CO-468

DESIGN, IMPLEMENTATION AND DISTRIBUTION OF 3D GEOSPATIAL DATA TYPES FOR URBAN TOPOGRAPHIC APPLICATIONS

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1. INTRODUCTION

In cartography, traditionally prevalent is the presentation of spatial information in two-dimensional graphic form - with the help of geodetic plans and maps. This way of presenting the world around us can be considered rather outdated, given the development of computer and other technologies. However, one should bear in mind that most people still expect (when referring to presenting space) that it is shown on paper (in two dimensions), with the appropriate character set, which the person can recognize and easily observe. Therefore, one should be careful in using advanced technologies and techniques when enriching the content of traditional maps. By introducing new tools and media in the creation and the presentation of maps, use of other human senses is provided, where in addition to the senses of sight, hearing, smell, touch are also introduced with the display of options of the third dimension (height). Furthermore, the use of advanced technology helps to achieve the dynamism of the map and to increase the user’s interaction when viewing the content of the map.

The map is a product that is purposefully made for an "end user", who expects a certain number of required information that he needs and an appropriate layout of the map, regardless of whether the request is for a map in analog or digital form. Given the large number of people who use maps and who have a different spectrum of knowledge and different abilities of cognition, it is highly likely that the multimedia tools are considered more acceptable than traditional way of displaying spatial data. Therefore, cartographers too have to adapt to different ways of presenting the world that surrounds us. New forms of interaction with computer bases are introduced. That is way cartography is more and more frequently called cyber cartography, which provides different opportunities for different presentations of reality in different forms and media.

The next section (the following presentation) will provide: a brief historical overview of spatial presentation in Bosnia and Herzegovina, the analyses of the current situation reviewing the manner of collection, storage, manipulation and presentation of the three-dimensional spatial data, the possibility of an efficient upgrade of the existing two-dimensional spatial database, thus giving recommendation for the formal description of 3D objects. The next issue that will briefly be described is the manner of accessing data and the processing procedures used to perform specific tasks in the various institutions that are involved in planning, management and protection of space (such as the Bureau of Statistics, Spatial Planning Departments, Agency for the Preservation of the National Monuments and Cultural Heritage and other similar institutions).

2. A BRIEF OVERVIEW OF HISTORICAL EVENTS AND REPRESENTATIONS OF BOSNIA AND HERZEGOVINA

The first reliable records of Bosnia originate from the X century. In the file De Administrando Imperio (About managing an Empire) the Byzantine emperor Constantine VII Porfirogenit mentions the province Bosona (Bosnia) and two cities: Kater and Desnek. At the time of Kulin Ban (1180-1204), Bosnia was fully established as a political entity- the medieval Bosnia. Bosnia during the reign of Stefan Kotromanic (1322-1353) was extended to the western part of Hum and Dalmatia from Dubrovnik to the river Cetina. Bosnia experienced the culmination of the territorial expansion and political expression in the second part of the Tvrtko I Kotromanic’s reign (1353-1391). In 1377 Bosnia becomes a Kingdom ("the King of Srbs, Bosnia, the Coast and the Western areas"). In 1463 Mehmed II Fatih conquered Bosnia and destroyed the medieval Bosnian state. In 1697, during the Viennese war, Eugene of Savoy’s army occupied the largest city in Bosnian eyalet -Sarajevo, looted it and burned it (Antoljak, 1978). The fire burned down almost the entire city (Figure 1). Battles were planned and fought for every major city. This is evidenced by the military map of the Austro-Hungarian army with sketches of the siege of Bihac, Banja Luka, Mostar and other, showing the layouts of medieval towns and military positions around them. Such plans (maps) contained an established criterion, with drawn sides of the world and basic topographic characters. On some maps aside from the display of the ground plan, there is a panoramic view of the city.

Figure 1: The burned down Sarajevo: Map dating from 1697. J. PH. Frast:
Carte de la Bosnie, Croatie, ... dating from 1740 (Sehic and Tepic, 2002).

The first known geographical map with the name of Bosnia on it was created circa 1339, by the hand of Angelino Dulcert from Majorca on two parchments in color (Sehic and Tepic, 2002). There are no maps from the time of the Ottoman occupation in the archives of Bosnia and Herzegovina. Only during the occupation by the Austro-Hungarian monarchy did the systematic measurement of Bosnia start. The first cadastral maps were created, and cadastres and land registries were formed. An appropriate scale of the cadastral maps (Austro-Hungarian survey) for a town was 1:1562,5, and for the settlement adjacency (forests) 1:3125 or 1:6250. These cadastral maps are still used today to prove ownership, though in the meantime a new survey was created, which is primarily used by registers of B&H. A new survey of cities implies using the following scale map: 1) M = 1:1000 - for populated areas, 2) for especially densely populated areas and for the cadastre of underground and overhead power lines M = 1:500, 3) for villages and the cities' surroundings M = 1:2500. The basic state map scale is M = 1:5000 for populated areas and cities, and 1:10000 for other areas. The listed maps are two-dimensional maps. The third dimension is achieved with shading, contour lines and elevations.

The three-dimensional display, of usually cities, was achieved using a perspective view, which demonstrated certain historical events. More recently the three-dimensional view of cities was achieved in the form of models, mainly used by architects (displaying individual architectural solutions, and showing the master plans of the city). Modern technology - hardware, software and networks, provides an opportunity of a perspective view of the earth's surface on the screen monitor, and thus of the cities as well. This provides us with a number of additional features in the assessment of the three-dimensional space, such as rotating, light under arbitrary angles, changing viewing positions, the addition or subtraction of the planned urban array (trees, street lights, benches, etc.), analyzing space (intersections, daylight , the availability of TV signals, etc.), the underground elements of urban space, etc. The three-dimensional data listing collected and preserved in the database, remained mostly two-dimensional (printers, images, etc) although there is still the possibility of displaying them in three dimension (3D printers, hologram).

What proved to be an advantage when using the three-dimensional data was a more realistic view of space and the option of creating appropriate planning and other documents, and using a more realistic simulation of the possible events. Regardless of the benefits that the manipulation of such data provides, there still remains a big battle between the traditional thinking of most people (who are not engaged in this type of work) and the investment of significant financial resources in that kind of processing of spatial data and their presentation.

3. GEODATA AND DATA INTEGRATION

Earth sciences are related to defining the position in space, i.e. knowing the position of a certain object (by using a specific coordinate system), knowing the geometry of the object and other characteristics that describe the object (semantic and radiometric). Usually there are two sets of spatial data involved for a particular object: 1) data with clearly defined borders (buildings, streets, etc.) and 2) objects with vaguely defined borders (ore exploitation zones, water protection zones, etc.). This paper especially focuses on buildings and natural features specific for the urban areas.

In the physical sense of the word a city (Latin urbus) is a collection of buildings. An important factor in building an integrated urban data model is manipulating existing data sets which were collected for other purposes. These data have the properties of being complex and multidimensional. Objects in space are subject to weather changes. There is an evident necessity for monitoring the phenomena (air pollution, noise pollution, etc.) in the urban areas, monitoring the geometric changes of existing objects as well as the various thematic changes (the age of the buildings and their stability, the historic importance of the building, the reconstruction of objects - buildings, streets, river beds and etc.; the demographics and changes in street names, etc.).

Coding of space and buildings must be composed in more or less complex syntagms. Elements of lower rank (point, line, polygon, and element – all form so-called geometric primitives) do not have any meaning without their incorporation into the general spatial context. Also, the geometric representation is not only related to physical objects, but also to advents and the phenomena (real or imaginary). On the other hand, thematic data are most often represented in a textual or in a numerical form, with an image or with an audio or video recording, whereas the geospatial data is usually presented in a graphic form (with the use of the coordinate system), presented as maps or plans in a cartographic, that is, geodetic applications. Based on the created urban data model, one can run spatial analysis, for example, by using urban parameters (density, general housing, relief, climate, components of the settlement for the collective and the individual use, housing density, build-up density, the coefficient of land utilization etc.) .

When managing urban areas, one must consider the participating organizations which are responsible for monitoring changes and planning, and which use a variety of different applications and media designed for collecting, distributing and presenting the data. There are numerous database models, which should be integrated in order for us to be able to perceive common problems in a particular area and so that we can generally and gradually solve them. The basic premise for the communication between different database systems is the use of standard communication formats (XML, GML etc.) There are several ways one can use to integrate data - sharing data in short time intervals, filling-up the warehouse, and data migration. In the category of information sharing in relatively short time intervals one includes data synchronization between systems or replicating data to another location (to ensure a continued easy functioning in case of a mishap). Filling the data warehouse is usually performed once a day, usually when the source and the target system are not burdened with user requests. The third method of data integration is the data migration from one system to another.

Integrating data is a process which combines or connects two or more sets of data from different sources, in order to use these data in space management. The integration of cartographic data for the purpose of document planning, in this case the regulative plan, it is necessary to collect different types of previously used and new data, and to perform their analysis in order to assess the accuracy and the quality of the used data model. Therefore, graphic mapping data should be integrated (both bitmap and vector graphic) together with the text data, image, video and audio files on the selected area which is being processed. Cartographic data mainly rely on the official two-dimensional topographic data (here we are talking about larger scale maps of 1:500, 1:1000, 1:2500 and 1:5000), which were recorded analogously until a few years ago and they were separated in two documents - the cadastral map and cadastral operation . All data collected so, are strictly controlled and must satisfy the prescribed geometric and semantic accuracy. However, the problem in using such data is a considerable tardiness in obtaining the final product - the cadastral map and the report, because they are strictly related to registering the ownership over the real estate, resulting in them not being updated regularly. Therefore, large-scale official maps are just the basis for integrating data with the purpose of managing space. Therefore, from time to time and if necessary one needs to perform additional geodetic surveying (in the classical manner: with a total station or a GPS device) of a smaller area, which is usually not implemented in the registers. So we have data which are mainly delivered to the planners in some form of the CAD format, which either remain in that form or are included in the existing geoinformation systems. Such data are not subject to strict controls of their accuracy and can be two or three - dimensional . In addition to this, various thematic data that are essential for land management are also used (statistics, data on protected monuments, etc.), which can be stored in different forms (images, sounds, text, video, animation).

The means of storing digital topographic data in Bosnia and Herzegovina are still unsystematic. Data is usually stored in the form of different file systems and in the form of both relational and object-relational database type with no data model. Therefore, the integration of such data, even if they were stored in digital form, is quite a difficult task. In order to study ways of storing and presenting the three-dimensional objects, an analysis of existing traditional models of topographic and cartographic representation of data was carried out, and as a result a formal description of 3D objects was proposed, which is connected with the existing (official) data base of real estate cadastre (BPKN).

4. ANALYSIS OF TWO- AND THREE-DIMENSIONAL DATA

Collecting cartographic data in B&H is achieved by using both primary and secondary methods, assuming data from existing numerical sources , downloading data from existing digital sources and by combining these methods (Fig. 2).

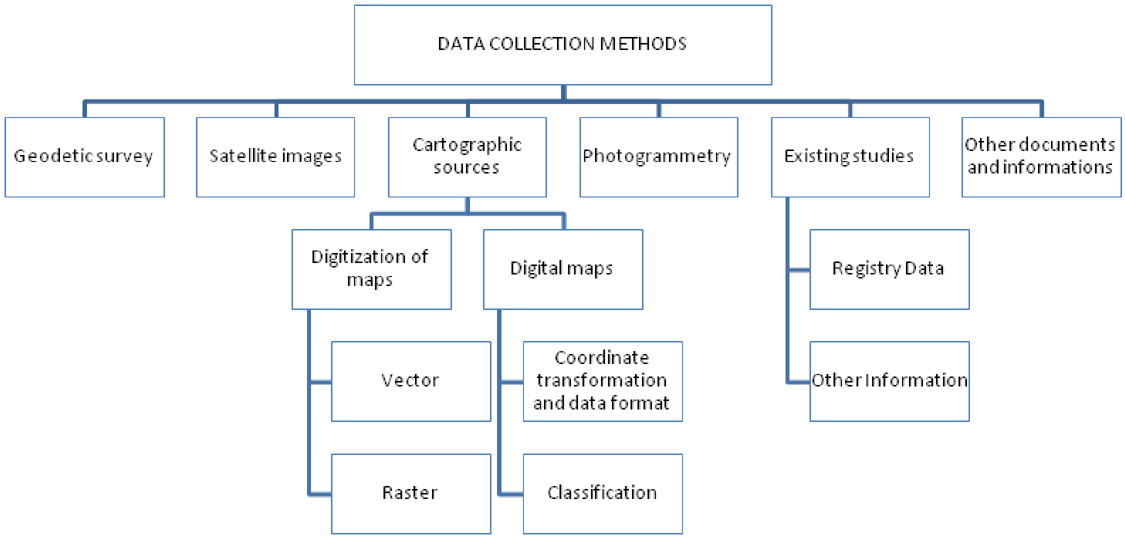

Figure 2: Methods of data collection

Unlike two-dimensional data, three-dimensional data are not collected systematically. They are collected, checked, analyzed, processed and displayed only on a case by case basis, from one project to another, i.e. only when needed. These data are available in digital form, but in a traditional manner, thus implying a series of file systems and different data formats. In addition to these data, for research purposes one also needs to collect: cadastral data on the objects (number of the cadastral plot, the culture, information on the landowner, number of floors of the buildings and floor plans of the apartments), precincts, historical data and information about the underground and overhead lines (electrical lines, telecommunication lines, pipelines, gas pipelines, water supply, sewerage), urban parameters (buildings' age, type of construction, quality of the construction materials, i.e facades, street lighting), traffic data (bidirectional, unidirectional, the density of traffic, pollution), data about the period of certain information (time representation) etc.

Since these spatial data are collected from multiple sources (e.g. Center district, Old Town district, Department of Development Planning of the Canton of Sarajevo, Institute for the construction of Sarajevo) using the content that has extended the height of buildings obtained by aerophotogrammetric methods, adequate controls have been made which are now applied to the primary methods and are used when downloading data from the existing digital sources. Controls of the collected topographic data were undertaken in accordance with the Regulations on the real estate cadastre database from 2008 (URL1).

5. CONCEPTUAL DESIGN - A FORMAL DESCRIPTION OF 3-D OBJECTS

Each model tends to use simple geometric primitives and also tends to merge them into complex structures. Out of the many presentations of spatial objects, we single out the 2D TIN object presentation due to certain advantages that it posses compared to other models. One advantage is its extension to three-dimensional representation of complex spatial structures (Abdul-Rahman and Pilouk, 2008.), and for that reason it was chosen to define the thematic and geometric hierarchy of the object classes in this paper.

In this paper, used as an example for real-world spatial data modeling purposes we applied the object categories classification (which are classified as objects with certain common traits) (Fig. 3). Further on, the object categories contain sub-units, called the object class, and they in turn contain some elements, which have geometric and other properties. In this case, we used the 3D primitive simplex and complex (Fig. 4).

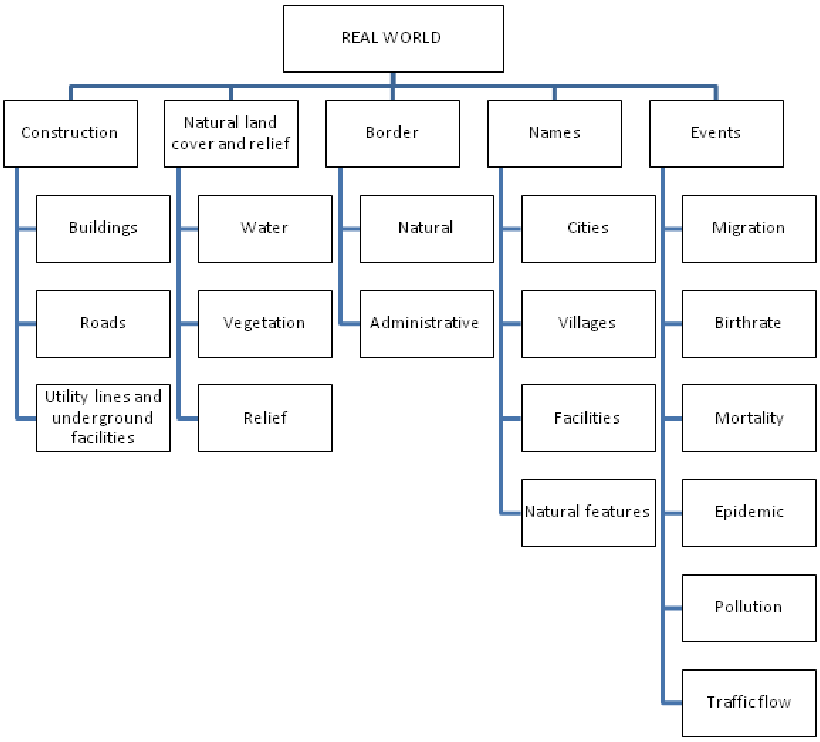

Figure 3: Distribution of object categories in classes

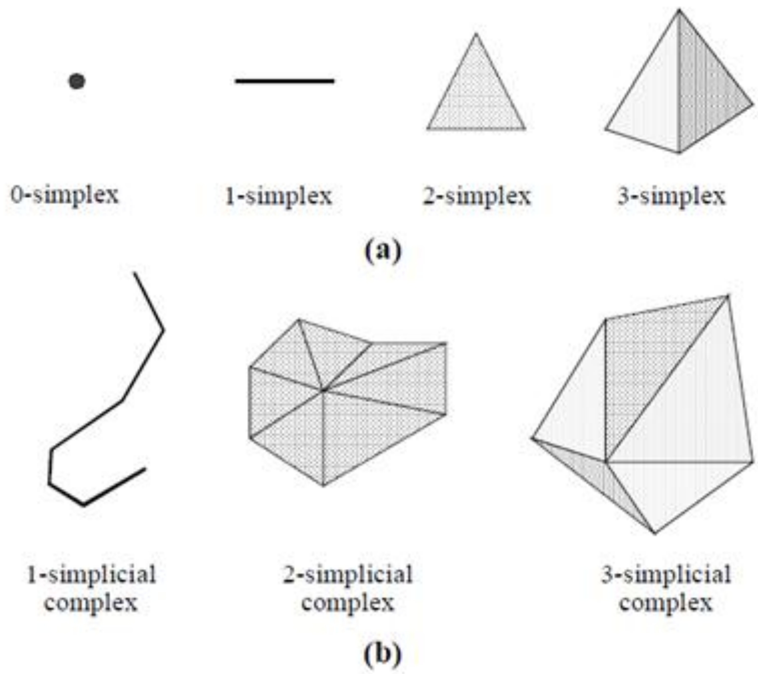

Figure 4: Examples of simplex (a) and complex (b) as the geometric primitives (Abdul Rahman and Pilouk, 2008)

The rules of linking the geometry of space are related to the CityGML geometric model (URL2). The formal description of the 3D topographic objects is achieved by expanding the existing 2D cadastral database (BPKN), so that apart from the use of the additional description (geometric and descriptive) we also define the relationships with the existing database. With this we achieve the conditions necessary for the systematic collection of other data that are essential for the three-dimensional view of objects. An example of the 3D extension of BPKN model's formal description is attached as an appendix to this paper.

6. DATA INTEGRATION AND 3D PRESENTATION

The expansion of the existing cadastral database (BPKN) aimed at the possibility to use these data in different topographic applications, and solving various problems related to the planning and arrangement of space (whether it is a two-or three-dimensional presentation of data, and no matter what the type of media is used). For the purpose of integration, we used CAD, GIS and ORDBMS applications that are represented the most in the institutions and agencies for the adoption and implementation of the spatial planning documentation from the territory of Bosnia and Herzegovina (MapInfo, ArcGIS, AutoCAD, Oracle). We used SpacEyes and Google Earth as the interface for the presentation of the integrated data.

The collected data were placed into the database, according to the proposed model. Before conducting the placement, one needs to check the integrity and the overlapping of the data, together with performing checks of the functionality and the ease of data manipulation. Figure 5 shows the appearance of the user interface that allows spatial queries to the database about specific (3D) objects (for example, buildings in the area of the urban neighborhood Markale with the altitude below 15 m) and it allows the two-dimensional graphical presentation to be presented on the computer screen. The results of the set spatial query are then implemented with the corresponding three-dimensional view using Google Earth interface (Fig. 6).

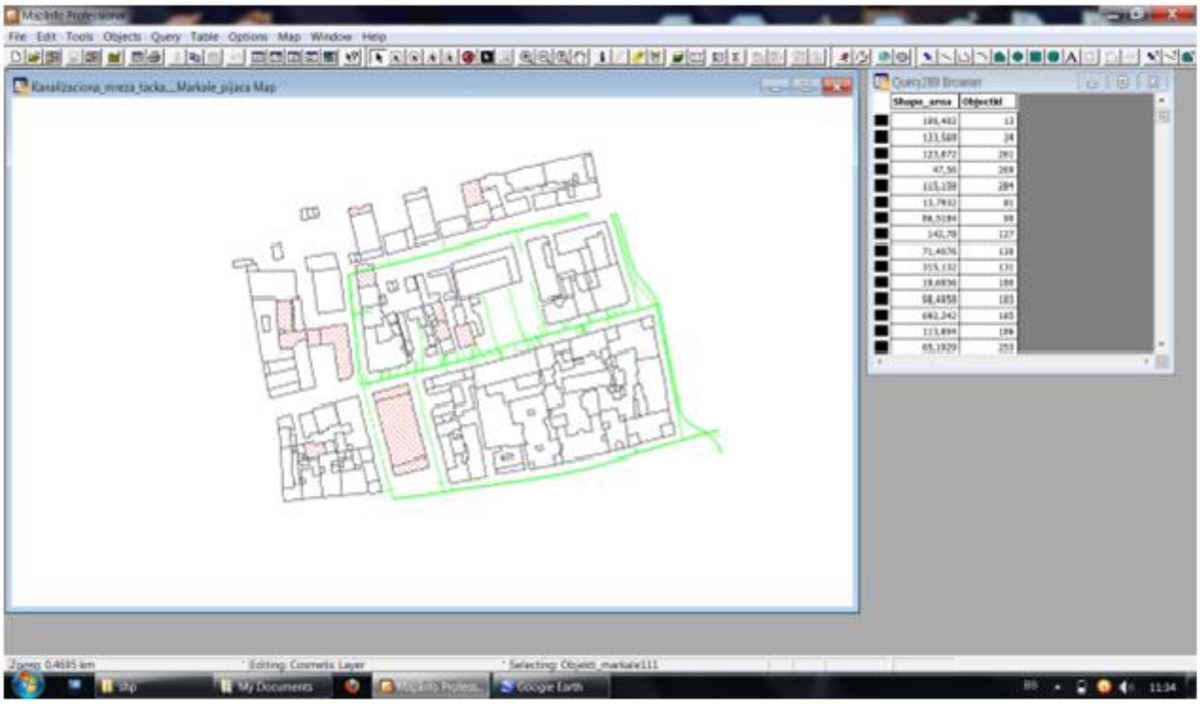

Figure 5: Depiction of the user interface in GIS

Figure 6: Results of a query in Google Earth – the buildings in the Markale area that are lower than 15m

This approach to data structuring (with the use of the proposed extension of BPKN 3D data model) enables the display of the data, and also enables the functional and easy handling of the 2D and 3D data in other various topographic applications.

7. CONCLUSION

The main objective of this research paper is to integrate different types of data that are available and their three-dimensional topographic representation in the commonly used applications. After gathering the necessary information and data, the next step is to create opportunities to store three-dimensional objects and their connection with the existing cadastral data model (BPKN). After the formal 3D object description, comes testing the model over a specific set of spatial data. Based on this, the following conclusions regarding the possibilities of design, integration, presentation and distribution of 3D geospatial data types for urban applications in Bosnia and Herzegovina have been adopted.

Modern technologies for collecting, handling and presenting 3D geospatial data in the territory of Bosnia and Herzegovina are neither sufficiently popularized nor widely applied due to lack of the fundamental assumptions for their use: a) insufficient infrastructural development for the procurement of the data and for the data exchange, b) lack of national regulations (laws, regulations and instructions) for the collection and use of 2D and 3D data and lack of standardization of criteria for their quality, c) lack of standards, data models and of systematized implementation of the international standards related to these issues, d) lack of financial support for the development monitoring and for the application of these technologies; together with other reasons.

The application of the proposed upgrade of the existing BPKN models can technically alleviate these reasons and help create conditions for the mass use of 3D geospatial data and topographic applications.

It is an indisputable and a realistic user necessity to use 3D geodata in solving series of tasks related to space, with the advantages of their use that are evident through their very large applicability in urban applications, despite the current difficulties in their collection, storage, management and exchange. In order to overcome these difficulties it is necessary to improve the capacity and the quality of the network infrastructure in the environment, it is necessary to provide regulations regarding the use and sharing of the spatial (3D) and it is also necessary to create the corresponding catalogs of the standard 3D topographic symbols and other symbols as well (pictorial signs, animations, sound-information signs and warnings) and finally it is necessary to test the proposed extended 3D model.

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URL2:

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APPENDIX:

Table 1

Object categories	CONSTRUCTION	
Object class	BUILDINGS	
OBJECT	Building	
Stereotype	*<<Feature>>*	
Attribute	**oid: UnlimitedInteger** unique identifier within the system	M
	rooftype: TipKrova	M
	texture: FasadaZgrade	O
	cadastre: oid	O
	functionbuilding: NacinKoristenja	M
	address: KucniBroj	O
	transactionTime: TM_Duration time period (interval duration) of the object within system	M
	validTime: TM_Duration time period (interval duration) of the object in the real world	M
	heightBuilding: Real building height in meters	O
	basement: TRUE or FALSE	M
	depthBasement: Real basement depth in meters	O
	notice: CharacterString notice of any kind related to the object	O
	geometry: gml_MultiSurface	M
Relation	KAT_Zgrada ADM_KucniBroj CL_KN_TipKrova CL_KN_FasadaZgrade CL_KN_NacinKoristenja	

Table 2

TypeToponyms	
Type	**Code**
Landscapes	01
Towns	02
Villages	03
Cities	04
Islands	05
Buildings	06
Mountains	07