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DEVELOPMENT AND IMPLEMENTATION OF THE URRAN TECHNOLOGY ON RAILWAY TRANSPORT

Tasks faced by the Russian economy highlight the need to find ways of enhancing operation efficiency developing railway transport. At the same time, we should not forget that railway transport, like any other complex system, faces uncertainty or risks while carrying out its activities. Uncontrollable risks can lead to unplanned maintenance costs, harm to people, property and other negative consequences that adversely affect the operating performance of JSC RZD.

Keywords: *reliability management, railway transport, life cycle cost, resource management, risk management, management of functional safety.*

The purpose, goals and objectives of the URRAN system

The URRAN system is a technology of management of reliability, resources and functional safety on railways. It is based on the integrated application of modified RAMS methodologies (reliability, availability, maintainability and safety) and LCC (life cycle cost), new information technologies to support decision making, distributed information systems, operational data collection and its analysis and the new regulatory framework [1,2]. The URRAN system provides practical management of resources, risks, reliability and functional safety management on the network of Russian Railways. For the first time, this system allows under the circumstances of shortage of funds to increase the assigned life span of railway facilities to limiting state on the basis of risk assessment and reallocation of investments to maintain the reliability and safety of them as the most problem facilities. And close attention is paid to consideration of the human factor influence on the company's technological process. The list of the components that are included in the project URRAN is presented in fig. 1.

The possible impact of any factor affecting the reliability and safety of rail facility under consideration should be evaluated taking into account the vitality of a given facility. Such an assessment should include consideration of the impact of each factor on each stage of a life cycle, as well as it should take into account the relationship of affecting factors.

While developing the URRAN system methodology, many of RAMS propositions have been developed. Let us consider the most significant ones:

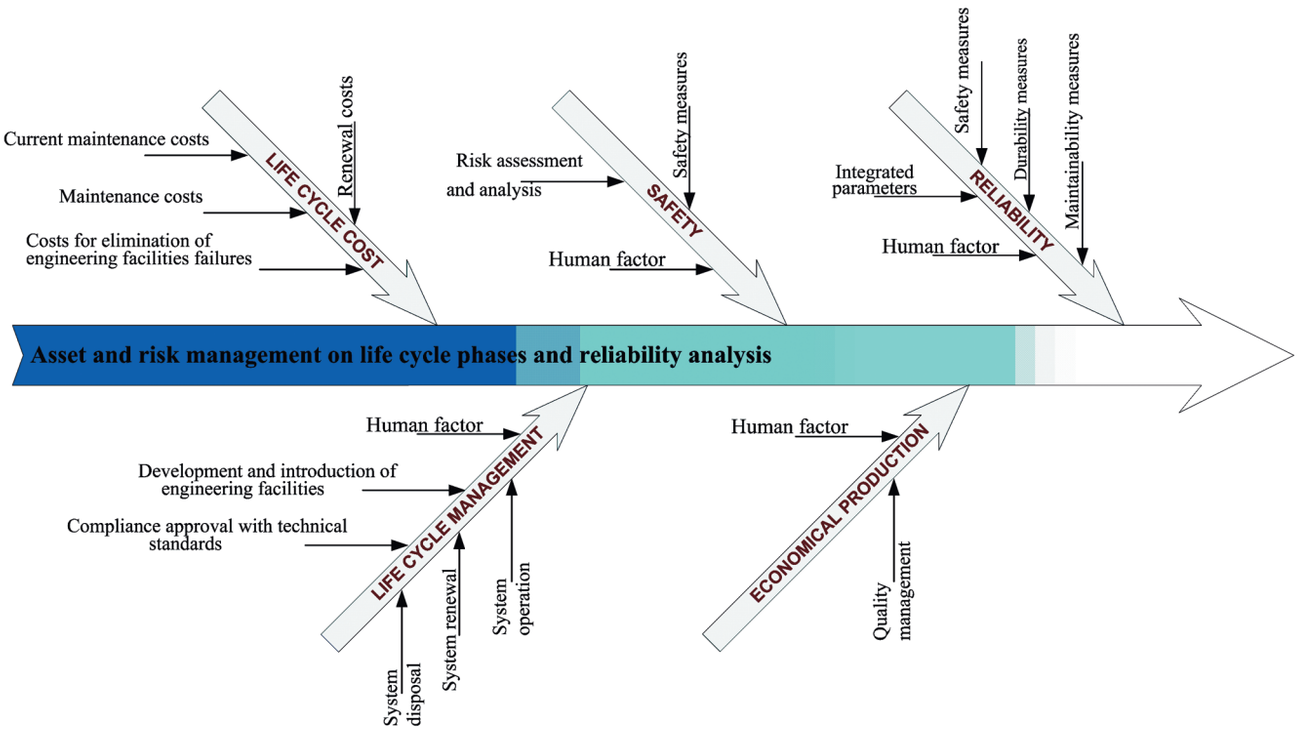

Fig. 1. Basic components of the URRAN system methodology

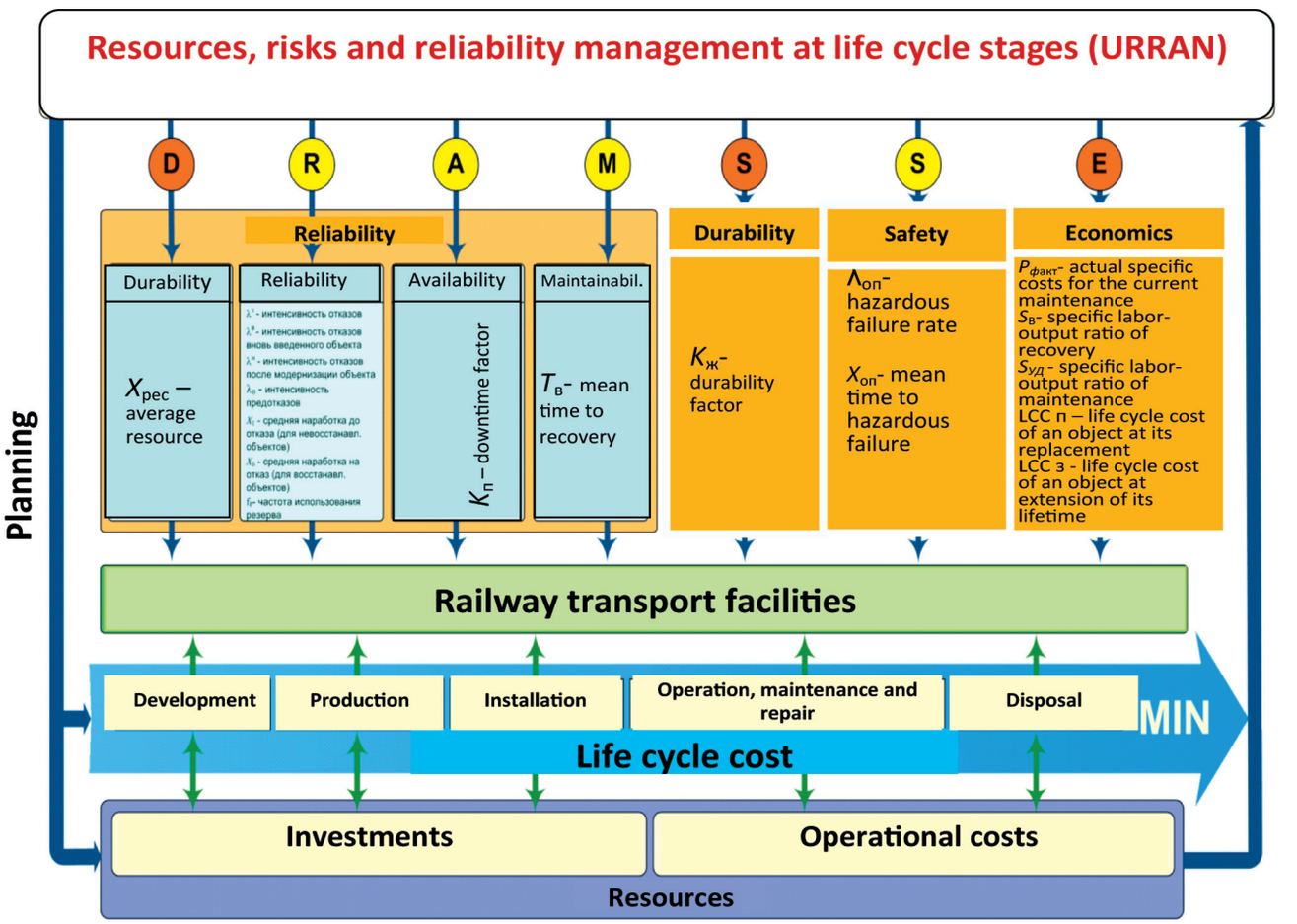

Fig. 2. The structure of the URRAN system

1. The transition from the integrated reliability and safety management of a facility to the integrated reliability and safety management of the transportation process with the help of developed information technology;

2. Managing reliability and safety of the transportation process on the basis of the developed system of measures for operational reliability and operational safety of objects and processes;

3. Investments management based on risk assessment taking into account the life cycle cost, durability, and maintenance of railway facilities as to state.

The structure of the URRAN system is shown in fig. 2.

The URRAN system is being implemented in six RZD enterprises: track facilities, automation and remote control (telemechanics), electrification and power supply, traction, telecommunication, multiple units rolling stock enterprises. For the purpose of the implementation of the URRAN system, sets of sub-goals are defined for each enterprise (Table 1).

Table 1. Objectives of the implementation of the URRAN system in enterprises

Enterprise	Objective
Track system	Reduction of track infrastructure life cycle cost at the expense of resource redistribution under condition of ensuring the required level of operational reliability and acceptable level of train operation safety
Automation and remote control facility	Improving the reliability of railway automation and remote control under condition of ensuring the required level of safety of the transportation process based on optimizing the use of resources and life cycle cost
Electrification and power supply facility	The increase of power supply systems' life cycle based on risk assessment, under condition of insuring the required level of operational reliability and acceptable safety level of the transportation process
Locomotive complex	Reduction of locomotive life cycle cost through the increase of efficient use of resources under condition of ensuring the required level of operational reliability and acceptable level of train operation safety
Communication facility	Reduction of railway communications' life cycle cost by increasing the efficiency of resource management based on improving the technology of telecommunication networks' operation under condition of ensuring the required safety performance and reliability at the provision of telecommunication services
Multiple units' rolling stock facility	Reduction of life cycle cost of multiple units' rolling stock facility through the efficient allocation of resources, under condition of ensuring the required level of reliability and acceptable level of safety while maintaining the requirements of passenger travel comfort

Tasks of the URRAN system

I. The development of the regulatory framework, including the interstate, national and industry standards and procedures.

II. The methodology development for reliability management of railway facilities, including metrics of operational reliability and methods of their calculation and analysis.

III. The methodology development for risk management in industrial activity on railway transport.

IV. The development of mechanisms to increase motivation level of the Company divisions in improving indicators of operational reliability and functioning safety of railway facilities.

V. Ensuring credibility and efficiency of collecting and processing data on process violation and failures of technical facilities in rail transport.

VI. The development of quantitative measures' for assessing the technical efficiency of railway sections.

VII. The development of information technology to support decision-making in management of risks, resources and reliability at the life cycle stages.

VIII. The methodology development for prolongation of assigned lifetime of railway facilities and decision-making support for the determination of the limiting state.

IX. The development of the management system of human, material, financial and other resources based on algorithms for their optimal allocation.

The main findings of investigation of the URRAN project:

• The developed methodology for the calculation and prediction of operational reliability of the reference railway infrastructure facilities (1 km of permanent way, switch, block section, 1 km of overhead contact system, etc.), with metrics and calculation methods, including semi-Markov graph methods of calculation and prediction reliability of complex recoverable systems with latent failures [3].

• The developed methods for decision-making support (the methods of factor analysis according to a posteriori and a priori information), allowing estimation and prediction of safety violation at railway facilities.

• The information system for operational data collection, accumulation and analysis of data on failures of technical facilities – Integrated Automated Accounting System, control of failures' elimination of technical facilities and analysis of reliability (KASANT), developed and introduced on the railway network during 2010-2011.

• The developed methodology of risk management in industrial activity on the Russian railways and the introduced method of injury rate management at pedestrian crossings.

• The developed information technology has being implemented step-by-step to support decision-making in management of risks, resources, reliability and safety. On its basis of Information-management system for automated system of Integrated Management of Resources, Risks and Reliability (AS URRAN) has been created and is under implementation on the Russian railway network.

• The regulatory framework for the widespread introduction of the URRAN project has been developed, including 2 interstate standard, 5 national standards and 11 industry standards, as well as 23 methodologies and guidelines.

• Scientific-technical journal "Reliability" is regularly published in the Russian and English languages for extensive discussion of the results of studies on the URRAN project. This journal is included by the Higher Attestation Commission of RF in the list of recommended editions for the publishing of doctoral and candidate's theses.

Testing of the intermediate and final findings of the URRAN project research has been conducted on 261 stations and 288 open lines, in 29 track enterprises and in railway enterprises of automation and remote control, power supply and electrification on the over 3200 km operating railway line of the Northern Railway for 28 months.

The application of the URRAN technology allows the following:

• Significantly increase the efficiency and objectivity of failure data and process violations' information.

• Manage the technical content of railway facilities according on the current state of their reliability and safety.

• Under shortage of funds to appoint repair of the most problem sections and to ensure fail-safe operation of the infrastructure and train operation safety. Thus, according to the trial operation on the Northern Railway in 2012, based on the URRAN methodology, the possibility was found to reduce the cost of the current track maintenance compared to the current planning for more than 85 million rubles.

• Promptly evaluate risks of hazardous situations' occurrence on railway transport and predict the possibility of accidents. For example, on the station Povarovo (main line Moscow – St. Petersburg) the possibility of injury and even loss of life on the single-level pedestrian crossings has been predicted, which, unfortunately, really happened. The reconstruction of the selected pedestrian crossings is under way.

• Predict the possibility of accidents' occurrence on the identified problem sections of railway lines.

• Provide management of reliability and safety of transportation systems under conditions of incomplete and uncertain information.

The scientific novelty of the URRAN project in relation to existing developments:

• The system of operational reliability measures and functional safety of reference facilities of track, automation and remote control, electrification and power supply has been developed, as well as conversion factors of existing facilities' performance to the reference ones.

• The graph semi-Markov methods of calculation and prediction of reliability and functional safety of complex technical systems has been designed, which differ from the known methods by calculation and prediction directly from the graph states almost all indicators of reliability and safety of complex recoverable railway facilities with reservation and / or natural redundancy and incomplete control.

• The methods of factor analysis to predict accidents have been developed.

• Methods of risk assessment of the of injury or loss of life on pedestrian crossings taking into account the crossing equipment and the intensity and speed of vehicles has been presented.

The methodological novelty of the URRAN project:

• In the development of RAMS methodology indicators of reliability, availability, maintainability, safety, and durability of railway transport are studied. Moreover, for each sector of infrastructure and rolling stock facilities a complex operational performance is formed, taking into account the nature of the manufacturing sector.

• In the development of RAMS methodology methodical regulations for management of reliability and safety of railway facilities in the course of their operation on the basis of actual data, design calculations and acceptable levels of risk.

• In the development of the methodology for life cycle cost (LCC) developed methodological regulations for cost management of maintenance and improvements infrastructure facilities based on the values of their performance reliability according to the URRAN methodology.

• In the development of the methodology RAMS methodical regulations for the transition from a normalized lifetime to the ultimate railway facility state of rail transport taking into account risk assessment of transportation process safety violation have been designed.

• A regulatory framework for management of resources, risks, reliability of typical railway infrastructure facilities has been created.

It is worth to mention another area of the application of the URRAN system in 2013. It is well known that there is a significant increase in the number of incidence of side bogie frames breaking of freight cars in the Russian and some CIS countries' railway networks. Each such break is associated with derailment of a car or cars, and sometimes leads to more serious consequences associated with loss of life.

The characteristic feature of the present situation with the side bogie frames breaking is detection of their breaks on the operation life from of 1 to 4 years, which indicates that they have an unacceptably low level of reliability. The dynamics of the break frequency of side bogie frames' lots from different manufacturers in 2002-2012 are shown in fig. 3.

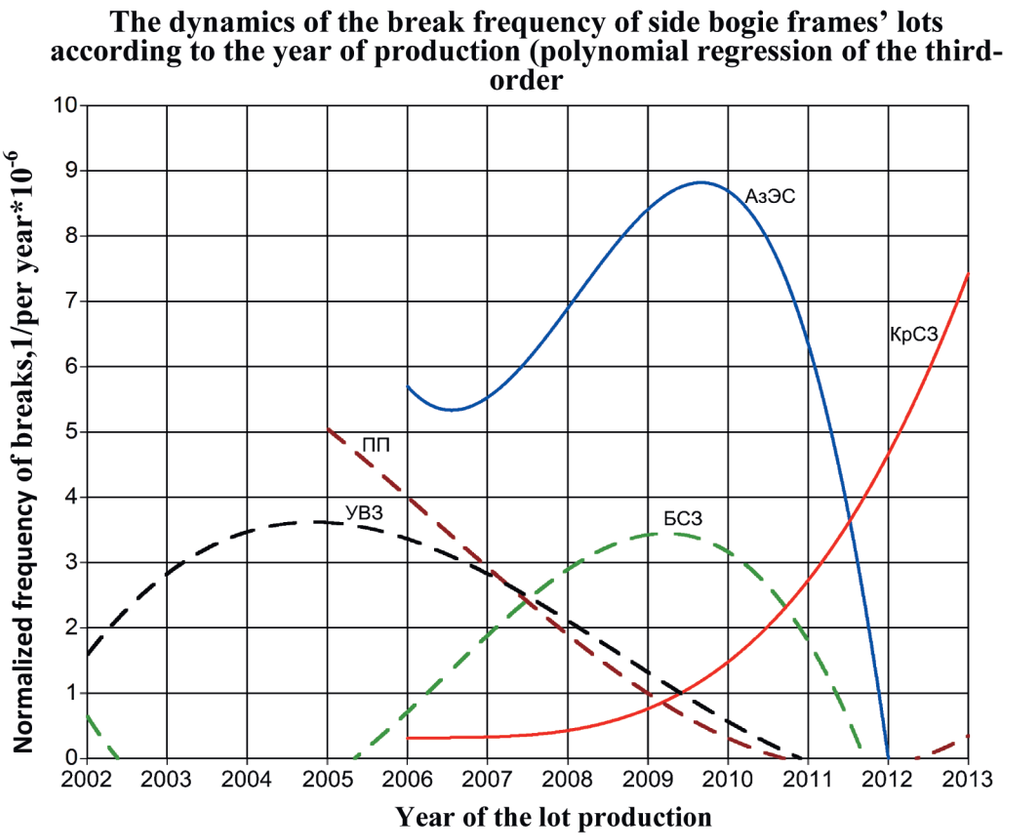

Fig. 3. The dynamics of the break frequency of side bogie frames' lots from different manufacturers in 2002-2012

On the basis of the presented dynamics it is possible to evaluate predicted for 2014 the total break number of side bogie frames according to manufacturers by the quantity of 38 pieces (see Figure 4), under condition of non-fulfillment of measures to reduce the risk of side frame breaks.

In 2013 "Guidelines for calculation and construction of risk matrix associated with breaks and defects of side bogie frames of freight cars" were developed, which are intended for use in the risk assessment

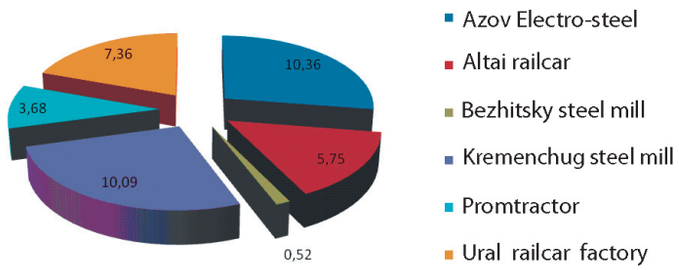

Fig. 4. The total break number of side bogie frames predicted for 2014 (according to manufacturers)

process of derailments, accidents and rolling stock wreckage because of side bogie frames' breaking, as well as the risks of operation stopping of freight cars as a result of cracks' detection of and other defects of side bogie frames.

Based on available statistical data on the number of defects and breaks of cast side bogie frames, as well as on consequences caused by them (wreckage, accidents and rolling stock derailment), the methodological guidelines allow us to calculate the necessary measures and evaluating the risk level with results displayed in the form of risk matrix.

The use of a risk matrix constructed according to the guidelines, will allow taking reasonable decision about reliability and safety state of side bogie frames of freight cars in a given period of observation.

As part of the URRAN methodology duplication for the railway network, the two-stage training of Infrastructure Directorate experts was carried out. From 27.05.2012 until 07.06.2012, training took place in Moscow on the basis of The Main Computation Center of JSC RZD. Further, the trained teams' forces carried out network training on railway divisions. Because of this activity over 2,600 professionals of JSC RZD were trained. Thus, the work to implement the URRAN system in industrial activity on each structural division is being carried out nowadays.

Currently, a great activity on cost accounting and criteria calculation for the appointment of repairs in 2014 based on the URRAN system performance is carried out the track complex. This work will allow forming in the AS URRAN system the title track sections to be included in the plan of repairs for 2014 according to the criticality of their actual state.

In 2013, together with the Center for Competitive Procurement organization the works were started on the use of the URRAN system measures in the procurement activities of JSC RZD. This work will provide a presentation of clear and reasonable requirements for products and services and will allow implementing:

– Compliance with the mandatory safety and reliability requirements for the railway rolling stock, special equipment and infrastructure elements, permanent way elements and structures located on them;

– Compliance with the interests of JSC RZD as for presentation of requirements to a high level of safety and reliability in order to minimize risks;

– Minimizing the life cycle cost of facilities for the purpose of positive impact on the financial results of JSC "RZD".

Completion of the URRAN system technology implementation on infrastructure of the whole Russian railway network is planned in 2013, and in 2013-2014, this technology will be developed for the rolling stock and introduced on the railways of the country.

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