3D-document and Digital Earth

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The paper considers the question of bringing the existing set of laws, regulatory and legislative documents in line with the Digital Earth - new and promising universal and global environment for the information integration on all possible scales simultaneously. Existing of 4 possible geovisualization methods is stated, typology of geovisualization methods is proposed and discussed. A practical approach for determining the belonging of visualization to a particular type, based on the use of diagrams "angle-range", is proposed. Concept of 3D-documents within Digital Earth paradigm is unveiled and explained, brief history of the developing and adopting of this concept is described, the prospects of the future evolution of 3D-documents are considered briefly.

Keywords: *3D-document, Digital Earth, visualization, governance, "angle-range" diagram.*

1. Introduction

The development of the Internet, scientific visualization and Digital Earth at the turn of the XXI century has led to the formation of a radically new, heterogeneous information environment that brings together all possible types of information — visual (images, videos, 3D-models, maps), temporal (music, audio), as well as abstract representations (texts, numbers, symbols). Main factor of it was the emergence of a single, "digital" information carrier — discrete electromagnetic signals — that makes possibly to unify the procedures for storing, processing and perception of information of any kind. In fact, it was a dissociation of matter and information [7] - material objects ceased to be the main carriers of information and the only possible means of documenting it. The "digital revolution" [15], in turn, led to a change in the nature of management activities, allowing to assess the situation and make decisions using a comprehensive set of information tools; different types of information are focused on the representation of different aspects of external reality and reflect it differently, so their combination obviously gives a radically new quality of perception. New types of information, especially visual, are increasingly used in management for the situation awareness and for the decision-making.

However, instant leveraging of different types of information, achieved through the technological revolution, came into conflict with the established architecture of management, based on legal and legislative documents of various kinds. Up to now the symbolic representation of information (in the form of letters and numbers) is completely dominated in that kind of documents.

It is obvious that the increasingly apparent mismatch between legislative, rule-making, management and control practices, on the one hand, and actual management and decision-making practices, on the other, is a radically new challenge for management.

For example, this misalignment makes possible the emergence of new types of corruption, crimes or methods of illegal impact on public administration procedures. Conversely, involving the new types of information and new semiotic tools into management architecture could leads to «smartification» of governance and adaptation of management practices to the realities of the "digital revolution". One of the most important examples of such tools is a visualization. In various forms, it is already widely used in the decision making. However, it is now necessary to incorporate visualization into the formal system of laws. One of the first and illustrative examples of the approach to solving this problem is the introduction of the concept of 3D-document proposed in the last decade [2, 13]. This new type of documents makes it possible to implement in practice the possibility of 3-dimensional "holographic" representation and documentation of geospatial objects.

It is obvious that this type of document is naturally combined with Digital Earth, since the Digital Earth is similar in nature to 3D documents and is in fact a documented 3D image of the entire planet and a natural context for 3D documents. To achieve this goal, it is necessary to study and formalize the features of the Digital Earth as a visualization method and a natural fraimwork of 3D-documents.

2. Concept of 3D-document

Technological development at the turn of the XX and XXI centuries led to the emergence of qualitatively new types of information products, including the so-called 3D models — three-dimensional images of various objects, scenes or processes. Such models can be viewed from any arbitrarily and interactively user-selectable angles, and from various, arbitrarily and interactively selectable distances, unveiling in details their complexity and internal structure.

Specific demands for this kind of 3D-models caused the need to allocate them to a new, special class of documents, the so-called 3D-documents — this happened no later than 2007 [2]. In Russia already in 2012 in work [13] the first definition of the 3D-document as "especially organized information intended for representation of the three-dimensional (spatial) visual image (3D-model) of object or process, and also various additional information on the basis of this visual image" was given.

Later the concept of 3D-document was discussed, substantiated [12], demonstrated and verified on numerous different practical examples [16].

In the same work examples of practical creation and use of models suitable for use as documents were given, features of their display and perception were considered — in particular, high relative accuracy of such models reaching tenths of percent, and, consequently, possibility of change of degree of their detail at viewing within a dynamic range in three orders. This is not the limit-the technology of creating and presenting 3D models continues to develop, and their quality can significantly increase.

The first 3D document in Russia has already been deposited in the Russian state archive of scientific and technical documentation [17], but the mass introduction of a new type of documents and the study of their properties is a matter of the future. The continuing uncertainty of their status creates various difficulties in the transfer of rights to the 3D-document and other actions with it. 3D models can be protected by various institutions of intellectual property law: as objects of copyright, patent law and the right to the means of individualization of legal entities, goods, works and services. In this regard, an important issue is the choice of the regime of legal protection of three-dimensional models [11].

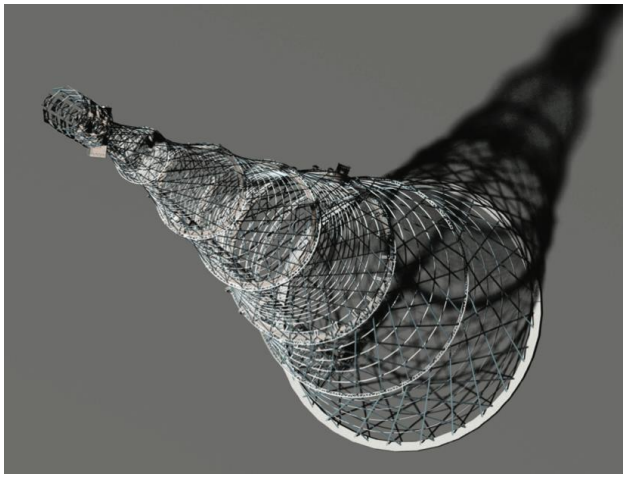

Fig. 1. An image of the Shukhov tower generated by its 3D model and presented beyond of its geospatial context (from [14]).

Realistic representation of such objects with the help of 3D models makes them related to photographic images (Fig. 1). At the same time, they cannot be cosnidered as photographic images due to requirement of a special, three-dimensional coordinate system, just as an ordinary document needs a two-dimensional basis — for example, a sheet of paper.

In parallel with the development of the concept of 3D-documents at the turn of the XX and XXI centuries was proposed [5, 9], and then developed and put into practice the concept of the Digital Earth (Fig. 2 a, b) — a special environment for presenting information in a single geocentric space.

Fig. 2 (a, b). Example of Digital Earth and integrated 3D model (from [11]) in different scales and viewing angles.

Such an environment [5, 9, 10] has two properties: 1) three-dimensionality, or the ability to view it from any direction of sight, and 2) scale-independency, or the ability to study the situation from any distance (or at any scale) within a certain dynamic range [8]. Later it was shown that new opportunities are achieved by eliminating the use of conventional cartographic signs in the representation of geospatial context — now their role is performed by images of the earth's surface, the so-called remote sensing data [6]. This provides a unique opportunity to store in the new geospatial "container" any information at all (for example, maps, texts, etc.), while the opposite is impossible.

The convenience and naturalness of integration in the Digital Earth of any information and, consequently, any documents are inextricably linked with its contextuality — the ability to localize an object, phenomenon or process in space and time, immersed in its natural environment, outside of which the perception of an object or scene will inevitably be incomplete. In addition, the globality of the Digital Earth and the possibility of introducing an unlimited number of information models into it make it a "system of systems" and allow it to formulate or clarify uniform requirements for geospatial documents, as well as to consider the prospect of new types of documentary representations of objects and processes. To do this, it is necessary to offer a visual and practically applicable method of attribution of geovisualization to a particular class, reflecting the internal logic of the method development, i.e. to create a typology of geovisualization.

3. Typology of geovisualization methods

In [1, 4] proposed a typology of geo-visualization methods, based on the notion of the fundamental and comprehensive character of the two parameters of visual perception subject, in conjunction to ensure the integrity of the situation awareness: 1) the ability to arbitrarily change the viewing angle of the object (or scene), and 2) the ability to arbitrarily change the distance to the observed object, or its degree of detail. In the case of geovisualization, the second parameter (distance to the object) becomes especially important due to the fractal nature of geospatial formations [14] and the fundamental impossibility to describe it using scale-dependent scalar and vector parameters [3]. Four theoretically possible types (or modes) of geospatial visualization were identified, differing in the degree of realization in them of the possibility of arbitrary and interactive choice by the user of the viewing angle and distance to the visualized object — 1) maps(GIS), 2) globes, 3) geoportals, and 4) Digital Earth (Fig. 3).

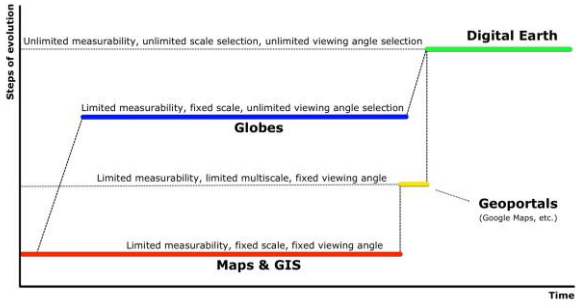

Fig. 3. Evolution of 4 possible types of geospatial visualizations.

Classification of geospatial visualizations should be supplemented by a simple, practical set of definitions of them. This problem is proposed to be solved with the help of the diagram "angle/range", which allows to visualize for each possible type of visualization a set of values of viewing angles and distances provided by it.

For example, a geographic map or GIS map is represented as a single point in such a diagram, since it is relevant only in one projection and only for one scale value (Fig. 4).

Classical geographical globes, in turn, allow you to view the situation under any arbitrary angles within the hemisphere, but only on a strictly defined scale, depending on its diameter (Fig. 5). In fact, the globe is an example of holographic visualization, because it fulfills its only requirement — the ability to view the situation from any arbitrary angle.

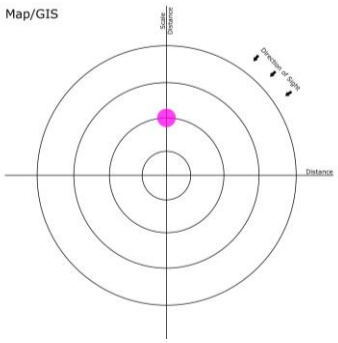

Fig. 4. Geographic map on «angle/range» diagram.

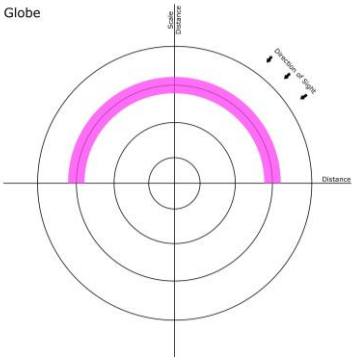

Fig. 5. Geographic Globe on «angle/range» diagram.

Almost simultaneously with the Digital Earth online mapping services, the so-called "geoportals" appeared; an example of this service are, for example, Google Maps, Bing, etc.

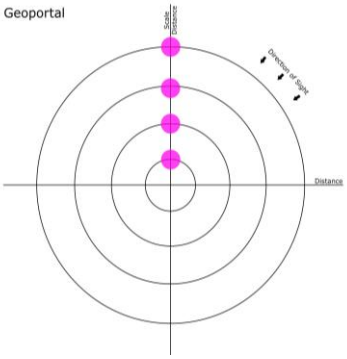

Fig. 6. Geoportal on «angle/range» diagram.

They implement discrete multiscale, achieved by presenting a single map projection of a limited number of map layers of different scales. The layers follow one another automatically as the user changes the scale of representation of the terrain. The view of the geoportal in the angle/range diagram is shown in Fig. 6.

Finally, Digital Earth has made it possible to achieve in practice the possibility of arbitrary, interactive and seamless selection of any possible viewing angle (including the meaningless in classical cartography "bottom-up" angle) and, at the same time, any distance to the object. The Digital Earth in the angle/range diagram is shown in Fig. 7.

Thus, the Digital Earth, along with providing holographic visualization mode, also allows to select freely any viewing distance of the object, unattainable in conventional holography, which allows to call the Digital Earth a special, super-holographic geovisualization mode [5]. At the same time, the dynamic range of viewing distances (or conditional "scale") in its early practical implementation, the Google Earth geointerface, could be estimated at eight orders of magnitude and was not limited in principle.

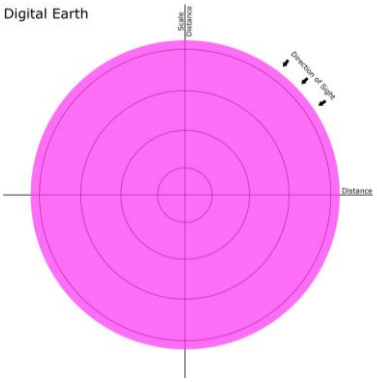

Fig. 7. Digital Earth on «angle/range» diagram.

The angle/range diagram allows you to understand the place of 3D models in the Digital Earth as a single spatial information integration environment. A 3D model is an element of spatial visualization that has the property of all-angles and a wide range of supported scales-limited or (in the extreme case) comparable to the Digital Earth itself. Digital Earth as a single, global, off-scale and all-angle 3D model of the planet allows you to integrate together a variety of different 3D-documents, creating from them complete complexes and 3D-landscapes.

At the same time, each of the 3D documents is a local element of the Digital Earth as a single 3D complex and is represented on the diagram as a polygon, like the Digital Earth itself.

An interesting and important feature of the Digital Earth is the fact that the modes of all-angle and extra-scale are achieved in it by eliminating the use of signs in the representation of geocontext. This, in turn, raises the question of the relationship of information and sign. The development of a new, organic way of presenting information, especially for the Digital Earth era, is becoming a trend of the new society. It is possible that soon no one will be surprised by 3D-Constitution, 3D-audit, etc.

4. Digital Earth and a future of 3D-documents

The emergence and increasing popularity of 3D-models, as well as their formalization in the form of 3D-documents and the emergence of an environment for their integration (Digital Earth) allow us to ask about the prospects for the evolution of the semiotic structure of documents and about what kind of tasks new classes of documents can be particularly effective.

At present, from the whole spectrum of semiotic instruments, almost exclusively textual, digital and cartographic means of presenting information are used in legislation, with the text dominating absolutely (Fig. 8).

In contrast, in actual decision-making practice, a variety of semiotic tools are increasingly used, together allowing for the most complete and holistic perception of the situation in the mode of so-called “situational awareness” (Fig. 9). Bringing legislative documents in line with the already established practice of decision support will inevitably require the formalization of various types of information presentation, primarily visual, and their active introduction into legislative practice. Of particular importance is the active dissemination of 3D documents, which will evolve into a system to ensure maximum inter-scale, and the Digital Earth as a natural aggregator of 3D documents. At the same time, the role of 3D-documents in the organization of a reliable representation of natural geographical objects is seen as particularly significant.

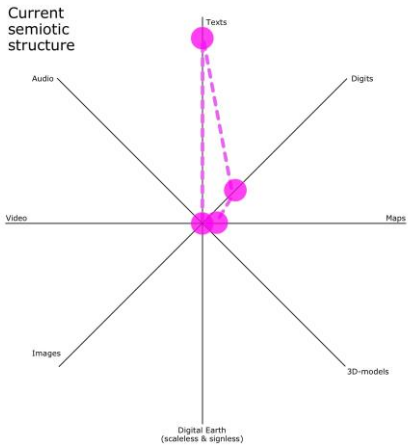

Fig. 8. Actual prevalence of various semiotic instruments in current legislative documents (conditional representation).

The use of three-dimensional models, not mediated by sign conventions, allows to resolve, for example, the complex of contradictions that arise when trying to form a land cadastre with the help of signs – vector (maps) or scalar (indicators of the length of the coastline, etc.) and caused by the fractality of geoobjects (see [3] for details).

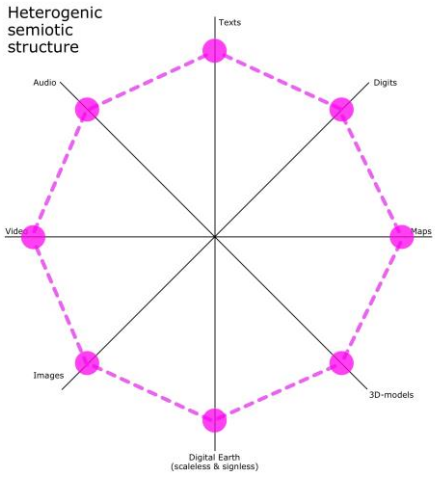

Fig. 9. Current availability of various semiotic tools in decision support practice (conditional representation)

5. Conclusions

Within the framework of the proposed typological model and demonstration of the natural complementarity of the Digital Earth and the corpus of 3D-documents, it becomes possible to draw a conclusion about the direction in which the development of 3D-documents in the future is likely. Currently, the 3D-document, as its name implies, embodies the idea of holographic, or all-angle representation; at the same time, its great "inter-scale" potential is already noted. Obviously, the next stage in the development of 3D-documents will be avoiding their scale limitation at all. It will allow, for example, to model as a whole complex and spatially extended systems of objects — for example, continental models of pipeline networks. Such a document can be called an "scaleless 3D-document", or a "scale independent 3D-document".

The next and natural step is to study the prospects of using as documents unsigned visual models and first of all the most famous of them — the Digital Earth itself. This will improve the quality of the situation awareness and fully realize the inherent visualization capabilities of such documents.

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