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Quantum Leap in Cartography as a requirement of Sustainable Development of the World

Vladimir S. Tikunov,[a] Iryna N. Tikunova,[b] and Eugene N. Eremchenko[c]

[a] *Lomonosov Moscow State University, Moscow, Moscow Region, Russia; vstikunov@yandex.ru*
[b] *Lomonosov Moscow State University, Moscow, Moscow Region, Russia; tikunov@geogr.msu.su*
[c] *Lomonosov Moscow State University, Moscow, Moscow Region, Russia; eugene.eremchenko@gmail.com*

Abstract: Sustainable development is one of the most important challenges for humanity and one of the priorities of the United Nations. Achieving sustainability of the whole World is a main goal of management at all levels – from personal to local to global. Therefore, decision making should be supported by relevant geospatial information system. Nevertheless, classical geospatial products, maps and GIS, violate fundamental demand of 'situational awareness' concept, well-known philosophy of decision-making – same representation of situation within a same volume of time and space for all decision-makers. Basic mapping principles like generalization and projections split the universal single model of situation on number of different separate and inconsistent replicas. It leads to wrong understanding of situation and, after all - to incorrect decisions. In another words, quality of the sustainable development depends on effective decision-making support based on universal global scale-independent and projection-independent model. This new way for interacting with geospatial information is a quantum leap in cartography method. It is implemented in the so-called 'Digital Earth' paradigm and geospatial services like Google Earth. Com-paring of both methods, as well as possibilities of implementation of Digital Earth in the sustain-able development activities, are discussed.

Keywords: Sustainable Development, Digital Earth, cartography method, decision-making, scale-independent, projection-independent

1. Introduction

Sustainable Development is a core concept of globalization and one of five main priorities of the United Nations. Resolution 'Transforming our world: the 2030 Agenda for Sustainable Development', adopted by the General Assembly on 25 September 2015 (UN 2015), declares 17 Sustainable Development Goals and 169 associated targets and defines sustainable development:

…sustainable development – development that promotes prosperity and economic opportunity, greater social well-being, and protection of the environment – offers the best path forward for improving the lives of people everywhere.

Obviously, achieving the sustainability throughout the World requires adopting of most effective technologies of resource management based on precise, high-accuracy, comprehensive and holistic representation of situation, that constantly and simultaneously changed on all levels from local to global, as information basis for understanding situation and making correct decisions (Pyankov, Tikunov, 2011). There are obstacles – both objective and subjective. It is significant and truistic, that idea of sustainability requires harmonization of activities on different hierarchical levels: global, national, regional, local, personal, etc. Therefore, inconsistency of information on different levels is significant objective factor of errors (Fig. 1). Moreover, inconsistencies of decision-making on different levels is a source of severe problems like wars, unbalance of developing, uncontrollable migration, degradation of environment, crimes, etc.

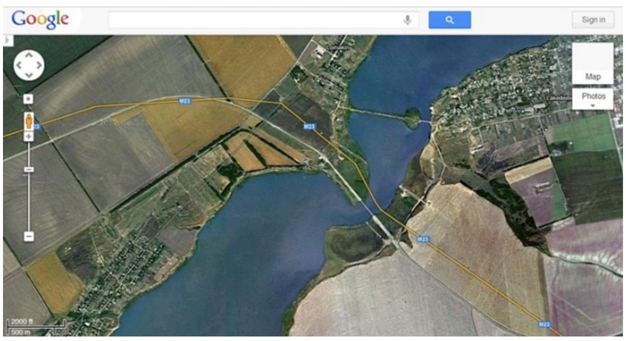

Fig. 1. Sample of topological inconsistency of raster (road) and vector geospatial data. (Source: Eremchenko, Tikunov, Sun, 2013)

2. Understanding the problem

The philosophy of decision-making is well-known as 'Situation Awareness' concept. Situation awareness is a set of principles of providing information for decision-makers, and art of 'feeling' the situation, art of creating correct dynamic model of situation in mind and using it for planning of acts. There are number of definitions of situation awareness. One of the most classic and comprehensive definitions of situation awareness provided by M. Endsley (1988):

...the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future.

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From the geospatial and cartographic point of view there are two main requirements in this definition: 1) direct perception of the situation without using of sign systems, and 2) representation of all information within one volume of space and time. First requirement addressed semiotics (Eremchenko, 2016). Second one means that all information should be spatially and temporally located as one, single and universal dataset for all scales and, therefore, for all hierarchical levels. It is self-evident requirement for simple and local management systems, but it is a significant challenge for big, spatially distributed management systems – for example, nation-wide or global-wide, because of scale-dependence and projection-dependence of all classical geospatial products: maps (both ordinary and digital) and GIS. The source of these problems is fundamental is-sue of all classic cartographic products, regardless of physical media and technological specificity.

Classic paper maps, digital maps and geographic information systems (GIS) used same carto-graphic method. In accordance with the basic definitions of maps, there are three main carto-graphic principles: 1) map projection; 2) generalization; 3) object layers. A map projection is strictly limitited direction of view and provides specific, biased representation of situation. Generalization restricts changing of scale and, therefore, shattering scale-independent real world into the set of different, inconsistent scale-dependent replicas. As a result, direct flow of topologically correct data through the system from one scale to another became impossible, because of different generalizations for each scale and, additionally, different sets of object layers.

Therefore, classic maps and map-based GIS produce aberrations in the perception inevitably, limiting the situational awareness. Possibility of use maps and GIS in decision support for sustainable development is severely limited.

Qualitative change in the realm of cartography occurred in 2005, when new class of geospatial products, so-called ‘Digital Earth’, was emerged with the start of famous Google Earth geoservice (Google Earth, 2005). Nevertheless, despite the ten-year history of Google Earth, its scientific origins are still a matter of debates. Along with the term ‘Digital Earth’ the term ‘neogeography’ is used usually for the differentiation of new class of geospatial products like Google Earth from ‘old’ ones. Andrew Turner makes first attempt to define it as ‘neogeography’ (Turner, 2005):

> Neogeography means ‘new geography’ and consists of a set of techniques and tools that fall outside the realm of traditional GIS, Geographic Information Systems. Where historically a professional cartographer might use ArcGIS, talk of Mercator versus Mollweide projections, and resolve land area disputes, a neogeographer uses a mapping API like Google Maps, talks about GPX versus KML, and geotags his photos to make a map of his summer vacation.
>
> Essentially, Neogeography is about people using and creating their own maps, on their own terms and by combining elements of an existing toolset. Neogeography is about sharing location information with friends and visitors, helping shape context, and conveying understanding through knowledge of place.

However, this definition of neogeography does not provide basis for classification of ‘old’ and ‘new’ geospatial products; it only manifests isolation of neogeography ‘realm’ from the ‘realm’ of classical maps and GIS. Therefore, we propose intensional definition (Eremchenko, 2008) of neogeography, based on analysis of Google Earth and other online geoservices, like ERDAS Titan. It provides three clear recognizable criterions for all possible neogeography products (and, so on, Digital Earths):

- geocentric coordinates, not mapping projections;
- using raster, not vector for representation of geospatial context;
- using hypermedia as transport for semantics.

This set of criteria identifies Digital Earth as ‘true’ neogeography, based on new approach for processing and visualizing of geospatial data. This definition is consistent with vision of Digital Earth (ISDE; Gore, 1998), statements of ISDE, as well as visions of future development of Digital Earth concept (Max Craglia et al, 2012).

3. Discussion

On the one hand, Digital Earth does not meet any definition of a geographic map and/or map-related products, like GIS. On the other hand, it is obvious that Digital Earth belongs to the same scientific realm. Significant differences between method of classic cartography, from one hand, and method of Digital Earth, from another hand, leads to significant differences in properties, (Tab. 1). Thus, it became possible to characterize Digital Earth as a quantum leap in cartographic method. In another word, Digital Earth is not a new technology or new social practice only, but rather new scientific paradigm (Kuhn, 1970). New opportunities of this new paradigm are equally significant.

Property	Classic Cartography Paradigm	Digital Earth Paradigm
Mathematics	Projection	Similarity
Datasets	Reduced	Unreduced
Dimensions	2D	3D
Measurability	Limited	Unlimited
Situational Awareness	Limited	Full

Table 1. Fundamental differences between classic cartography and Digital Earth. (Source: Eremchenko, Tikunov et al, 2015)

First of all, Digital Earth approach provides unprecedented possibility to create scale-independent datasets for very high range of geographical scales (Fig. 2). It enables to implement basic requirement of situational awareness concept – creating single dataset for all decision-makers on all levels of hierarchical management system. Moreover, this dataset could be regularly updated for reflecting real dynamic of situation.

Secondly, Digital Earth is fully projection-independent way for processing geodata. In fact, it is holographical way of visualization (Eremchenko, Tikunov, 2016). Understanding projection and scale independency as a factor of evolution of method of cartography, allows to propose universal typology of all cartographic products from ancient and modern maps to Digital Earth (Tikunov, Eremchenko, 2015).

Huge integration potential of Digital Earth makes this approach 'miracle cure' for sustainable development. New level of situation awareness, provided by Digital Earth, helps to implement sustainable development by reducing factors that prevent effective decision-making due to in-consistency of management on different levels – global, regional, local, personal, etc. Existing of single dataset with possibility for unobscured circulation of accurate spatially located data across the hierarchical management systems eliminates significant source of errors in decision-making and provides unique possibility for flawless integration within single common space-time geocentric framework – Digital Earth.

Study of scientific method used in Digital Earth is a vital task for maintenance of sustainable development. In particular, representation of geospatial environment in the Digital Earth and geoportals with the help of images instead of cartographic signs is a significant semiotic problem. We propose the concept of "zero sign" by analogy with the zero sign in mathematics for separation of remote sensing data and iconic images (Eremchenko, 2016).

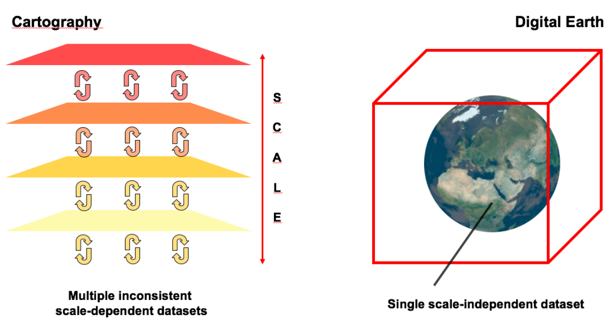

Fig. 2. Differences between information flows in cartographic (left) and Digital Earth (right) approaches. Cartographic approach re-quires new generalization of data at every transition from one scale to the next; direct data circulation in a hierarchical system be-comes impossible. Instead, Digital Earth approach allows to create single common scale-independent dataset, that minimize incon-sistency errors in decision-making at different hierarchical levels. (Source: NeoGeography Group)

4. Conclusions

Providing situational awareness for sustainable development of the World by the means of classic geospatial products – maps and GIS – is impossible due to fundamental limitations of principles of classic cartography. Instead, Digital Earth as a new approach, new scientific paradigm and quantum leap in cartography solves this issue and allows to support sustainable development with the scale-independent and projection-independent single global model of the situation, that encapsulates all scales, all possible points of views, all places and all thematic areas. The integration potential of this new approach seems limitless.

5. Acknowledgements

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