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# Conception of Registration of Underground Spatial Structures in Modern 3D Cadastral System

**Abstract:** The rational administration and management of properties requires obtaining and gathering information about the properties and their surroundings as well as implementing an IT system that makes it possible to update information regularly and prepare analyses of such information. Work on creating a uniform 3D cadastre that would facilitate the rational management of those spaces that until now have been considered undevelopable is carried out around the world. There is ongoing work on the manner of making the transition between 2D and 3D cadastres.

The continuing investment and economic development in Poland requires the development of a spatial registration concept for objects located above or below a plot of land. The recording of spatial object data is to be in line with initiatives and standards between the national standards for the harmonization of spatial data sets.

**Keywords:** LADM, 3D Cadastre, real estate management, object-oriented spatial plot

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## 1. Conceptual Model of Polish Cadastral System in Light of "Land Administration Domain Model" (LADM)

The development of a modern cadastral system in the world shows that it will be a multi-purpose system that allows us to determine the position of a plot of land in space and register the rights to this space. This view is expressed by A. Rajabifard, R. Bennet, and K. Mohsen [1]. V.H.S. Khoo [2] stresses that a modern cadastral system should have data in one format and adopt an international data-modeling system. In addition, it should contain spatial objects and automatically power the system with the measured data.

The ISO 19152 *Geographic information – Land Administration Domain Model (LADM)* international standard can be used for this purpose [3]. The Land Administration Domain Model is the subject of that part of property administration that is related to the rights, obligations, and restrictions of the property and its spatial components.

The introduction of a single conceptual model based on the Land Administration Domain Model would allow for a combination of information that is stored in different forms and the representation of these objects with a known position in space. The Land Administration Domain Model is a conceptual model written in the Notation of the Unified Modeling Language (UML).

J. Bydłosz [4] states that the Cadastral Model of Terrestrial Management has four basic classes:

1) Class LA_Party (the subjects of this class are parties),
2) Class LA_RRRR (rights, restrictions, and responsibilities) of this class,
3) Class LA_BAUnit (the objects in this class are basic administrative units),
4) Class LA_SpatialUnit (spatial units [spatial elements] are in this class).

The Land Administration Domain Model provides spatial objects. The international standard supports a two-dimensional, three-dimensional, and a mixed (two- and three-dimensional) representation of individual spatial units that can be notated in descriptive form (e.g., a plot extends from that plot to a river) by means of a single point represented in the form of a set of unstructured lines, as a surface, or as a three-dimensional solid.

## 2. Concept of Registration of Spatial Objects in Polish Cadastral System

In Poland, a functioning land and building register (a property registry) is in the process of being modernized and will be transformed into a modern cadastral system in the future.

The legal regulation describing the conceptual model of a land and building register in Poland is the regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records [5].

According to J. Bydłosz, K. Góźdź, and W. Radzio [6], it aims to accomplish the following:

- harmonize the cadastral collections with other data sets underlying the national land information system,
- create conditions for making cadastral data available.

The basic format for exchanging and sharing the cadastral data sets is the Geography Markup Language (GML).

In accordance with Annex 1 to the regulation (land and buildings register), the conceptual model of the land and building register data consists of the following:

- UML (Unified Modeling Language) application diagram of EGiB data,
- a catalogue of EGiB facilities,
- UML Application Diagram of the Primary Model,
- a directory of Basic Model data objects.

Regulation [5] in Annex 1 indicates that "the object catalogue shall contain definitions and descriptions of the object types shown in the application schema, their attributes, and the relationship between object types in one or more spatial data models (application diagrams). All types, attributes, links, related roles, and operations included in the object directory are identified by their name, unique within this directory." The database objects have attributes concerning the date of their creation and archiving as well as the date of creation and archiving of subsequent versions of objects as well as an infrastructure identifier for spatial information.

The Regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records [5] allows for the registration of spatial objects. This regulation [5] introduced the possibility of disclosing the underground space invested in public registers (e.g., an underground story) but did not specify the scope and manner of disclosing the information on these facilities.

The aforementioned amendment to the abovementioned regulation does not constitute a solution that allows for the registration of space invested in the tunnels and metro stations in Warsaw nor underground garages (among others) or diameter lines with the right of ownership.

It should be noted that, in the light of the legal regulations in force in Poland, the investor will obtain limited information from the public registers on the facilities constructed in the area of the plot. The space of one parcel may contain many limitations; e.g., a railway diameter line running under the area of the parcel or an air corridor in the above-ground space of the parcel.

## 3. Registration of Underground Space Investment in Polish Cadastral System

The Polish cadastral system is a multi-tasking object system. Cadastral objects are plots, buildings, and premises. These objects have a specific position in space and are characterized by specific spatial and descriptive attributes called accounting data. Plots of land are shown on the register map and in the descriptive documentation (which includes registers, lists, statements, and other documents). The registration of these objects in the cadastral system shall take place by assigning them to the appropriate registration unit and determining the attributes. The basic attribute of an accounting plot is its spatial character. Although the building and premises are also spatial in nature, the collection and compilation of the accounting data for all objects is related to the plot. In the present cadastral system, the position of a parcel and the shape of an object are determined by flat coordinates $x$, $y$ (2D cadastre).

The two-dimensional model used for numerical cadastral management limits the model of reality and its processing and analysis may not be sufficient in many cases for the needs of broadly understood real estate management. Particular limitations are visible when considering the possibility of registering underground investment on the example of the Warsaw subway.

### 3.1. Survey of Register Records Kept for Selected Section of Warsaw Metro

The facilities (i.e., the Warsaw subway) are a linear investment consisting of a solid geometry of the defined dimensions located within the space of many registered plots located in various registration areas. In the existing Polish real estate registration system, there is a separate individual registration (plant and mortgage registers) and subject registration (land and building register).

The author examined the information contained in the land and building register.

The survey of entries in the land and building register frames carried out for the first line of the Warsaw Metro (from the Politechnika station to the Arsenal Town Hall station) shows that the tunnel and station location covers 135 registered plots of land.

Entries concerning the owner/perpetual usufructuary in the frames of the land and building register are entered on the basis of notification from the Land and Mortgage Register Division of the district court. The information contained in the register of grounds and buildings on plots of land on which Section I of the Warsaw subway line is located (from the Politechnika station to the Arsenal Town Hall station) is presented in Table 1.

**Table 1.** Information from land and building register frame

| Object | Number of plots constituting investment area of the subway | Types of utilized land identified at EGiB | Disclosed rights at EGiB | State of power disclosed at EGiB |
|---|---|---|---|---|
| Station Politechnika | 21 parcels of which:<br>– 17 settled in the mortgage registers<br>– 4 unregulated in mortgage registers | 13 – road (dr)<br>3 – other built-up areas (Bi)<br>4 – residential areas (B)<br>1 – recreation area (Bz) | Capital City of Warsaw – ownership (21 parcels) of which:<br>– perpetual usufruct (3 parcels) | Management of the resource – President of the Capital City of Warsaw (8 parcels)<br>Sustainable management – Municipal Road Administration (7 parcels)<br>Possession – President of the capital city of Warsaw (2 parcels) |
| Station Centrum | 15 parcels<br>All regulated in mortgage registers | 12 – other built-up areas (Bi)<br>1 – recreation area (Bz)<br>2 – road (dr) | Capital City of Warsaw – ownership (15 parcels) | Sustainable management – Municipal Road Administration (6 parcel) |
| Station Świętokrzyska | 13 parcels of which:<br>– 12 settled in the mortgage registers<br>– 1 unregulated in mortgage registers | 5 – other communication areas (Ti)<br>1 – other built-up areas (Bi), other communication areas (Ti)<br>7 – road (dr) | Legal persons – ownership (2 parcels)<br>Capital City of Warsaw – ownership (11 parcels) | Sustainable management – Municipal Road Administration (5 parcels) |
| Station Arsenal Town Hall | 3 parcels of which:<br>– 1 settled in the mortgage register<br>– 2 unregulated in mortgage registers | 3 – road (dr) | Capital City of Warsaw – ownership (2 parcels)<br>State Treasury – ownership (1 parcel) | Sustainable management – Municipal Road Administration (3 parcels) |

**Table 1.** cont.

| Object | Number of plots constituting investment area of the subway | Types of utilized land identified at EGiB | Disclosed rights at EGiB | State of power disclosed at EGiB |
|---|---|---|---|---|
| Tunel Politechnika-Centrum | 32 parcels of which:<br>– 26 settled in the mortgage registers<br>– 6 unregulated in mortgage registers | 1 – recreation area (Bz)<br>2 – other built-up areas (Bi)<br>28 – road (dr)<br>1 – residential areas (B) | State Treasury – ownership (7 parcels)<br>Capital City of Warsaw – ownership (25 parcels) of which:<br>– perpetual usufruct (1 parcel) | Management of the resource – President of the Capital City of Warsaw (3 parcels)<br>Sustainable management – Municipal Road Administration (28 parcels) |
| Tunel Centrum-Świętokrzyska | 32 parcels of which:<br>– 30 settled in the mortgage registers<br>– 2 unregulated in mortgage registers | 20 – other built-up areas (Bi)<br>3 – recreation areas (Bz)<br>9 – road (dr) | Natural persons – ownership (2 parcels)<br>Capital City of Warsaw – ownership (30 parcels) of which:<br>– perpetual usufruct (4 parcels) | Sustainable management – Municipal Road Administration (6 parcels) |
| Tunel Świętokrzyska-Ratusz Arsenał | 19 parcels of which:<br>– 13 settled in the mortgage registers<br>– 6 unregulated in mortgage registers | 2 – recreation areas (Bz)<br>1 – other built-up area (Bi), other communication areas (Ti)<br>13 – road (dr)<br>3 – other built-up areas (Bi) | Legal persons – ownership (1 parcel)<br>Capital City of Warsaw – ownership (16 parcels)<br>State Treasury – ownership (2 parcels) of which:<br>– perpetual usufruct (1 parcel) | Management of the resource – Mayor of the Capital City of Warsaw (4 parcels)<br>Sustainable management – Municipal Road Administration (11 parcels) |

Tunnels and metro stations are not disclosed as separate spatial objects in land and building register frames.

Land and building registry operators do not record information on the restrictions on the use of the plot, which would be essential information for a potential investor in a ground investment.

### 3.2. Introduction of Concept of Object-Oriented Spatial Plot

In order to allow for the spatial registration of the Warsaw Metro, the author proposes the introduction of a new concept defining the space invested in (or intended to be invested in) of a certain volume: an object-oriented spatial plot [7].

The plot of land could be used to identify and describe the three-dimensional space occupied by the tunnels and metro stations in Warsaw, but it could also be used for investment or planning to invest in the aboveground real estate space.

For the purpose of the legal regulation of an object-oriented spatial plot, the first stage should be introducing the possibility to establish the ownership right of an object property of a spatial plot. This solution would require an extension of the definition of real estate.

To this end, it would make sense to extend the provisions of Article 46 § 1 of the Law of April 23, 1964, Civil Code [8].

It is proposed that Article 46 § 1 be worded as follows:

"A property shall be the part of the ground surface constituting a separate property (land) as well as any buildings permanently attached to the ground or parts of such buildings if, under special regulations, they constitute **a separate property from the ground and separated from the underground or above-ground space of the three-dimensional part constituting a separate object of property**."

The introduction of changes in the civil code would allow us to establish a separate land and mortgage register for the three-dimensional space invested in or intended for investments.

The proposed object spatial plot should be understood as a space in the shape of a cuboid or other straight prism that is separated from the underground space of one or more registry plots located within a single area (homogeneous due to the legal status). Limit points determining the position of an object-oriented spatial plot shall be defined by the coordinates $x$, $y$, $z$. An object spatial plot of land would contain a space protecting the object against damage, which would be defined in the building and architectural design (Fig. 1).

In the proposed concept of registering spatial objects realized in the underground space of real estate, it is important that the realized tunnels and metro stations, being functionally separate objects, constitute separate object spatial plots in the shapes of cuboidal or other straight prongs into which physically invested space and space protecting the object against damage would be inscribed. However, when planning the subway extension, the spatial plot of land would be separated from the underground space of a single plot of land or multiple evidential plots within the limits necessary for the execution of the investment project. This space would result from a construction project.

An object's spatial plots can also be combined into one object-oriented spatial plot (Fig. 2).

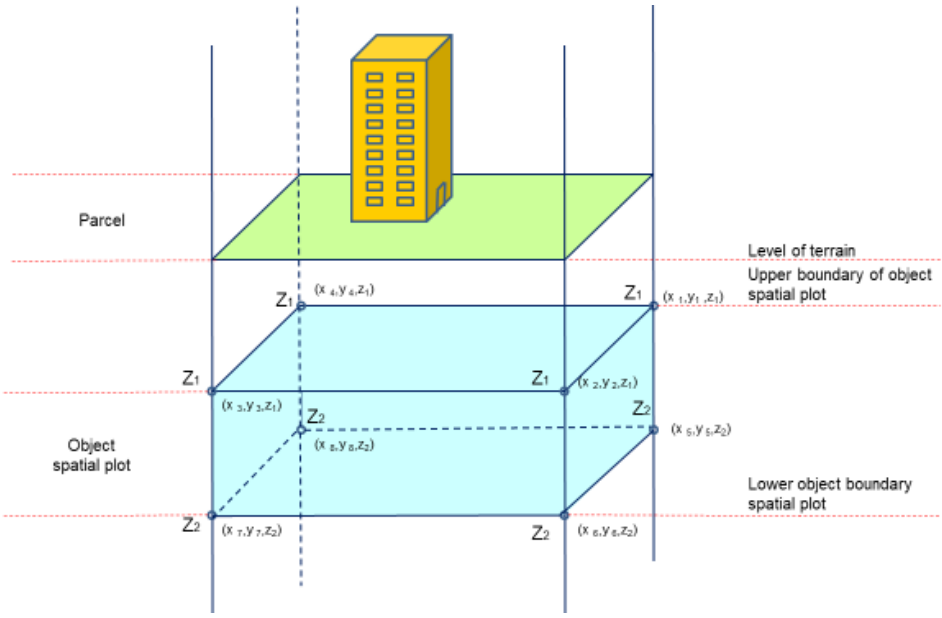


**Fig. 1.** Idea of proposed object-oriented spatial plot
(on drawing object of spatial plot in underground zone)

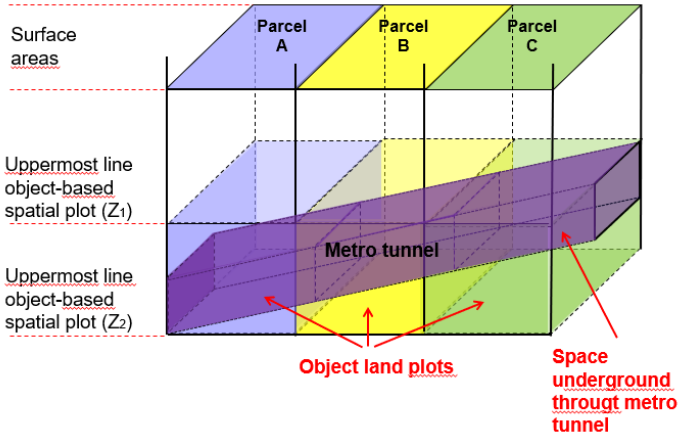


**Fig. 2.** Idea of proposed object-oriented spatial plot
(on drawing object spatial plot in underground zone)

In the light of the legal regulations in force in Poland, land parcel border points are field details of the first class; therefore, a geodetic situation measurement is performed in a manner ensuring that the location of the situational point with respect to the closest horizontal points of the geodetic grid and the measuring matrix is determined. The mean basic coordinate error is 10 cm [9].

The same accuracy of the $x$, $y$ coordinates would be valid for the boundary points of an object spatial plot.

According to the current regulations, coordinates $x$, $y$ should be defined as flat coordinates in the PL-2000 system, while the $z$ coordinate would be defined in the PL-KRON86-NH system and ultimately in the PL-EVRF2007-NH system, which is a realization of the European Earth-based EVRS system.

### 3.3. Proposal to Register Object-Oriented Spatial Plot of Land in Polish Cadastral System

Three types of registration units are defined in the register of land and buildings operating in Poland:

– ground,
– building,
– premises.

Diagram 9 described in Appendix 1 to the Regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records [5] presents the relationship between registration units (Fig. 3).

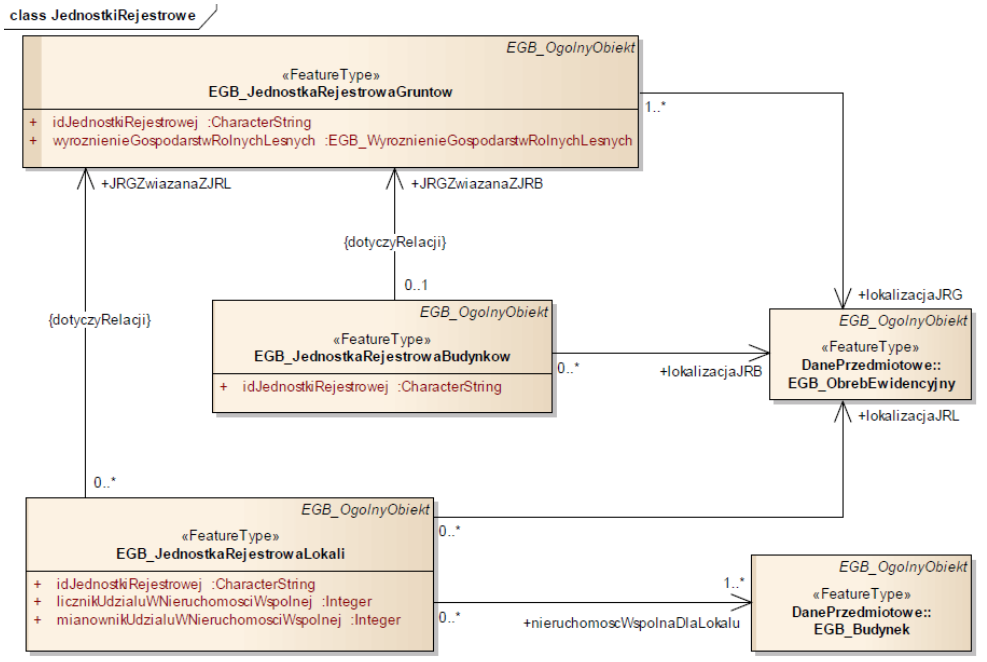


**Fig. 3.** Diagram 9 of Appendix 1 to the Regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records

Source: www.sejm.gov.pl

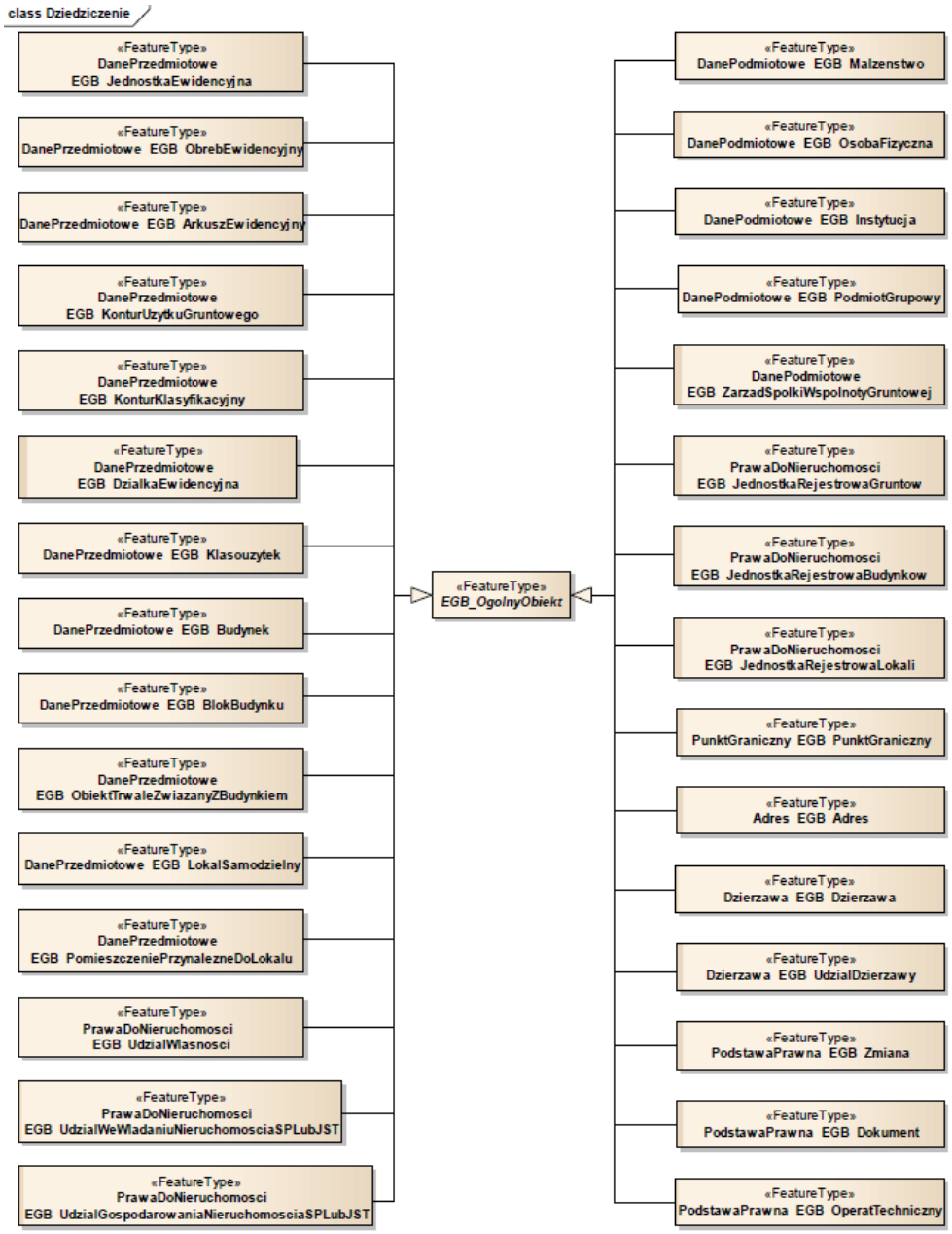


**Fig. 4.** Diagram 2 of Appendix no 2 to the Regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records

Source: www.sejm.gov.pl

The regulation of the Minister of Administration and Digitization of November 29, 2013, amending the regulation on land and building records does not specify a separate registration unit in which information on separate facilities constructed at different levels of a property could be disclosed (note: outside the underground story).

It is therefore necessary to extend the scope of Diagram 9 (Fig. 3) describing the relationship between the land, building, and premises registration units by an object registration unit.

It follows from Diagram 2 of Annex 1 (Fig. 3) to regulation [5] that EGB_GeneralObiekt does not allow the registration of spaces not constituting an underground story as a separate subject data not related to the registration plots. With this in mind, it is appropriate to extend Diagram 2 (Fig. 4), which presents the EGB_General property supply data, with the object registration unit and the object in question (i.e., the spatial object parcel).

It would also be necessary to introduce the spatial object identifier in the Ordinance of the Minister of Internal Affairs and Administration of October 20, 2010, on the recording of spatial data sets and services covered by the infrastructure for spatial information [10], which was as follows:

PLZGiK. EGB. ODzP_XXX. 1,

where:

PL – code of Poland,
ZGiK – a type of resource from which information on an objectified spatial plot of land has been obtained (PZGiK – a state surveying and cartographic resource),
EGB – land and building register,
ODzP_XXX – a local identifier; i.e., the designation of the registration unit;
1 – the version of the object; i.e., if the object specification contains information about the object's life cycle, the version identifier is used to distinguish between different versions of the object.

The proposed changes to the legal regulations concerning geodesy would make it possible to register 3D objects.

## 4. Conclusions

In Poland, there are no solutions that allow for the registration of objects constructed in the underground space of "somebody else's real estate."

The proposal presented in the article concerning the registration of completed or planned objects on different levels of a plot of land can be considered as an ad-hoc solution, which would enable the rational management of real estate in highly urbanized areas.

Taking into account the progressing urbanization process of Warsaw and the insignificant supply of undeveloped investment land in central locations, it was proposed to extend the information on the description of underground space occupied by the subway and to introduce a "layered" registration of ownership rights to objects realized in the space of "other people's" real estate in public registers.

The proposed solution to this problem requires several steps:

1. A description of the separated underground three-dimensional space (here: a straight prism describing a tunnel or metro station) using coordinates $x$, $y$, $z$.
2. Extension of the definition of real estate given in Article 46 of the Act of April 23, 1964, Civil Code [8] entry: this will allow for the establishment of a separate land and mortgage register.
3. Extension of the contents of land and building registry frames with the possibility of registering the right of ownership of three-dimensional objects completed in an underground three-dimensional space of "somebody else's" real estate.

To this end, the author has proposed to do the following:

– introduce the new concept of an object-oriented spatial plot regulated in a separate land and mortgage register,
– entry in the land and building register of the registration unit.

In addition, it is appropriate to provide for the possibility of 'tiered' ownership and registration.

Due to the need for investors to acquire new investment spaces, there is an increasing demand for information on underground spaces. In the light of the current legal provisions, it is not possible to reflect the geometric characteristics of the invested underground space with its ownership rights in the register records.

## References

[1] Rajabifard A., Bennet R., Mohsen K.: *Let the dialogue begin-Beyond Cadastre 2014*. GIM International (FIG Special), vol. 25, 2011, pp. 6–7.

[2] Khoo V.H.S.: *Towards "Smart Cadastre" that Supports 3D Parcels*. [in:] *3rd International Workshop on 3D Cadastres: Development and Practices 25–26 October 2012, Shenzhen, China*, 2012, pp. 243–251.

[3] ISO 19152:2012: *Geographic information – Land Administration Domain Model (LADM)*. Draft International Standard. International Organization for Standardization, 2011.

[4] Bydłosz J.: *Polski system katastralny w aspekcie ISO 19152*. Roczniki Geomatyki, t. 11, z. 2 (59), 2013, pp. 13–23.

[5] *Rozporządzenie Ministra Administracji i Cyfryzacji z dnia 29 listopada 2013 r. zmieniające rozporządzenie w sprawie ewidencji gruntów i budynków*. Dz.U. 2013, poz. 1551.

[6] Bydłosz J., Góźdź K., Radzio W.: *Model pojęciowy polskiego systemu katastralnego na tle rozwiązań ujętych w "Katastralnym modelu administrowania terenem" (LADM)*. Przegląd Geodezyjny, r. 84, nr 6, 2012, pp. 9–15.
[7] Matuk O.: *Trójwymiarowy opis przestrzeni inwestycji podziemnej na potrzeby nowoczesnych systemów katastralnych*. Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2013.
[8] *Ustawa z dnia 23 kwietnia 1964 r. – Kodeks cywilny*. Dz.U. 1964, nr 16, poz. 93.
[9] *Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 9 listopada 2011 r. w sprawie standardów technicznych wykonywania geodezyjnych pomiarów sytuacyjnych i wysokościowych oraz opracowywania i przekazywania wyników tych pomiarów do państwowego zasobu geodezyjnego i kartograficznego*. Dz.U. 2011, nr 263, poz. 1572.
[10] *Rozporządzenie Ministra Spraw Wewnętrznych i Administracji z dnia 20 października 2010 r. w sprawie ewidencji zbiorów i usług danych przestrzennych objętych infrastrukturą informacji przestrzennej*. Dz.U. 2010, nr 201, poz. 1333.

## Koncepcja rejestracji podziemnych obiektów przestrzennych w nowoczesnym systemie katastralnym 3D

**Streszczenie:** Racjonalne administrowanie i gospodarowanie nieruchomościami wymaga pozyskiwania i gromadzenia informacji o nieruchomościach i ich sąsiedztwie oraz wdrożenia systemu informatycznego umożliwiającego systematyczną aktualizację informacji i sporządzanie ich analiz. Na świecie prowadzone są prace nad stworzeniem jednolitego katastru trójwymiarowego, który ułatwiłby racjonalne gospodarowanie przestrzeniami dotychczas uważanymi za niemożliwe do zagospodarowania. Prowadzone są prace nad sposobem przejścia pomiędzy katastrem 2D a katastrem 3D. W tym może się okazać pomocna norma międzynarodowa ISO 19152 *Geographic information – Land Administration Domain Model (LADM)*. Wprowadzenie jednolitego modelu pojęciowego opartego na LADM pozwala na połączenie informacji związanych z administrowaniem nieruchomościami o niejednolitym sposobie zapisu oraz reprezentację obiektów o znanym położeniu w przestrzeni.

Polski system katastralny jest wielozadaniowym systemem obiektowym stanowiącym podstawowy system referencyjny dla baz danych przestrzennych. Obowiązujące w Polsce przepisy prawne definiują nowy model katastru nieruchomości, systematyzując sposób zapisu i przechowywania danych w ewidencji gruntów i budynków. Jednak zakres tych danych jest niewystarczający i wymaga rozszerzenia o rejestrację obiektów przestrzennych jako odrębnych działek wraz z określeniem osób fizycznych lub prawnych, którym przysługiwałyby prawa do tych działek. W związku z tym zasadne jest wprowadzenie sposobu rejestracji obiektów przestrzennych usytuowanych nad lub pod powierzchnią terenu działki ewidencyjnej jako odrębnych działek przez wprowadzenie dodatkowej jednostki rejestrowej obiektowej rejestrującej obiektowe działki przestrzenne wraz z przysługującymi różnym podmiotom do nich prawami.

Postępujący w Polsce rozwój inwestycyjny i ekonomiczny wymaga opracowania koncepcji rozszerzenia rejestracji zrealizowanych, ewentualnie planowanych obiektów przestrzennych jako odrębnych działek. Rejestracja powinna być zgodna z inicjatywami i standardami międzynarodowymi służącymi harmonizacji zbiorów danych przestrzennych oraz stanowić odpowiedź na zachodzące zmiany w przestrzeni inwestycyjnej.

**Słowa kluczowe:** LADM, Kataster 3D, gospodarka nieruchomościami, obiektowa działka przestrzenna