GeoTerrace-2020-003

Theory and practice of 3d cadastre development in Ukraine

*M. Malanchuk, N. Muzyka, O. Yastrebkova *(Lviv Polytechnic National University)*

SUMMARY

Environmental protection currently in the world cadastral registers of rights is mostly based on 2D packages, which are designed to register property rights, easements, restrictions, encumbrances, including public law restrictions on land, to provide comprehensive information on the legal status of real estate. However, in cases where space with partial ownership of land is reused (underground parking lots, multi-storey road junctions, etc.), a 2D cadastre cannot be represented and display geospatial information about 3D rights. 3D technologies are becoming more efficient than 2D, especially when integrating urban and regional planning and management, and above all, when working with 3D underground and aboveground spatial infrastructure.

Introduction

The essential factor for Ukrainian cadastre development is the study of the 3D cadastre basics, international experience and jurisdictions and its functioning at all levels, as well as the theoretical creation of a basis for the further functioning of a 3D cadastre. This approach leads to the definition of 3D legal and 3D physical objects, their registration in inventories and modelling. Environmental protection currently in the world cadastral registers of rights is mostly based on 2D packages, which are designed to register property rights, easements, restrictions, encumbrances, including public law restrictions on land, to provide comprehensive information on the legal status of real estate. However, in cases where space with partial ownership of land is reused (underground parking lots, multi-storey road junctions, etc.), a 2D cadastre cannot be represented and display geospatial information about 3D rights. 3D technologies are becoming more efficient than 2D, especially when integrating urban and regional planning and management, and above all, when working with 3D underground and aboveground spatial infrastructure.

Methods of investigation

To study the process of functioning of a three-dimensional cadastre, the formal-logical and content-genetic aspects of this issue were involved. In other words, the formal logical side is responsible for the collection and processing of materials following the research topic, and the content-genetic side is responsible for theoretical generalization using laws. The choice of research method determines:

- processes of a three-dimensional cadastre, which together form a single essence and principle of management, conservation of land in the land management system;
- the use of links, relationships, quantity, quality, contradictions in the study of the parameters of the 3D cadastre in conjunction with functions;
- the role of the 3D cadastre in the performance of land management, management and urban planning works;
- determination of the feasibility and role of a person in the formation of a 3D cadastre in the real estate market.

Results of investigations

The cadastre is always connected with the land. In large cities, land use is becoming more intense as different types of land use emerge. In other words, land plots are located below and above other land plots. This is a significant challenge for the current cadastral system, which is unable to solve the problem without the introduction of the third dimension. The platform for the functioning of a 3D cadastre are objects with different types of space use, which can be classified as follows:

- objects located one above one;
- objects with infrastructure above and below ground;
- a large number of cables, pipes;
- multi-storey apartment complexes.

These physical 3D objects do not correspond to legal objects, which in turn are clearly defined. Therefore, they cannot be determined as cadastral objects on cadastral plans. In other words, these objects cannot be used as a basis for registration. Implementation of a 3D cadastre in Ukraine requires the functioning of a perfect cadastre model. General 3D cadastral registration is the process of implementation of rights in three-dimensional space. The legal framework, with the specified real estate agreement and cadastral registration, should support the installation and transfer of 3D rights. The completeness of the information is formed during the registration of an object. Therefore, 3D cadastral registration must ensure the completeness of data in three-dimensional time about real estate objects and ensure the completeness of data for all areas of production. At the moment, there is no registration in 3D, even professionals (notary, real estate agents, cadastral workers) may not know about the complex spatial position of a 3D object, and, accordingly, the public and specialists who are not cadastral services (planners, contractors) also do not own information. Therefore, the most important from the information point of view is the need for a better understanding of the 3D position structure of the object.

The better the availability of registration (objects that do not have a complex geometry), the better the legal security of the property. The start of 3D registration will lead to the formation of a 3D cadastral registration. If we investigate three-dimensional registration in the legal field, it is necessary to introduce the concept of 3D legal objects, which in turn entails changes in the legislative field (civil code), which is a long process. The best practical application of a 3D cadastre with the most significant utility is in densely built-up areas.

Storing a physical object in a 2D cadastral registration is quite promising, given the economic situation. In other words, it is very beneficial in terms of accessibility. That is, information about 2D and 3D must be available and then merged automatically. The disadvantage is the existing model of data registration, which is only two-dimensional. When implementing 3D cadastral registration, several stages can be separated. 3D registration begins with the defined possibilities of creating 3D property units within the land plot. The next step is to study the units of 3D properties, such as filling a public register with a description of the land or integrating 3D information into cadastral registration. At the final stage, the provisions can be established, which define the structure and size of the 3D data, which in turn is used to support the 3D registration properties. The countries with advanced 3D cadastre functioning have examined the following issues (Stoter, 2004):

- how to create 3D property units within the existing legal framework?
- what was the main driver for creating property units in 3D?
- whether 3D-property rights exist independently of the land registration?
- what are the main disadvantages of the current registration with the 3D property?

Land cadastral information is a cadastral basis with a description of data on each land plot, which together forms a model of information, in other words, any source that provides specific information is the primary source. All information contained in the information model of the Earth is divided into spatial and attributive. Necessary cadastral information on land is collected during the implementation of cadastral land management, land privatization and other technological procedures on land, which is then collected in the database of the land cadastral system, regardless of whether it is presented in paper form or the form of electronic media (Benhamu, 2002). In the course of economic development, the need for more diverse information materials becomes more and more urgent. The data stored in traditional cadastral systems do not meet the requirements of surveillance, management, decision making, forecasting and development planning. The most significant problems are:

- insufficient accuracy of geometric data;
- quality and speed of data access;
- differences between the plan and the register.

Another type of problem is the ability to perform analysis and reporting. Using a traditional analogue register, the owner cannot easily specify a primary parameter, such as the number of land plots described. At the stage of collecting certain information, verification of the clarity of spatial data, as well as the reliability of the attribute data of the land plot, should be introduced. Particular attention should be paid to the electronic card or the user's ability to create a personalized card (Sohnych et al., 2005). One of the main factors of the 3D cadastre, which is not considered in the modern understanding of land cadastral information, is the volume of the object and the structure of the terrain, which in turn causes the incorrect functioning of the 3D cadastre. Besides, there is an equally popular factor, such as timekeeping, i.e. historical information about an object over time. When operating a 3D cadastre, it should be noted that all cadastral information should be integrated, in other words, the connectivity of all data that create a single information system in three-dimensional space when they are superimposed. 3D-geoinformatics is gaining importance for decision-making on land acquisition and land use rights. The increase in the number of landowners in urban conditions is a problematic situation associated with subsequent factors, namely the demarcation of objects. This problem can be solved with the help of 3D-visualization and 3D-design with subsequent implementation in practice. But there is a significant omission when a legal object materializes by binding it to a physical object.

Registration of rights to a 3D plot must contain and ensure certainty of ownership, protection of rights and precise spatial placement (Stoter et al., 2016). In general, not all cadastral jurisdictions in the world maintain a digital cadastral database. The conceptual design of such registration is preserved regardless of whether it contains a paper or digital cadastre or not. This applies to the jurisdictions of the 2D cadastre and the 3D cadastre, thereby ensuring the ownership of the 3D parcel. In other words, it protects the rights of owners and provides valuable financial instruments such as mortgages, insurance, valuation and taxation. In the future, 3D information modelling should support 3D visualization, i.e. not only cadastral registration but specific spatial units of rights, duties, restrictions. It is essential that in the 3D information model as a basis, it is necessary to include public and private entities, which in turn will perform a number of crucial functions for the functioning of the 3D information model, including:

- development and registration of zoning plans in 3D;
- registration (public law) of restrictions in 3D;
- design of new spatial units (underground parking lots, road junctions, etc.);
- obtaining a specific land plot in 3D space;
- request and response for extensions in the land plot (after relevant checks);
- securing funding for future pending objects in 3D;
- reconnaissance and measurement of spatial units, objects in 3D;
- granting complete rights to customers;
- storage in space and time, analysis of spatial 3D units;
- distribute, visualize and use spatial objects.

A 3D information model requirement is to support various types of 3D units. In turn, measurements with a specific period should be attached to the information model, which will allow representing several versions of the same object in a period, which is associated with the terrain. The problem of combining two-dimensional land plots with three-dimensional plots, namely the database and the exchange format, is one of the main issues that must be eliminated before the creation of cadastral modelling. Various approaches were proposed by (Thompson 2017) for European countries, which can also serve as an example for us in solving the problem in the modern understanding of the functioning of 3D, as follows:

- storing 3D objects in a separate database from another 2D database;
- saving only the front face, without bindings;
- storage of all topographic plans in the central database system only in 2D form;
- storage of 3D areas in CAD or pdf format, which can later be extracted from the archive;
- integration of 2D sections and 3D objects into one database, with preliminary compatibility clarification.

Spatial modelling of information is impossible without the 4th coordinate, which is responsible for time. In other words, the fourth space in real estate is an essential aspect of cadastral registration (van Oosterom, 2013). It should be noted that the rights, obligations and restrictions are temporal. Thus, cadastral information in 4D becomes necessary when the past period is required for a specific property, or when historical details on the development of land tenure in a particular region are necessary for the implementation of future land policy, i.e., this is an aspect of time (4D). A visual representation of the combination of 2D and time factor (4D) as the basis of cadastral modelling of information is given in Figure 1. Since each object in the future will contain 4D information, such an information model must support the time dimension by adding separate attributes of the time range. The left side (stationary) is represented by two-dimensional axes X and Y, and the axis which is responsible for the temporal position of the object time (time), in this example is the land plot P_1. Thus, we have one land plot (P_1) with a timestamp t_0, which after a certain period will be divided into two separate objects P_2 and P_3. In the process of division, a new time reference t_1 was made, for some time the real estate object P_3 was divided into two independent plots P_4, and P_5 with a new reference t_3, i.e. land consolidation is observed. The right part (progressive) reflects the movement of the areas of land plots for grazing P_1 and P_2 in time t_0. The difference in this part is that the area itself moves in time, but with the fixation of the original area at time t_0.

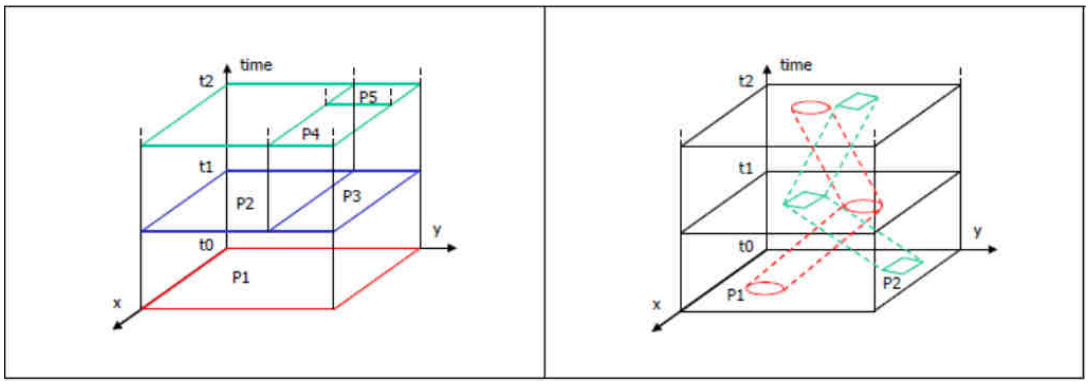

Figure 1 *Visual representation of a combination of 2D and time factor (4D).*

It is clear that time plays a decisive role in cadastral systems, but the temporal point of view (4D) is considered completely independent of spatial aspects (2D or 3D).

Thus, the basis for 3D-cadastral modelling of information should be 4D information, that is, a three-dimensional space with the involvement of time, but without overlapping and errors in the cadastral information at all its levels. In other words, 4D data must be considered in conjunction with 3D cadastral modelling of information, i.e., time forms information.

Recommendations and conclusions

Therefore, changes in the cadastre system are inevitable, because there is a change in the legal framework, which operates depending on each other. Along with the change, it is necessary to set long-term goals for the rapid implementation of the 3D-cadastre:

- creation of a 3D model taking into account the system of property rights;
- processing the process of introducing the definition of "three-dimensional real estate";
- development of mechanisms for real estate formation and registration;
- outline proposals for updating and amending the legislative field.

References

Benhamu M., Doytsher Y. (2002) A Multilayer 3D Cadastre: problems and solutions. In FIG XXII International Congress, Washington, D.C. USA, April 19-26.

Stoter J.E., Peter J.M. van Oosterom, Ploeger H.D., Aalders H.J G.L. (2004) Conceptual 3D cadastral model applied in several countries. In *FIG Working Week 2004. TS25 – Appropriate Technologies for Good Land Administration II – 3D Cadastre, Athens, Greece, May 22-27,* 1-27.

Sohnych O.A., Yevsyukov T.O., Smolarchuk M.V. (2005) Development of land-cadastre information system, *Scientific Bulletin of UNFU*, 15(3), 184-190. (in Ukrainian).

Stoter J., Ploeger H., Roes R., van der Riet E., Biljecki F., Ledoux H. (2016). First 3D Cadastral Registration of Multi-level Ownerships Rights in the Netherlands. In *5th International FIG Workshop on 3D Cadastres*, Athens, Greece, 491–504.

Thompson R., van Oosterom P., Soon K. (2017). LandXML Encoding of Mixed 2D and 3D Survey Plans with Multi-Level Topology. ISPRS International Journal of Geo-Information 6(6), 171–26

van Oosterom P. (2013) Research and development in 3D cadastres. computers, environment and urban systems, 40, 1-6.