THE EARTH KNOWLEDGE BASE AND THE GLOBAL INFORMATION SOCIETY

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ABSTRACT

Today many countries have applied the strategy of developing an information-oriented society and data infrastructure. Although varying it their details and means of realization, all these policies have the same aim - to build a global information society. Here in Russia this crucial role belongs to the Electronic (Digital) Earth initiative, which integrates geoinformation technologies in the Earth Knowledge Base (EKB). It i designed to promote the economic, social and scientific progress. An analysis of the problem has been done in the article.

Keywords: Earth Knowledge Base, Geoinformational Technologies, the Electronic Map System, Standards of Spatial Data, Electronic Maps, and Spatial Model of Terrain.

It may seem strange, but the idea of the Electronic (Digital) Earth originated in the Russian writer M. Bulgakov's greatest novel "The Master and Margarita" (1929-1940), where the magician Woland shows his globe to Margarita (Bulgakov, 1993).

"I see my globe interests you," said Woland.
"I have never seen anything so ingenious".
"Yes, it is nice. I confess I never like listening to the news on the radio. It always read out by some silly announcer who can pronounce foreign names properly. Besides, one in three of the announcers is tongue-tied, as if they were chosen especially. My globe is much more convenient, especially as I need exact information. Do you see that little speck of land, for instance, washed by the sea on one side? Look, it's just bursting into flames. War has broken out there. If you look closer, you'll see it in detail.

Margarita leaned toward the globe and saw that the little square of land was growing bigger, emerging in natural colors and turning into a kind of relief map. Then she saw a river and a village beside it. A house the size of a pea grew until it was as large as a matchbox. Suddenly and noiselessly its roof blew upward in a puff of black smoke, the walls collapsed leaving nothing of the two-story matchbox except a few smoking heaps of rubble. Looking ever closer, Margarita discerned a tiny female figure lying on the ground and beside her..."

From this extract we can see the main advantage of an electronic map in comparison with a paper one. It can immediately, in real-time, and at different scales, render actual information for any terrain. This is a symbolic cartographic model that contains the most complete set of spatial data from existing maps, aerial and satellite photos, and other sources that describe the terrain and its phenomena and processes.

Nowadays there are three approaches to the problem of the Electronic (Digital) Earth :

- Digital Earth (USA) - which uses high resolution satellite images to create a topographic (three-dimensional) and thematic representation of the Planet in raster and vector form (Gore, 1998; Morrison , 1999);
- Digital Earth (China) – which is comprised of National Information Infrastructure, National Spatial Data and Earth Systems Studies Infrastructure and digital mapping (Bi, Zhang & Jing, 2001; Chen, 2001);
- Electronic Earth (Russia) - a universal information model of the structure and development (lithosphere, hydrosphere, atmosphere and biosphere) of our Planet created from the enacted Electronic Maps System, with an integrated analysis of geographic, survey, cartographic, geological, geophysical data and other explorations of the Earth (Martynenko, 1995; Martynenko, 1999).

The Electronic Earth aims to fulfill, in a conceptual and methodical way of measures directed at developing and implementing, normative and legislative documents and standards of metadata for geographic, geodetic, gravimetric, space, photogrammetric and cartographic information, 3D terrain models (3D cadastres), formats for spatial data interchange.

During the last decade in Russia the demand for information and telecommunication services has risen sharply, in line with our society's increased need for geospatial data. We believe, there is a need to integrate all the available information about the Earth, Russia, its regions, Moscow, and other cities in the EKB (Martynenko, 2002; Martynenko , 2003). The Institute of Informatics Problems of Russian Academy of Sciences, together with the leading scientific institutions and universities of Russia have been carrying out fundamental and applied research on the theme of the EKB.

For the first time during the project the development of methods to electronically represent land cover, ground and underground facilities (including 3D cadastre); has been proposed as well as the development technologies for analyzing and processing geodata, and the building of an integrated information space.

The EKB has actually been designed to promote economic, social and scientific progress and will allow the analysis and prediction of situations, modeling, the solving of information and calculation tasks, and the representation of final results. It is created using the Electronic Maps System adopted in 1999, and the Russian Federation State's Standards on electronic maps and their metadata. The following data are used as information sources: cadastre planes at scales of 1: 500, 1: 1 000, 1: 2 000, 1: 1 0000 and 1: 25 000; topographic and thematic maps at scales of 1: 25 000, 1: 50 000 and 1: 1 00 000, 1: 200 000, 1: 500 000 and 1: 1 000 000; city plans at scales of 1 : 1 0 000 и 1: 25 000, high resolution aerial photo graphs, satellite images; reference (statistical) data in digital and paper form. The contents of the EKB include geological structures and resources; rivers and their water regimes, hydrochemistry, contaminations, temperature regimes, hydro-energy resources, water protection measures; relief forms, landslides, soils and land resources, growth and vegetation resources; population and social activities, economics, ecology, history and cultural heritage.

The EKB is based on the following principles:

- The principle of mathematical and cartographic modeling as a way of visualizing terrain features and objects;
- The principle of managing digital cartographic data;
- The principle of the full interoperability between systems (the EKB, GIS, GPS) for open users.

At the heart of the EKB is the Electronic Maps System which accumulates information about the lithosphere, hydrosphere, atmosphere and biosphere. The Electronic Maps System is the aggregate of electronic topographic and thematic maps, city plans, digital terrain models, satellite images and semantics. These are integrated according to common ideas and requirements about the geodetic base, content, legends, as well as about classifications and encoding, digital descriptions and data formats. In Russia the Electronic Maps System is used for solving problems in the fields of the state administration and national security.

Standards and normative documents could provide effective mechanisms for unifying the information, mathematical and technical support for the EKB at both national and international levels. Standards statements enable the concepts and logical models of metadata, spatial data and electronic maps to be described, as well as regulating their classification, encoding and digital representation (Martynenko, 2001).

During the last few years several normative documents and standards were adopted in Russia:

- GOST R 50828-95 «Geoinformatic Mapping. Spatial Data, digital and electronic maps. General Requirements»
- GOST R 51353-99 «Geoinformatic Mapping. Metadata of the Electronic Maps. Composition and Content»
- GOST R 52055-2003 «Geoinformatic Mapping. Spatial Models of Terrain. Technical Requirements»
- Principal regulations of the Electronic Earth System;
- Specifications for designing raster-based and vector-based electronic maps.

Millions of high-resolution images, electronic maps of different functions/purposes and scales, and textual reference information will be used to create the geodetic base (spatial data infrastructure) of the technology used to build the EKB. The technology allows the synthesis of the digital (electronic) image as a spatial and temporal model of the Earth. The Temporal representation is based on the mathematical and semantic modeling of dynamically changing spatial data and is generated from the aggregate of distributed electronic cartographic libraries united by means of telecommunication technologies (Internet) (Eliushkin & Martynenko, 2001; Martynenko, Lyuty, Zemlianov, Serdyukov & Lunyova, 2001; Martynenko, Nyrtsova & Karachevtseva, 2001). One of the EKB project's foremost tasks is the development of technologies for the creation of 3D images (3D cadastres), dynamic cartographic models, and virtual maps. Spatial Models (3D) of Terrain are used by many for solving information problems and calculations, analysis, modeling, as well as situation and terrain presentation. Together with electronic maps they are a cartographic component of current and future control systems, as well as information and calculated systems.

Spatial Terrain Models allow the solving of the following problems:

- Overall evaluation of terrain;
- Analysis and assessment of terrain characteristics; individual ground, underground (underwater) objects;
- Orientation;
- The presentation of terrain and situation data;
- Situation modeling;
- The solution of information, calculation and navigational tasks;
- Training users on the real-time simulators;

- Conducting studies, training and other actions for preparing experts in terrain decision-making;
- Improving the production of spatial models of terrain;
- Improving the compatibility of various controls and navigations systems, geoinformation systems, and simulators.

The content of a Terrain Model includes the following elements: terrain relief, hydrography, settlements and stand-alone buildings, agricultural, industrial, social and cultural objects, road networks, soils and vegetation, borders, place-names and their characteristics, including underground (underwater) objects. It should also include the topological links between them along with their essential characteristics. The image creation tools (graphic, color, light and shade techniques) used in the Terrain Model must provide the maximum possible correspondence between the displayed model and real terrain in terms of clarity, readability and the ability to recognise the model's elements. These must not hinder the display of the model's elements. Visualization factors of the Terrain Model must include: the dimensions of the displayed region's terrain; its vertical and horizontal scales; the angles (trajectory) from which the 3D model can be viewed; position data of the user; the focal distance of the simulated optic system (in case needed); position data of the lighting source. The Terrain Model must also provide the georeference information of the thematic data, as well as on the operational and tactical situation. The accuracy of the Terrain Model can vary depending on its digital sources and project goals.

Another important aspect of an effective EKB is a well designed user interface. The navigation structure should be clear and logical, so that the user of the electronic product finds taking action intuitive. Thus new methods for the artistic construction of cartographic products have been used. They include methods for the computer-aided projection of different compositions, optimal formats, map symbol systems and elements of outer appearance, as well as psychovisual methods of estimating and creating cartographic and reference products. Modem industrial computer-aided technologies have the great advantage of using expert systems.

The results of the EKB are to be used by specialists from different areas of study and businesses. It will, we believe, be a step towards the creation of national and global information societies. Milan Konecny, the President of ICA, analyzed the problem in his report on the 20^{th} ICA International Cartographic Conference, Beijing, 2001 (Konecny, 2001).

Finally, the EKB must be created according to the UN's recommendation on sustainable development, and promote further growth of the geoinformation technologies market; it should take into account the results of the International ICA conferences (Beijing, 2001, Durban, 2003), and the International Symposiums on Digital Earth (Beijing, 1999; Fredericton, 2001; Brno, 2003; Tokyo, 2005) and the Russian Scientific and Practical Seminar on Electronic Earth, Electronic Russia, Electronic Moscow (Moscow, 2002).

For a functioning global information society the following issues must be resolved:

- An investigation into and standardization of the international experience in Earth mapping and application of geospatial data;
- Developing cartographic theories examining the common objectives and features of Earth mapping; formulation of the principles of the EKB based on these;
- Developing of basic categories and notions, as well as international and national standards in the area of the EKB;
- Creating an International Earth Knowledge Management System, a Global Metadata Base and Banks of Geospatial Data, as well as improved telecommunication networks;
- Developing the and implementing of highly-skilled cartographic expert systems and GIS for different purposes;
- Improving the professional skills of personnel of all educational levels in the area of GIS and intellectual technologies;
- Exposing contradictions in the area of the EKB, determining the directions of its evolution, and elaborating the criteria and methods for evaluating the effectiveness of new technologies;
- Developing and implementing cooperative international programs in the area of EKB strategies, which should include the participation of both governmental and private cartographic enterprises.

REFERENCE

Bi, S-W., Zhang, X. & Jing, D-S. (2001) Pilot study of Digital Earth Basic Theory System. *Proceedings of Digital Earth 2001,* Fredericton, Canada

Bulgakov, M. (1993) The Master and Margarita. Meridian, New York, US, Meridian.

Chen, S. (2001) Cartographic Methodology for Geo-Information Science. *Proceedings of the 20th ICA International Cartographic Conference,* (Vol.1, pp. 32-39), Beijing, China.

Eliushkin, V. & Martynenko, A. (2001) On the new high-precision technology of obtaining and processing space survey materials and creating digital orthophotos and electronic maps. *Proceedings of the 20th ICA International Cartographic Conference,* (Vol. 1, pp. 659-661), Beijing, China.

Gore, A. (1998) The Digital Earth: Understanding our Planet in the 21st Century. Retrieved February 14, 2004 from the World Wide Web: http://digitalearth.gsfc.nasa.gov /VP19980131. html.

Konecny, M. (2001) Global Issues and Cartography. *Proceedings of the 20th ICA International Cartographic Conference,* (Vol. l, pp. 17-31), Beijing, China.

Martynenko, A. (1995) The development of Concept and Methods for Creating an International System of Geographic Maps as an Universal Basis of the Earth Knowledge. *Proceedings of the 17th ICA International Cartographic Conference,* (Vol. 2, pp. 33-40), Barcelona, Spain.

Martynenko, A. (1999) Global Geoinformatic Mapping as Methodology and Technology of the Future. *Proceedings of the 19th International Cartographic Conference,* (Vol. 1, pp. 39-42), Ottawa, Canada.

Martynenko, A. (2001) Digital Earth based on Metadata Electronic Standard. *Proceedings of the 21st ICA International Cartographic Conference,* (Vol.4, pp. 2747-2752), Beijing, China.

Martynenko, A., Lyuty, A., Zemlianov, I., Serdyukov, A. & Lunyova, N. (2001) Searching Internet Server for the Electronic Libraries of maps and Geospatial Information Metadata as a scientific and practical problem of the Global Geoinformatic Mapping. *Proceedings of the 20th ICA International Cartographic Conference,* (Vol. 2, pp. 1184-1189), Beijing, China.

Martynenko, A., Nyrtsova, T. & Karachevtseva, I. (2001) GIS for modeling cartographic design. *Proceedings of the 20th ICA International Cartographic Conference,* (Vol. 2, pp.1169-1175), Beijing, China.

Martynenko, A. (2002) Electronic Earth, Country and City: Theory, Methodology and Technology. *Proceedings, InterCarto8 International Conference. CIS for Sustainable Development of Territories,* (pp. 17-21), Helsinki - St.-Petersburg, Finland-Russia.

Martynenko, A. (2003) The Earth Knowledge Base: Methodology and Technology. *Proceedings of the 21st ICA International Cartographic Conference,* Durban, South Africa.

Morrison, J., (1999) Important Initiatives in Geographic Information Science and Spatial Data Collection with Implication for Cartography. *Proceedings of the 19th ICA International Cartographic Conference,* (Vol.1, pp.43-49), Ottawa, Canada.