Methods and Methodology of Railroad Natural Technogenic Complexes and Their Structures Assessment

A Strelkov¹, S Teplykh¹, P Gorshkalev¹

¹Institute of Architecture and Civil Engineering, Samara State Technical University, Molodogvardeyskaya St, 194, Samara, 443001, Russia

E-mail: kafvv@mail.ru

Abstract. The paper considers railroad natural technogenic complexes (RNTC) and their engineering systems, such as: technogenic system, structure of natural-industrial railway system, natural-technogenic systems, borders of natural-industrial railway system and RNTC within the framework of a binary system.

1. Introduction
At present researchers undertake a few theoretical studies on development of environmental engineering systems together with natural objects on which they are constructed [1-12]. It is proposed to modify them into techno-natural systems, which are called natural-anthropogenic complexes.

This paper introduces a railroad natural technogenic complex (RNTC) which is a new concept. RNTC consists of two main parts: natural and technogenic. To the natural part of RNTC we refer organic soil, geological formations, surface and underground water sources, atmospheric air, flora and fauna. Stationary (railway tracks, electric power supply lines, etc) and mobile objects (railroad engines, railroad carriages, etc) are referred to the technogenic part of RNTC.

Railroad natural technogenic complexes are quite complicated from the viewpoint of legal relationship. Thus, in accordance with the Water Code of the RF water bodies and rivers are the public domain and are in state ownership, and capital (stations, bridges) or transportation, communications and utilities lines (railways, highways) situated on river-banks can belong to any legal or physical person, while transport infrastructure (railway trains, motor vehicles) can belong to another person.

2. Types of railway natural-technogenic complexes and engineering systems
Natural-technogenic complexes (NTC) include restored lands in railroad rights-of-way and further; river crossings and bridges; lands protected from erosion, floods, washouts, mudflows and landslides; lands with recreated ecological infrastructure (with protective forest windbreakers and forest plantation); protected environmental zones.

When restoring natural elements, there is a need to create long-term strong impact on these elements on a large territory. This is done for the sake of their productivity, recovery, purification and protection. This impact is usually exerted by systems of water supply, wastewater disposal and watering. It is a complex of constructions and series of actions which provide population and industry with water of required quality, and also remove used waters (purifying these waters and transporting them into a receiving basin). These systems are all-pervasive. They increase the usefulness of the territory for people and therefore are related to C engineering. The most relevant and ecologically
important for RNTK is the system of wastewater drainage and removal of surface run-off to reduce watering from railway tracks and surrounding areas. This issue should be considered within a certain time interval, which causes the use of such methods as prediction and choice of technical solutions.

Forecasting is a research method based on retrospective analysis of the system and its behavior. This method makes it possible to obtain a specific prediction or a probability assertion on the state of the system in the future (i.e. forecast). In fact, forecasting is the choice of one or more of the most probable scenarios of the system state in the future from many possible options.

For railroad natural technogenic complexes under analysis we need forecasts of functioning and development of natural systems under anthropogenic influence. Forecasting of natural and technonatural processes is complicated by uncertainty of conditions in which they occur, as well as by the fact that natural bodies change their properties over time; by non-linear nature of natural processes, and at last by a sharp variation of weather conditions.

Forecasts can be quantitative or qualitative. As for the scale of predicted events, forecasts are divided into global, regional, national and local. In terms of their time spread, forecasts are divided into short-term (mainly for the needs of RNCT operational management), medium-term (for ten years, for a year, for vegetation period, etc.) and long-term (for a time comparable to the lifetime of RNCT). The methods of forecasting are as follows: linear extrapolation, model extrapolation, intuitive (expert) forecasting (Delphi method), cause-effect analysis (analogue method), method based on the hypothesis of the primary push, qualitative leap.

3. **Methods and Methodology**

In our research we are using the following methods of forecasting:
- linear extrapolation with the help of functional dependencies found for the previous and current development of the process;
- model extrapolation by means of calculations on the process model, which takes into account possible nonlinearity of the process for conditions of the future;
- cause-effect analysis (analogue method), when it is assumed that the future process for this system is similar to the already known phenomena held in similar conditions;
- the method based on the hypothesis of the primary push when the observed weak change, insignificant now, is considered to be able to grow into a strong significant change.

4. **Main Body**

4.1. **RNTC subsystems**

RNTK may include several subsystems.

One of them is a technogenic system. This is a complex, man-made system that works in contact with the natural environment. This system, continuously evolving, has a growing devastating impact on the Earth. We distinguish the following types of technogenic systems: residential (residential area and city infrastructure), industrial, transport, recreational, forestry engineering, water protection and agricultural systems.

Another subsystem is a natural-technogenic system. It is a complex of natural objects and engineering structures, interacting with the environment. For example, a natural-technogenic railway system presents a complex of interdependent natural objects of water-geological environment and technical structures (for example, a mining complex).

Contemporary scientific and technological revolution greatly complicates the relationship between society, industry and nature. Production activities double every 15 years. This figure initiates a change in the quality of natural environment and its resources. Production activities and their results have a negative impact on the natural environment, e.g. air and water pools, soil, thermal pollution, increased noise, ionizing radiation and much more. In order to solve this problem, we have to determine the limits of biosphere sustainability and natural systems balance, to identify main aspects of human economic activity impact on natural processes in the biosphere and to prevent their – negative impact.
Human economic activities result in specific noo-biogeocoenosis formation. These formations include tehnobiogeocoenosis which appear in the process of industrial enterprises development; agrocoenosis created as a result of agricultural activities; urbabiogeocoenosis which is formed as a result of the construction of cities, towns and transport communications.

When transport and industrial production is introduced into some ecological system, this ecological system is changed artificially and transformed into natural and industrial railroad system. The structure of the natural and industrial railroad system consists of transport (railway and motor), industrial, municipal, natural independent objects which function as a system exchanging energy, information and substance.

The main component of the technogenic system determining its activity and its impact on the environment is its transport-industrial branch. In this transport branch we distinguish objects of basic transport, enterprises of auxiliary transport production, objects of energy engineering, organization for construction and reconstruction of existing transport enterprises.

The natural and industrial railroad system boundaries depend on the boundaries of transport enterprises influence on natural environment which is the part of this system. The main feature of the ecological system, in which the natural-industrial railway complex operates, is that practically all components of this system are under the constant influence of transport enterprises and are affected by them. Agricultural, forest and other lands located in the territory of the natural industrial railway system, as a rule, reduce their production, and sometimes deteriorate completely. In this regard, it is efficient allocate nonproductive land to railway industrial complexes. The quality of agricultural products on the territory of RNTK also worsens because a certain part of industrial emissions is involved in the natural circulation of elements and is absorbed by people who are a link in the ecological chain. Therefore, -agricultural lands located in the territory of RNTC, should be assessed not only by their productivity, but also by the quality of their products.

For a certain period of time the majority of natural-technogenic systems tend to return to their initial natural or to relatively steady-state condition by means of natural-ecological factors of environment. In general, the balance is achieved through the nature's desire to restore its original structure as well as through the human factor, while maintaining technical systems in good working order [1]. In his part we make the first attempt to formulate RNTC theory and assessment methodology. Other sources that we have carefully studied do not give enough information about RNTC formation, their structure and components influencing and forming them. No method of controlled recovery of natural-industrial complexes and railroad natural (water)-technogenic systems has not been found yet, either.

RNTC theory and assessment methodology should take into account changes in its structure and in properties of its elements, focusing on the preservation of both technogenic systems and natural-water systems. We introduce a binary approach to RNTC assessment and recovery. This approach can be employed to both stationary objects and to territorial units of influence on natural-water objects.

RNTC consists of two constantly interacting global systems: railway-technogenic formations and natural-water components. Technogenic influence is constantly dominating, and natural-water effect is only periodic and is characterized by targeted impulses with different degree of direct effect (Fig. 1).

Railway technogenic structures surround the entire surface of the earth, Russia in particular. They produce detrimental effect on natural environment, water bodies in particular. The environment responds to the intrusion of railway technogenic formations by secondary responses. It leads to violation of technogenic structures homogeneity, continuity, watering and natural substances movement.
Railway technogenic structures are located both in major population centers and cities, in regional industrial entities, and in areas with complete absence of absence or with insignificant industrial cluster. Nowadays there is currently no direct targeted approach to solving the problem of interconnection and mutual influence of railway natural-industrial, natural-technogenic complexes and railways natural (water)-technogenic systems on each other. Such an approach should take into account conditions of RNTC formation and natural-water systems position in time and space. We believe it is necessary to consider the previously existing natural-water balance, the current situation and its influence on the subsequent decades of RNTC development and the foreseeable future of natural environment within the framework of the solution we introduce. Thus, to RNTC restoration work we refer the following activities:
- recultivation works related to soil and subsoil movement;
- installation of building structures, products and equipment (reinforced concrete, metal, composite, etc.);
- hydrogeological, geological, hydrological works, etc.

To solve this problem, it is necessary to create a complex system of RNTC research and restoration of natural (water)-technogenic systems up to possible initial level of water systems.
4.2. RNTK within a binary system

The theoretical foundation of RNTC assessment is based on a systemic approach which takes into account the binary characteristics of spatial-temporal positioning, structural organization and potential regenerative ability (see Fig. 2). RNTC here is treated as a local unit, as many units of concomitant development of a geo-environment and hydro-geologic environment and as a technogenic object. The main goal of RNTC is to find the balance between technogenic influence and natural and nature-water environment, which is inseparable from the concept and assessment of RNTC life cycle (technogenic objects activities).

![Figure 2. Structure of RNTK assessment system.](image)

Elements of RNTK assessment system are shown in Figure 3. The binary principle is based on the possibility of RNTC differentiation into such basic components as technogenic constructions, natural and natural-water complexes. These basic components can be further divided into smaller components. In modified natural and natural-water complexes, they are accidented relief, soils, subsoils, groundwater and surface water. Technogenic components, in their turn, include man-made earth structures, buildings, structures, bridges, communications, etc.
5. Conclusion
Processes which are a result of technogenic influence and which are accompanied by changes of natural-water hydrogeological characteristics can be described as a response to technogenic impact. The binary approach to RNTC assessment is based on the theoretical RNTC study.

![Figure 3. Elements of RNTK assessment system.](image)

6. References
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