

The Concept of Functional Road Condition Management

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Abstract — Currently, there is the practical reliability of roads in terms of safety, durability, maintainability, operability and other important consumer properties of the groups of providing of significant speed, continuity, convenience and traffic safety. These include throughput and traffic load, permissible axle load, total weight and dimensions of cars permitted for the movement, the level of road service, ecological, ergonomic and aesthetic properties of the road. All of these are inferior to the benchmark reliability and other important consumer properties of roads of the advanced world countries. A new concept for the functional management of reliability and other most important consumer properties of domestic roads are proposed. The concept is focused on the management of these indicators of reliability and other most important consumer properties of domestic roads in order to ensure their values. They are not lower than the levels of values of reliability indicators and other major consumer properties of advanced world countries. The concept is based on the fundamental fragments of the proposed typical technical project for an automated control system.

Keywords — *concept, indicators of reliability, functional method of management, planning, control, regulation.*

I. INTRODUCTION

Experts in the field of design, construction, repair and maintenance of domestic roads are well aware of the following fact. At present their practical reliability in terms of safety, durability, maintainability, operability and other important consumer properties from the groups of providing significant speed, continuity, convenience and traffic safety, capacity and level of traffic load, permissible axial load, total mass and dimensions of cars allowed for movement are discussed. The level of the road service, ecological, ergonomic and aesthetic properties of the road are significantly inferior to the benchmark reliability indicators and other major consumer properties of roads of the advanced world countries [1].

In most developed countries, including Germany, Japan, the United States, the formation of a road network is carried out within the framework of long-term government programs that establish indicators of their reliability and other important consumer properties and the amounts of funding corresponding to these indicators and properties [2].

After a period of instability in the economy of previous years, Russia has now overcome the decline in the volume of construction and reconstruction of roads. So there is an urgent need for the early development and introduction of fundamentally new technologies, concepts, techniques, etc. into

the national economy [3]. They are focused on the design, construction, reconstruction and maintenance of competitive domestic roads that are not inferior to the benchmark reliability indicators and other important consumer properties of roads of the advanced world countries [4].

In the near foreseeable future (5–10 years), to significantly approach or compare the foregoing indicators and the properties of Russia's roads with the requirements of their indicators and the properties of advanced world countries is necessary in the framework of the "Transport Strategy of the Russian Federation for the period up to 2030". This includes the long-term federal priority project of Russia for 2017–2025 "Safe and high-quality roads". It is necessary to create new ("know-how") concepts for managing the reliability and other most important consumer properties of the country's roads. One of these possible concepts is proposed in this article.

The concept is focused on the management of specific indicators and properties in order to ensure their values are not lower than the levels of indicators and properties of advanced world countries.

II. MATERIALS AND RESEARCH METHODS

The problem of managing the reliability and other important consumer properties of roads should be considered in two main aspects. In the first case, the task is of managing the design, construction, repair, and maintenance of roads at all stages of their service life cycle.

In the literature, such management is usually called to as reliability management and other most important consumer properties of functioning [5]. In the second, more general case, the task of managing reliability and other important consumer properties is set as a task of managing indicators in order to ensure their values at the level of indicators of roads of advanced world countries for a certain program period, for example, for a year, two, or for several stages their life cycle [6]. At the same time, the objects of management are the foregoing-mentioned specific indicators or certain combinations of these indicators and properties of a road, and first of all those for which there is a lag behind the values of indicators and properties of roads of advanced world countries [7].

The article is devoted to the second aspect of the problem.

To date, the management of various technical, technological, organizational and other systems has accumulated quite a large number of publications. They mainly

relate to the 60th ... 80th years of the last century. It was during these years that various automated control systems were created abroad and in our country. Many publications on the foregoing problem were the results of specific developments in relation to various subject areas of science, engineering, and technology.

The proposed standard technical design provides for research, analysis, and discussion of a number of methodological approaches to managing various complex systems that have been proposed by our domestic researchers, as well as foreign campaigns over the past 20–25 years [8].

These approaches are based on the use of the following fundamental methods: the method of rigid deterministic control [9] and the method of situational control [10], the method of configuration control [11], the method of embedding tasks and models with identification [12]. This also includes the method of control based on the theory of catastrophes [13] and the method of functional control [14], the method of terminal control and the method of adaptive control [15].

Based on the research conducted by the author in a typical technical project proposed for development, it is proposed to use the functional method of management as the most promising at this stage in the formation and development of the road sector in Russia. This method is based on the program – target management principle.

The essence of this management method is the integrated application of the main functions (forecasting, planning, rationing, accounting, control, analysis, regulation, feedback) to the relevant objects of management. They are concrete indicators of reliability and other important consumer properties from the subgroups of safety, durability, maintainability, operability, road speed, continuity, convenience and traffic safety, throughput and level of traffic load, permissible axial load, total mass and the dimensions of cars allowed for movement, the level of road service, ecological, ergonomic and aesthetic properties of the road [6].

As an example, let's consider the content and order of implementation of only one of the foregoing management functions: forecasting functions.

In the course of implementing the forecasting function in retrospect of reliability indicators and other most important consumer properties of domestic roads at points in time t_1, t_2 etc. up to t_N , the natural tendency of the statistical behavior of a specific indicator of their reliability or the most important consumer property x at a certain interval of pre-emption t_N, t_K is determined.

Here t_N means the end time of the retrospective in terms of reliability and other important consumer properties of the domestic road of this modification, which coincides with the time when the next modification of the road began to be developed, t_K – the end time of the development of the domestic road of the next modifications. According to the retrospectives using the least squares method, the regression equation is found – linear model, quadratic model, etc. The concrete form of the polynomial is established by the F – Fisher criterion. The obtained correlation equation is identified by estimating the mathematics expectation of a certain discrete random process that characterizes the statistical behavior of a particular indicator. According to the

numerical characteristics of this random process, the correlation function η and its analytical approximation are found. Using these data we calculated correlation interval Δ by an amount which can be distributed effect obtained regression equation to the interval extrapolates t_N, t_K .

Exactly the same actions are carried out for a certain road of this modification with indicators of roads of the advanced world countries.

The ultimate goal of the forecast procedures is to obtain point and interval estimates of specific indicators of reliability and other important consumer properties of the road at the time of the end of the design stages and the start of construction of the next modification of the domestic road.

New in this formulation of the functional control method is the using of the terminal and adaptive control, which makes it possible to drastically reduce the cost of obtaining initial information and control the process in real time [15].

III. RESULTS OF THE STUDY

Conventionally, it can be assumed that the proposed typical technical project sets out all the main fragments of a formalized presentation of planning, control and regulation procedures within the framework of the general methodological concept of program-target management of reliability indicators and other important consumer properties of a road. This ensures their values at the level of advanced countries in some program period. Formalized representations of the main management functions included in the procedures for forecasting, planning, rationing, accounting, control, analysis, regulation, feedback are implemented in the process of performing standard steps in the course of managing indicators.

In general, these stages include:

- the establishment of the most likely trends in the statistical behavior of reliability indicators and other important consumer properties of roads of this modification at a certain interval;
- development of specific plans for the implementation of the values of reliability indicators and other important consumer properties of new modifications of roads created at the level of indicators of roads of the leading world countries;
- rationing indicators with the corresponding optimization calculations;
- development of an information base and its specific structure to ensure all management tasks;
- calculation and control of indicators;
- analysis of indicators of roads in a typical road and climatic conditions;
- regulation of values of indicators of roads when detecting a tendency to go beyond the established limits;
- consistent development of programs to ensure the factor of roads.

These stages in their entirety implement the system management of reliability indicators and other important consumer properties of roads with a focus on managing their specific indicators and properties. At the same time, formalized descriptions of the main management functions allow for the system-wide management of specific indicators of new modifications of roads being created under ACS and CAD conditions.

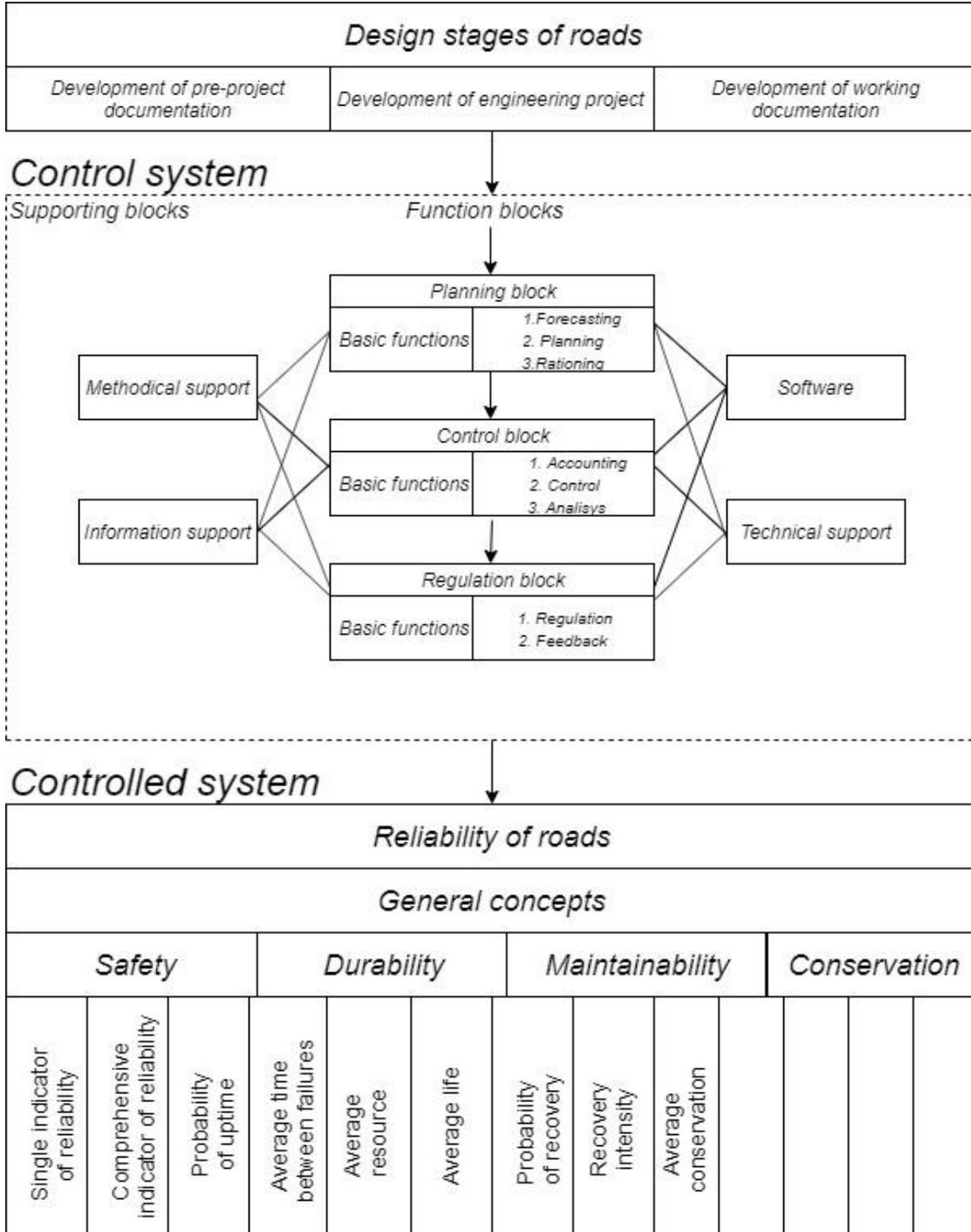


Fig. 1. Functional diagram of automated management of indicators of reliability of roads at the stages of their design

The main advantage of the system management of specific indicators of reliability and other most important consumer properties of roads using ACS and CAD is its systematic nature and sufficiently complete elaboration used in its mathematical apparatus. In addition, this approach fits well with the methodological concepts of developed automated control systems for design and industrial enterprises, as well as automated design systems for various technical objects (CAD) [16]. These important advantages of the approach proposed below make it very effective and promising in relation to the management of road reliability indicators in order to ensure reliability indicators of domestic roads exceeding the levels of reliability indicators of advanced roads of advanced world countries.

A functional diagram of the automated management of reliability indicators at the design stages of roads is presented in Figure 1. The control system of this functional diagram includes three main functional blocks (planning, control, and regulation) and supporting blocks (methodical, information, software and technical support). Their controlled systems include nodes that implement the values of the main groups of indicators of reliability of roads.

In the blocks of planning, control and regulation of this functional diagram, the control procedures for the above functions are carried out, which contributes to a fairly effective and reasonable establishment of quantitative requirements for reliability indicators of newly designed options for roads at the stage of development of their pre-project documentation and refinement of these requirements at the stages of development of their engineering project and working documentation. The specified quantitative requirements for the reliability indicators of specific categories of roads are provided during their construction [17], reconstruction and operation [18].

The development of an automated system for managing road indicators based on the foregoing conceptual model and introducing it into the process of designing, building, repairing and maintaining roads will allow:

- to increase the consumer property of these modifications of roads according to the specified indicators due to the careful study of the whole complex of the project and regulatory documentation;
- reduce the costs of the main types of resources (monetary, labor, material and temporary) for the creation and implementation of effective programs to ensure reliability and other important consumer properties by reducing ineffective design solutions, as well as reduce scrap and claims in road construction;
- to reach the world level in terms of reliability and other important consumer properties of domestic roads.

Thus, the proposed technical project presents a new concept of automated control of reliability and other important consumer properties of roads. The concept is focused on the creation of competitive highways with indicators not lower than the levels of reliability indicators and consumer properties of advanced world countries.

The project examines and analyzes possible methodological approaches to the problem, sets out specific management methods, provides meaningful and formal statements of tasks for its practical implementation. An interconnected complex of formalized tasks is proposed for fundamental management functions. In relation to this set of tasks, a system basis (typical structures of algorithmic, information and software), a technology for constructing interactive human-computer procedures and an order for creating a working draft of an automated system within an integrated ACS and CAD can be formed.

IV. CONCLUSIONS

The proposed standard technical project contains significant innovative material. Since the project is typical from the point of view of the commonness of problem statements and methods for solving them, it can be replicated on a wide range of modifications of roads. It is also possible to import a number of results obtained by the author of the project in the course of many years of research and development on this issue. These results should include the original formulation and solution of problems, the approach to managing the scientific and technical level of products created, the use of materials for certifying various products, for evaluating and managing product quality, for structuring the problems of managing various systems, processes, etc.

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