Improving the Technology for Implementing a 3D Cadastre in Existing Accounting Information Systems

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Abstract. In the Russian Federation, the issue of improving the cadastral system is currently more relevant than ever. This is determined by the complication of the procedure for designing and building the cadastral real estate objects. Modern architecture is becoming more complex and diverse year-by-year. The configuration of the construction facilities is becoming more increasingly complex, and these days, they can be built not only on the ground surface but also above or under the ground. In practice, such design solutions lead to uncertainty and ambiguity of their routine cadastral registration, and these objects are registered according to their two-dimensional projection on the ground. Currently, almost all design agencies use 3D simulation in solving issues related to the design, construction, and sale of both industrial or agricultural facilities and residential or office buildings and apartments. Leading Krasnodar enterprises engaged in the design of various real estate objects use three-dimensional models in providing customers with the complete scope of work.

The paper authors reveal the basic concepts of a three-dimensional cadastre in a modern system of engineering, design, construction, and architecture. The prerequisites for switching to the 3D cadastre have been considered, the cadastral registration aspects specified, and the issues concerning three-dimensional representation and processing 3D real estate data discussed. The main 3D data representation models are listed.

1. Introduction

In modern conditions of the development of a new stage of market relations, both in Russia and around the world, a special role is assigned to regulating land relations. The land becomes a direct object of legal relations and market turnover. The above conditions give rise to new priorities in the land management. The major priority is creating an effective system for ensuring the rights of both real estate owners and users. The two-dimensional cadastral system currently used in Russia cannot fully describe the complex architecture and intertwining infrastructure of modern urbanized areas [7].

In large cities, intensive use of land resources is a consequence of their scarcity, which leads to the real estate objects located above, under, or even passing through the ground. It should be noted that in practice, this leads to some ambiguity in the routine accounting of objects based on their 2D projections on a land plot in relation to both the large city boundaries and the land plots adjacent to them. Therefore, the problem arises to create and implement on a massive scale a new registration system for complex (multidimensional) objects such as pedestrian crossings, parking lots, tunnels, utility networks, multi-level buildings, underground communications, and bridges [4].
This conclusion is confirmed by the country's economic development requirements. Thus, one of the priority Russian economy development tasks is to improve the land and real estate market and take place among the top five countries in terms of property registration. To achieve this goal, several projects were developed and adopted within 2012 to 2018.

The analysis of the documents allows assuming that the gradual introducing a three-dimensional spatial description of real estate in the Unified State Real Estate Register (USRER) is a rather important stage in the cadastral development. This approach is aimed at solving issues existing in the state cadastral registration of real estate located at different levels, unique objects, bridges, utilities, and underground structures, associated with the intersection of the projections of their structural elements. Despite the existing legal potential for the registration of 3D real estate models in the USRER, the availability of geoinformation technologies and solutions, geodetic equipment, and software required to keep a 3D cadastre, the simulation of three-dimensional buildings and the use of 3D models in the cadastral work are not developing in Russia. This situation is associated with the lack of an appropriate scientific and methodical justification of the use of 3D real estate simulation in the cadastral work.

2. Research objective
The paper is aimed at the development of a concept for implementing a 3D cadastre in existing accounting information systems exemplified by the Krasnodar municipal entity.

To achieve this goal, several problems should be solved:
- analyzing domestic and foreign scientific literature on the creation and implementation of a 3D real estate cadastre,
- studying the experience and prospects of implementing a 3D cadastre in Russia,
- studying accounting information systems to implement a 3D cadastre in Russia,
- developing the main provisions of the concept of introducing a 3D cadastre into existing information and accounting systems.

3. Relevance & scientific significance of the issue with a brief literature review
Before proceeding to studying the paper issue, let us analyze some works devoted to the 3D cadastre system. It should be noted that most of the work has been performed by foreign authors, e.g., the paper by Nurit PERES and Moshe BENHAMU 3D Cadastre GIS - Geometry, Topology, and Other Technical Considerations describes in detail the advantages and shortcomings of a 3D cadastre.

In the paper by R. Billen and S. Zlatanova 3D Spatial Relationships Model: A Useful Concept for 3D Cadaster, the 3D topology technique is tested, and the model of spatial relationships studied. J. Stoter’s Needs, Possibilities, and Constraints to Develop a 3D Cadastral Registration System describes the needs, possibilities, and constraints of implementing a 3D cadastre. In the study 3D Real Property Legal Concepts and Cadastre - A Comparative Study of Selected Countries to Propose a Way Forward, Greek engineer D. Kitsakis raises issues of 3D legal concepts of real estate and cadastre and performs a comparative analysis of individual countries to develop proposals for further actions.

Domestic researchers such as T. Nikolaeva and I. Snezhko are studying the issues of creating a 3D cadastre in leading countries and the possibility of implementing it in the accounting information systems of Russia. Rector of the Siberian State University of Geosystems and Technologies A.P. Karpik has published several works on the assessment of cadastral data, the place of geodesy in the information space, and the 3D cadastre role in the existing accounting information systems. The review of sources on the research topic allows concluding that currently, the ways to improve the techniques for introducing a 3D cadastre into the accounting system for land resources, real estate, and many other objects are extremely relevant.

4. The theoretical part of studying the 3D cadastre implementation issue
Ground, underground, and above ground areas can be described in several ways. From a technical point of view, three types of geometric shapes can be considered: flat 2D, spatial 3D, and 2.5D ones
The most advanced option is a full 3D geometric shape with finite volume. This requires profound changes in the legal, economic, and technical aspects of the cadastral work but allows using the 3D cadastre functions in full.

There are several solutions for recording 3D situations:

- full 3D register,
- hybrid register,
- 3D functions in the existing cadastral register system.

Full 3D register means that the property concept should be represented in 3D space. Legislation, civil law, and cadastral agreements should support and facilitate the transfer of 3D rights. From a practical point of view, it is preferable to keep the 2D resolution complex as before and use the full 3D complex only in complex 3D situations. In a modern cadastral registration system, the 3D functions allow keeping a 2D cadastre but with external links to digital representations of 3D situations.

The prototype comprises three objects—a telebuilding, a residential building, and a gas pipeline (Fig. 2, 3, & 4).

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**Figure 1.** 2D, 3D, and 2.5D plots: Nurit PERES and Moshe BENHAMU 3D Cadastre GIS–Geometry, Topology and Other Technical Considerations [Electronic resource]. Access mode: http://www.mapi.gov.il/UsefulInfo/MapiPublications/FIG2009_peres_benhamu_3242.pdf.

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**Figure 2.** Multi-Apartment Residential Complex with Underground Parking and Commercial Premises: Gavryushina, N.V. Analytical review of 3D real estate cadastre systems // Interexpo GEO-Siberia-2012.
Figure 3. Gas Pipeline (purple line): Natalia Vandysheva, Petervan Oosterom 3D Cadastre Modelling in Russia [Electronic resource] - Access mode: https://rosreestr.ru/wps/portal/cc_news?news_id=16202&news_line_id=11662

Figure 4. Telebuilding and Its Environment: Snezhko, I. Creating a 3D Cadastre Model in Advanced Countries and the Possibility of Implementing the Experience Gained in Russia [Electronic resource]. - Access mode: http://www.slideshare.net/opts/3d-12167416.
5. The Practical Significance of Implementing a 3D Cadastre

The transition of Russia to 3D cadastral registration is inevitable, but this work is very expensive and time-consuming. The 3D cadastre allows the executive bodies and city services to solve various problems of territorial development management. Modern technologies provide the fastest, simplest, and cheapest way to get, process, and manage spatial data [10].

The new technical characteristics of a 3D real estate cadastral study allow describing and summarizing the exact object parameters represented in the cadastral plan on the Rosreestr website. The new technical formats meet the requirements of the Russia’s Unified Law on Cadastral Policy. At the customer’s request, new spatial property data representation modes can be introduced. This technique allows getting the criteria required for determining the height and depth of ownership, particularly for the land plots with uneven relief. Also, the new 3D format allows determining the height and depth of the room space. Starting from January 1, 2017, new criteria for choosing the object data representation format are already being implemented in practice. New legal provisions allow implementing the new formats in practice. Thus, the customer may order the option of providing the property right overview in the DXF, RVT, PLN, and SKP formats. A visual model will allow describing the exact object parameters, which should coincide with the cadastral figures on the Rosreestr website.

Practical foreign experience in implementing 3D technologies has shown that the 3D cadastre is used and applied in 24 EU countries. Particularly noteworthy is the Netherlands’ state land registration system with a functioning real estate market. This cadastre has been developed on a professional platform and is flawless in both theoretical and practical terms. Implementing such an innovation in Russia would improve the entire cadastral system and make it simultaneously innovative for designing and ultra-modern for accounting the land plots.

The practice of foreign countries has repeatedly showed that direct transfer of experience to Russia does not lead to the results expected. Currently, a detailed analysis of foreign cadastral systems and their historical formation is important to adapt them to the historically formed features and natural and climatic conditions of Russia. The 3D facility cadastre comprises individual graphical tools: those can be the land edges, ravines, slopes, or premises, apartments, and other real estate cadastre objects with simultaneously displaying the colors. Each graphic primitive corresponds to a separate raw in the summary table of attributes, which includes the state real estate cadastre data (object number, cadastral number, address/location, form of ownership, copyright holder, etc.) [16].

6. Conclusion

As of the beginning of 2020, the legislation of the Russian Federation concerning the Rosreestr land plots and the state cadastral registration virtually does not refer to 3D objects. Herewith, there are no obstacles for introducing 3D plots in the cadastral registration [14]. This means that the cadastral law provides a sufficient basis for the development aimed at using a 3D cadastre in the modern cartography system [17]. Implementing the 3D cadastre can improve the existing right and cadastral registration system and expand the list of services provided to various users. It is logical to assume that the further use of modern geoinformation innovations will allow not only actively implementing the 3D cadastre technique but also moving to a new level. Soon, a four-dimensional cadastre should be created, which will allow reviewing the changes associated with any facility both at the moment and throughout the entire period of its existence [18].

In the paper, the author has explored improving the technique for implementing a 3D cadastre in existing accounting information systems.

The key problems have been solved:
- the literature on the research issue has been analyzed,
- the experience and prospects of implementing a 3D cadastre in Russia have been studied,
- the accounting information systems for implementing a 3D cadastre in Russia have been studied,
- the main provisions of the concept of implementing a 3D cadastre in existing accounting information systems have been considered.
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