

## **From 2D representation of the buildings into cadastral maps towards 3D GIS applications and BIM – a case study for Prishtina**

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**Keywords:** 3D cadastre, property registration, BIM

### **SUMMARY**

This paper gives an overview for the actual situation of the building cadastre in Republic of Kosovo. The author has tried to summarize the actual situation of the cadastral system regarding building registration and also a simple roadmap that might be used from authorities for future improvements. In addition the author will elaborate the concepts of 3D cadastre and the need for its development; this paper aims to bring in front of the reader a simple model which was used to define common properties for condominiums as result of a pilot project. This model can be used as a simple and low cost model for 3D representation of buildings' inner spaces. The author has used the same data for analysis and has come with some conclusions that might be used in future for 3D cadastre development based in BIM principles.

# **From 2D representation of the buildings into cadastral maps towards 3D GIS applications and BIM – a case study for Prishtina**

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## **INTRODUCTION**

Property registration is a process well known all over the world and cadastral systems as the tool dealing with this problem are also well known institutions. The main reason for property registration from the government's point of view is the payment of taxes while for the property owners the need for registration is based in the need for defining and securing their properties. Nowadays we're moving from the concept of area more and more towards volume concept for property definition. While geo-referencing of land parcels was the problem of the 20<sup>th</sup> century nowadays we have to think in the direction of "geo-referencing our property rights".

In general it is accepted that the owner of a land parcel owns not only the thin layer of the land cover but the space below the surface and the space above the surface (Stoter, 2004). The ownership is not defined as only the possession of the property but the restrictions and obligations related to that property as well (Mattsson, 2009). The situation will become more complicated when the buildings are in question. In the urban areas where the value of the land is increasing in a linear progress the need for property registration is increasing proportionally. New modern buildings and skyscrapers brought to the situation where mapping manually and in 2D plans is not sufficient. Urban areas where a lot of buildings are constructed accompanied with surface and underground infrastructure need a more detailed mapping and ownership registration. All this can be better managed by 3D registration.

For the time being Kosovo, regarding buildings has developed a registering system consisting from two main data basis: graphical database and textual database. The graphical database, as shown in figure 2, contains a collection of sketches drawn using CAD and archived as PDF files while the textual database is more organized and contains all the data collected from former registers and information collected directly on the field. But while this project was finished during 2010/11 no information regarding common properties was collected on the field and no information regarding common properties is given into the graphical data or within textual registers. Therefore the municipality of Prishtina has initiated a project aiming to create an attribute table and classification of common properties within condominiums of urban area in Prishtina and a graphical design for those common areas as well. In Kosovo's cadastral system the buildings and parts of the buildings are defined as cadastral units together with parcels and utilities but there is no elaboration of common spaces within the actual law on cadastre. (Law no. 04-L/013). "Part of the building" is a term which is mostly referred for apartments.

Aiming to reach the steps of other countries, the local authorities started to invest their efforts towards 3D representation of the properties and with special focus into the buildings by applying 3D GIS applications. One of the first steps in this direction is the pilot project for common properties registration for the existing condominiums. There are initiatives for BIM application as well. The data collected during this pilot project, in future developments, can be designed based on IFC standard (Industry Foundation Classes) or ISO 16739:2013 which is conceptual data standard designed for BIM data sharing ([www.iso.org](http://www.iso.org), 2013).

## 1. PERFORMING A PILOT PROJECT – THE STUDY AREA

The idea of contracting authority was to develop such a project as a preventive act considering some disputes that already are at the court regarding common spaces. As pilot project area and with higher priority was selected the so-called urban area and this is a notion which describes in fact the centre of Prishtina more than its real urbanized region. Special and “in need” buildings were selected as the first stage of this specific pilot project. The informal or illegal buildings were not treated in this stage. Meanwhile the Cadastral Municipal Office offered access to necessary data such as existing sketches from building cadastre database, owners register and other needed documents.

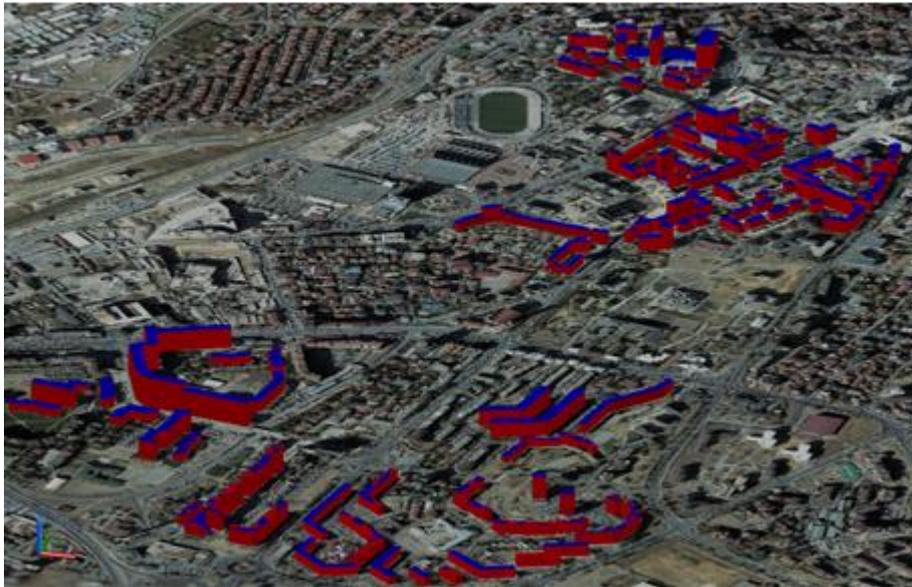


Fig. 1. The selected area for implementation of the project and the final 3D model.

## 2. RESULTS FROM THE PROJECT AND LESSONS LEARNT

### 2.1 textual data – coding common units

Before the implementation of the project, as follows below, the list of common spaces for which the detailed data should be collected, was proposed and approved by contracting authority:

1. Entrances and hallways of the condominiums,
2. Spaces used for stairs,
3. Spaces used for elevators,
4. In front platforms dedicated for public usage,
5. Common areas inside the building used for parking,
6. Warehouses used for common purposes,
7. Common areas used for waste collection within the condominiums,
8. Structures used for building connection and Flat and non-flat roofs (Law no. 04/L-134).

After the common spaces were identified an attribute table containing information collected on the field was also proposed and approved by the municipality. This attribute table was combined with the already existing database for the condominiums from the Building Cadastral system. In table 1 the olive colour shows a part of the existing data within the buildings' cadastre register while the maroon colour shows the new data collected as part of the pilot project.

NO	Municipality	Cadastral Zone	Building Number	Address of Building	Place name	Area [m <sup>2</sup> ]	Unique No of common property	Actual Use	Floor Number	Area of C.P.	Unit Status	Owner	Remarks
1	Prishtinë	Prishtinë									C P	Common property of the owners of parts of the buildings	

Table 1. The attribute table for registration of common spaces. (Master Plan, "NEWS" LTD, 2015)

And finally a logical model for codifying the designed common units

was proposed. This codification method was developed especially for this project and the proposal was based analyzing the situations identified on the field and the requirements for database development.

The codification model was based on the existing codes for the buildings by adding the common property code as described within this chapter:

**“Cadastral Zone Number” – “Parcel Number” – “Building Number” – “Common Property Code”**

The “Common Property Code” should be: **HPn-E-No** and where:

**HP** – means Common Property,

**n** – means the floor,

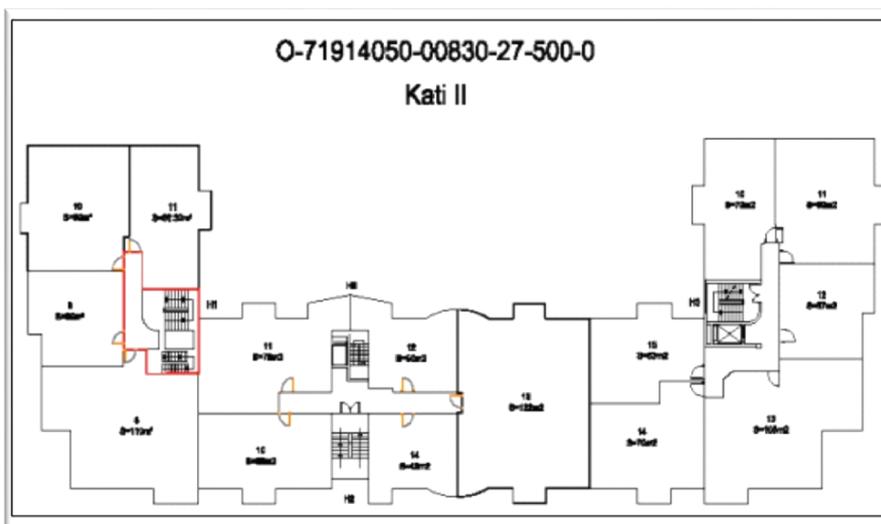
**E** - is the entrance number and finally

**No** - is a number which starts from 1 and ends depending on the number of the common areas within one building.

The information, as represented above, fulfils the requirements for legal representation of cadastral units or the buildings in this case.

## 2.2 Graphical data – data collection on the field and preparation of 3D model

For 3D presentation of the data collected on the field Civil 3D, 2012 version from the CAD family was used. The footprints of the buildings were measured using classic geodetic equipments (GPS and total stations) and the inner spaces of the buildings were measured using distant measuring equipments. All teams were equipped also with a sketch where they should where they draw directly on the field the position of the lines defining the common spaces. Based on those sketches the final 3D version was prepared and finally the CAD file was linked with the database offering the attribute table for all the common spaces designed

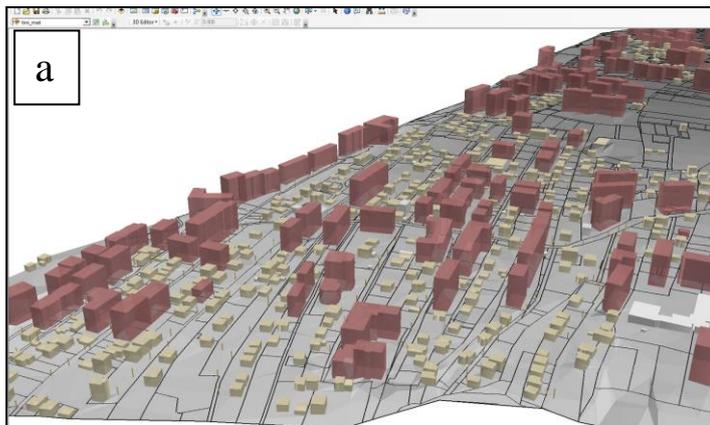


according to the actual situation on the field as represented in figure 3.

Fig. 2. A 2D PDF sketch from the building cadastre database

As a final result of this pilot project a total area of 172000 m<sup>2</sup> of common areas was designed in 3D, covering approximately the 11% of the total number of the condominiums of urban area of Prishtina. (Statistical Report, “NEWS” LTD, 2015). Future plans of Prishtina Municipality are to continue the registration of common spaces for the other parts of the city as well and cover the all area within 3-4 years.

Previously in Republic of Kosovo, regarding the buildings, we have had old maps where the building footprints were sketched. The same tradition was followed during Building Cadastre Construction in 2006 where LoD0 (Level of Detail) for the buildings' footprints were presented into digital cadastral maps. The level of detail (LoD) for Prishtina has increased into LoD1 as the result from another previous project during which performing detailed geodetic measurements for buildings' heights (excluding roofs) in combination with buildings' footprints a new graphical database was designed. The geodetic measurement's error, by requirements from the contracting authority, was set to be below +/- 10 cm in all dimensions (Y, X, Z). Finally, as the result the pilot project, which is the main focus of this paper, the detail of information has increased from LoD1 to LoD2 considering roofs and other inner details representation for condominiums.



a

b

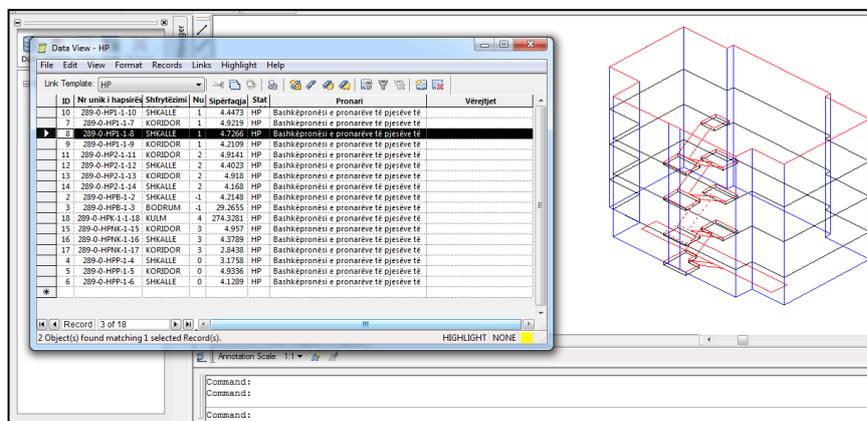


Figure 3. a- The DTM prepared for the area covered by the pilot project and b - the presentation on 3D of the common spaces for a certain building.

### 3. CONCEPTUAL PLAN OF A NATIONAL 3D CADASTRE, BASED ON BIM PRINCIPLES

Even though new technologies especially new GIS applications were applied in cadastre, the Kosovo's cadastral system is far from 3D cadastre. The concept of 3D cadastre is not yet introduced by Law on Cadastre. But being late sometimes can have positive impact! The responsible authorities can directly focus their attempts towards developing the 3D cadastre based on BIM principles.

Known as "parametric" modelling, Building Information Modelling (BIM) is a computer based system which is a powerful tool in the hands of spatial experts and engineers for buildings' lifecycle management. BIM aims to be the supporting system from the planning stage of a building, during the building process and ends when the building ceases to exist. It is considered to be the compendium of all GI systems developed till now (Ajvazi et al, 2016). Even though introduced as idea more than 40 years ago; BIM is becoming reality only nowadays (Silva, 2011). As a suggestion for future developments IFC (Industry Foundation Classes) can be a key to 3D cadastre implementation based on BIM principles. From a land administration perspective and therefore from cadastral aspects, IFC provides highly detailed physical information about the buildings; however it does not specify legal information associated with ownership of properties inside buildings (Atazadeh, 2016). Lack of possibilities for legal information can be considered the weak point of the BIM for the time being and researches should be focused in overpassing this technical problem.

The building cadastre based on BIM principle (as shown in figure 4) should go through those basic steps:

- Analyse the software capacities to fulfil the cadastral requirements streaming from certain national or international standards legitimate for the country e.g. ISO19195 or LADM;
- Define the group of buildings to be treated by 3D cadastre and using BIM technology;
- Test the technology and analyse the results;
- Prepare the legal guidelines based on the report from the test

In many countries the 3D cadastre developments are focused only in "problematic" buildings but this approach has to be evaluated once more.

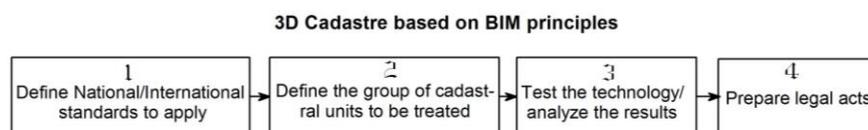


Fig.4. The conceptual plan for BIM application in 3D cadastre in national level

A 3D cadastre in national level and especially in small countries like Kosovo is, has to be oriented in that way to cover all kind of buildings for how long they are considered cadastral units.

BIM can be considered a management system dealing with a buildings' lifecycle from "its born to its death"; but what about the existing buildings that exist and are in use for hundreds of years? In this case the application of BIM can be expanded based on the concept: "from NOW to its death". This means that the actual situation of the buildings should be recorded and designed using BIM software applications. The buildings measurements from surveying point of view can be performed using existing technology which is quite sophisticated nowadays or even simple techniques, as the one described within this paper can be used successfully.

#### 4. CONCLUSIONS

Recording common spaces of the condominiums within urban area of Prishtina was just a pilot project resulting with a very simple model for registering properties using 3D cadastre techniques but even so it can be considered a very first step towards 3D graphical definition of the properties in Republic of Kosovo.

This pilot project and the results derived from it show that:

- There is no need to spend a huge amount of money to come to valuable and useful 3D data regarding buildings,
- This model can be applied for definition of property boundaries not only for common spaces but appartmens and other cadastral units as well,
- Simple 3D techniques can be applied within extistin legal acts.

But in order to fulfil the actual needs and trends throughout the world; Kosovo's government should perform the following:

- The law on cadastre should be fulfilled or a new law regarding 3D cadastre should be issued
- The common spaces should be treated more deeply and technical specifications should be developed
- The data collection using simple equipments can be adopted for BIM technology. Standards and procedures must be well define previously.

Being a country that aims to join the big EU familly, Kosovo must invest much more efforts and money in spatial data. As examples from other countries show 3D cadastre is considered a nescesity therefore Kosovo has to follow those trends as well. But the future of 3D and 4D cadastre will be BIM. Therefore those efforts in spatial data gathering, data designing and data management should be in accordance with BIM standards.

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## **BIOGRAPHICAL NOTES**

Fisnik LOSHI has finished his bachelor degree at the department of geodesy, University of Prishtina, Kosovo in 2007. In 2012 he has finished the master level studies at Royal Institute of Technology in Stockholm, Sweden with main focus in Land Management. Actually he is studying 3D cadastre under supervision of Prof. Dr. Bela Markus and Prof. Dr. Kiraly Geza at the University of West Hungary. He works as teaching assistant at University of Prishtina, Kosovo.

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