Application of space information for updating and improvement of topographic maps

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ABSTRACT

Topographic maps are of fundamental importance since they provide comprehensive, precise and complex information concerning landscape elements. All countries now consider the complete topographic map coverage of their territory as being essential for the rational use of natural resources and economic development, as well as for environmental monitoring. The author proposes a scheme for the improvement of object classification in the compilation of topographic maps.

1. INTRODUCTION

We understand space topography as being the measurement of all objects on the Earth's surface taking into account their spatio-temporal properties and relations, remotely recorded through the ratios of their own and reflected radiation. Values acquired from space data are determined by spatially-localised, image-visualised information represented in graphical form on an image, map or display screen. A topographic map possesses a most comprehensive, precise and complex representation of information, depending on the combined representation of visual natural and cultural landscape elements, interacting through their location, together with the characteristics of each element.

2. IMPORTANCE OF TOPOGRAPHIC MAPS

Topographic maps are of fundamental importance since they depict the true nature of a given terrain by map elements obtained using instrumental and field investigations. The most iimportant properties of topographic maps are: high accuracy of horizontal and vertical control networks, the ability to show landmarks and the current situation, contents matching of the whole scale-set of maps, the presence of qualitative and quantitative characteristics of objects, the ability to show various types of administrative boundaries and natural border lines, and reliability when carrying out measurements and estimations. Topographic maps are of great importance when solving ecological impact issues, since they make it possible to derive certain characteristics and to draw up maps giving the morphometric properties of forests, ravines, swamps, etc., indicating the anthropogenic stress on the environment.

At a higher level of utilisation they form a basis for theoretical conclusions and the development of map sheets. This is why all countries consider the topographic map coverage of their territory to be an important condition for the complete and rational usage of natural resources and their economic development. A specific role is assigned to topographic maps as a basis for general geographic and thematic mapping.

The complexity and universitality of their contents, together with their high measurability, make topographic maps the major source of information at governmental level. In most countries they form the major part of the map database used for obtaining not only topographic but also resources, ecological and cadastral information, as well as for creating GIS. Such a wide range of applications obliges those responsible for their creation to update them constantly and increase the richness of their information content.

Map coverage of the world is continuously improving. Mapping is carried out at an increasing rate and within a wide range of scales. Moreover, maps available vary considerably with respect to their purpose and techniques of compilation and revision. New types of maps appear. Mapping for the purpose of the world ocean and inland water bodies exploration has generated bathymetric maps of shelf, rivers, lakes, reservoirs etc. along with land maps. The increasing requirements of various sectors of the economy as to the contents, compilation rates and quality of topographic maps has resulted in the division of topographic maps (of both water and land areas) into basic and special-purpose ones. A separate type of products with respect to information representation is "topographic photomosaics". Topographic surveying information can also be presented in the form of digital models. The variety of operationally-produced and experimental topographic maps is illustrated in Figure1.

3. TOWARDS UNIFIED MAP LEGENDS

Among the main inter-related topographic activities should be singled out the various scales of the multipurpose topographic maps that form the existing unified systems in each country (national map systems). Among these maps are those compiled according to the traditions of the best cartographic schools; the maps are complete and perfect with respect to their contents and appearance. However, systems of symbols and signs on the maps are composed of sets which have developed empirically, that is by a gradual increase of their number or by entering changes into signs of separate objects or groups of objects but without a comprehensive analysis and scientific substantiation. We suggest that topographic map contents should be defined from the system standpoint *as an integral, comprehensive, hierarchically arranged system of data about visible natural and anthropogenic objects and phenomena, their typical properties, relations and links. This system is represented by symbols and signs which correspond to the classification of map objects* (Figure 2).

Hence, there is a need to elaborate a unified system and structure of topography based on modern Earth sciences classifications, including nature, nature protection and the level of economic development of a territory. All parts of the system (contents components) require scientifically based criteria for classification and systematisation of objects to reveal their genetic and logical unity. An integral, logically organised and dynamic system of mutually subordinated notions (and signs and symbols), which are classified according to a certain logic, can be easily subjected to further changes and supplemented without changing the structure of the legend as a whole. *That is how the problem of improvement and unification of topographic*

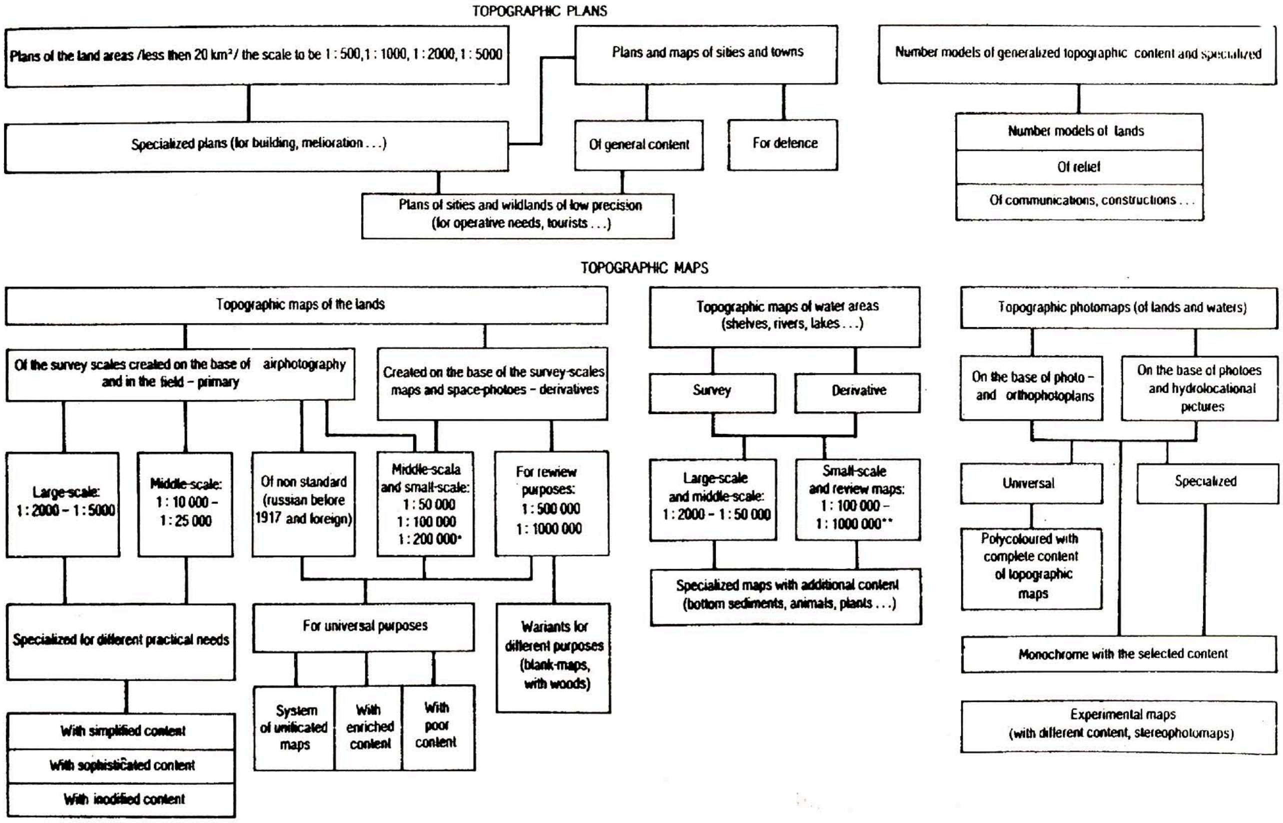

Figure 1 - Topographic maps (classification)

** First edition of maps 1:100 00 and 1: 200 000 was compiled by means of survey.*

*** For off-shore and deep sea areas (for depths of more than 200m) scale 1:100 000 is allowed.*

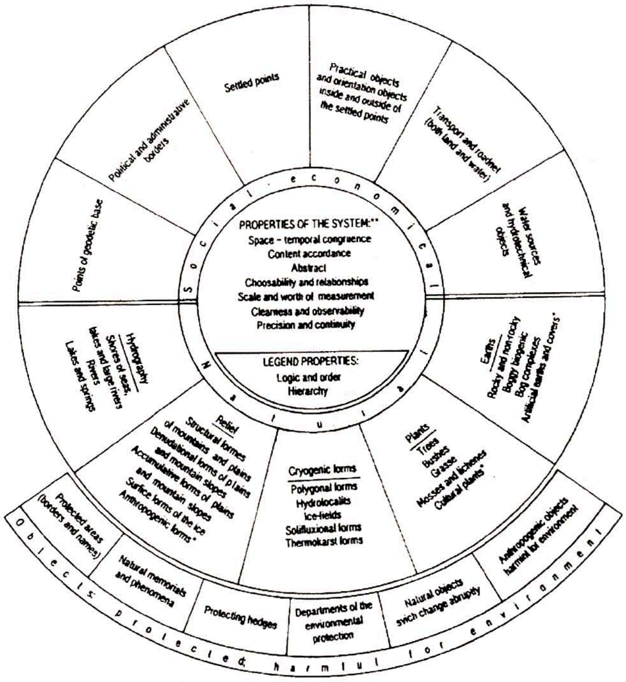

Figure 2 - Graphic model illustrating contents systems of topographic maps (mapped objects – social, economic and natural – are represetned by groups according to the contents sections
** Objects originated and developed mainly by the anthropogenic influence are marked with selected colour.*
*** Properties of the system are given according to Prof. A. M. Berlyant.*

map language can be solved, thus contributing to the theory and practice of general cartography.

4. IMPROVEMENT OF TOPOGRAPHIC MAP LEGENDS

Such an attempt has been made by the author. A uniformed system and structure of the contents of general topographic maps is suggested. Figure 3 shows object classes and principles for their grouping.

5. SPACE IMAGERY FOR TOPO MAP IMPROVEMENT

The following general directions of map improvement from space imagery can be given:

- expansion of maps with new objects and characteristics if of special practical value and with well-defined identificational attributes;
- enrichment of maps with new objects and indices revealing genetic and regional differences, dynamics of phenomena and their cyclicity over a long-term period; such

OBJECT CLASSIFICATION IN TOPOGRAPHIC MAPS

Object classes	Basis for object classification and grouping (within a class)
Geodetic network	Orders and types of networks
State and administrative borders	Political and administrative division
Settlements, buildings their parts	Type of dwelling. Population density. Political and administrative importance. Character and types of buildings. Their cultural and historical importance
Economic objects and landmarks (within and outside settlements)	Economic importance. Specialization. Landmarks properties. Nature preservation importance °
Transport. Railway and road network and transport water	Transport types. Railway and road classes. Coverage. Technical provision. Exploitation readiness. Facilities of facilities on land and various purpose (for air, land and water transport)
Water supply and hydrotechnical objects	Types of water supply objects. Periods and volume of water supply. Water quality. Purpose and types of hydrotechnical constructions.
Hydrography Ocean water	Types and sizes of hydrographic objects. Water regime, properties and dynamics. Usage and protection. Morphology and genesis of banks and shores.
Land and shelf relief. Anthropogenic forms	Type, genesis, morphology. Dynamics indices. Morphometric characteristics.
Snow and ice and permafrost formations	Type, genesis, dynamics, morphology.
Vegetation (natural and cultural) Bottom flora and fauna.	Living forms of natural vegetation. Changes caused by natural or anthropogenic impact. Agricultural and technical plants and crops. Species signs, habitat.
Soils, bottom sedimentation, artificial coverages. Swamps and salines	Soil types. Stability, degree of destruction and passibility. Genetic types, granulometric composition, sizes of bottom sedimentation.

enrichment is very important when maps are used for prediction purposes;

- system representation of territorial/environmental complexes by means of the combination of symbols; such representation involves the scientific simulation of spatial composition of the complexes; the composition reflects typical characteristic properties, origin, internal ties and outer structure of objects spatially related to each other with respect to terrain as observed in reality or on images.

One of the most important trends in research for the improvement of topographic maps is the elaboration of a new spectrum of the map contents intended for the solution of ecological problems and the implementation of nature protection projects.

Taking into account the fact that topographic maps are used for nature protection purposes, it is advisable to enlarge their contents in order to depict the objects and attributes that provide a detailed description of natural landscape conditions and changes, anthropogenic influence, etc.

6. UPDATING OF MAPS USING REMOTE SENSING TECHNIQUES

Problems related to the topographic coverage of a territory can be solved on condition that maps are updated. The problem of revision is particularly important for those countries that are carrying out their programmes of primary mapping of their territory or are reaching the completion of their programmes. Map revision is made as a rule on the basis of new aerial or space surveys.

In Russia some topographic maps (TM) are updated only after 20 years or more. This time problem arose in the Sixties, when the whole country was covered by 1:100 000 maps. In 1988 a 1:25 000 map of the former USSR territory was finished. Its 300,000 sheets represent unique information which needs constant updating as the work began in the early Fifties.

The whole territory is covered by 1:25 000 to 1:1 000 000 topographic maps, about 30% of it is covered by 1:10 000 maps. 70% of the stock available needs updating. It will be necessary to delineate the border lines of Russia with its former Union Republics and other countries in the near future. The total lengts of the Russian State border line is 70 000 km, including islands and it should be shown on a topographic map depicting the present situation of the territory.

Scales of aerial and spaceborne images used for the production of topographic or photomaps range from 1:2 000 to 1:1 000 000, the main ones being: 1:25 000 for the whole country; 1:10 000 for prospective developing and farming; 1:5 000 and 1:2 000 for cities and settlements. Updating of topographic maps should start with these scales, but the goal is to update all scales (within the boundaries of a certain territory) with the optimum combination of aerial and space images. The State administration which is still governing the prospecting of natural resources and environmental monitoring makes good use of remote sensing in visible optical, IR, UH- and radiofrequencies. The Kosmos-series satellites with KFA-200, KFA-1000, SA-M cameras aboard giving most information in panchromatic and spectral band (up to 6) images of 18 x 18 cm^2 and 30 x 30 cm^2 formats with 5 m to 8 m spatial resolution.

The relationship of map scales and space images is as follows:

Maps	Images	Cameras:
1:1 000 000	1:1 350 000 to 1:1 700 000	KFA-200
1:500 000	1:800 000 to 1:1 000 000	SA-M
1:200 000	1:600 000 to 1:800 000	SA-M
	1:270 000 to 1:340 000	KFA-1000
1:100 000 to 1:25 000	1:200 000 to 1:270 000	KFA-1000

Map updating in the broadest sense of the word presents two problems: to record changes having occurred on the surface being mapped and to improve the map. Space images have rich capabilities in this respect.

In satellite remote sensing there are two inter-related directions: 1. natural-scientific (satellite research), 2. scientific-technical (satellite methods, technologies, technical means).

The first direction is the most important for topographic maps as it focuses on the object of research and investigation. Computer technologies are still not fully competitive in photo interpretation and especially in such heuristic applications as visual analysis for complex topographic interpretation.

7. GENERATION OF RS-BASED ENVIRONMENTAL TOPO MAPS

Based on the above interpretations, the author has developed a scheme for improving every element (seashore, hydrography, relief, snow and ice and permafrost cover, vegetation, soils) of unified land-and-sea topographic map systems. Also suggested is a special topographic support for ecological research and directions for possible specialisation of topomap contents.

The most important problems to be solved with the help of space imagery in order to improve topographic maps and to widen the applications are the following:

1. Delineation and verification of the shore and bank lines on the border of lakes, swamps, river deltas, mangrove forests and along the banks formed by dynamic sand sedimentation.

2. Interpretation of flooded offshore and irrigated zones in the area of tidal waves. Outlining or delineation areas flooded in periods of inundations, spring tides (at the maximum height of water level).

3. Recording of processes of intensive irrigation and increase of water bodies, of zones with intensive washing-down of banks and shores.

4. Analysis of the state of water supply facilities, hydrotechnical constructions, consequences for water supply. Representation of river (lake) portions with strong anthropogenic hydrological impacts on the maps, mineralising of lakes due to sewage water from natural depressions.

5. Rectification of the relief representation from space imagery. Tectonic structures (rocks, dykes, structural lines) are clearly mappable from them. Many forms of the relief can be interpreted, among them hazardous zones, e.g. of active dynamic and/or even catastrophic processes. Examples are: uncovered forms of linear erosion (ravines, dried-up river beds, precipices), landslips and landslides, regions of carst, forms of permafrost (thermocarst, solifluction, ice-coverage, sea, and mountain-covering glaciers).

6. Discovery and representation of objects of anthropogenic impact, destroying the environmenton, on maps,: (mines and open pit wastes, dumping plots, land areas polluted with oil, places of unpurified waters and sewage outlets, river portions "littered" by wood floating and rafting and others).

7. Detailing of vegetation representation (through formations and vegetation types), detection of vegetation health-state from imagery. Representation of damage to the vegetation cover (by fires, felling, wind damage, landslides, mud streams, industrial pollution, over-grazing, construction of communication lines).

8. Interpretation of remote sensing images and representation on maps, specially of protected territories (reserves, national parks, forests of scientific importance, natural and architectural complexes), precious and rare naturally growing tree types, field- protecting tree plantations, natural monuments and phenomena.

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