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Study of railway traffic safety based on the railway track condition monitoring system

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Abstract. The solution to the problem of monitoring the railway track, as well as potentially dangerous objects and phenomena in the adjacent territories, is determined by the need to implement increased requirements for traffic safety (primarily to the geometric parameters of the devices of a long railway track under construction and functioning load-bearing highways), prevention of technological disasters and large-scale negative effects of natural phenomena on the railways. The continuous process of integrating methods and means of monitoring and preventing emergencies into a single information management system is shown. The possibility of determining a dynamic model of the adverse effect of the train on the track and the most unfavorable for the track train and traction parameters, which must be avoided when forming trains in this section, is established. Three key factors are formulated, the use of which will reduce the negative impact on the track from trains. The concept of information technology improvement of the monitoring system for potentially dangerous sections of the railway on the basis of new innovative technologies has been developed.

1. Introduction

Ensuring the continuity of the transport process and the prevention of emergencies is an urgent task for rail transport. Emergencies pose serious anthropogenic risks for railway workers and the population living in the surrounding areas. The innovative technical solutions used for the monitoring of long stretches of track make it possible to achieve the maximum integrated effect for railway safety.

Thus, the urgency of solving the problem of monitoring the railway track, as well as potentially dangerous objects and phenomena in the adjacent territories, is determined by the need to meet the increased requirements for traffic safety (first of all to the geometrical parameters of longitudinal railway track devices on under construction and functioning freight lines), prevention of man-made catastrophes and large-scale negative effects of natural phenomena on railways.

An effective means of implementing new forms of track monitoring is the remote sensing space technologies, which allows simultaneous assessment of the geometric parameters of the path and adjacent territories over extended sections [1]. With the widespread introduction of heavy and high-speed traffic, there is a need for an operational comprehensive assessment of long sections of the railway [2]. This and a number of other factors required the search for fundamentally new principles for monitoring and diagnosing the railway track, which led to the use of satellite-based geolocation systems in railway transport [3].

2. Formulation of the problem

Simultaneously with technological development, there is a gradual integration of national railway systems into a single world transport system [4], which requires a unified scientific and technological approach to monitoring and maintenance of the railway track and, first of all, unification of measurement methods, forms of presentation of information and regulatory requirements to its completeness and accuracy [5, 6].

Foreign rolling stock, primarily high-speed and speed trains from Skoda, Hyindai, and General Electric, is gaining ground on Ukrainian railways. Their effective and safe operation requires the generalization and integration of foreign and Ukrainian experience in maintaining the railway track, as well as the regulatory requirements for its technical condition and, first of all, for the geometric parameters of the rail track.

The purpose of the article. Study of railway traffic safety based on the railway track condition monitoring system by improving the structural scheme of a system for monitoring extended deformations of a railway track.

3. Analysis of literary data

Currently, the world practice of monitoring the geometric parameters of the path [7] distinguishes two main types of control - expert assessment (technical inspection) and automated control. In the case of expert assessment, the person himself acts as a diagnostic system, and the effectiveness of control depends on the experience and analytical qualities of the inspector. An experienced engineer determines the geometry of the path according to physical sensations during an examination trip on a train. In the case of automated control, most of the functions for collecting and processing diagnostic information are transferred to electronic computer technology [8, 9, 10].

The fundamental difference between global control means is the ability to assess the condition of the railway on a macro-territorial scale, in a single coordinate-time measurement system [11, 12].

The existing system of information and technological support for monitoring the railway track includes 2 levels (Figure 1): a complex of local infrastructural technical solutions – reference networks, travel patterns, geodetic equipment, etc. and the second level – the so-called continuous monitoring means (of which the track vehicle is the most striking representative and performs periodic measurements of the geometric parameters of the rail gauge).

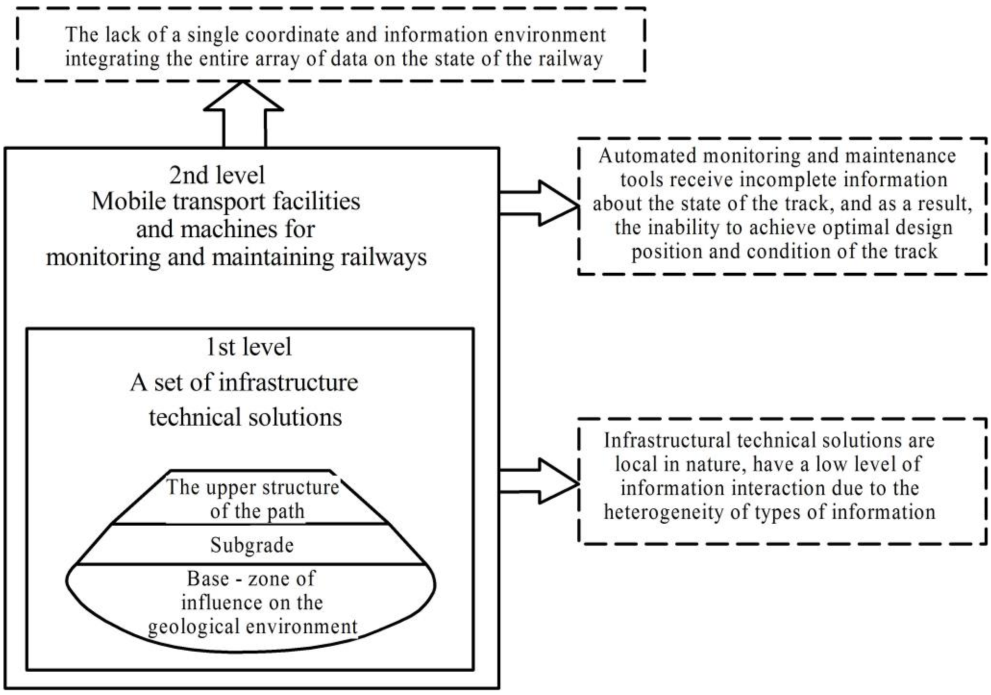

Figure 1. The main technological problems of monitoring.

Moreover, all these tools give a discrete and heterogeneous picture [13], which does not allow, in principle, to build an adequate spatial model of the state of the railway track.

To solve the presented technological problems, it is advisable to use global control means – space, aviation, and ground-based remote sensing means with high-precision geolocation equipment [14].

Rail transport has entered the active phase of the application of new technical means, and, first of all, of new rolling stock (long-haul freight and high-speed passenger trains) which cause the track to be subjected to a new form of impact - volumetric deformation (displacement of embankments and other structures, appearance of multi-radius curves, etc.) [15].

The use of satellite navigation systems for locomotives, according to experts of the locomotive economy "Ukrzaliznytsya", is the most effective tool for identification of vehicles and creation of a digital model of the railway track of Ukraine. On mainline locomotives, satellite radio navigation systems (SRNS) have been widely used [16, 17].

The causes of crashes and crashes are, first of all, deviations in the condition of the track and undercarriage of rolling stock from the norms of their contents [18, 19, 20].

4. Research results

In the case of mixed traffic on the Ukrainian railways on most sections of the track, it is not possible to single out one type of train that can be oriented in calculations. In the case of following trains with different lengths, masses, speeds, traction distribution and other parameters, it is advisable to build a different calculation algorithm (Figure 2). First of all, it is necessary to identify sections of the path subject to deformation. Based on the result, it becomes possible to determine a dynamic model of the adverse effect of the train on the track and the most unfavorable for the train parameters of the train and traction, which must be avoided when forming trains in this section.

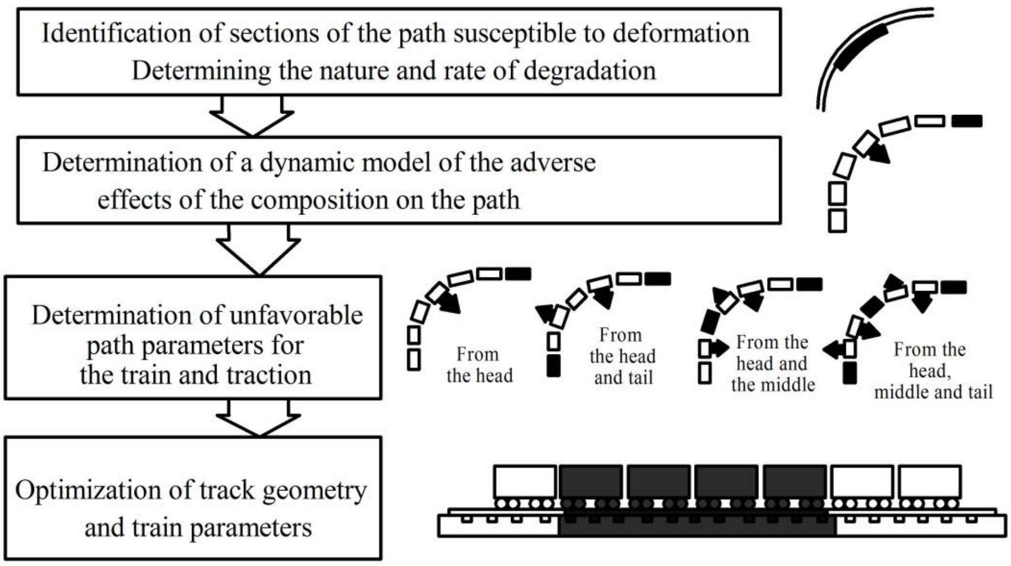

Figure 2. Building the optimal train model and track for mixed traffic.

Integrating the results of the studies, a modernized block diagram of a system for monitoring the longitudinal deformations of the railway track is proposed, providing for 4 main levels (Figure 3).

The results of specific studies by European organizations in the area of creating a single coordinate space for railways implementing the “Europe without Borders” principle confirm that the use of geolocation satellite navigation technologies provides solutions for monitoring and maintenance of the railway track. One example is the widespread use of spatial data in the German railway infrastructure, where route information is constantly updated as a result of maintenance, repair and upgrading.

The first step in implementing a promising track monitoring system is to form a single, high-precision rail coordinate space (Figure 3 – Level 1) based on satellite navigation systems and their differential additions.

The second stage is the introduction of a unified technology for the technical diagnostics of the railway track (Figure 3 – level 2-3) with the use of high-precision satellite positioning and inertial system. This will optimize the timing of the road works while improving their quality, reduce the number of restrictions on the movement of trains, increase their speed, and will also save money on the maintenance of the railway track.

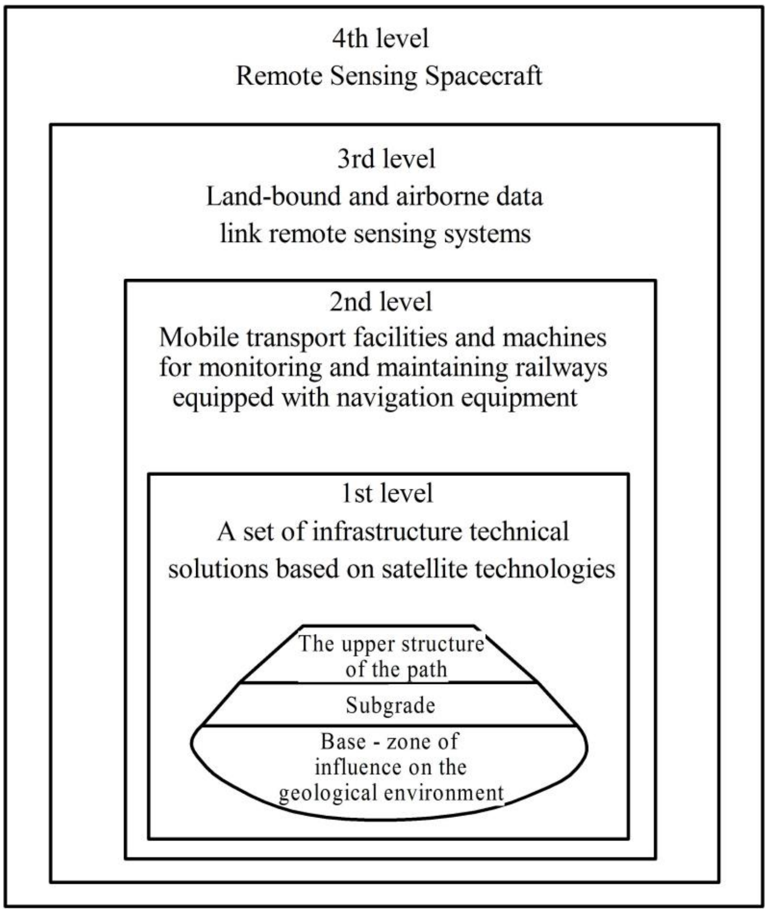

Figure 3. Upgraded monitoring system.

The third stage is the introduction of railway monitoring technology, artificial structures and negative natural-technogenic processes affecting traffic safety on the basis of modern information-measuring systems and technologies of remote sensing of the Earth (Figure 3 – Level 4). It will allow to reduce difficult costly engineering and geodetic works at technical diagnostics of artificial constructions and monitoring of negative natural-technogenic processes on railways, to prevent possible accidents and catastrophes on railway transport.

5. Discussion

Analyzing the relationship of the track and the dynamic load on it (Figure 4), three key factors can be formulated, the use of which will reduce the negative impact on the track from trains and the negative natural and anthropogenic phenomena in the territories adjacent to the track [2]:

- optimization modeling of the geometric parameters of the path over extended sections [22];
- monitoring of the geometric parameters of the track and infrastructure over extended sections;

- monitoring the influence of natural and technogenic factors that worsen the condition of the track and infrastructure (tracking changes in the geometry of potentially dangerous objects in the adjacent territories to the track).

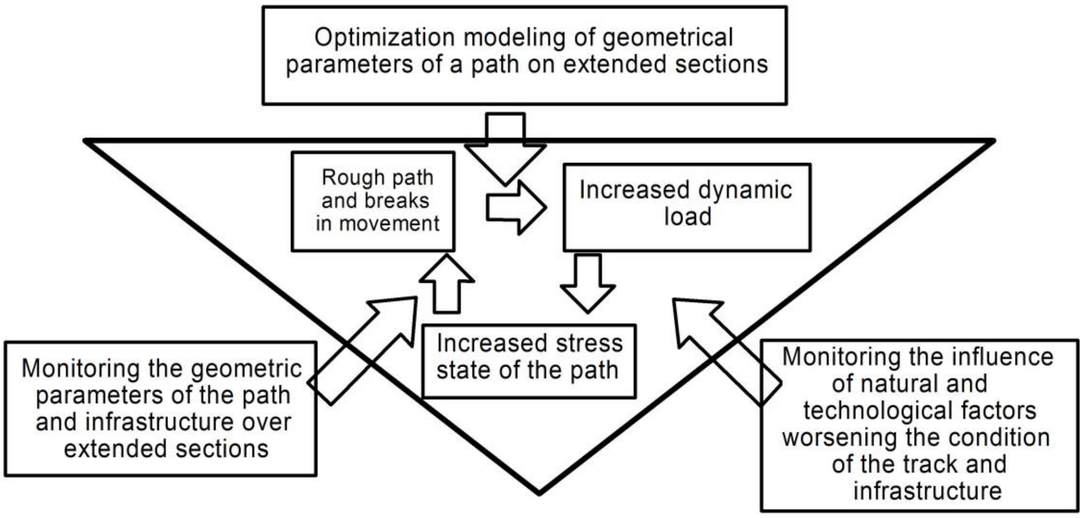

Figure 4. New tools to counteract the negative impact on the track of trains and natural and man-made phenomena.

6. Conclusion

The concept of information technology improvement of the monitoring system for potentially dangerous sections of the railway on the basis of new innovative technologies has been developed.

For track facilities, the following new technological opportunities arise to evaluate the geometric parameters of the track in combination with infrastructure objects:

- assessment of the spatial position and geometric parameters of the railway track in combination with artificial structures on a macro-territorial scale (displacement of embankments, approach / removal, etc.);
- adaptive control of monitoring and routine maintenance of the track (control of the monitoring frequency during monitoring, less time to eliminate defects by direct transmission of information from the monitoring equipment to the track machines, speed control of the track machines during repairs, etc.);
- identification of the epicenters of potentially dangerous phenomena over large areas adjacent to the railway line (the formation of water bodies, the growth rate of ravines in the direction of the track, flooding and waterlogging of soils, etc.).

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