Automation of the Study of Railway Safety Subsystems Response

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Abstract: The problem of the safety of the functioning of railway transport and the effective response to contingency, emergency situations, including acts of unlawful interference, is one of the main issues being solved as part of the improvement of the country's railways. One of the parameters that determine the level of operational safety is the response time to these events. The paper considers the issues of automation of the research model of the reaction process of structural units of subsystems for ensuring the safety of the production process of railways. Based on the results of early research conducted by the authors on the development of a simulation model of the response process in the event of threats, acts of unlawful interference and other abnormal and emergency situations, the software was developed, the principles of its operation and the simulation results presented to the user are outlined.

1 INTRODUCTION

According to the Russian railways development program, one of the main and urgent goals is to increase the level of safety of the production process (Reference information JSC "Russian Railways", https://cssrzd.ru/). The achievement of this indicator is expected to reduce the risks of human influence and the development of automated systems (AS).

The safety of the production process, in this article, is considered as countering the effects of all kinds of abnormal, emergency situations leading to violations of the normal functioning of the production process, including traffic safety and possible dangerous effects on participants in the transportation process. From a similar position, the effect of the use of AS is also considered.

The AS operated on the railways of Russia can be conditionally divided into:

– Systems of control and operational management of the transportation process that minimize the risks of incorrect decision-making by employees of structural divisions. Such AS include systems used at all levels of operational train traffic management and responsible for: transportation management (ASOUP), control and management of operational work (DISCOR), accounting, control of dislocation, analysis of the use and regulation of the car fleet (DISPARK), train traffic management (SAUDP), control and analysis of operational works (OSCAR) and others (Legkiy, 2018; Order of Russian Railways JSC No. 769/r, 2018; Tushin, 2014).

– Traffic safety monitoring, forecasting and risk assessment systems focused mainly on the control of technical malfunctions. Such systems are installed in specialized units responsible for traffic safety. AS data include systems responsible for monitoring: elimination of failures of technical means and analysis of their reliability (CAS ANT), the work of the audit apparatus (AS RB), situational analysis of traffic safety (ICSAR SC) and others (SCBIST, http://scbist.com/).

The issues of the sustainability of the production process of railways to the impact of abnormal, emergency situations are relevant and are considered in different countries in a number of positions, such as improving the principles, strategies for organizing

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practical interaction of management bodies and functional response subsystem based on statistical indicators, and the creation of intelligent control systems in real-time emergencies (Balboa, 2021; Koshkarov, 2020; Jia, 2022; Jiyanbekov, 2019; Taylor, 2017).

At the moment, there is no automated system on the railways of Russia that allows automating the process of receiving, processing, transmitting, storing primary and subsequent updated information about emerging abnormal, emergency situations, including acts of unlawful interference (AUI) in the activities of railways, in unified databases with access to them in real time, providing the function decision-making support to bring this information to the responsible persons of structural divisions at all levels of the territorial administration of railways, emergency operational services operating within the boundaries of the territorial entity in which this situation has developed.

The presented process of responding to situations leading to traffic safety violations will be further referred to as the information response process, and the AS being developed as an information response automation system.

This article presents the results of constructing and automating a simulation model of the information response process, which allows us to evaluate the parameters of the effectiveness of the functioning of the information response system being developed for railways.

Research in this area is carried out with the support of federal budget funds within the framework of the project "Development of the concept of digital interaction of the organizational structure in emergency situations and ensuring transport security of railway transport entities".

2 MATERIALS AND METHODS

In the early studies conducted by the authors in this area, based on the analysis of regulatory documents, the structuring of the process of information response to various emergency situations, including AUI, was carried out. An algorithmic model of the response of structural divisions of the railway, forces and units of transport security and other security agencies at transport infrastructure facilities and vehicles has also been developed (Sirina, 2020; Sirina, 2022). The

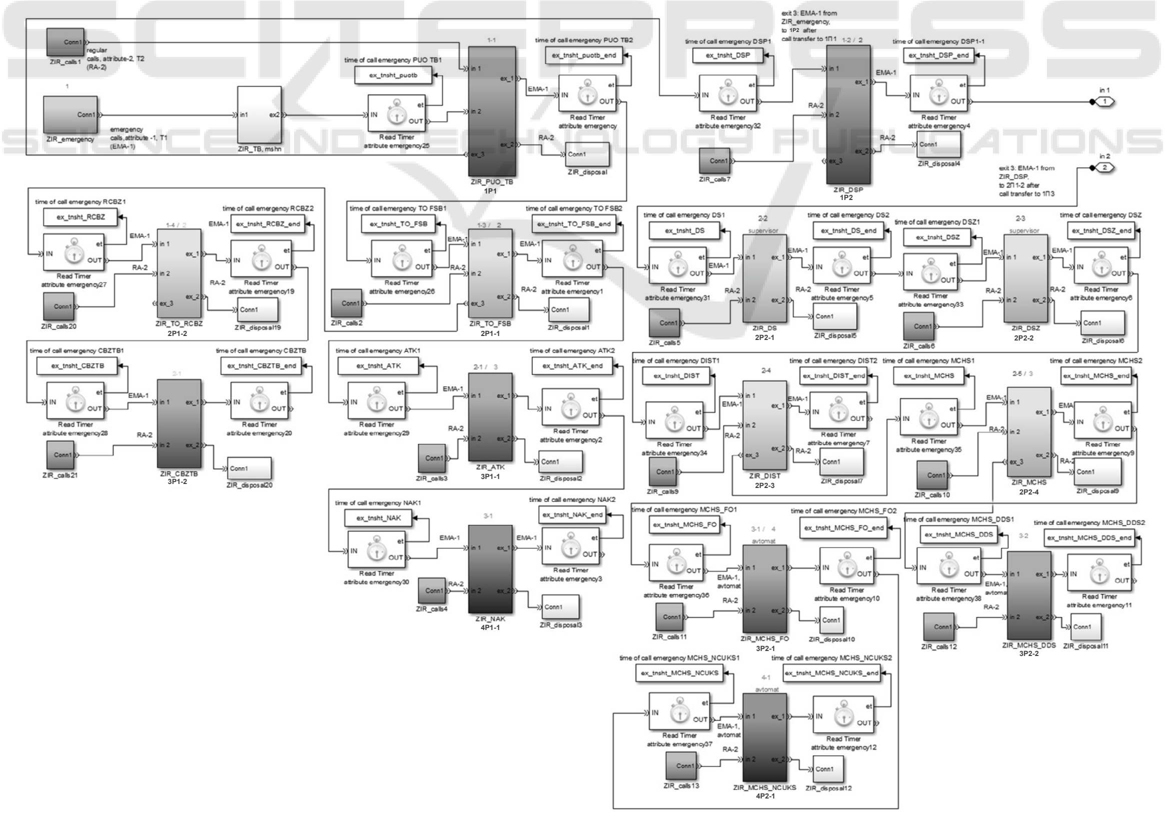

Figure 1: Simulation model of information response of structural units responsible for safety on the railway.

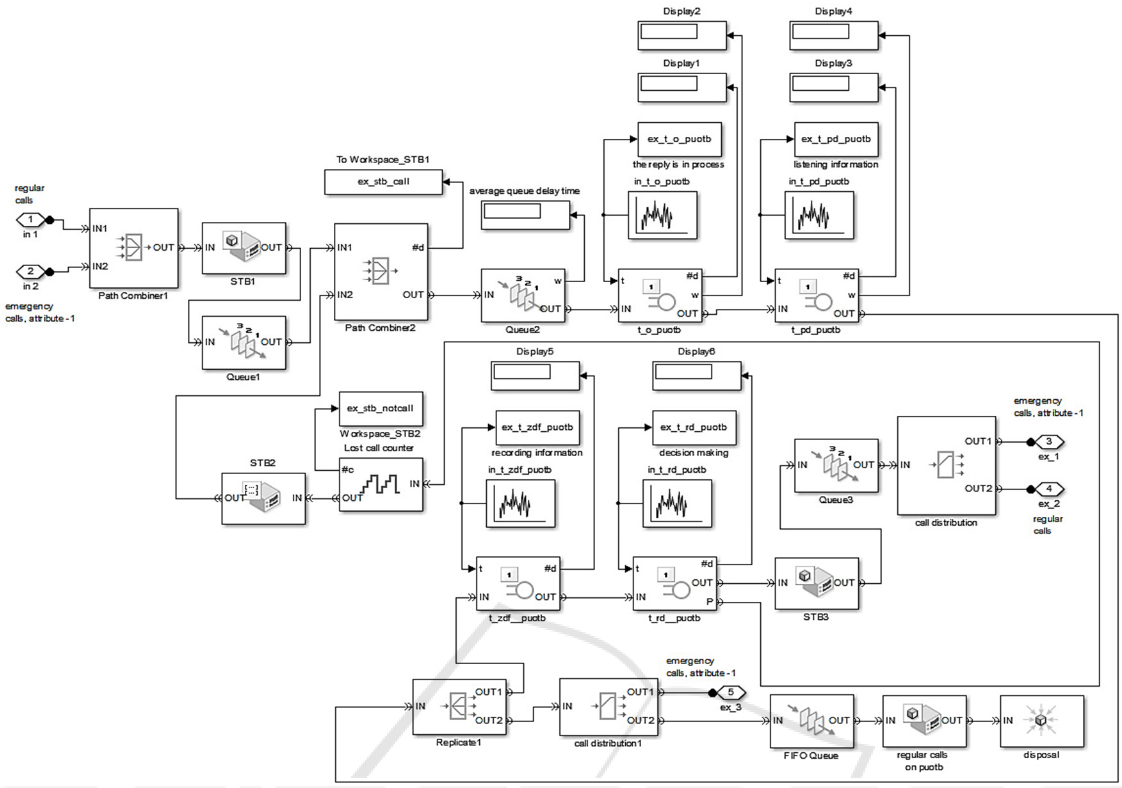

Figure 2: Architecture of the information response link.

simulation model of information response is shown in Figure 1.

The architecture of the model includes interconnected links (ZIR). Each link simulates the work of an official of the structural unit responsible for the response.

The first-order link 1P1 is the primary recipient of information. There are also links of the same order 1P2 – 1P5. Figure 1 shows only the first-order links 1P1, 1P2. The architecture of all first-order links is similar and is shown in Figure 2.

Each link generates time delays according to the stages of servicing the received information. The number of service stages and their characteristics depend on the systems and means of communication used in structural divisions.

In the chains of links 1P1, 1P2, there are information response chains: 1P1 has a chain consisting of second-order links 2P1-1, 2P1–2, 1P2 - a response chain with links 2P2-1 – 2P2-4. The order of the link starts from the link that is the primary recipient of information about the emergency situation.

The response chains of first-order links differ in the architecture of interaction with higher-order links. Higher-order links can also have their own response chains with links of an even higher order. An example is the information response chain of a third-order link 3P2-1 interacting with a fourth-order link 4P2-1.

Changing the time parameters of the response of the links leads to a variation in the response time of the entire structure, which has a direct impact on the damage to the production process.

3 RESULTS AND DISCUSSIONS

In order to automate the study of the information response model, software (AMIR software) was developed. The software interface is shown in Figure 3.

The software operates in two modes:

- the first one is designed to study a response model that reflects the actual structure of interaction over operational and technological communication networks of the railway and public telephone networks when interacting with external response structures in which the response process can be partially automated;
- the second is to study the information response system when introducing functionality into it

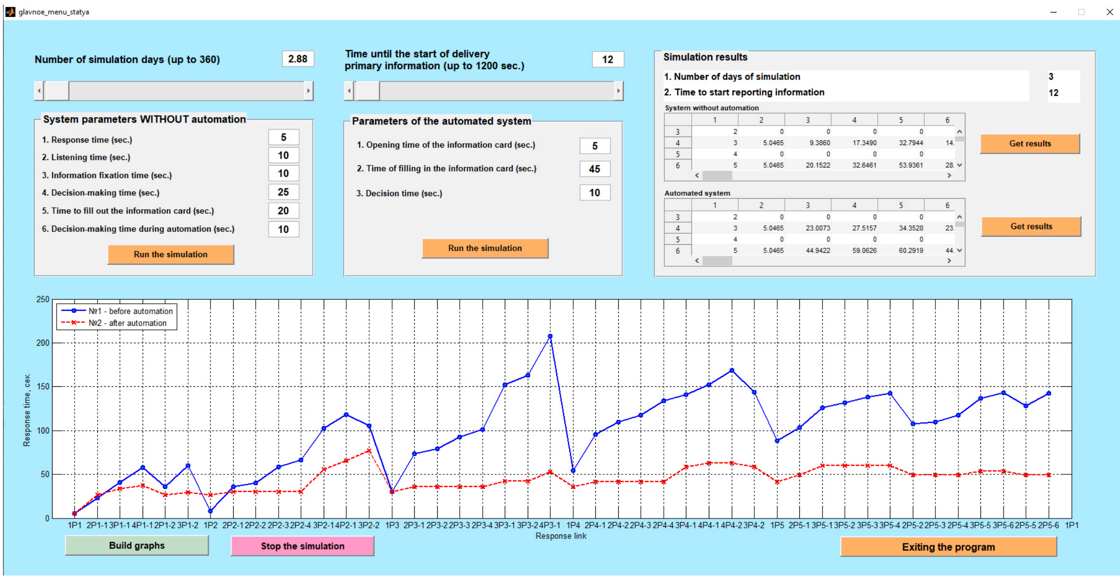

Figure 3: Program for automating the study of the information response process.

that allows automating the process of receiving, processing, transmitting, storing primary and subsequent updated information, providing a decision support function to bring this information in real time throughout the response structure.

The time parameters entered into the fields of the working window are perceived by the system as mathematical expectations of the laws of distribution of these quantities. All parameters requested for modeling are varied by the user.

In the field of the working window, the results of the simulation of the information response process are displayed as numerical with their unloading in the form of data tables and in graphical form.

Graphical dependencies are presented to the user in the same axes for the two modes of operation of the model, which allows a comparative analysis of the operation of the structure in the modes under consideration. The displayed graphs demonstrate the dependence of the time of receipt of information by the response link.

According to Figure 3, the first-order links 1P1 – 1P5 are the primary recipients, i.e. information is provided first to link 1P1, which transmits it to link 1P2, the latter in turn to link 1P3, etc. In turn, link 1P1 transmits information to the second-order links of its response chain 2P1-1 and 2P1-2. Link 2P1-1 forms a response chain with a third-order link 3P1-1, and the latter with a fourth-order link 4P1-1.

The first-order link 1P2 forms a response chain with the second-order links 2P2-1 – 2P2-4. Link 4P2-1 is a fourth-order link in the response chain of link 3P2-1, and 3P2–1 is a third-order link in the chain of link 2P2-4.

Thus, both modes of operation of the model are characterized by an increase in the response time of a link with an increase in its order within the response chain formed by a lower-order link.

With the redistribution of responsibilities for responding to higher-order links located in the response chain of lower-order links, there is a decrease in the response time of the links furthest from the lower-order link.

4 CONCLUSIONS

The architecture of the simulation model can be rebuilt by the user if it is necessary to change the rules of interaction of structural units of the investigated production process, as well as software automating the process of model research.

Automation of the research process makes it possible to significantly increase the efficiency of obtaining data on response time parameters, according to which it is possible to analyze and make response forecasts. The simulation will also result in obtaining optimal response parameters for various combinations in the response architecture.

Determining the optimal response parameters will allow, if necessary, to optimize the response architecture, including when using an automation system.

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