AEROSPACE EMERGENCY MONITORING METHODS

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ABSTRACT

The article provides a comparative analysis of natural and man-made factors that lead to the occurrence of emergency situations on railway transport. The issues of information and technological support of monitoring and data collection about the state of potentially dangerous sections of the railway track using aerospace technologies are considered.

Keywords: *aerospace monitoring, railway track, safety, emergency situations, control technologies.*

Background. *Ensuring stability of a transportation process and prevention of emergency situations (ES) is an urgent task for rail transport. Innovative technical solutions used for monitoring of long sections of the railway track make it possible to achieve the maximum integrated effect for train traffic safety and prevention of ES.*

The urgency of monitoring of a railway track, potentially dangerous objects and phenomena on the adjacent territories is determined by the need to implement increased requirements for traffic safety and, in particular, to geometric parameters of long-distance track arrangements on the being constructed and functioning heavy main lines, as well as prevention of man-made disasters and large-scale negative consequences of natural phenomena [1].

The occurrence of natural and man-made emergencies on a railway transport is due to a number of factors, the influence of which is increasingly intensified with time. Most of the railways are built and operate in difficult climatic conditions (plains and lowlands with a predominance of moistened soils). The intensification of the transportation process and the increase in axle loads led and lead to irreversible physical and chemical processes in the roadbed, which change the nature of the behavior of the railway track and expand the risk zone.

Objective. *The objective of the authors is to consider aerospace emergency monitoring methods.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, scientific description.*

Results.

Need to control risks

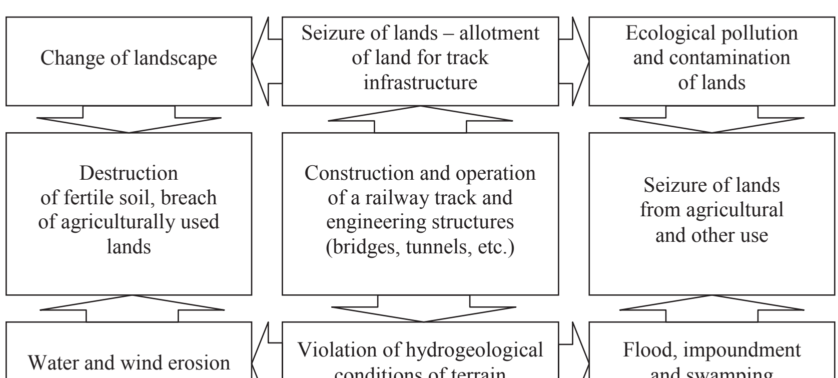
Let's consider the comparative characteristics of emergencies in the territory of the Russian Federation in 2015–2016, using the data of officially published materials of the Ministry of Emergency Situations of Russia (Table 1).

Based on the above data, it is quite natural to determine the priority direction of the scientific and technical activities of the Ministry of Emergencies of Russia in 2017: «Scientific support for development of a system for monitoring and forecasting of large-scale emergencies and disaster risk reduction». According to the statistics (Table 2), it follows that the water risk factor prevails on the territory of Russia.

Analysis of natural and man-made factors that lead to emergencies on railway transport, however, also suggests that the railway track itself is a serious risk factor for an emergency situation – as an anthropogenic part of the ecosystem that is torn away [2]. And the more complex the climatic conditions are, the stronger the nature struggles with the «virus» and manifests its «immunity». The appearance of this effect is explained simply: during construction and operation of the track there is a disturbance of the

Table 1

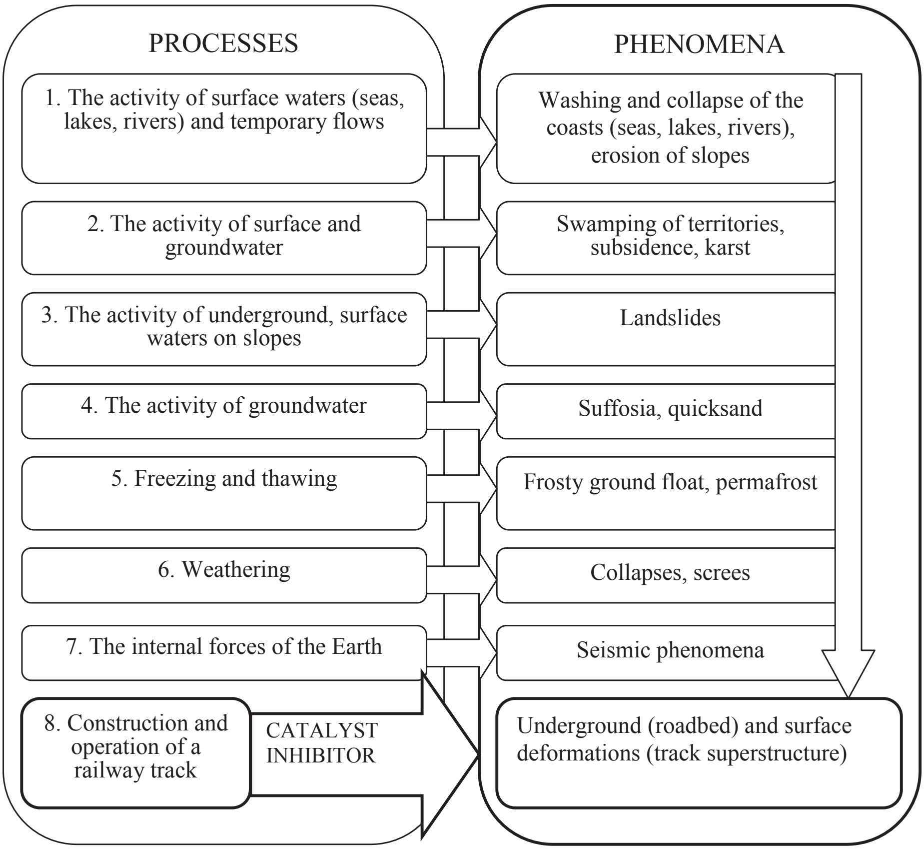
ES by nature and kind of sources of occurrence	Number of ES			Died		Injured	
	2016	2015	%	2016	2015	2016	2015
Technogenic	177	179	-1,12 %	708	656	3970	1629
Natural	54	45	20,00 %	3	43	126465	18114
Biological-social	67	33	103,03 %	75	0	503	1041
Total	298	257	15,95 %	786	699	130938	20784



Pic. 1. Negative ecological consequences of construction and operation of a railway track.

Table 2

ES by nature and kind of sources of occurrence	Number of ES			Died		Injured	
	2016	2015	%	2016	2015	2016	2015
Earthquakes, volcanic eruption	0	0	0,00 %	0	0	0	0
Dangerous geological phenomena	2	0	+ 2	0	0	0	0
Increased groundwater	0	3	-100,00 %	0	0	0	1742
Storms, hurricanes, tornados, squalls, strong snowstorms	6	4	50,00 %	0	1	383	1229
Heavy rain, heavy snow, large hail	21	11	90,91 %	3	1	78818	8989
Snow avalanches	0	0	0,00 %	0	0	0	0
Frost, drought, dry winds, dust storms	7	16	-56,25 %	0	0	0	0
Marine hazardous hydrological phenomena	0	0	0,00 %	0	0	0	0
Separation of coastal ice	1	0	+ 1	0	0	40	0
Dangerous hydrological phenomena	15	4	275,00 %	0	0	47224	0
Major natural fires	2	7	-71,43 %	0	41	0	6154

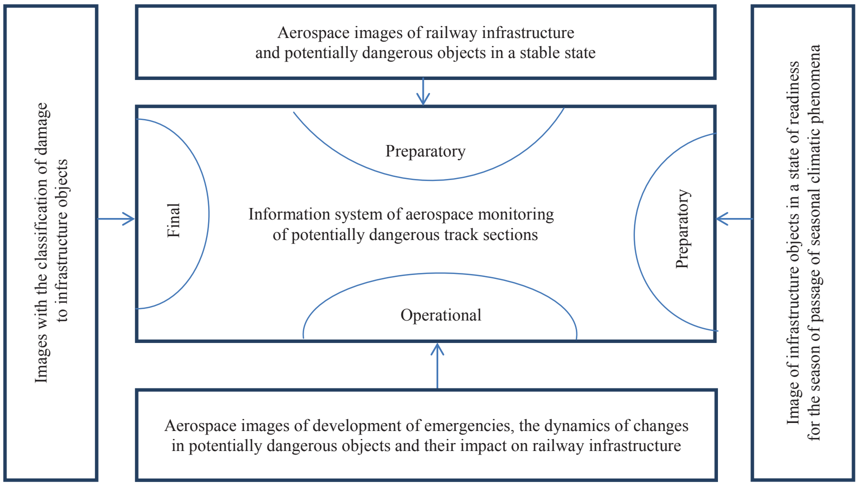


Pic. 2. The main natural factors of the emergence of ES on railway transport.

natural environment [3], which can provoke and aggravate natural emergencies (Pic. 1).

According to the classification [3] proposed by F. P. Savarensky (1941) and I. V. Popov (1951), it is possible to group and associate a number of geological processes and physico-geological phenomena, which give reason to consider them as main causes of natural and technogenic emergencies in railway transport (Pic. 2).

It is obvious that the territory of the railway track is subject to the negative impact of the entire known spectrum of physical and geological phenomena provoking the occurrence of emergency situations. At the same time, one should note the prevailing importance of a water impact factor on railway infrastructure, in particular, the floods that have become frequent in Russia, entailing serious material losses and human casualties.



Pic. 3. Information system of aerospace monitoring.

Table 3

Key technological problems of monitoring of a railway track	The main reasons for insufficient effectiveness of monitoring of potentially hazardous areas and implementing possible measures for traffic safety
Absence in the scales of the network of integration of readings of track-measuring and diagnostic tools in a single coordinate system	• Impossibility of revealing a number of geometric parameters of the track gauge. • High error in the coordinate binding of track defects in the coordinate system. • Impossibility of maintaining a continuous «history of the state (disease)» of each kilometer of the railway track with continuous updating of information in a single global coordinate system.
Absence of a single system for monitoring the compliance with the design and passport data of the railway track (including on large extended sections)	• Impossibility to determine and control with the required accuracy of the design parameters of the track on large extended sections, primarily high-speed lines. • Impossibility of monitoring of mutual influence when changing the state of the railway track on other railway transport facilities and artificial structures (primarily dimensions).
Absence of technologies for comprehensive monitoring of the railway track for monitoring dangerous natural and man-made disasters and emergencies.	• Impossibility of monitoring events on long areas adjacent to the railway track (up to tens of kilometers of remoteness) and exerting direct influence on it (landslides, avalanches, storms, etc.). • Monitoring of potentially dangerous sections of the railway track is of a local nature, the results are not integrated into the complex system.

Especially dangerous among the rapidly developing emergency situations for the railway infrastructure are seasonal and storm water.

To combat the possible negative consequences, enormous material, technical and human resources are attracted. Rational planning, distribution and effective use of the existing potential allows to reduce the damage caused to the railway infrastructure, minimize the danger to people and increase the economic efficiency of the activities carried out.

Therefore, operational monitoring systems should provide the regional infrastructure directorates and line enterprises with the necessary information about the state of the railway track and the adjacent territory, as well as objects that pose a danger, regardless of the degree of their remoteness from the right-of-way.

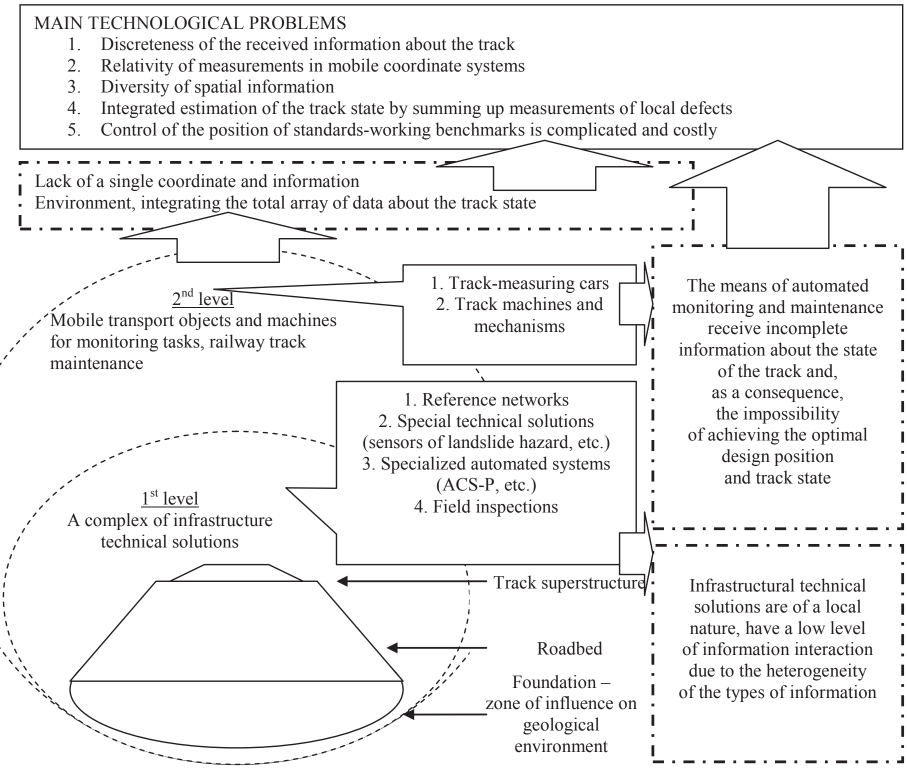
Combined technologies

The monitoring system at all stages should provide information support for the decisions made and provide data on changes in the state of the infrastructure and potentially hazardous facilities. First of all, those values that are critical for the safety of the functioning of the railway transport.

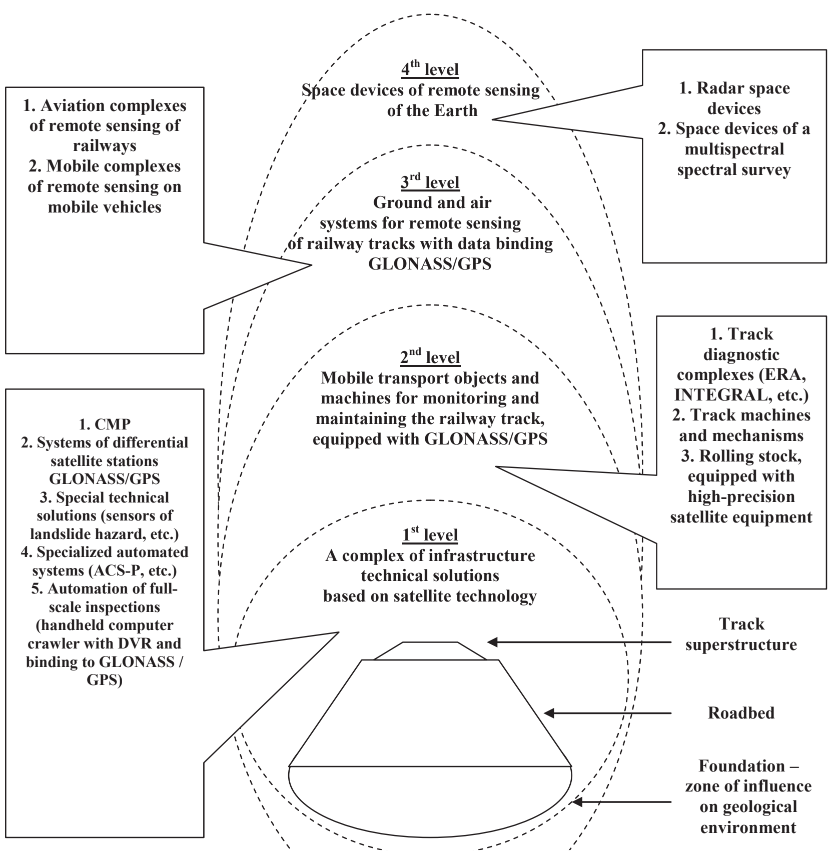
That is, it is about the monitoring system assessing deviations from certain reference values for a number of certain criteria. In the presence of aerospace control the reference values are the images of the railway track (Pic. 3).

Moreover, when building monitoring on the basis of such technological tools as satellite remote sensing systems, it becomes necessary to run a complete technological cycle, with the specified measurement parameters, cyclicity and frequency of information acquisition, communication interaction schemes.

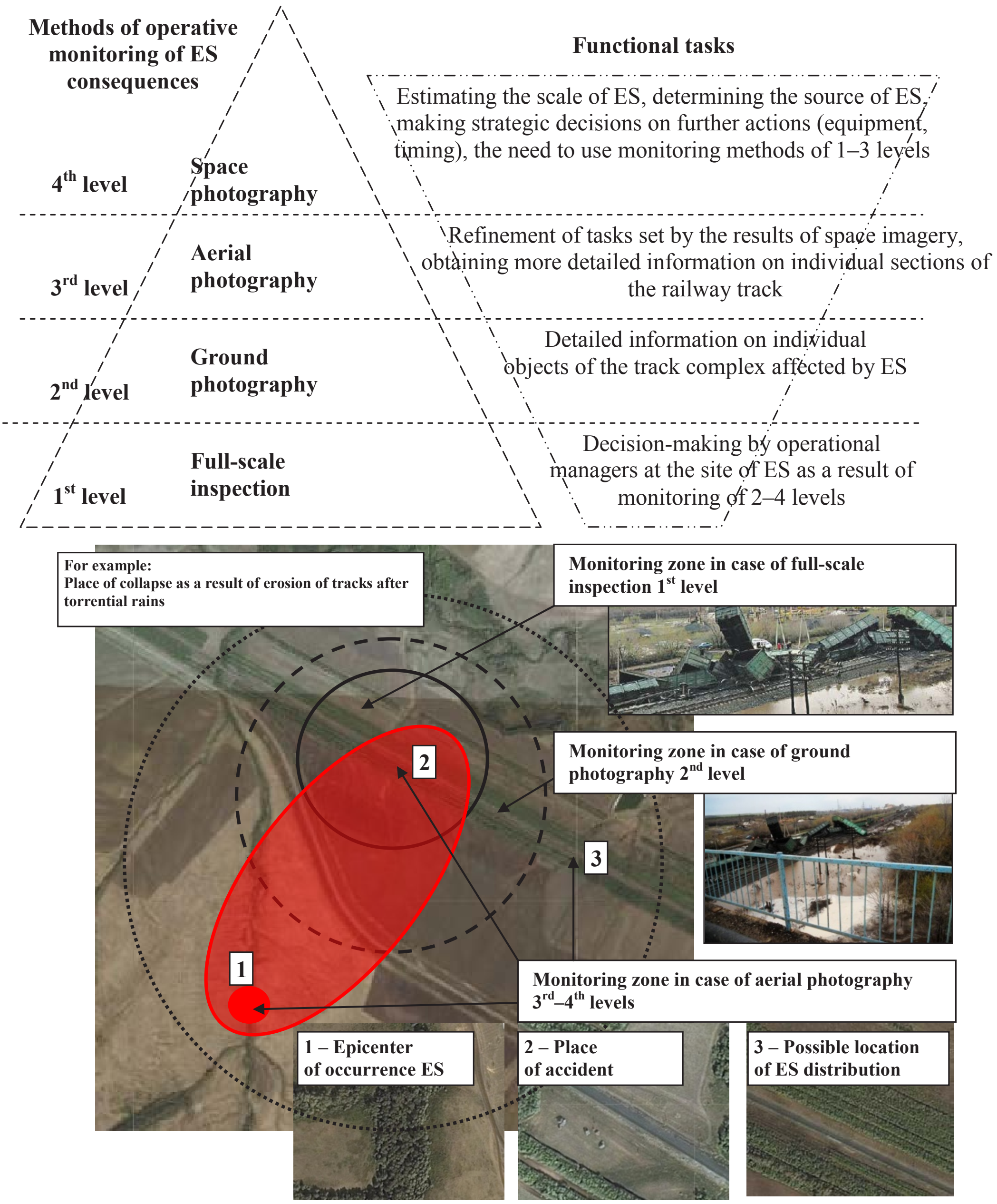
Space technologies have proven to be an effective monitoring tool, primarily for large territorial objects and phenomena, as well as their integrated interaction with the environment in large areas. Proceeding from this, it should be noted that space systems can not as effectively solve all tasks of monitoring infrastructure objects when assessing the situation at a local facility. Application of them is expedient nevertheless within the framework of large-scale and complex monitoring.



Pic. 4. The main technological problems of monitoring of the track and preventing emergencies.



Pic. 5. Upgraded track monitoring and emergencies preventing system.



Pic. 6. Hierarchical structure of the tasks to be solved and a promising technology for monitoring emergency situations have been constructed.

The presented picture confirms the thesis about the need to create a global system for preventing emergencies by means of aerospace monitoring of the railway track and adjacent territories to track the factors of the occurrence of natural and man-made emergencies [4, 5].

Such a statement of the problem requires a single scientific and technological approach (the task of interoperability) to the monitoring of potentially hazardous sections of the railway track [6–10] and, above all, to key technological problems: unification of measurement methods, forms of information provision, regulatory requirements for the completeness and accuracy of data Table 3).

The existing system of information and technological support of track monitoring and emergency prevention includes two levels: a set of local infrastructural technical solutions (reference networks, track templates, geodetic equipment, etc.) and so-called means of continuous control (of which the track-measuring car is the brightest representative and performs periodic measurements of the geometric parameters of the track gauge) [11, 12]. At the same time, all the mentioned means give a discrete and heterogeneous picture that does not allow in principle to build an adequate spatial model of the state of the railway track (Pic. 4).

To solve the presented technological problems it is desirable to use the means of global control –

space, aviation and ground remote sensing with high-precision binding by GLONASS / GPS equipment [12, 13]. Integrating the results of the research, we proposed a modernized structural diagram of the railway deformation monitoring system, which includes four main levels (Pic. 5).

Based on the basic methods of assessing the operational situation in the emergency, a hierarchical structure of the tasks to be solved and a promising technology for monitoring emergency situations have been constructed (Pic. 6).

Conclusions.

There are other technological opportunities for assessing the state of the track and preventing emergencies in conjunction with infrastructure objects [14, 15]:

1. Assessment of the spatial position and geometric parameters of the railway track in combination with artificial structures on a macroterritorial scale (displacement of embankments, approaching / removing the ISSS, etc.).

2. Adaptive management of monitoring and routine maintenance of the track (management of control frequency during monitoring, less time to eliminate defects due to direct transmission of information from control equipment to track machines, control of the speed of work of track machines during repairs, etc.).

3. Identification of epicenters of potentially dangerous phenomena in large areas adjacent to the railway track (formation of water bodies, speed of ravine growth towards the track, watering and swamping of soils, etc.).

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