Necessity of 3D Cadaster and Possible Cases

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Abstract. The paper describes the current state of cadaster and land registration in Bulgaria. The objects of cadaster are clarified. The necessity of information about rights, restriction and responsibilities increases in complex spatial situations. After a brief review of cadastral and land registration legislation, the possibility of future development of a 3D presentation of the cadastral objects is presented, taking into account the current state of the cadastral system in Bulgaria. The prerequisites, the possibilities and the means for application of 3D cadaster in Bulgaria are clarified and the challenges to its realization. Problems concerning the design of an efficient system for land administration, possible technologies and standards for realization of 3D cadaster are described. The possible data sets, in accordance with ISO 19152, which should be present in the realization of 3D cadaster in Bulgaria are analyzed. In addition to the data from the digital model of the cadaster, specialized data is also needed. Some of the specialized objects require a three-dimensional representation, which is a prerequisite for 3D cadaster development. Many of the various specialized objects impose restrictions on land immovables, even though the presence of the object itself is not required. Schematically are described the necessary steps to go through to unify data and achieve interoperability.

1. Introduction

The main purpose of the cadaster is to show objects of cadaster, to identify them and to connect object and subject by the property rights. This role of the cadaster is important to be retained and upgraded by the modern technologies which are available nowadays [15].

The current task which is faced Bulgarian cadaster is the completely creation of the 2D cadaster for whole territory, because 3D presentation is based on 2D. It can be assumed that the first steps in this direction are made by applying European directives about infrastructures for spatial data (INSPIRE). Various specialized data are necessary for creation of most of the themes.

2. Current state of Bulgarian cadaster

The beginning of the current modern legislation starts at 1991 with adoption of new Constitution of the Republic of Bulgaria, which establishes new principles of ownership.

The Restoration of Ownership in Settlements and on Agricultural Land and Forests Acts (1991 - 2002) imposed a change in the regulations related to the cadaster [13].

The main document and important act is Cadaster and Property Register Act (CPR Act), according to which immovable properties, that are the objects of cadaster are (Figure 1):

- **land property** – this is the basic unit of the cadaster. Land property is a part of the surface of the earth, including durably covered with water, defined by boundaries compliant with the right of...
ownership. The land properties fully cover up the territory of the country, defined by the state borders, without overlapping each other;

- **building**, including also rough construction;
- **self-contained object** in a building or in a facility of the technical infrastructure (SCO)- part of the building or facility that has a self-dependent function and building with exposed walls. SCO can be an apartment, office, studio, garage, store, etc.

Each land property, building or self-contained object is attributed an identifier, a unique number by which the immovable property is singularly identified within the territory of the country.

![Figure 1. Objects of cadaster](image)

Nowadays there is no registered information about the heights of the immovable properties. For the buildings is registered only the number of floors of the building. For the self-contained objects is registered the number of floor on which the object is situated.

The restriction zones also must be present on the cadastral map. The restriction zones are on the land properties and they are result of easement or restriction, based on a normative act, an administrative act or a contract.

All other objects that are not objects of cadaster are specialized objects and it is necessary specialized maps about them to be produced. The chapter 4 of [4] defines them:

a) immovable properties, other than basic cadastral data;

b) buildings, structures and other improvements in land properties, including the overground and underground linear utilities and facilities, other than buildings and self-contained objects in buildings;

c) perennial plantations;

d) water courses and water surfaces;

e) mineral deposits in the earth's womb;

f) the relief of the earth's surface;

g) other defined by act.

There is a wide variety of specialized objects, which will be listed later. Many of the various specialized objects impose restrictions on the objects of the cadaster, although the presence of the specialized object itself is not required.

Internet module “KAIS portal” of the cadastral information system is accessible on [http://kais.cadaster.bg](http://kais.cadaster.bg) (Figure 2).
Currently the country is in a process of covering the whole territory with cadastral map and cadastral registers and the coverage is shown on figure 3.

3. Cadaster 2014 – where are we?

Cadaster 2014 is a report, published in 1998 by FIG working group (commission 7). The working group worked between 1994-1998 and has defined trends in cadastral development for the next 20 years.

The report of the World Bank for 2014 examines the state and development of 11 eastern European ex-socialist countries, among which is also Bulgaria, and these countries are part of the first 20 countries all over the world as the most favorable for business and effective registration of land property. There is an evaluation of the country economics about realization of the six statements in Cadaster 2014 [11].
**Statement 1:** Cadaster 2014 will show the complete legal situation of land, including public rights and restrictions

![Figure 4](image4.png)

Level of achievement of statement 1

Restitution activities are made, but cadastral maps and registers are still not complete and the land register is not finished yet. Cadastral parcels that are object of business transactions are registered in land register. There is a slow progress about showing the complete legal situation and the reason is the change of [4] by 2014 that claims: „Art. 2 (2) The cadaster includes and: 4. Data about restriction zones on cadastral parcels. (3) These data are shown on the cadastral maps and are registered in cadastral registries “. According to [10]: „Art. 24, (2) Registers about restriction zones and objects of the information-administrative maps are designed and upgraded“. In [10], art. 78 the content of the project about restriction zones is specified as well as the content and the structure of the register of the restriction zones. It is expected to achieve some result after these changes are applied.

**Statement 2:** The separation between ‘maps’ and ‘registers’ will be abolished

![Figure 5](image5.png)

Level of achievement of statement 2

There is minimal conformity with that statement in Bulgaria. The digital model of cadaster (figure 2) contains graphical part (cadastral map) and attribute part (cadastral register of immovable properties). The registration system of the cadaster and land register is still dual [6].

The information systems of the cadaster and land register are made as distributed data bases in 28 cadastral offices and 113 regional courts where the information about immovable properties and land rights at every moment is stored.

**Statement 3:** Cadastral mapping will be dead! Long live modelling

![Figure 6](image6.png)

Level of achievement of statement 3

This statement is achieved. The cadastral map and registers are made and updated in digital format.

It is necessary to extend the existing 2D model to a 3D model in order to show complete legal situation of immovable properties along with the restrictions, which are 3D in many cases.

**Statement 4:** ‘Paper and pencil - cadaster’ will be gone

![Figure 7](image7.png)

Level of achievement of statement 4

This statement has considerable realization during the last years due to the announced Public Procurements about cadastral maps and registers.
The available maps of the restored properties are created and upgraded in digital format and soon they will be added as cadastral map. This means that statement 4 will be achieved very soon.

**Statement 5: Cadaster 2014 will be highly privatized! Public and private sector are working closely together**

![Achievement progress](image)

**Figure 8.** Level of achievement of statement 5

The Geodesy, cartography and cadaster agency (as representative of the state) is responsible for cadastral activities. It is written in art. 8 of [4] – „The cadaster and the land register are public. The cadastral map and cadastral registers are property of the state“.

The private sector creates and updates the cadastral map and cadastral register (in some cases it is possible to control the activities), but the state assigns and administers it. The Geodesy, cartography and cadaster agency is responsible for the whole process of creation and updating of cadaster.

**Statement 6: Cadaster 2014 will be cost recovering**

![Achievement progress](image)

**Figure 9.** Level of achievement of statement 6

It is achieved because the taxes which are collected for the services of cadaster and land register provide the possibility for self-financing.

4. **Necessity of 3D presentation of the objects of cadaster**

4.1. **Preconditions for implementation and usage of 3D cadaster**

Nowadays Bulgarian cadaster is strongly 2D, which is a precondition for incomplete presentation of the objects of cadaster and the reason about arising some problems, as:

- Dispersion of the information about effective and sustainable land use. There is bilateral relationship between information system of cadaster and land register, but there are data which are in separate information systems (such as data about underground network, digital terrain models, etc.). This is precondition for duplication and inhomogeneity of the information. If there is data exchange between the different systems, cadastral data services would be easier to provide and there would be precondition for development of 3D cadaster;
- Restricted registration of the objects of cadaster – property rights sometimes are 3D and they should be restricted not only in 2D.

The reasons which impose 3D cadaster are given in [17]:

- The registration of the legal state of complex infrastructure and densely built-up areas can only be presented to a limited extent by existing 2D systems;
- Registration of overlapping and intersecting objects;
- Increasing the technical infrastructure above and below the ground;
- Increasing the underground parking lots, buildings above roads, separate object over bridges, overpasses, underpasses, multi-level buildings and etc;
- Usage of 3D approaches at other fields (3D GIS, laser scanning, 3D planning) makes three-dimensional cadastral registration technologically feasible [14].

Urbanization and industrialization exert more and more pressure on land use and the need to increase space, such as the increasing complexity of infrastructure, and require registration of legal status (private and public) that can be presented limited by the existing 2D cadastral registrations. 2D
cadastral systems cannot manage and show the 3D rights, restrictions and responsibilities in space. One of the most important challenges for them is the management of 3D rights, restrictions and responsibilities, including the 3D cadaster [12].

3D cadaster is next stage of cadastral development not only as possibility to include all immovable properties, but as an instrument that assures more quality data about objects of cadaster from the point of view of accuracy, visualization, possibility for calculation of heights, volumes, spatial zones of restriction, responsibility and etc.

The task about initiation of standards for model description and data transfer is actual task for the current spatial information systems.

Many countries all over the world work hard in the field of 3D cadaster. Bulgaria as a full member of the European Union is obliged to observe European legislation. The infrastructure for spatial information (INSPIRE) is part of it and as a result of it, there is approved Law on access to spatial data. It regulates development of the national geoportal for spatial data, which will be connected with the European geoportal. For the realization of a large number of themes are necessary specialized data, which can also be considered as a first step towards the development of a 3D cadaster [7].

4.2. Data for 3D cadaster realization

In order to be possible the registration of complete legal situation (including rights, restrictions and responsibilities) of the immovable properties (Statement 1 of Cadaster 2014) to the spatial (physical) object, it is necessary presence of the legal object that is part of the space. The legal object (legal land object) is part of the territory on which homogeneous rights, restrictions or responsibilities have been established on the basis of a statutory instrument. The aim of the cadaster is to identify spatial object with a legal object, but this is not always possible (right of superficies).

![Figure 10. Presentation of physical and legal objects](image)

There is a direct connection between the physical and the legal object in many cases. According to the packages of ISO 19152 – LADM, although the following groups of data are conditionally classified as:

- Necessary data for registration of the physical objects – can be described with SpatialUnit package of ISO 19152 – LADM;
- Necessary data for registration of the legal objects – can be described with Administrative package of ISO 19152 – LADM;

Table 1 and figure 10 shows the available potential data sets according to the Bulgarian legislation.
Table 1. Data sets

| Object type | Data | Data type                | Spatial presentation¹ |
|-------------|------|-------------------------|-----------------------|
| Physical object |      |                         |                       |
| Land property | Graphic and attribute | 2D                    |
| Building     | Graphic and attribute | - 2D;                 |
|              |                   | - Number of floors     |
| Self-contained object | Graphic and attribute | - 2D;                 |
|              |                   | - Number of floors on which is situated |
| Technical infrastructure | Graphic and attribute | 3D/2D                |
| Legal object |      |                         |                       |
| Restriction zone | Graphic and attribute | 3D/2D                |
| Ownership right | Attribute          | Attribute to physical object |
| Superficies | Attribute         | Attribute to physical object |
| The right to build on already existing building | Attribute | Attribute to physical object |
| Concession | Attribute         | Attribute to physical object |
| Lease | Attribute         | Attribute to physical object |
| Mortgage | Attribute         | Attribute to physical object |
| Tax purpose | Attribute         | Attribute to physical object |

¹ According to the current legislation

The physical objects are described with LA_SpatialUnit.

The division of physical and legal object is a little bit conditional. For example it can be pointed out that land property, which is a physical object on one hand, but also by its definition in CPR Act it is "a part of the land surface, defined with boundaries according to the property right" follows that it is also a legal object.

The restriction zones can be assigned both to the physical object group and the legal objects.

Some of the possible cases for the realization of a 3D cadaster are discussed in the next section.

The following ownership restrictions are used in Bulgaria:

- **Right of superficies** - a restricted property right on a foreign land parcel, which allows a person to construct a building in a foreign land property on the basis of a legal transaction. According to the Bulgarian property right, there are three forms of superficies:
  - The right to build on already existing building;
  - When something will be built "adjacent" to existing building in the same cadastral parcel;
  - When something will be built under the adjacent terrain.

- **Easements:**
  - Temporary roads - each land parcel should have an exit on a public road. They are determined on the basis of a written contract with notary certified signatures of the stakeholders. In cases when the owners cannot reach a contractual agreement, this is made by an order from the mayor of the municipality;
  - Passing through a foreign property – it is possible in case that several conditions are present - there is not any other technical solution or another technical solution is clearly economically inexpedient. The right shall be established by a written contract concluded between the owners of cadastral parcels with a notary certification of the signatures;
  - Building of deviations from networks through foreign property - aggravation of a property by means of deviations from common networks and facilities of the technical infrastructure (system of facilities and linear engineering networks of transport, water supply, heat supply, gas supply, telecommunications, etc.). This easement is established exceptionally
when there is not any other technical possibility or another technical solution is clearly economically inexpedient. It is established on the basis of a written contract with a notarized signature of the stakeholders.

- **Responsibility:**
  - Concession – “The right to exploit an object and/or a service of public interest granted by a concessionaire to a dealer - concessionaire against the concessionaire's obligation to build and manage and maintain the concession object or to manage the service at its their risk” [5];
  - Lease - "the lessee is obliged to provide the tenant for the temporary use of the object of the contract and to make a certain lease payment" [3].

- **Restriction zones:**
  Some larger groups of restriction zones, which in some cases can also be considered as responsibilities, are:
  - Restriction zone in protected territories and zones - derive from the Protected Areas Act and the Biological Diversity Act;
  - Restriction zone in areas for territorial planning protection - derive from the Black Sea Coast Planning Act;
  - Restriction zone for overground and underground pipelines and facilities - The easement areas around the different types of networks are specified in various regulations - the Water Act, Ordinance №16 for the easements of the linear objects, Ordinance №5 for the procedure and the way of determining the size, distribution and special regime of the easements of the electronic communications networks, facilities and the related infrastructure;
  - Restriction zone on roads and railways (easements) - derive from the Roads Act and the Railway Transport Act;
  - Restriction zone on waters, water objects and facilities - derive from the Water Act and other sub-normative documents;
  - Restriction zone of cultural heritage constraint - derive from the Cultural Heritage Act.

The various protected areas for nature, noise, pollution and other restriction zones illustrate restrictions on the ownership of immovable property and at the same time the responsibility of the respective operator (company / administration) [8].

According to [2] “…The restriction zones are territories on, above and below the surface, formed around a spatial object that is not object of the cadaster. Restriction zones may be territories defined by pipelines and facilities or boundaries of a general development or detailed development plan. Territories with the same durable purpose may also be represented as restriction zones. In general, the restriction zones are other spatial objects that change the use of cadastral parcels and impose restrictions on it.

Restriction areas shall be determined by administrative or regulatory act or contract and on the basis of data provided for spatial characteristics of the area. In the case of plotting restriction, these data are the dimensions of the facility and the size of the buffer zone around it. In the case of a restriction stemming from the Master Plan, these are the boundaries of the development zones…”

### 5. Possible cases of 3D cadaster

At present, the cadaster and registration regulations are strongly limited in the 2D. The conventional description of the objects of the property uses 2D geometry and presents the objects of the cadaster by lines and polygons. The identification of the objects is an essential part of the description, which is the key to the property data registers.

The presentation of the restriction zones provided in [4] is 2D again, although in many cases they impose spatial constraints. Consequently, the cadastral register currently offers information about the holders of rights, but not for their spatial dimension.
In recent years, the object of business transaction has also become parking lots in land properties, attic and basements, which according to Spatial Planning Act and the subordinate acts to it should not be the objects of a deal, but objective reasons turn them into such. The cadaster cannot be inactive in these processes and if for the attic and basement rooms an analogy can be made with the SCO, then for the parking lots, which are part of a land property and cannot be identified with a land plot because of its predetermined purpose, a means of identification should be introduced, as the owner of the land property is generally different from the owner of the parking space. Concessions and leases may also be included in the latter case when the relevant limited right extends over part of the property. The problem in this case is legal rather than technical, so the parking lot does not create a problem that would be solved with 3D Cadaster. If there is a legal reason for the parking lot to be considered as a standalone object of a transaction, it will be drawn in the map.

These examples illustrate a part of the problems of the conventional 2D cadaster. In many cases, however, the used geometry is not sufficient for a complete description of ownership. These are all cases of defining boundaries of ownership in the space around a particular object. These cases are the result of the intense development of the urban environment and the desire of people to make better use of the resource in the area. Thus, different objects of ownership appear in the underground and aboveground infrastructure of the urban environment, the objects to which they may have different spatial relationships (above, below, neighboring).

5.1. Case 1 – residential building with SCO and underground parking space
There are many residential complexes at the territories of the big cities. There are various SCO - apartments, commercial areas, underground parking lots and / or parking spaces which do not present on the cadastral map. Their existence is known from the floor schemes, the cadastral register of immovable properties, the register of the identifiers and their changes, part A of the immovable property accounts in the property register, in the acts, which recognize or transfer the right of ownership or establishes, transfers, modifies or terminates another right on immovable property, as well as in other cases determined by a statutory instrument. They are identified in the outline of the building where they come with a unique number using a hierarchical structure. The common areas and premises in the building are not depicted or numbered because they are co-owned among the holders of property rights in the building.

The [10] does not provide identification of underground parking or parking spaces. It is possible that they are described in the ownership document of the apartment, but on the other hand they are transformed into objects of a transaction, which have to be considered asSCO on the underground floor(s) and to draw schemes on the floors for them, the underground floors are numbered "." before their numbers.

5.2. Case 2 – Self-contained object in a facility of a technical infrastructure
Currently this example is a part of the legislation and these objects are identified as an object in a (underground) building.
A common example is the subways where are built stores and respectively may be the subject of a transaction. The entrances of the metro stations are in some of them - the subways of the Central Station, "Serdika", Sofia University "Kl. Ohridski ", Eagle bridge and others in Sofia. The subways according to [4] are not objects of the cadaster and are not present on the cadastral map and the registers to it. The commercial areas in them are SCO and therefore they are treated as it. And the probability of SCOs occurring in subways on more than one floor is large - for example, in subway stations.
Therefore, [1] proposes that if there are SCO in a subway, the subway be entered in the cadastral map as a "underground building" for which "underground floors" schemes are being drafted and SCO in the subway are identified as SCO in a building. Schematics of floors (as in buildings) are the means of determining neighborhood. Clear rules for the identification of spatial ownership and a standardized
numbering scheme should be introduced. For the graphical part, it is proposed to introduce a symbol for the outline of the subway. In this way the approach to documenting the SCO in the subway with the one in the building is unified. Preconditions are created for the territorial delimitation of the SCO location in the subway on the map and the determination of the neighborhood adjacent to the floor above and below the floor where the SCO is located.

Another similar example is the cafe "Panorama-Kulata Snezhanka" located in the tower of Snezhanka Peak in the Rhodope Mountains.

**Case 3 – Land property under facility**

Bridges and overpasses are not subject to the cadaster according to [4]. On the cadastral map only the part of the facility (its beginning and end), which "steps" on the ground, is drawn. The complete drawing of the facility is subject to a specialized map and registers. Consequently, landed properties under them are limited in their use in height. Examples about it are Brussels Blvd which is overpass and the bridge over the Aviation Square in Sofia.

**Case 4 – Underground and ground networks and facilities**

Underground and ground networks and facilities are another large group of specialized objects that impose spatial constraints and different types of networks should be considered separately. As mentioned, they are the subject of the specialized maps and registers, but due to the limitations they create on the cadastral sites, the information about the cadastral site should also contain information about the restrictions imposed on the conduits and facilities.

6. Conclusions

Many countries all over the world are working hard for development of a modern presentation of the objects of the cadaster by implementing standards and formats. Because the reason for the above is that this facilitates the combination of cadastral data with spatial data of other systems. Another reason is the complete description of both spatial objects and the full legal description of rights, restrictions and responsibilities.

The creation of a 3D cadaster has many advantages, including an increase in possible solutions that are currently a problem for the cadastral system, increase of the provided services, etc.

Another important stage in the realization of such a cadaster is the creation of a well-thought-out and structured legal framework describing clearly and precisely the procedures, activities, data exchange formats, etc.

Information in 3D allows better presentation of the objects of the cadaster, their location and interaction with other objects.

The shown examples present the possibility of developing and finding solutions for the registration of various spatial objects. The introduction of spatial rights and restrictions necessitates rethinking the plane cadastral concept and depends on the legal system. There is a field for different specialists in this subject area.

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