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TOPOGRAPHIC MAPS IN THE SYSTEM OF THE NATIONAL SPATIAL DATA INFRASTRUCTURE: PROBLEMS AND PRACTICAL SOLUTIONS

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At present, many countries of the world have generated their national spatial data infrastructures (NSDI). Some countries have already gone through all stages of building an NSDI from working out the concept up to its implementation, others are still working on their programs or completing them. International cooperation in the sphere of NSDI integration is extending. The creation of an organization for promoting NSDI building – The Global Spatial Data Infrastructure Association – bears witness to the importance of the issue world-wide. Generally, by the spatial data infrastructure it is usually meant an information and telecommunications system, but the routines and tools of the system can have their own peculiarities in each country. Thus, the map component has become an essential element not only in the NSDI but also in building information-oriented society. We will consider in detail the role of topographic maps in the NSDI and the main problem connected with their updating – the problem of topographic monitoring.

In Russia, the concept of building and developing an NSDI was adopted in 2006. It singled out goals and objectives and the main principles and directions of activities in the field of building an NSDI. It considers the NSDI to be a territorially-distributed spatial data gathering, processing, and delivering system. The necessity of an infrastructure like that stems from the continuous growth of the number of tasks requiring information in the digital format, the spread of geo-information technologies, the development of information and telecommunications networks, and the Internet. The building of such a system is supposed to integrate the state information resources and construct common information space of the country. It is only possible through the basic component. The basic component is taken to mean available digital data on various objects and features, they being a) – distinguished with their stability in space; b) applied very often to solving various problems; c) used for referencing other objects and features. topographic maps meet these requirements perfectly.

Nowadays, the system of the basic topographic products of Russia consists of: - topographic and geographic maps of scales from 1:25 000 to 1:1 000 000; they are available for the whole territory of the country at present;

- 1:10 000 scale maps; they cover all industrial and farming areas;
- topographic maps of sea water areas , i.e. sea shelves and inner basins;
- specialized topographic maps and plots to various scales;
- topographic maps and plots to scales from 1:2 000 to 1:5 000, made for all cities, towns, urban settlements, and industrial areas; plots to scales from 1:500 to 1:1 000;
- digital maps to scales 1:100 000, 1:200 000, 1:1 000 000, made for the whole territory of Russia. The efforts are being increased to produce digital maps and plots of scales 1:50 000, 1: 25 000 and larger ones;
- state digital navigational charts for motor transport (federal information resources) in scales 1:10 000; 1:25 000; 1:100 000. On the basis of topographic maps and plots a few series of open use maps are produced, among them: a series of geographic maps of scale 1:500 000; regional topographic maps of scale 1:200 000; a series of «General Geographic Maps of the Federal Subjects of the Russian Federation» within a range of scales from 1:200 000 to 1:1 000 000; a series of «The Topographic Maps of Russia», «The Maps of Cities and Towns of Russia». The topographic maps and photomaps of the Antarctica in scales 1:100 000; 1:200 000; 1:500 000 and 1:1 000 000 are unparalleled in their accuracy and details to foreign maps.

The strictest requirements are placed upon all topographic maps as the most in-demand state information resources for all user classes. Due to that one can distinguish two most important problems in the NSDI building and development:

1. Updating (up-to-dateness) of the state topographic maps as the basic component of the NSDI;
2. Creation of a common open digital map basis in the form of digital topographic maps and plots, photomaps and orthophotoplans; implementation of new procedures and technologies for informational interaction at different levels (federal, regional, municipal) in an effort to update the basis.

Creation of a common basis is directed at 1) - its application to special, thematic mapping; 2) - reduction or elimination of redundant map activities on a national scale; 3) - compatibility of the information

resources obtained from other sources, their integration and joint use in solving state, municipal and other problems.

It is easy to notice that the both problems are closely interrelated and the solution of the latter one is impossible without the former. And since the physical ageing (due to changes of the terrain) and obsolescence (inconsistency with the scientific and technical level, the ideal map standard) of maps are taking place permanently, thus the problem of their updating, making them up-to-date also exists persistently. The solution of the problem is to arrange for a continuous updating of maps through state topographic monitoring. This is a prerequisite to make map products conformed with the world standard requirements. Let us consider the conceptual model suggested by the authors.

Topographic monitoring or topographic map updating is a pressing and cross-cutting problem of today. As a rule, by monitoring we usually understand the awareness of the state of the environment, its changes in order to streamline both nature management and land management. It is a multipurpose information system. Its basis is made by aerospace surveys materials (data from their processing), a network of ground-based observations, map information making it possible to keep track of changes in the environmental state through maps for expeditious decision-making (a map unit, a map monitoring subsystem). Types of monitoring differ in spatial and temporary coverage, methods and purposes, monitoring objects. Any component of various spheres of the geographical envelope can become an object for monitoring.

But the learning begins with studying the visible part of the Earth's surface available to direct observation (including from space), that is the exterior “face of the Earth”. This includes: forms of its surfaces (relief), water bodies, vegetation cover, soils, human settlements, communication lines (both land and water ones), administrative boundary lines, monuments of nature and culture. It is the representation of these objects that makes us choose the topographic map as the one that provides us with the basic information for monitoring of any type as well as for solving other multiobjective problems.

Topographic maps are a source of different time and spatial information containing data of remote sensing, statistics, versatile data on natural and social and economic entities. Thanks to high accuracy of horizontal and vertical map control all the objects to be studied can be valued by a lot of parameters: their location (coordinates), sizes (length, area, volume, height, depth), orientation (exposure, angles of slope), shape (general outline, oblongness, tortuosity, camber), density (thickness, concentration), relief roughness (common, vertical, horizontal). These metrical properties are closely related with genetic and dynamic features and the processes determining the character of a geographical system development. Natural-and-territorial complexes are mapped on topographic maps to different scales. Scientific studies with their help can be made on various level, which depends on the map territorial coverage, the level of their detail representation and the purpose of the study as well as the scale of the map or a set of maps.

Topographic maps allow one to obtain derivative characteristics (morphometric ones, percentages of forest land, plough land, swamps, karst caves) for various types of investigations. In a target analysis of non-uniformly scaled maps, typological features of nature are spotted, the organizational level of a farm or an enterprise, structures and complexes of different levels that are hierarchically subordinate and built in each other (local-regional-federal-global), which leads to theoretical generalizations and conclusions. That is, in the development of theoretical, methodological, organizational bases for any type of ecological monitoring (geologic, geographical, biological, biospheric, ecosystemic, social, etc.) there is always available a topographic aspect , and so is in its implementation. The significance like that of topographic maps emphasizes even more the importance of topographic monitoring.

In our understanding, the State Topographic Monitoring is a system of continuous state- regulated tracking of changes of objects of a terrain and their continuous registration on the map. (When making up-to-date changes all the modern horizontal and vertical map control requirements are to be met in full, which needs sometimes examination and evaluation of the state of the Governmental geodetic network control points).

Topographic monitoring is connected with state topographic maps and is to be done on a nation-wide level ensuring a high quality of maps. Governmental support and financing play a significant part, especially at the first stages of implementing the project. In a further course of monitoring and its successful implementation in the form of highly sought-for certified products it will be possible to make it commercial , but still keeping the regulating function of the state.

Time-and-spatial changes of geographical features are the elements of state general-purpose topographic maps that can serve as monitoring objects.

The conceptual idea of the authors, unlike to available conceptions and experience in map updating, is that by topographic monitoring we will understand not only bringing maps to the conformity with the present

state of the terrain but also its being a tool for increasing the information level, the semantic contents of maps on the basis of the latest space surveying, new methods and technologies of image processing.

Thus, the scientific basis of monitoring will constitute:

- adjustment of the system for expeditious obtaining of space images with high resolution, for their geographical interpretation (and systems for data gathering from other sources);
- working out an atlas of standards of topographic interpretation of space images (in the interactive and automated modes);
- adoption of basic and derivative (generated in automated production) scales of continuously updated maps;
- development of methods for an expeditious assessment of the level of the modernity of maps and the sequence of their updating;
- substantiation of a stand-by topographic map, the procedure of its making and keeping;
- determination, unification and standardization of the information support, technologies, hard- and software and technical characteristics of necessary information;
- formation of legislative norms and standards and regulatory and technical support;
- learning of potential users' requirements to topographic information and its delivery in required formats, including GIS- applications.

This monitoring is indispensable to all succeeding scales of topographic maps. In Russia, however, it is of special importance for the scales of 1:100 000, 1:50 000, 1: 25 000. Maps of scales 1:100 000 and 1:25 000 are the basic state maps on the whole territory of our country, 1:50 000 scale map is the basic "tactical" map of a majority of countries of the world.

State topographic monitoring is supposed to become a constituent (basic) component of the NSDI of the Russian Federations. Topographic maps quite meet the requirements to its basic component, which is confirmed by the practice of traditional multiobjective use of the information contained by topographic maps and plots (including city and town plans) and in geodetic and leveling networks.

Inherently, topographic map updating is a complex process including numerous stages and various scientific, methodological, technological aspects. In the system of continuous map updating - topographic monitoring - we can identify a number of interrelated segments: a) – a geographical one, b) – a space one, c) – a map one, d) – a satellite navigation one, e) – a geo-information one.

The all together make an integrated system ensuring the processes of gathering, processing original information, machining, its documenting, checking up and generating output products on the basis of common scientific principles, unified methods and technologies for digital map-making, remote sensing of the Earth and satellite navigation.

The Geographical segment. The contents of the work envisages the awareness (learning) and representation of natural and social and economic peculiarities of the Russian terrain to be mapped of Russia and those of a particular geographical object, as well as the specificity of regions, including locality changes on updated (from the data of the State topographic monitoring) maps.

The Space segment is aimed at working with non-simultaneous materials of remote sensing of the Earth in order to establish a sequence for map updating and for updating maps of some particular region. In developing this aspect there should be established requirements to space information obtained from spacecraft (systems of optical-electronic and radar observations), as well as defined methods and technologies for processing space information in order to building the State topographic monitoring system.

The Map segment ensures the representation of topographic monitoring results in full on the master copy of changes, on the digital stand-by topographic basis (in a map form) and in the database on changes of the objects of the terrain (in the form of semantic descriptions), and in other forms of map representation of updated information.

The Satellite Navigation segment is aimed at coordination and time referencing of both the terrain objects changed throughout the region field investigation by the State topographic monitoring and control and fixed points for making orthophotoplans.

The Geo-Information segment. Its basic purpose is automation of monitoring processes, insurance of compatibility with special geo-information systems and GIS-technologies in making digital map products, insurance of unity in the metrical and semantic descriptions of spatial objects, usage of common data formats for a unified digital map basis.

Each of the listed segments has its own spatial information resources, is realized technologically in the State topographic monitoring system organization structure, formed and functions in accordance with the

general legislative norms and standards and regulatory and technical support, has specific features in its technology, engineering and software.

Any monitoring system is presumed to build and arranged for organizational interacting of certain base units - participants of the system.

The state topographic monitoring is to be one of the areas of the activity of the federal enforcement authority in the field of geodesy and cartography, now it is the Federal Service for State Registration, Cadastre and Cartography (Rosreestr). It is specified by the Federal Law «On Geodesy and Cartography». Rosreestr headed by its administration – the central body of the State topographic monitoring system - has large powers in the field of organizing, adjusting, coordinating, managing and controlling all types of activities, including determining the financial policy (order) of proving and using information services.

Other participants of the system are enterprises and organizations functioning historically in this field and operating today. They make scientific and manufacturing facilities of the cartographic and geodetic industry, having their traditional profile of activity. In order to integrate and use jointly spatial data from all sources available in the state interdepartmental interaction is supposed to be on different levels - federal, regional, municipal ones.

On the *federal level* the activity is to be carried out by basic legal entities allotted scarce raw materials of topographic information and other industry ministries.

The basic informational-analytical centers are to be organized on the same level. They are to execute: a) - external functions on the federal level and b) – internal ones on the regional level, namely: a) - to plan the sequence for the State topographic monitoring; organize information interchange, control the process and b) – to do and coordinate the monitoring (gather materials, process them, document, build a metadata basis).

On the *regional level*, the basic participants of the monitoring system are territorial operating control bodies of Rosreestr. They are to be granted the status of the regional informational-analytical centers. They are meant to ensure information interaction between regional services of the industry ministries and the administrative bodies of the subjects of the Russian Federation, to share available spatial data. The main map updating activity is executed by the enterprises of Rosreestr.

On the *municipal level*, the regional centers will cooperate with the administration bodies of regions, cities, towns, and other human settlements.

The results of the State topographic monitoring system work will depend in many respects on the character of the participants interaction on various levels. Therefore, an Interdepartmental Coordination Council will do quite well in its hierarchical (three-level) structural system. The Council will control the system activity on the interdisciplinary and inter-regional levels. Besides, the main operator and the main coordinator is envisioned to be available within the industry.

Fully up-to-dated information is supposed to be collected in a Geo-portal proving a wide range of geo-information services. Information will be transmitted to users from it as a state service.

Data traffic of different levels is suggested to be implemented as part of electronic document circulation according to the legislative standard-legal and technical regulation.

Different levels of the monitoring system organization are caused by its stages and types: surveying monitoring – on the federal level, detailed and completing one (complete updating) - predominantly on the regional level.

Surveying monitoring is aimed at: a) - determining regions with a high level of changes (20 %; 50 %; 80 %) from non-simultaneous space images with a resolution ~ 10 m; b) – a complex analysis of provision of the country with digital topographic maps in view of the level of their modernity, working out a provision chart; c) – Making a monitoring plan (establishing its sequence); d) – planning space surveying, developing requirements to it or purchasing materials with a resolution of 10 m and 1 m (for subsequent surveying and detailed monitoring, respectively). The work will be executed by the basic informational-analytical centers (within the limits of their territories) under the coordinating activity of the central body of Rosreestr.

Detailed monitoring is focused on mapping changes in the regions specified by the plan drawn up at a stage of surveying monitoring from the results of interpreting space images of high resolution (of an order of 1 m) with the usage of all other available information sources. The work will result in: the digital stand-by topographic basis, the master copy of the changes, a database on the object changes of the region. The work will be done by territorial bodies of Rosreestr within the limits of their territories of the subjects of the Russian Federation under co-ordination and methodical support of the basic informational-analytical centers.

At the completing (*3^{d}) stage*, a particular complete map product will be compiled and designed, it might be an updated topographic map (a navigation chart) in a digital and analogue format, including custom-tailored ones.

In the general production technology of the State topographic monitoring system there can be singled out three integrated units: collection and analysis of original information; its processing; creation of output products with continuous on-line information exchange between the participants of the State topographic monitoring system and users of the output products in the certified forms. A majority of processes and operations will apply the GLONASS/GPS innovative satellite technologies as well as the Internet technologies (electronic information exchange with the FTP server).

As it has already been mentioned, the monitoring system functioning is envisaged by legal acts defining its element interaction. Besides, a technical order (standards, certification system) and normative and technical (soft- and hardware, information, technology) provision are being developed at present.

The monitoring concept envisions conducting a geo-map audit, its main objective being a really independent estimation of the state of the activities in this field as a whole and of the component processes of it (before, after and throughout the system implementation activities).

Thus, we consider the nation-wide system of topographic monitoring as a new, scientifically formulated type of the activity on a state-of-the-art level of development and integration of geosciences. The concept stated shows various aspects of monitoring, including, that is especially important, scientific aspects, ensuring generation of the topographic map as an information model characterized by high richness of its contents, geographical conformity, completeness, authenticity and, of course, modernity.

The presentation is illustrated with flow charts of the State topographic monitoring system:

- Organizational-functional structure
- Integrated technological units,
- Stages and types of the State topographic monitoring,
- Legislative and standard basis,
- Geo-map audit.