Information modeling in the context of highways property complex management

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Abstract. This article reveals the topic of the implementation of information modeling in the legislation of the Russian Federation. The world experience of creating information models of capital construction and the main features of control and standardization of BIM formation are considered. The analysis of the existing legal framework is carried out in relation to the responsibilities of organizations for the formation and maintenance of information models. The scheme of the life cycle of the model was developed. The article is related to the field of highways property complex management. The main features of the formation of BIM roads, their systematization, storage and regular updating were identified. As a result of the study, a geoportal of highways was developed for the modernization of the land and property complex management of highways. It serves as the basis for geoinformation support for information modeling, cadastral, urban planning, inventory and other works on highways. Conclusions and recommendations for the further development of this area in the territory of the Russian Federation are presented.

1. Introduction

Highways as an element of the transport infrastructure are an integral part of the social and economic life of the country. Accounting and management of highways property complex are an important process that includes the management of movable and immovable property and requires prompt collection, processing and analysis of the information about highways. This article focuses on the obligation of organizations to create and maintain information models of capital construction projects [1].

Highways include land plots, different structures like roadbed, protective structures, bridges, overpasses, pipelines, special use areas and other components. Due to the large number of accounting objects and their length, the management process becomes cumbersome. There is also a need to store not only spatial and semantic data about roads, but also 3D models of roads, bridges and other structures and related documents.

In order to modernise the real estate management process of road enterprises, it is proposed to introduce modern geo-information technology tools into various structural subdivisions of the organisations. These technologies include road geportals that provide regular data updates as well as data processing, storage and visualisation [2-3].

Now, Russia has embarked on the path of developing the geoinformation space on the Internet in connection with the introduction of the State Standard on the Spatial Data Infrastructure. At the
moment, it is the question of standardization of the development of such systems, taking into account the information models of capital construction objects.

2. Study objectives
The purpose is to study the issue of information modeling of capital construction objects and optimization of the processes of forming and maintaining information models, as well as the process of management the property complex of highways.

In the course of the study, it is planned to solve the following tasks: to study the theoretical and regulatory foundations of information modeling of capital construction objects; to determine the position of information models in the process of road management; to develop a system for optimizing the process of road management, which is a modern geoinformation system.

3. World experience in information modeling of capital construction projects
The introduction of BIM abroad began in the last century, so Singapore in the early 1990s created the CORENET project, which was supposed to automate the verification of building model designs. However, CORENET never got out of the beta testing stage, but this project prepared an effective perception of the emerging BIM technology. Now, the Building and Construction Authority is responsible for managing BIM in Singapore.

The United States of America also has a centralized management body, the General Services Administration, which is responsible for the construction and operation of buildings and structures of federal significance. In 2003, they developed a national program for the transition from 2D modeling to 3D-4D-BIM.

In European countries, the government requires strict use of BIM. For example, in the UK in 2011, a construction strategy was created, which was more focused on information modeling of buildings and structures. The requirements for the use of BIM apply not only to public projects, but also to private ones. In addition, the UK legislative bodies have taken a responsible approach to the development of common standards for creating BIM, to enable the integration and exchange of this data between different services and companies. A specialized body, AEC BIM Standard Bentley, was created to control the information model infrastructure. The Committee is working on similar standards for other applications, such as BIM ArchiCAD and Vectorworks, as well as updated versions of the standards that were released earlier.

The global experience of implementing BIM is to create a single body for standardizing the creation of models, as well as monitoring their formation, maintenance and integration into a single infrastructure. Now, Russia has taken the path of separate creation of BIM, the responsibility for their creation has fallen on a large number of state and commercial companies, but there are no common standards and requirements. The authors believe that it is necessary to adopt foreign experience and centralize the implementation of information modeling.

4. General information about information models of capital construction objects
The question of the active implementation of 3D models in cadastral construction and other activities on the territory of Russia remained open over the past decade. Although the relevant hardware and software is developing in step with foreign countries, the legal aspect of the issue began to change only in 2019.

As a result of the changes the concept of "information model of a capital construction object" was introduced by law. In accordance with the Decree of the Government of the Russian Federation, operating organizations are responsible for "forming an information model of a capital construction object" and maintaining an information model of a capital construction object. Formation is the collection, processing, systematization and inclusion the information about the object of capital construction. Maintenance is the updating of this information. Based on the definitions, we can conclude that it is necessary to introduce geoinformation systems into the process of management the
property complex of highways, since they implement, first of all, the functions of processing, analyzing and storing spatial and semantic data.

The formation of an information model is a multi-stage process, at each stage of which various information about the capital construction object is included, this process is displayed as a block diagram in figure 1.

![Figure 1. Stages of information model formation.](image)

The development of a system of geoinformation support for information models of capital construction objects is becoming one of the main tasks for road operating organizations. The model displays each change throughout the entire life cycle of a real estate object, thus accumulating a huge amount of spatial and semantic data that must be constantly systematized and stored [4-5].

Information models of highways are characterized by a large length, so only their formation becomes a difficult process, even with the use of aerial photography and mobile laser scanning methods. Since a highway can pass through several federal subjects, and an organization can manage tens of thousands of kilometers of roads, it is considered impossible to maintain information models without additional software.

This paper examines the experience of creating a geoportal of highways by a federal institution in cooperation with the State University of Land Management (Moscow). The geoportal contains data on 14 federal highways, 30 capital construction projects and more than 960 land plots. In the future, it is planned to increase the database of roads of various categories.
5. Building the geoportal architecture for the highways

Geoportal, first of all, was created for the purposes of accounting for the real estate complex of highways, as well as for optimizing the management system, but the changing legislation of the Russian Federation regularly affects the expansion of the system's functionality. At the moment, it solves a number of the following tasks:

1. organization of storage and accounting of spatial and semantic data about highways;
2. creation of registers of highways, land plots, allotments, etc.;
3. cartographic support of land and property for cadastre, monitoring, urban planning and other activities in relation to highways;
4. geoinformation support of management activities on highways;
5. formation and maintenance of information models of capital construction objects.

To develop the geoportal, Yandex.Maps API application services were used with the expectation of prompt and regular updates of map data and satellite images. The service is integrated using the JavaScript API software library. The program code is written in the programming languages Java, Groovy, Angular 6, TypeScript. All information entered on the site is stored in the PostgreSQL database [6-7]. The hypertext markup of the page is written in HTML.

The content of the geoportal takes into account the main features of maintaining the GIS of highways and is built in such a way that the system is fully understandable to the user. The modules that make the geoportal work are shown in the flowchart (Fig. 2).

![Figure 2. Logical scheme of the system operation.](image-url)

The process of geoportal operation consists of 4 main stages: information input into the system, layer-by-layer loading, information processing and displaying, information output. Let us consider the principle of operation and functionality of the geoportal at each of the stages.

First stage: Entry of information into the system. The loading of spatial semantic information into the system is made automatically from .txt and .XML format files, or by filling in boxes in the Add Information window. When manually adding an object, it is necessary to enter the following information: the type of the object, cadastral number, coordinates of specific point borders, and information on registration of rights and the rights holder. An area and a length are calculated automatically by the system using coordinates. As the registration objects are highways, which often pass through different regions of the country, a coordinate re-calculation module is implemented in the geoportal to ensure reliable data representation in the system. At present, the sources of information...
are data from the Unified State Register of Real Estate, planning-mapping materials, engineering-geodetic survey materials, technical passports for highways, etc.

The second stage is "Layer loading". Information loaded refers to this or that type of objects and therefore is displayed in the appropriate layer: kilometer poles, capital construction objects, land plots, roadside strips, road service facilities, municipality boundaries, engineering communications, topographic plans and information models. As information models contain quite a lot of data, the storage of which in the geoportal database can affect its performance, hyperlinks to cloud storages have been implemented for them. This solution is also implemented in relation to topographic plans.

In addition to the classification of objects by their type, there is a classification by the form of ownership. Each type of the object and type of right is assigned a color for a clear display (Fig. 3).

![Displaying objects in the system.](image)

The third step is "Processing and displaying information". The information is divided into spatial and semantic information. Spatial information is displayed in a vector form on the Yandex.Maps substrate, as shown in Figure 3 above. Semantic information is displayed in a tabular form in the corresponding Information window. This window contains information entered during uploading, namely: address, cadastral number, area or extent of the object and other data. Optional information window containing coordinates of distinctive points of the object is also available. At this stage the information is systematised, analysed, processed and registers of roads, land plots, capital construction objects, roadside strips, cadastral errors, intersections of roads with utilities, etc. are formed.
This stage reflects the main work of the user with the information. The system does not contain unnecessary information, so visual and geoinformation analysis is simplified. In this case, the geoportal serves as a solid basis for geoinformation support for cadastral, urban planning, monitoring and other activities in relation to highways.

The fourth step is "Information output". As the information is displayed in two formats: vector and tabular, it is also output as an image, combining the map substrate and spatial object data, and as .csv tables containing basic information on the objects of record [8-10].

6. Results and discussions
The final result of this work is an applied geoportal of highways, which serves as a basis for the creation, support and management of models for monitoring, cadastre, land management and inventory activities on federal, regional, and local highways [11-13].

This topic has been raised during the speeches at scientific conferences, in articles and research papers. Also, geoinformatics of transport is the subject of scientific works by Levin B. A., Kougiya V. A., Kruglov V. M., Baykov V. N., Dmitrienko V. E., etc.

The relevance of this topic for the Russian Federation is undeniable, since highways are the basis for the development of the economy and logistics on the territory of the state; therefore, accounting and systematization of data on highways are necessary for high-quality management.

7. Conclusions and suggestions
Geographic information systems are becoming an integral part of the life of modern society; they provide citizens and government agencies with up-to-date and reliable data on various areas of human activity. Their development is currently one of the most important issues for the state.

Road infrastructure property management systems in most cases are implemented in the form of summary tables, which are difficult to use in operational management decision-making, due to the massiveness and, in some cases, the lack of search for them. The authors suggest the geoinformation systems, as they will provide a visual display of information, the output of only those semantic data that the user requires, the connection of various departments of the organization and the effective exchange of data between them [14-15].

The legislation of the Russian Federation has been rapidly changing in recent years, primarily due to the active digitalization of modern society. The introduction of information models in cadastral,
construction and other activities was inevitable, but in terms of the technical aspect, enterprises were not ready to take responsibility for the formation and maintenance of such models. The creation of geportals similar to the one under consideration is aimed at solving these issues quickly.

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