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3D Cadastre as a Tool for Water Bodies Account

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SUMMARY

The classification of cadastral systems depending on the dimension is analyzed. The existing cadastral systems in Ukraine and their problems are considered. The necessity of introduction of 3D technologies for water objects registration is proved. The existing methodical approaches to obtaining three-dimensional information are systematized. Examples of water objects representation in three-dimensional geoinformation environment are given.

3D кадастр як інструмент обліку водних об’єктів

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РЕЗЮМЕ

Проаналізована класифікація кадастрових систем в залежності від розмірності. Розглянуті існуючі в Україні кадастрові системи та їх проблеми. Доведена необхідність запровадження 3D технологій для обліку водних об’єктів. Систематизовані наявні методичні підходи до отримання тривимірної інформації. Наведені приклади представлення водних об’єктів у тривимірному геоінформаційному середовищі.

Introduction

Full displaying and functioning of the three-dimensional space in accounting and registration systems is not a haunting future, but a regular trend, clearly formulated in the international concepts "Cadastre-2014" and "Cadastre-2034". Instead, the state of cadastral systems in Ukraine today is unsatisfactory.

Theory

So we have to deal with the problem of delineation of the two-dimensional and three-dimensional cadastre concepts. The basis of these terms is the dimension, that is, the ability of the cadastral system to simulate the real world object in a certain amount of spatio-temporal measurements. In almost all existing cadastres, the boundaries of accounting units are presented in the form of their projections on a contingent level, so the cadastral metric is described in two dimensions (2D cadastre). The concept of the 2.5D cadastre occupies an intermediate position between two and three-dimensional cadastres. In this case, height values of the accounting units' projections may be different from the zero relative to the conditional level surface. And although the 2.5D cadastre allows you to set the rights in volume, it is not able to simulate real 3D surfaces. The 3D cadastre, using three-dimensional geodata, describes, on the one hand, the bulk physical objects (the mathematical model is as close to the real world as possible), and, on the other hand, the legal 3D space. In the full 3D cadastre, three-dimensional space is presented in the form of volumes, without overlays and spaces [3, 4]. Three-dimensional space allows you to control the objects` geometry.

The idea of a 3D cadastre has developed due to the need to record and reflect the spatial dimension of owners` and users` of the property rights, restrictions and responsibilities (3D RRRs). This required to link rights and restrictions with realistic models of existing objects unambiguously [5].

The spatial-temporal system, which allows to fix the time of appearance and termination of rights and their restrictions on objects of immovable property in three-dimensional space, is called the 4D cadastre [6].

The result of a full-fledged combination of three-dimensional space, time and scale (mutual compatibility of geospatial data type and topological primitives) in one accounting system is the so-called 5D cadastre [7]. Its main feature is the ability to automate the selection and synthesis of information from large-scale two- and three-dimensional models.

The last two concepts are theoretical, but the 3D cadastre, as a real estate accounting tool, is implemented and works in Australia, Denmark, Israel, Canada, the Netherlands, Norway and Sweden [3].

In Ukraine, at the same time, 11 cadastral systems coexist for the accounting and public administration of various kinds of resources that have a spatial distribution. Some cadastres exist in tabular form, another part – in the form of geoinformation systems. The State Land Cadastre has the most perfect technological and regulatory support. Technically, the State Land Cadastre is capable to keep records of objects in three-dimensional space. In reality, the Ukrainian land cadastre has no high-altitude component. Consequently, relief is not modelled in the form of mathematical surfaces, the part of information, important for land use, is lost.

In this study, we will not focus on the need to combine all existing cadastres into one complex system. Let's emphasize that it is expedient for Ukraine to adopt the world experience in creating three-dimensional cadastral systems. However, nowadays the water cadastre almost needs these technologies.

Water objects are three-dimensional in nature. They have characteristic relief of the bottom. One of the most important characteristics of water bodies is the volume of water in them.

At the same time, there are no normative and methodical documents in Ukraine how to implement precise three-dimensional imprints and to create three-dimensional cartographic and geoinformation materials.

In this regard, we have attempted to systematize the existing methodological approaches to obtaining three-dimensional information, in particular about water objects. Depending on the field of science that studies and develops these approaches, we identified four groups of methods: geodetic,

photogrammetric, remote sensing and geophysical. Geodetic methods consist in determining the objects` location on the Earth's surface by measuring the angles and distances between them. Photogrammetric methods are aimed at determining the shape, size and position of objects in their image. Methods of remote sensing are based on the registration of reflected electromagnetic radiation and do not involve direct contact with object. Geophysical methods are based on measuring the fluctuations of the physical fields of the Earth.
The most effective way to get information about the relief of the water bodies' bottom, which ensures the further construction of the three-dimensional model, is the method of active hydrolocation. This method is based on the removal of underwater objects by fixing the reflected sound of the signal generated by the sonar. In our study, we used an automated echo-shooter, which allows you to measure in automated mode at depths from 0.5 m and more. An upgraded echo-shooter with a narrowed and reinforced beam of sound is installed on a small vessel, an upgraded echo sounder with a narrowed and reinforced beam of sound beams is installed. It allows to fix depths up to 60 m and examine the bottom, penetrating through a layer of silt in the thickness of 0.5 m. The obtained results have high accuracy (X, Y, Z ± 10 cm), spatial discreteness of measurements is 1 sq. dm and is sufficient for the construction of digital terrain model. Due to the use of an on-board GPS receiver, the data has a spatial reference and can be imported into GIS.

Examples

With this device, an artificially created Camel gulf in Kyiv city was investigated. It was established that the depths of the bay sometimes exceed 20 m (Fig 1).

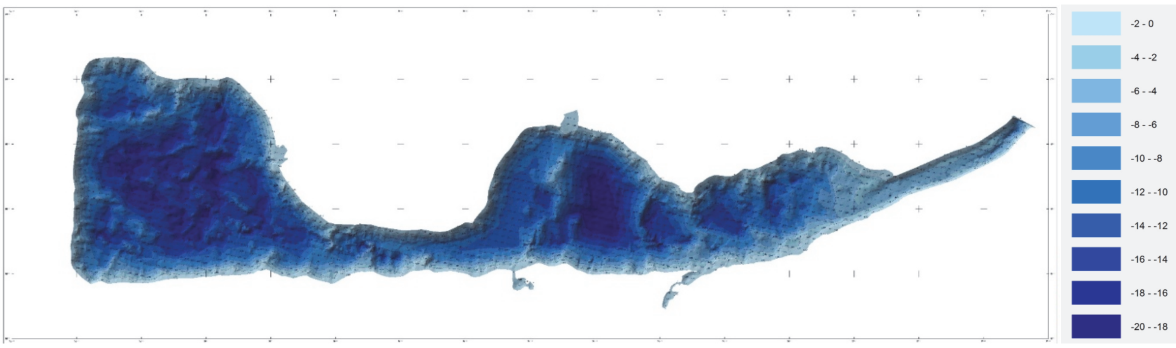

Figure 1 *Digital terrain model of Camel gulf bottom. In relative terms, the relative depths in meters are given.*

The relief of the Camel gulf bottom is complex and not typical for the Dnipro bays. The depths are much smaller and make 3–4 m at the mouth, while in the far western part of the bay average depths reach 15 m. The banks of the shores are quite steep. In such a situation, measurements should have high accuracy, small spatial discreteness and spatial binding, so the requirements for the measurement process increase.
Another example is the shooting of the bottom of the artificial lake Nebrezh, the results of which also compiled a three-dimensional model of the bottom (Fig 2).

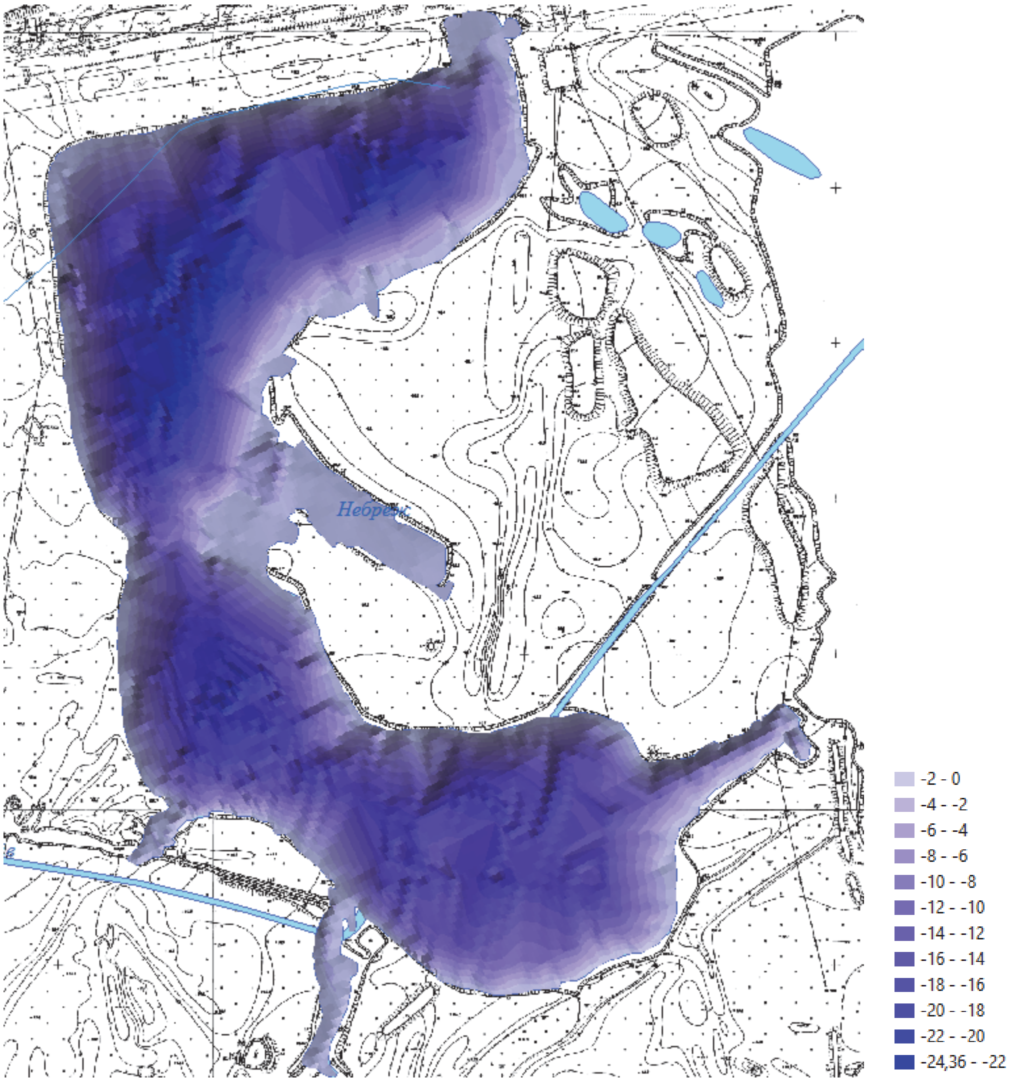

Figure 2 *Digital terrain model of Nebrezh lake bottom. In relative terms, the relative depths in meters are given.*

Conclusions

The automated echo-shooter is an effective technology for creating and maintaining a 3D cadastre of water objects. Such a cadastre can be developed at the level of individual settlements and united territorial communities. The automated echo-shooter allows to solve the tasks of lakes and beaches certification, analysing areas flooded when filling reservoirs.

Authors propose to create a three-dimensional system for water objects recording on the basis of abovementioned technology. One of the tasks of this system is installing coastal protection zones around water bodies in an automated mode (taking into account slope steepness). Similarly, it is possible to keep records of engineering networks. The protection zone will automatically appear only around those in service.

It is worth noting that the issue of normative, technical and methodological provision of cadastral, cartographic and geoinformation works is entrusted to the State Service of Ukraine for Geodesy, Cartography and Cadastre [8]. In our opinion, it would be advisable if this agency had created and regularly updated a certain catalogue of technologies and equipment authorized by the state to perform, including works related to the creation of three-dimensional geoinformation data.

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