Automatic technical systems for forecasting the safety level of traffic trains

V A Olentsevich¹, T G Konovalova² and I I Izotova³

¹ Irkutsk State Transport University, 15, Chernyshevskogo str., Irkutsk, 664074, Russia
² Irkutsk National Research Technical University, 83, Lermontova str., Irkutsk, 664074, Russia
³ Baikal State University, 11, Lenin str., Irkutsk, 664003, Russia

E-mail: seraf11972@mail.ru, izotovaii@bgu.ru

Abstract. The need to strengthen the role of JSC Russian Railways in the processes of ensuring transport accessibility of the main energy deposits and energy platforms, including on the Arctic, Sakhalin and Caspian shelves. The industrial development of the Arctic involves the intensive exploitation of hydrocarbon resources, the extraction of biological resources and, as a consequence, the development of transport and transport infrastructure. The possibility of further economic growth in the northern territories is determined by such sustainability criteria as the economic growth of territorial economic systems and the system of indicators characterizing the concept of sustainability of economic growth in the production sector, in the financial, social and transport spheres. The article presents a forecast of multilateral accounting for the East Siberian Railway, when developing probabilistic scenarios for regional development, it implies a constant expansion and improvement of forecasting tools.

1. Introduction

The need to strengthen the role of Russian Railways in the processes of ensuring transport accessibility of the main energy deposits and energy platforms, including on the Arctic, Sakhalin and Caspian shelves [1-3].

In order to ensure an efficient transport infrastructure in the Arctic, it is necessary [5-8]:

- to provide investments in a powerful, capital infrastructure;
- to implement large infrastructure projects at enormous costs;
- to invest in the versatility and safety of the vehicles themselves;
- to organize technical and economic activities for natural characteristics and rhythms, investments in a complex system of connections, external and internal bases, transshipments and reloading [9, 10].

2. The need for new approaches to improving the safety of the transportation process

In accordance with these requirements, all "new" operators, as users of the railway infrastructure, carrying out activities related to the operation of railway vehicles are obliged to:

- organize the work of personnel in accordance with the requirements that ensure the safety of train traffic and the production of shunting work, comply with the regulatory requirements for work and rest regimes, organize and carry out medical control and control of knowledge of regulatory documents;
• create conditions for staff development;
• analyze and eliminate the causes of failures and violations of regulatory documents governing the operation of railway transport with the participation of their vehicles and equipment, for this purpose, to conduct an official investigation of each fact of failure and their accounting;
• ensure the compliance of the technical condition of the rolling stock and technical means with safety requirements.

Compliance with the environmental safety of cargo transportation and the production of auxiliary operations consists in the proper technical maintenance of the vehicles and rolling stock in use. In addition to complying with the standards of emissions of harmful substances by engines of the locomotive fleet, during maintenance of the rolling stock, it is necessary to ensure that there is no leakage of liquids and oils. When transporting dusty and liquid cargo, the carrier is responsible for the reliable shelter and sealing of the bodies. Particular attention must be paid to protecting the environment when transporting dangerous goods.

3. The main reasons for the formation of excess carriage park
Railway industrial transport provides stable, uninterrupted operation with more than 90% of cargo transported through the network, and retains its leading role in providing transportation to enterprises of the ferrous metallurgy, coal and chemical, forestry and woodworking industries. At the same time, the material and technical base is being reconstructed on the basis of a proportional, interrelated development of all its elements, taking into account the provision of coordinated work with the mainline railway transport.

All these factors, according to [11, 12], form an excess car fleet, which occupies thousands of kilometers of railway station tracks, according to various estimates, up to 4-5 thousand kilometers.

The surplus park is formed as a result of the following factors:
• loaded wagons are mainly sent to railway unloading stations, without taking into account their unimpeded reception at the end points, which leads to the formation of so-called "abandoned" trains with loaded wagons on the approaches to them;
• empty cars are sent in advance by the operators of the rolling stock to the loading station, which causes their excessive accumulation at these stations and sections adjacent to these stations.

The specified use of the industry's railways is a limiter for increasing the speed of movement of wagons to the places of initial and final cargo operations. Insufficient capacity of the tracks of railway stations for the accumulation of wagons and sludge after loading and unloading does not make it possible to increase the number of wagons in the supply to loading and unloading points and the number of feeds themselves. The above factors increase the unproductive mileage of shunting locomotives, the turnover time of freight cars increases, the time spent by cars at the station increases, and the safety of train traffic and shunting operations decreases.

A number of other problems also arise. First of all, they are as follows: travel speeds are reduced (minimum radii, minimum inserts, track profiles do not correspond to technical standards), the downtime of cars under various operations increases (the possibility of using advanced technologies due to cramped conditions is excluded) and, which is especially important, safety is reduced production of work (all processes are carried out according to the minimum permissible standards) [11]. The analysis of statistical data of failure cases shows that most of them are associated with failures of technical means. Failures of technical means, as the main causes of violations of operational safety, prevail in the main technical complexes of railway transport. The diagram of the distribution of failure cases among the complexes that are part of the railway transport in 2020 is shown in Figure 1.

The analysis of statistical data [13-16] in recent years has shown that the reasons for the insufficient reduction in the number of security violations are systemic and associated with the current state of the technical and technological base of the complexes. In these conditions, the formation of requirements for the developed products of railway equipment and technological processes, including indicators of reliability, operational safety and general quality indicators, plays a leading role in reducing the number of safety violations. In the context of the development of high-speed traffic and the introduction of
innovative technologies, it is necessary to tighten these requirements, as well as the development of special procedures for monitoring their implementation [16-20]. At the same time, when developing modern technical systems related to traffic safety, special attention should be paid to software tools and constant monitoring of safety indicators.

![Figure 1. Distribution of cases of traffic safety violations by complexes.](image)

**4. Modern technical systems for predicting the level of traffic safety using software**

The results of predicting failures the level of traffic safety using software are presented in the table 1. Failure forecast is shown in Figure 2.

| No. | Service                        | Year | Failure forecast | No. | Service                        | Year | Failure forecast |
|-----|--------------------------------|------|------------------|-----|--------------------------------|------|------------------|
| 1   | Transportation complex         | 2018 | 4.50             | 5   | Automation complex             | 2018 | 3.77             |
|     |                                | 2019 | 4.12             |     |                                | 2019 | 3.99             |
|     |                                | 2020 | 2.91             |     |                                | 2020 | 4.00             |
|     |                                | 2021 | 3.02             |     |                                | 2021 | 3.52             |
|     |                                | 2022 | 4.22             |     |                                | 2022 | 4.21             |
|     |                                | 2018 | 89.50            |     |                                | 2018 | 1.89             |
|     |                                | 2019 | 90.35            |     |                                | 2019 | 2.09             |
| 2   | Locomotive complex             | 2020 | 89.71            | 6   | Passenger complex              | 2020 | 1.70             |
|     |                                | 2021 | 84.15            |     |                                | 2021 | 1.99             |
|     |                                | 2022 | 91.12            |     |                                | 2022 | 1.68             |
|     |                                | 2018 | 111.00           |     | Complex of cargo and commercial work | 2018 | 5.05             |
|     |                                | 2019 | 110.10           |     |                                | 2019 | 4.66             |
| 3   | Wagon complex                  | 2020 | 113.90           | 7   |                                | 2020 | 6.12             |
|     |                                | 2021 | 112.16           |     |                                | 2021 | 5.67             |
|     |                                | 2022 | 113.28           |     |                                | 2022 | 5.23             |
|     |                                | 2018 | 53.10            |     |                                | 2018 | 11.72            |
|     |                                | 2019 | 49.18            |     |                                | 2019 | 12.03            |
| 4   | Track complex                  | 2020 | 53.30            | 8   | Electrification complex        | 2020 | 11.18            |
|     |                                | 2021 | 50.44            |     |                                | 2021 | 10.81            |
|     |                                | 2022 | 52.90            |     |                                | 2022 | 11.53            |
Figure 2. Forecast of failures for the period from 2018 to 2022 for the East Siberian Railway.

The need for multilateral accounting of various kinds of functioning of all complexes included in the railway transport, when developing probabilistic scenarios for regional development, presupposes a constant expansion and improvement of forecasting tools.

5. Conclusion
The analysis of statistical data of failure cases shows that most of them are associated with failures of technical means. Failures of technical means, as the main causes of violations of operational safety, prevail in the main technical complexes of railway transport.

The analysis of statistical data in recent years has shown that the reasons for the insufficient reduction in the number of security violations are systemic and associated with the current state of the technical and technological base of the complexes. In these conditions, the formation of requirements for the developed products of railway equipment and technological processes, including indicators of reliability, operational safety and general quality indicators, plays a leading role in reducing the number of safety violations. In the context of the development of high-speed traffic and the introduction of innovative technologies, it is necessary to tighten these requirements, as well as the development of special procedures for monitoring their implementation. At the same time, when developing modern technical systems related to traffic safety, special attention should be paid to software tools and constant monitoring of safety indicators.

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References
[1] Dodin D A 2005 Sustainable development of the Arctic (problems and prospects) (Saint Petersburg: Nauka)
[2] Selina V S, Elokhina V R, Pachina T M et al 2002 Economic research in the Kola Scientific
Center of the Russian Academy of Sciences (Apatity: KNTs RAN)

[3] Euro-Arctic Pan-European Transport Area (BEATA) 2013 Joint transport plan for the Barents region. Proposals for the development of transport corridors for further study. (Moscow)

[4] Shtayger M G, Balanovskiy A E, Kargapoltsev S K, Gozbenko V E, Karlina A I, Karlina Yu I, Govorkov A S and Kuznetsov B O 2019 Investigation of macro and micro structures of compounds of high-strength rails implemented by contact butt welding using burning-off IOP Conference Series: Materials Science and Engineering 560 012190

[5] Kolosov A D, Gozbenko V E, Shtayger M G, Kargapoltsev S K, Balanovskiy A E, Karlina A I, Sivtsov A V and Nebogin S A 2019 Comparative evaluation of austenite grain in high-strength rail steel during welding, thermal processing and plasma surf ace hardening IOP Conference Series: Materials Science and Engineering 560 012185

[6] Balanovsky A E, Shtayger M G, Kondratiev V V, Van Huy V and Karlina A I 2018 Plasma-arc surface modification of metals in a liquid medium IOP Conference Series: Materials Science and Engineering 411 012013

[7] Balanovsky A E, Shtayger M G, Grechneva M V, Kondratiev V V and Karlina A I 2018 Comparative metallographic analysis of the structure of St3 steel after being exposed to different ways of work-hardening IOP Conference Series: Materials Science and Engineering 411 012012

[8] Gozbenko V E, Kargapoltsev S K and Karlina A I 2019 Environmental benefits of new industrial waste-based lubricant compositions IOP Conference Series: Earth and Environmental Science 229 012020

[9] Gruzinov V M, Zvorykina Yu V and Ivanov G V and others 2019 Arctic transport highways on land, water areas and in airspace Arctic: ecology and economics 1 (33) 6-18

[10] Klepach A and Razbegin V 2017 The role of transport projects in the development of the Arctic and the Russian North Gos.audit. Right. Economy 1 121-124

[11] Gladkih A M, Konyuhov V Yu, Galyatudinov I I and Shchadova E I 2020 Suggestions for improving the efficiency of repair activity IOP Conference Series: Materials Science and Engineering 760(1) 012022

[12] Olentsevich V A, Belogolov Y I and Grigoryeva N N 2020 Analysis of reliability and sustainability of organizational and technical systems of railway transportation process IOP Conference Series: Materials Science and Engineering 832(1) 012061

[13] Savelyev M V, Sheshukov O Yu, Metelkin A A, Shevchenko O I, Tkachev A S, Shmakov S V 2020 Sulfur partition by process stages of metallurgical production of JSC EVRAZ NTMK IOP Conf. Ser.: Mater. Sci. Eng. 966 012067

[14] Nishchik A V, Rodionova I G, Baklanova O N, Grishin A V, Adigamov R R, Nikitin D I, Kroitor E N Effect of Hot Rolling and Strip Tension on Mechanical Properties of Cold-Rolled Two-Phase Ferritic-Martensitic Steels Metallurgist 60(9-10) 930–936

[15] Temnikov V V, Sheshukov O O, Mikheenko M A, Metelkin A A 2020 Ladle-Furnace-Slag Reprocessing at Evraz Nizhniy Tagil Iron and Steel Works OJSC Metallurgist 64(5-6) 508–513

[16] Skiba V, Martyushev N 2021 MEACS-2020 IOP Conference Series: Materials Science and Engineering 1064(1) 011001

[17] Sachkov D I, Martyushev N V, Kutsiy A P 2020 Preface IOP Conference Series: Materials Science and Engineering 760(1) 011001

[18] Lombardi P, Sokolnikova T, Suslov K V, Styczynski Z Optimal storage capacity within an autonomous micro grid with a high penetration of Renewable Energy Sources IEEE PES Innovative Smart Grid Technologies Conference Europe 2012

[19] Bulatov Y N, Cherepanov A V, Kryukov A V, Suslov K Distributed Generation in Railroad Power Supply Systems Proceedings of 2020 3rd International Colloquium on Intelligent Grid Metrology, SMAGRIMET 2020, 2020, стр. 54–60, 9264013

[20] Noskov S I and Bazilevsky M P 2010 Software complex for automating the process of
constructing regression models *International Journal of Applied and Fundamental Research* 1 93-94