INTEGRATED RISK MANAGEMENT SYSTEM

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ABSTRACT

In the context of the proposed topic the author confirms the relevance of creation of the risk management systems on rail transport. The article is focused on modeling processes using proven management techniques. The priority is given to the risk management system based on the integration of international standards ISO 31000: 2009 and IEC 622 + 8: 2002 (RAMS). Its presentation is accompanied by a description of risk assessment techniques and their correspondence to appropriate stages of the life cycle of railway rolling stock.

ENGLISH SUMMARY

Background. *The development of international standardization in the field of risk management demonstrates serious attention of leading world powers to assessing the level of risk and its prediction. Standards such as ISO 31000 «Risk management. Principles and guidelines» and ISO 31010 «Risk management. Risk assessment techniques» offer universal approaches for different areas. ISO 31010: 2009 provides a risk management system using a variety of methods for their assessment and gives a clear classification of risks. The presence of international standards and practices create a necessary legal framework for selecting means that support high-quality, reliable operation of transport equipment.*

Federal Law «On Technical Regulation» [1] requires to assess risks with account for severity of the impact in relation to activities associated with safety. These requirements are expressed more specifically in the documents of some industrial sectors, e.g. technical regulation of the Customs Union TR CU 001/2011 «On the safety of railway rolling stock» [2]. However, this regulation deals with elements of the rolling stock only at design and production stages, while international standards assess risks at all stages of the life cycle of technical systems.

The life cycle of railway facilities is described in the international standard IEC 62278:2002. «Railway applications. Specification and demonstration of Reliability, Availability, Maintainability and Safety (RAMS)». From this it follows that safety principles should be based on the knowledge of all possible hazardous conditions in the system, under all modes of operation, maintenance, and they also should be based on performance indicators of each dangerous condition, of severity of its consequences [3].

RAMS requirements for the life cycle of railway facilities in Russia began to be applied only from 2012, in the form of a set of standards «Management of resources at the stages of the life cycle, risks and reliability analysis (MRRAR or URRAN if based on Russian term)» [4]. If RAMS presupposes that railway transport enterprises apply already implemented and well-established processes of quality control and risk management in accordance with international standards, MRRAR focuses on building management system.

MRRAR gives description of the life cycle of railway facilities, similarly to RAMS, and referring primarily to an opportunity to assess risks repeatedly at several stages and upon completion of each of them to formulate verification requirements necessary to match goals and results. In this case any discrepancy does not preclude repeated operations at previous stages, and if it is impossible to go back to a previous stage due to the in-use facility, risks increase and a method of their assessment is required that provides a low degree of uncertainty.

As the requirements of RAMS have been used recently in Russia, most of the rolling stock underwent the process of risk assessment not at all stages of the life cycle. Therefore a task of an integrated approach to risk management has become acute for the railway transport, including the combined use of international standards such as ISO 9001: 2008; ISO 31000: 2009; RAMS and IRIS.

Objective. *The objective of the author is to show advantages of creation of an integrated risk management system, which can be implemented at rail transport.*

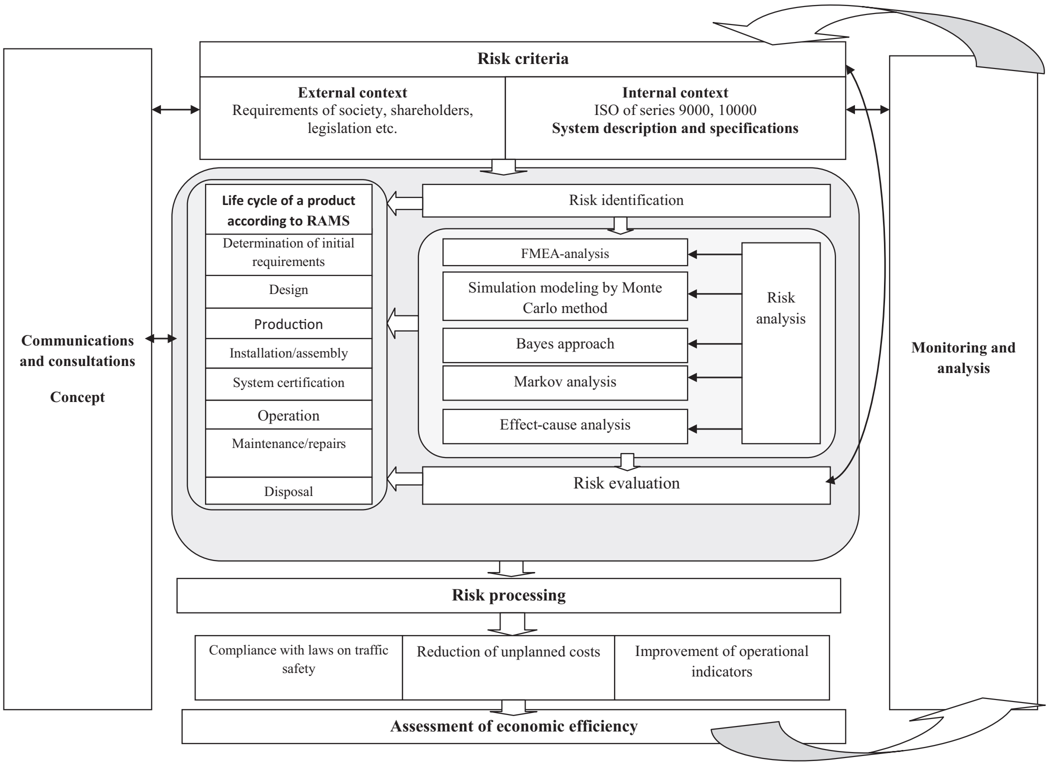
Methods. *The author uses analysis, descriptive method and comparison.*

Results. *With the aim of modeling risk management process, based on the international standard ISO 31000: 2009 and RAMS, an integrated system has been developed, which is shown in Pic. 1. It involves the assessment of risk at all stages of the life cycle of rolling stock, including: determination of a concept, description of system and specifications, risk analysis, system requirements, distribution of requirements, design and implementation, production, installation / assembly, certification of a system, acceptance, operation, maintenance and disposal.*

Input data to the risk management process are communications / consultations and the first stage of the life cycle by RAMS is determination of the concept. Communication and consultation are carried out with all stakeholders at all stages, meaning identification and documentation of opinions of the parties in relation to the process under evaluation. Determination of the concept includes: regulation of project management, the allocation of the scope and objectives, check of the project's safety relevance, funding analysis [3].

The process of risk management starts with determination of evaluation criteria, taking into account external and internal contexts. The first context is the external environment in which the organization seeks to achieve its objectives. It can mean different areas: social and cultural, political, legal, technological, economic and competitive environment [5]. The second context is the internal environment of the organization, which can affect the risk management process. The internal context, incidentally, involves the second stage of the life cycle of the rolling stock as stipulated by RAMS, which includes system description and specifications, setting up of risk assessment criteria.

The next stage of risk management is the analysis of risks, which is a universal process of identifying and assessing threats. In the first place the organization must identify the source of the risk, its area of influence, risky cases, their causes and potential consequences, that is, to identify a risk for each stage of the life cycle. Their classification and compliance with the stated requirements can be determined using standard ISO 31010 «Risk management. Risk management techniques».



Pic. 1. Risk management system based on the integration of ISO 31000: 2009 and RAMS.

Since risk management on rail transport is connected with traffic safety, among the methods of their assessment we should identify those that provide high performance and low degree of uncertainty. Given this, from the table «Selection of risk assessment techniques» of ISO / IEC 31010: 2009 Monte Carlo method, Markov method and Bayes networks were selected as tools of analysis. It is also advisable to include FMEA-analysis and analysis of causes and consequences, which is a set of fault tree and event tree.

Markov method is taken when the future state of the system depends only on its current state. In this case, we use the diagram of states and transitions, graphically representing the operation of the system and enabling to reflect the order in which multiple failures occur.

The main advantage of the Markov analysis is the possibility to simulate a maintenance strategy, including restoring priorities [6]. Within RAMS it is suitable for calculation of readiness and maintainability of systems that may be in different states, for example, «intact» and «defective» and also takes into account transitions between these states in time [7].

The method is applicable for risk assessment at such stages of the life cycle of rolling stock, as installation / assembly and maintenance / repair. For operation phase it is inconvenient since it implies a considerable number of assumptions and does not take into account failure interaction between nodes.

Causal analysis is a combination of event tree and fault tree. It gives a schematic description of the sequence of failure of the system, a probabilistic assessment of possible consequences, has the advantages of a «tree» of faults when displaying a sequence of failures and ensuring their full understanding at the system level.

In the construction of a method a critical event is set, which acts as an end event of a fault tree and an initial event of an event tree. Next, we apply a standard procedure for constructing a fault tree for the initial event. An order is determined in which states are considered, and upon the completion possible consequences are lined up, depending on various conditions. The method demonstrates a qualitative visualization of the process, but the calculation of probabilities does not involve accounting of relationships between selected nodes in the system and accounting of event importance.

Simulation modeling by Monte Carlo method is used to allocate the uncertainty within the analytical model. The method involves the use of random variables as input data and holding a number of simulations with selective formation of data to obtain a desired result. The required level of accuracy is usually achieved when around 10000 simulations are made. On the basis of calculations it is possible to determine the probability of failure of the system under a different set of elements with different reliability.

Monte Carlo method has advantages such as the possibility of combined use of probabilistic and expert estimates and calculations of probability, taking into account the significance of the event. Accordingly, it is appropriate for the risk assessment in determining initial data and the design of rolling stock. The method is not suitable for the operational phase of rolling stock, because it incorrectly takes into account low probability events, which entail serious consequences.

FMEA-analysis is applied to determine the sequence of failures and their impact on the overall system. The analysis process includes:

1. Determination of research objectives.

2. Formation of the group of experts.

3. Presentation of the system under investigation.

4. The decomposition of the system into components.

5. Identification of functions of each component of the system.

6. Determination of points of significance, occurrence and detection for each component of the system.

7. Determination of the boundary priority number of risks.

8. Organization of corrective and preventive actions.

The first five steps of the method construction are preparatory and must ensure that the research results will be adequate. Description of each type of defect is written in the report of analysis of types, causes and consequences of failures, compiled in accordance with Annex A of GOST R 51814.2–2001. At the sixth stage with the help of experts we set scales of points of significance (S), occurrence (O) and detection (D). Points S and O vary from 1 (the least significant failures as for the damage caused by them) to 10 (for the most significant failures see the damage caused by them). Point D, on the contrary, ranges from 10 (for virtually undetectable failure) to 1 (for reliably detectable failures). After obtaining expert judgments of S, O, D a priority number of risks (PNR) is calculated:

PNR= S·O·D.

Each PNR can have values from 1 to 1000. For priority number of risks critical boundary is set ($PNR_{bound.}$) ranging from 100 to 125. For the objects related to safety, $PNR_{bound.}$ value is less than 100.

FMEA-analysis is used to assess the risk at the stages of design, production and operation. It is easy-to-use and provides the final material in readable form. Among its disadvantages there is a lack of ability to simulate results of studies under the given conditions.

Bayes approach to risk assessment became widespread in medicine and military industry, as it allows predicting adverse events under stated conditions. A distinctive feature is that it combines probabilistic and expert estimates, and thereby enables to determine a reliable result even with the lack of initial data. The method involves the construction of a graph, a so-called Bayes network, in which the relationships between elements of the system are set.

Bayes approach enables to predict a risk of failure of railway rolling stock, which makes the method indispensable at such stages of the lifecycle as operation and maintenance / repair.

The next stage of management system is risk processing, which involves making decisions on risk's admissibility and assessment of the effectiveness of the analysis. It is necessary to determine clearly the economic feasibility of risk prevention, including by comparison with the value of the cost of its elimination. The risk management system is required to bring profits to a company by reducing costly discrepancies. However, the final decision should always be taken in favor of safety.

The results of monitoring and analysis should be documented and brought to the attention of internal and external stakeholders, as well as used as input data of risk management process [5].

Conclusion. *The use of described models of risk management will allow rail transport organizations to:*

- *comply with the requirements of the legislation on traffic safety;*
- *reduce unplanned expenses;*
- *to improve operational performance.*

The use of RAMS as a standard, focusing on providing quality performance and service delivery, in combination with a specialized standard on risk management ISO 31000: 2009 promotes an integrated approach that meets the conditions of rail transport.

Keywords: risk management, reliability, security, life cycle, rail transport, rolling stock, technical regulation, international standards.

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