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FORMATION OF SPATIAL DATABASES WITHIN THE SPATIAL DATA INFRASTRUCTURE

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ABSTRACT

The article is devoted to the question of designing, creating and updating spatial databases within the framework of spatial data infrastructures (SDI). The paper deals with key aspects of the development of models of spatial-temporal data based on the study of landscapes, as well as provides the main directions for updating the geospatial repository of information based on remote sensing data of the Earth.

Key words: Spatial Data Infrastructure, Project-oriented System, Spatial Data, Big Data.

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1. INTRODUCTION

In the structure of integrated information support of problem-oriented spatial data infrastructures (SDI), an important role belongs to geographical maps. Their purposeful use in combination with remote sensing data and other types of information support serves as a reliable source for building various kinds of geographic models that orient the SDI to quickly solve a specific set of tasks for territorial environmental management [1]. The solution to the problem of cartographic support for SDI is to develop principles for the selection, analysis and use of cartographic information and remote sensing data as the basis for a thematic database fund.

In this connection, when developing problem-oriented SDIs, the problem arises of creating basic cartographic software. The basic cartographic support of a problem-oriented geographic information system is defined as a certain set of mutually agreed base maps and geo-images that are subject to mandatory and long-term storage in a spatial database and used as sources of basic factual information about objects of territorial environmental management [2]. The frequency of accessing one or another of the basic elements of a spatial database is determined by the territorial features of environmental management and the specificity of the tasks solved by the system [3]. Key data flows in spatial data infrastructure are presented in figure 1.

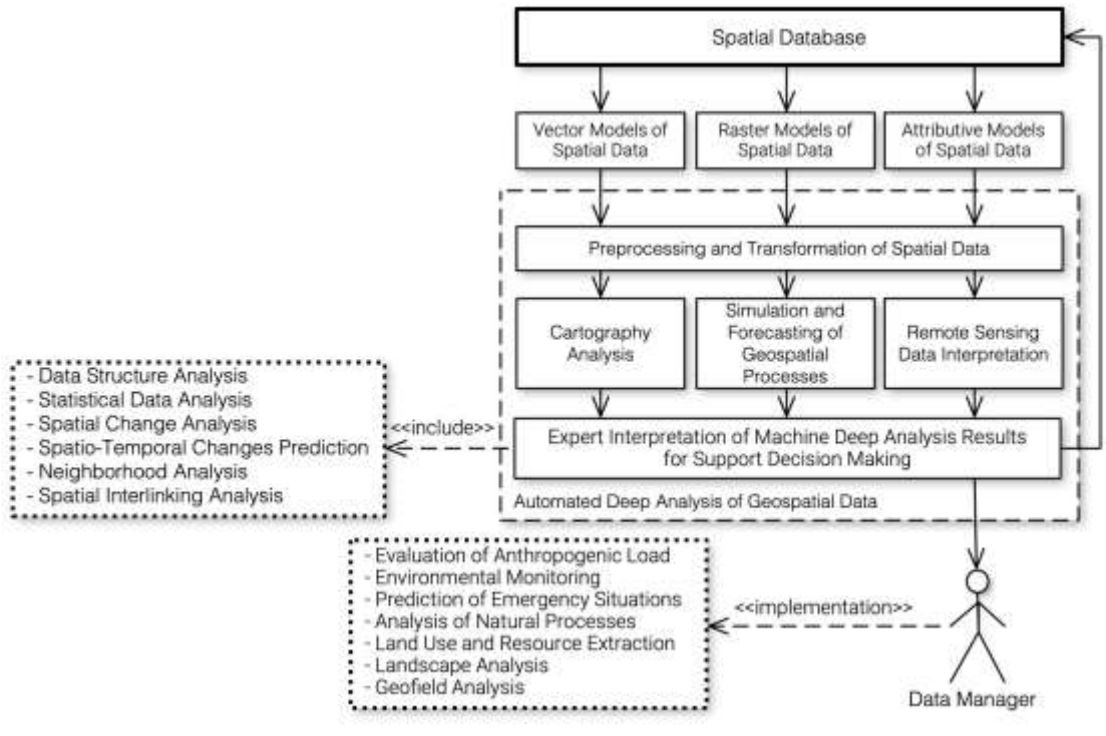

Figure 1 Data flows in spatial data infrastructure

The process of developing basic cartographic software includes the following main steps:

1) analysis of the topographic and thematic maps existing on a given territory and assessment of the advisability of involving them in the work of the system;

2) the creation of a specialized cartographic base with a multi-purpose in ensuring the operation of the SDI;

3) drawing up a series of specialized thematic base maps describing the natural resource basis of the territory for each of the blocks of the geographical model of the territory;

4) determining the sequence and frequency of accessing certain elements of the base maps in accordance with the specifics and scope of the tasks of the system;

5) development of technology input and methods for placement, storage, processing and use of basic map information SDI;

6) building a series of digital basic cartographic models;

7) determining the composition of the elements of the basic cartographic support in the output map of the SDI.

The initial stage of the SDI cartographic support is the development of the basic cartographic base of the territory. It is advisable to include general geographic objects typical for all groups of thematic maps and to supplement them with special elements emphasizing the characteristic features of the natural-economic organization of a specific territory. In addition, it seems necessary to include in the basis of the elements of the space-time reference, which provide opportunities for the interconnected input, storage, presentation and use of all the thematic information of the SDI. Thus, the presence of a coordinate grid and corresponding software determines the spatially coordinated localization of the entire set of large thematic SDI data. Availability on the basis of such general geographical elements of the locality as a hydro-network, settlements, canals, forests, swamps, intersections of roads, etc. Allows you to select the necessary reference objects that, in combination with the coordinate grid, provide geometric correction and geographical interpretation of large remote sensing data. It is obvious that the whole diversity of the complex characteristics of natural objects, which constitute the basic content of the problem-oriented SDI, makes it difficult to fully display them on a single layer of the spatial database. In this connection, the most expedient is the dismemberment of this complex into a series of specialized basic cartographic layers: relief and hydro network; natural contours and economic lands; boundaries of administrative units and land use. These elements on basic cartographic bases can be given individually or in certain combinations, supplemented by other natural and socio-economic characteristics. Thus, a block of specialized base map layers is formed, focused on certain groups of thematic maps.

Such an approach to the creation of base map layers allows to optimize the development of various thematic maps, facilitates their spatial and thematic coordination. Provides these processes with a high degree of automation. The automated creation of maps based on the use of digital cartographic foundations imposes special requirements on the latter, primarily on the modernity of their content.

The main sources of updating the basic cartographic bases are various on-duty cartographic materials, regularly updated land use plans, and state statistics.

A valuable source of territorial information is remote sensing data. Aerospace methods based on remote sensing data are now firmly established in the arsenal of geographical research [4]. Aerospace methods are effectively used to study the territorial structure, address environmental management and environmental issues, provide an integrated approach to the study of territories. Modern remote sensing methods are based on the detection of electromagnetic radiation generated by a geographic envelope. As is known, natural objects reflect or emit energy differently. This circumstance, as well as the frequency, efficiency and level of modern computer methods for processing remote sensing data, determined the effectiveness of the study and their quantitative interpretation.

Current trends in the use of remote sensing, mathematical modeling and cartographic methods perform a connecting function between the distance, cartographic and digital models of the natural environment [5]. The foregoing determines the importance of providing remote information in the base layers of a problem-oriented SDI. The set of elements of the basic cartographic and informational bases forms a framework that further provides for the binding and processing of all thematic information functioning in the SDI. In general, all general geographical and thematic maps and remote sensing data form a single information complex capable of solving problems for which the problem-oriented SDI is intended [6]. Each of these elements can directly or indirectly enter into certain management decisions, justify, supplement them. At the same time, the basic layers will participate in one way or another in the development of practically all tasks at different stages of the processes of modeling and preparation of solutions.

2. MODELS OF SPATIAL DATABASE

A model is a way of describing something that cannot be directly observed. In SDI, the key models of reality are layers of electronic maps of natural and man-made systems and the relationship between them [7]. Analysis of the centuries-old processes of economic development of the regions shows that it is successful when it is selective, focused on adapting the settlement structure, infrastructure and production activities to the spatial-temporal structure of landscapes.

In this case, the coordinating role of land surveyors is to:

1) the study of the laws of natural differentiation;

2) the formation of an adaptive-landscape farming system, in which the lands of a certain agro-ecological group are focused on the production of products of economically and environmentally determined quantity and quality in accordance with natural and productive resources, public (market) needs and the sustainability of the agricultural landscape and reproduction of soil fertility;

3) functional zoning of landscapes to streamline economic activity, preserve natural potential and healthy habitat;

4) organizing and maintaining the monitoring of the state of the land in order to prevent, minimize the development of destructive processes, develop and implement a set of measures for the restoration and protection of land.

In the XX century, the position was confirmed in natural science that the landscape shell — the zone of contact and the active energy-mass exchange of the lithosphere, atmosphere, hydrosphere, and biosphere — should be considered as the main geographical object. The lower boundary of the shell is carried out along the base of the first groundwater flow, and the upper boundary along the height of the influence of the underlying surface on the formation of the local climate. This area is distinguished by the most active development of geographical processes: weathering, exogeodynamic, hydrological, soil formation, biological processes; characterized by the highest concentration of life on Earth, the emergence and evolution of humanity and its ethnic groups.

Under the influence of solar energy and energy of intraterrestal origin, the landscape envelope is divided into landscapes (geosystems) - relatively homogeneous areas of the earth's surface, characterized by common origin, development and uniformity of interaction between surface sediments, landforms, lower layers of the troposphere with certain climatic characteristics, surface and groundwater, soil, vegetation and wildlife. These homogeneous areas, as a rule, have the same type of economic development and use.

Geosystems included in the structure of the landscape envelope have a hierarchical space-time organization. From the largest and most durable formations, which are physiographic countries (Russian Plain, West Siberian Lowland), to small and very volatile, such as sand banks on the river bank.

Systematization and classification of geosystems to develop a system of measures for the adaptation of economic activities to the structure of the landscape shell, harmonization of the interaction of natural, social and production systems and analysis of the spatial and temporal organization of natural-social production systems is carried out in compliance with genetic, historical and structural principles. The main feature of the landscape shell division into natural territorial complexes is the leading landscape-forming process.

The most common typological classification of landscapes was proposed by V. A. Nikolayev [8]. It uses such bases of division as the type of contact and interaction of the geospheres, the belt-zonal differences of the water-thermal regime, the morphostructure of a higher order, the type of the water-geochemical regime, soil-bioclimatic features, the genetic type of relief, the lithology of surface rocks.

The landscape envelope is an arena for the development of economic development processes - the saturation of geosystems with various anthropogenic structures, due to which the formation of a certain structure of lands and geotechnical systems results. Within the framework of this question, the formulation of K.P. Kosmachyov, who writes that “the society is always the active side, determining the type of development of the territory, is always relevant. But the result of development largely depends on the natural basis of the territory, on how it "takes" the impact of society, how much it is able to accumulate the results of human labor and save them for a long time. Therefore, during the development of the territory, it is necessary to compare two groups of interrelated processes of production and natural. The development of the territory depends on the combination and interaction of these processes, during which the basis is created for the distribution of productive forces” [9]. It is necessary to emphasize that experts in the field of land management explicitly emphasize the links between the efficiency of economic land development and social, political, economic and environmental factors [10]. In this regard, it is advisable to study the issues of economic development of land, based on the assessment of development and the correlation of its values with the optimum at each historical moment.

The generalized process of land development is embodied in specific types of development - spatially limited forms of human activity, which are formed by land use structures. When creating a classification of types of economic development, it is necessary to take into account the existing knowledge about the sectors of economic production and the formation of classes of man-made landscapes.

At any stage of the development of the territory as a result of the interaction of natural and technological processes, a specific structure of land use is created, accompanied by the activation of a specific spectrum of destructive geoecological processes, the features of which almost always result from the properties of the surrounding natural landscape [11]. Negative consequences of development can be noted outside the zone of the actual location of man-made systems (for example, depletion of groundwater and surface water, environmental pollution and the like). At the same time, the features of the development of economic development processes are currently characterized by the deployment of new stages of development on man-made modifications of geosystems of past periods [12].

As a result of preliminary experiments and the initial synthesis of materials, it was accepted that the SDI for assessing the functioning of natural and natural-man-made systems it is advisable to distinguish the following groups of models:

- *“Natural Systems and Processes”* reflects a set of interrelated components the lithogenic base, air masses, natural waters, soils, vegetation, and animal world. Electronic models characterize the real, energy. informational properties of natural components: digital elevation model; geology, tectonics, hydrogeology, endogenous and exogeodynamic processes; climate, surface water and hydroclimatogenic processes; the structure of soil and plant cover, elementary soil-forming processes, the spread of rare and endangered plant and animal species.

- *“Population”* includes geographical location, fertility, mortality, migrations, age and sex structure; ethnographic maps (national composition, national culture); state and trends in the medical-demographic situation.

- “*Economy”* – industry - history and modern geographical location, characteristic of power or value of industrial centers; placement of agricultural production, its evolution in terms of expansion (reduction) of agricultural land of various types, the intensity of agriculture and the prospects for its specialization; the territorial location of the communication lines (railways, road network, air transport lines with a characteristic of their value, freight traffic, etc.), as well as oil and gas pipelines; observational networks and landfills for environmental monitoring.

Analytical maps of the interaction of natural, social and industrial systems. This block of the spatial database consists of digital models of the geofields on a regular rectangular grid. This form of presentation is most convenient for recovering an indicator at any point in a digital model, its cartographic display, mathematical statistical processing, and spatial modeling. Since the initial data on the distribution of phenomena over the territory of the region were sets of indicator values at irregularly located points, it was necessary to perform modeling of indicators at the nodes of a regular rectangular network. Interpolators based on the known methods of kriging and spline were used for this.

The advantage of these interpolators is that the characteristics of the reconstructed surface give a good approximation to the similar characteristics of the original surface. This block includes the following digital models: digital model of the relief of the surface, digital model of the buried relief, digital models of basic surfaces, digital models of residual relief, digital model of gully dissection, digital models of beam, valley and hydrographic dissection, digital models of the depth of dissection, digital models density of the river network.

3. STRATEGIES OF SPATIAL DATABASES ACTUALIZATION

At present, remote sensing data (RSD) is the most operational source for obtaining large geo-information data. Therefore, they are the main source for keeping the spatial database up to date, especially if the relevance factor plays an important role (disaster control, environmental monitoring, assessment of natural conditions and resources, etc.). It is necessary to state the trend of mutual convergence of GIS technologies and technologies of remote sensing data processing [13]. Modern technologies for remote sensing processing are based on digital image processing methods and involve a number of basic steps:

- import of remote sensing data from various sources;
- geometric correction and coordinate reference of images;
- combining of several images in order to obtain a holistic picture of the studied territory;
- spectral correction of the synthesized image in order to improve its quality and bring different characteristics of the original images into a single system;
- automated classification of holistic image objects and their grouping by spectral properties and image structure.

The above-mentioned digital methods for processing remote sensing data form the basis for the application of GIS technologies for spatial analysis and modeling of the geographic shell during territorial environmental management. Such a complex technology is the most promising, since it helps to expand the possibilities of problem-oriented GIS as systems for processing and analyzing spatial data.

The effectiveness of the analysis increases significantly when using the database, which stores a variety of data obtained at different stages of analysis. One of the trends in the development of geoinformatics is the enhancement of the functional capabilities and intelligence of SDI and GIS technologies. The development of functional capabilities of SDI is a requirement of a modern scientific approach to the assessment and analysis of the geographic shell and leads to broader prospects for the use of SDI with the support of managerial decision-making. Expansion of the functionality of the SDI in the processing and analysis of information includes:

- a set of methods for automated processing and accumulation of data;
- a set of methods for analyzing and extracting knowledge;
- a set of methods for the interpretation of knowledge;
- automated data and knowledge update.

Issues of expanding the functionality as the basis of intellectualization in spatial analysis should be solved in problem-oriented SDIs.

All the wealth and diversity of the world represents a huge amount of information. It is almost impossible to fully display all of this, so they resort to a certain amount of generalization and abstraction, that is, all the wealth and diversity of the surrounding space lead to the creation of certain models, that is, to a finite amount of some natural objects and properties.

Historically, vector and raster forms are used as models for creating SDIs. In vector models, the entire space is represented as lines, points, and polygons, and in raster models, in the form of cells, which can be regular and irregular. Raster models indicate what is in a certain area of space, and in the vector where it is. Features of vector data in SDI:

1) in vector models it is easier to carry out operations with point and linear objects, if a point object in a raster format is represented as a whole cell, then in a vector format it is just a point;

2) the accuracy of vector models is higher. Vector data can be encoded with any degree of accuracy.

Raster data is formed by overlaying a rectangular or other mesh on the surface under study. The presentation of attribute information in raster models is carried out by cells, it can have a value of both numeric and alphabetic. Advantages of raster data in SDI:

1) data is collected evenly throughout the study area, hence the high objectivity of the original data;

2) raster models are easier to process than vector models, since the entire image is formed line by line over cells;

3) raster models are used to create buffer zones, that is, for analysis.

Production of digital models (DM) in modern conditions is a multi-step, relatively long process, in which cartographic information from a graphic form is converted into digital, recorded on machine-readable media, subjected to repeated processing and structuring. This process involves a large number of performers of different specialties, a complex set of hardware and software. In this regard, the occurrence of errors in the manufacture of DM is inevitable, since it is due to the complexity of the system and the variety of factors that have an impact on it. It is obvious that the main indicator of the quality of DM is its reliability - the degree of accuracy (non-distortion) of receiving, transmitting, processing and storing in the system of cartographic information under given conditions of its operation.

Analysis of the reliability of DM is a prerequisite for the sound design of control methods. The reliability of DM is an integral assessment of the level of errors, regardless of the reasons for their occurrence, and acts as a general measure of any errors. Control of digital cartographic information (DCI) by visual comparison of its copy with the original map materials is designed to identify errors in all previous stages of creating a digital center and thereby ensure the necessary level of product reliability. Therefore, the reliability of DM is most critical to the errors of the type of work under consideration. If the errors of other stages can be detected in the control process of the central control panel and eliminated, then the control errors directly fall into the output. Interpretation involves comparing perceived visual information from a reference document and from a controlled document and recognizing discrepancies that exceed permissible ones. Interpretation errors may occur due to insufficient operator knowledge of both cartography and the requirements for DM.

Thus, when developing methods for controlling the quality of the DM, it is necessary to take into account the factors set out above, as well as the following basic requirements: the reliability of the results of the monitoring, i.e., the ability of the methods to correctly reflect the real state of the DCI; speed, i.e. the speed of evaluation of monitored parameters; control efficiency, i.e. its accuracy and control costs.

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