process of design and production or service provision. They take

into account the expenses on purchasing and maintaining the necessary control, measuring and testing equipment, devices, tools, as well as the expenses on input, current and output quality control of products, etc.

3. Expenses on eliminating product defects (D) are divided into two parts: internal and external expenses. Internal ones go to the elimination of those defects that do not involve causing damage to consumers of transport services or third-party organizations. External expenses are those for eliminating the consequences of emergency situations in railway transport and compensation for damage to other organizations.

Thus, the total expenses on ensuring security, estimated by the PAD method, are determined as:

$$E = P + A + D.$$

Practice shows that defects account for up to 80% of all expenses. Having the opportunity to calculate the annual value of safety expenses using the PAD method, it is possible to assess the effect and effectiveness of measures to maintain and improve traffic safety. It should be borne in mind that in the field of ensuring traffic safety, increased payback periods should often not be the basis for rejecting these measures. In the case of negative events, there is a risk of causing damage to the lives and health of people (both passengers and railway transport workers), which is incomparable to the expenditure of financial resources.

3. Conclusions

To effectively analyze the variety of risks in transport, it is necessary to apply a set of methods. Which, in turn, confirms the relevance of a comprehensive risk management mechanism. The use of the considered methodology will increase the objectivity of the assessment of both the expenses associated with ensuring security and the effects of its increase. Thus, the proposed approach can be adapted to optimize transport facilities by assessing functional safety at the stage of their modeling/operation.

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