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REVISING SURVEYING AND REPRESENTATION PACKAGE OF LADM PROFILE FOR SERBIA TO SUPPORT 3D SPATIAL INFORMATION

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Introduction

- LADM profile for Serbia was developed by Radulović et al. (2017) reflecting the current state of Serbian cadastral information system which is based on 2D spatial information.
- It provides general discussion of the need for establishing 3D cadastre in Serbia without specific details about its possible implementations and developments.
- Given the increasing usage of 3D datasets acquisitions in Serbia in recent years, particularly by LiDAR technology we revise the surveying and representation package of Serbian LADM profile in the context of 3D spatial information and the process of retrieving 3D geometries of spatial units.

*Radulović, A.; Sladić, D.; Govedarica, M., 2017. Towards 3D Cadastre in Serbia: Development of Serbian Cadastral Domain Model. ISPRS Int. J. Geo-Inf. 2017, 6, 312.

Serbian 2D cadastre

- The Serbian cadastre recognizes three types of real properties defined by the Law on State Survay and cadastre (Official Gazette, 2009):
  - land parcels
  - buildings
  - building units
    - Building units are separate parts of the buildings that make one structural units, such as apartments, business offices, garages
- Cadastral information system contains:
  - Alphanumeric data about rights, right holders and real properties in the cadastral database
  - Geospatial data – digital cadastral map (DKP)

Serbian 2D cadastre

- Most of the municipalities in Serbia have 2D spatial data in the form of digital cadastral map containing 2D parcel boundaries and building footprints.
- These boundaries are represented by the class RS_BoundaryFaceString in the surveying and representation package of Serbian LADM profile.
- Building units in Serbian 2D cadastre are represented by the 2D CAD sketches of the floor plans.
- All this information is linked by unique property identification number (UPIN).

Unique property identification number

- According to the The Law on the Procedure for Registration in the Real Estate Cadastre and Utility Network Cadastre (Official Gazette, 2018), for each property a unique identification number is determined individually and recorded. Its purpose is to facilitate data access and management on properties.

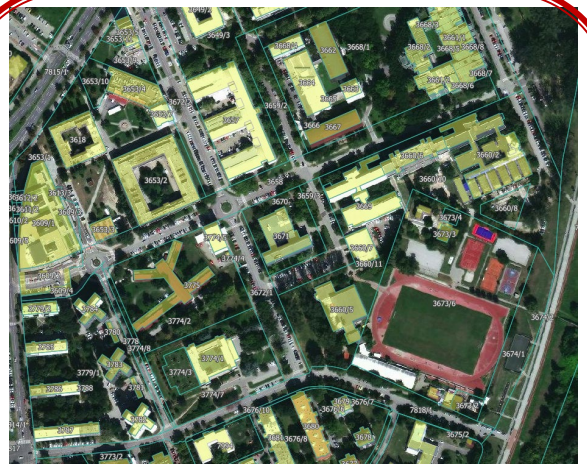
- Attributes needed to identify a property are:
  - administrative municipality code,
  - cadastral municipality code,
  - number and sub-number of the parcel,
  - a number of the part of parcel i.e. sequential number of building on the parcel (1-n),
  - sequential number of building unit within building (1-n, this number is 0 for the building itself).

Example: 89010-802166-949/1-1-19

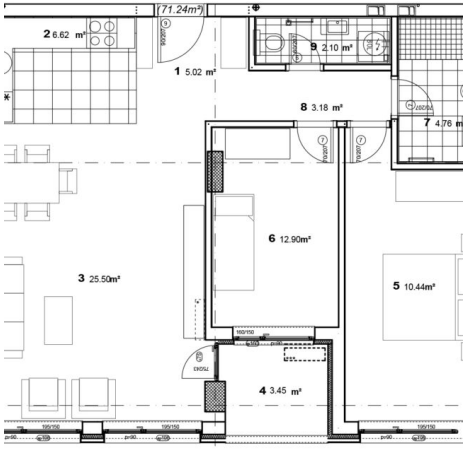
3D spatial sources and datasets

- With the proliferation of 3D datasets special attention should be paid to spatial sources such as LiDAR (airborne and terrestrial) and UAVs for buildings and BIM/IFC for building units, while formats for representation such as CityGML, CityDB, IndoorGML, BIM/IFC, etc. should also be addressed.
- Similar to 2D digital cadastral map supported by sketches of indoor information, we propose 3D digital cadastral map supported by indoor information represented by 3D formats (BIM/IFC, CityGML, IndoorGML).
- The link will be established by the means of unique property identification number.

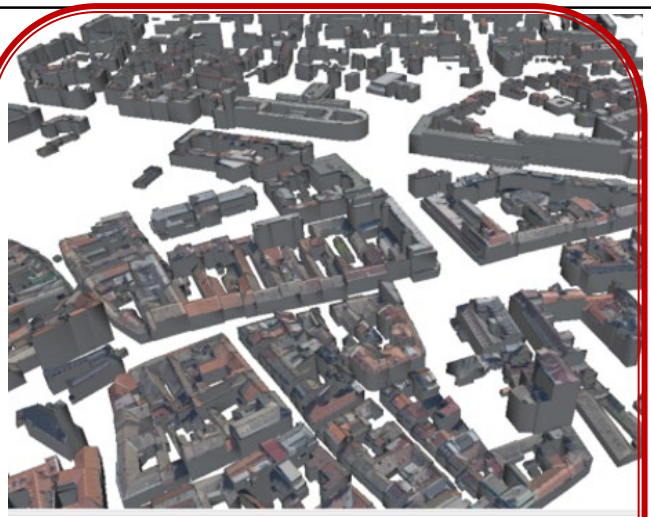
Current practices – 2D and 3D



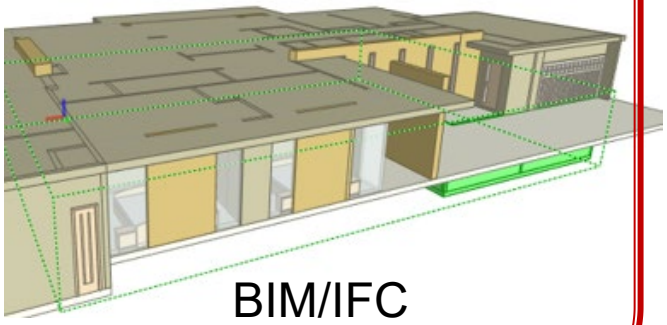
Digital cadastral map



2D CAD sketches

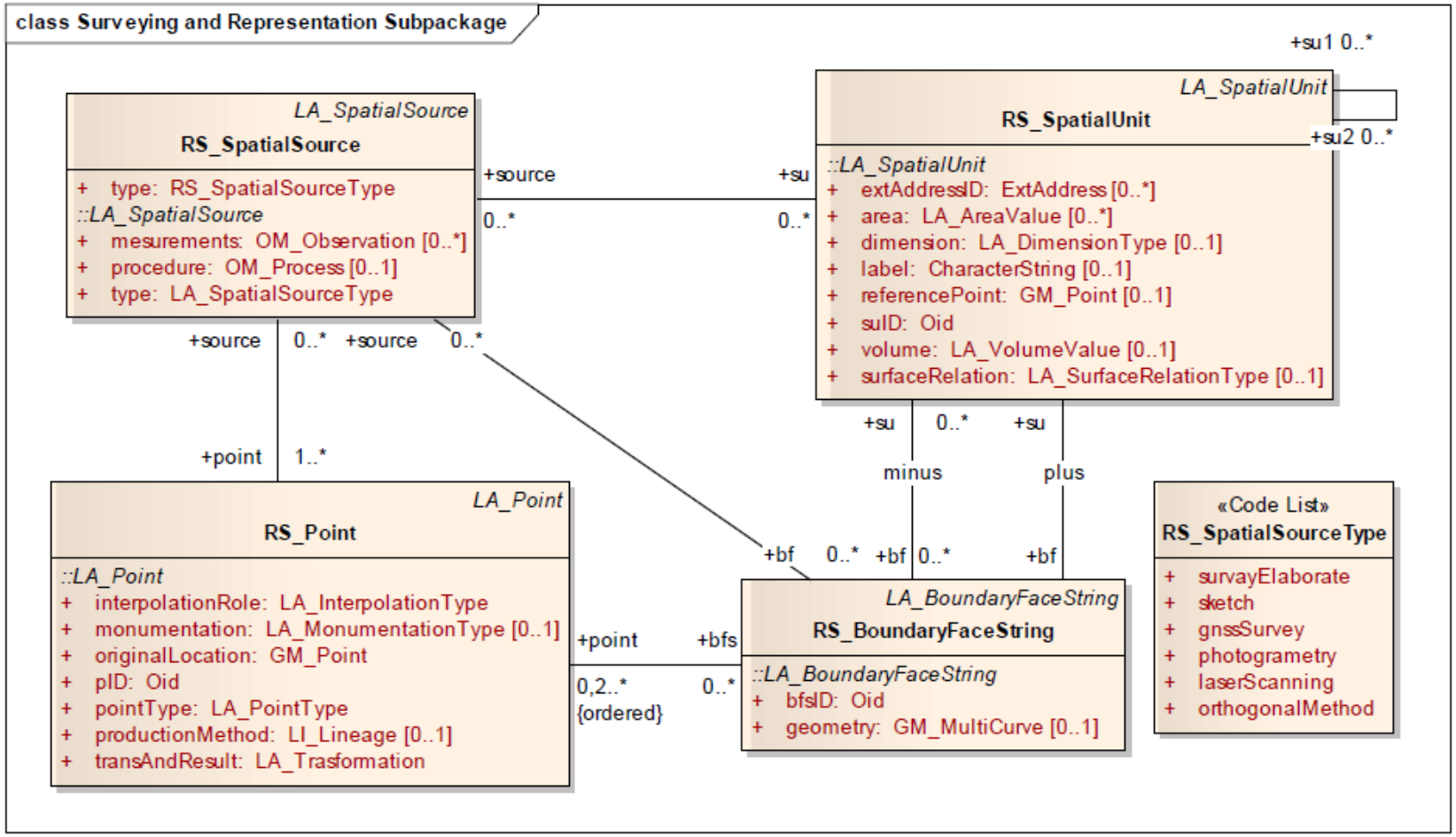


3D city model in CityGML

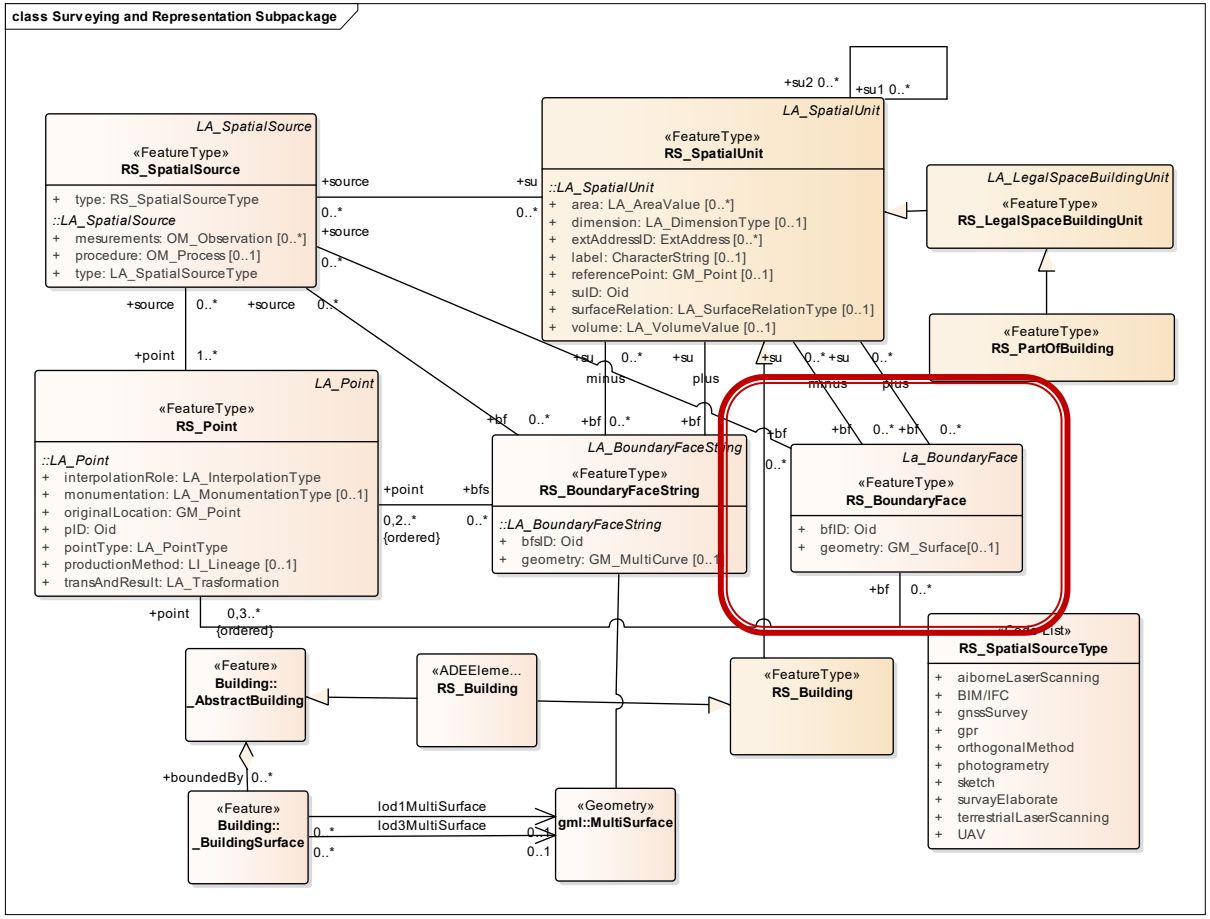


BIM/IFC

Surveying and Representation sub-package of Serbian LADM profile

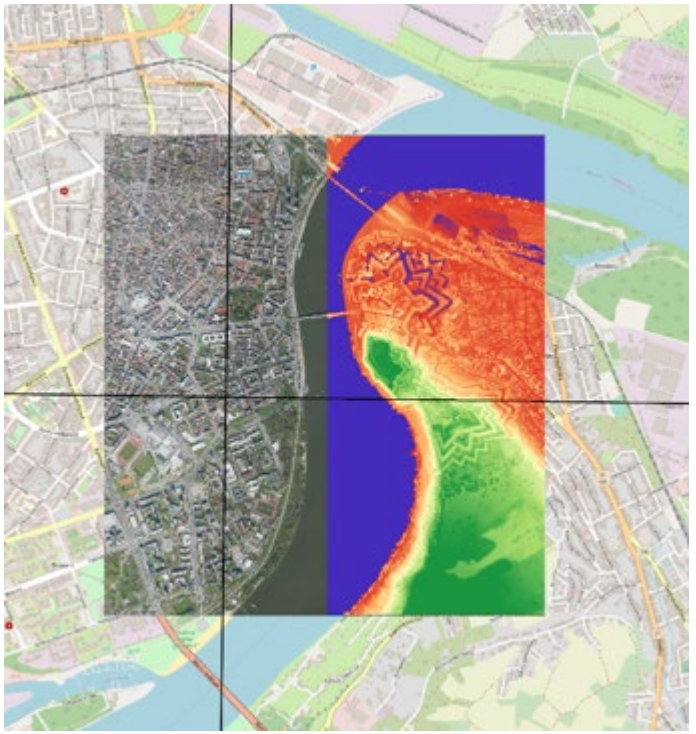


Extended UML model of surveying and representation to support 3D spatial information



Case Study 1 – Novi Sad

- The first case study uses the procedure to obtain 3D city database developed based on airborne LIDAR data for the city of Novi Sad.
- For this purpose, the Riegl LMS-Q680i laser scanner and digital camera DigiCAM H39 was used.
- The flight altitude, according to the orography of the area and safety standards, has been maintained about 200 m AGL and speed about 45 km.
- It has been operated with the parameters of 40 points per square meter, and aerial images with 5 cm per pixel.



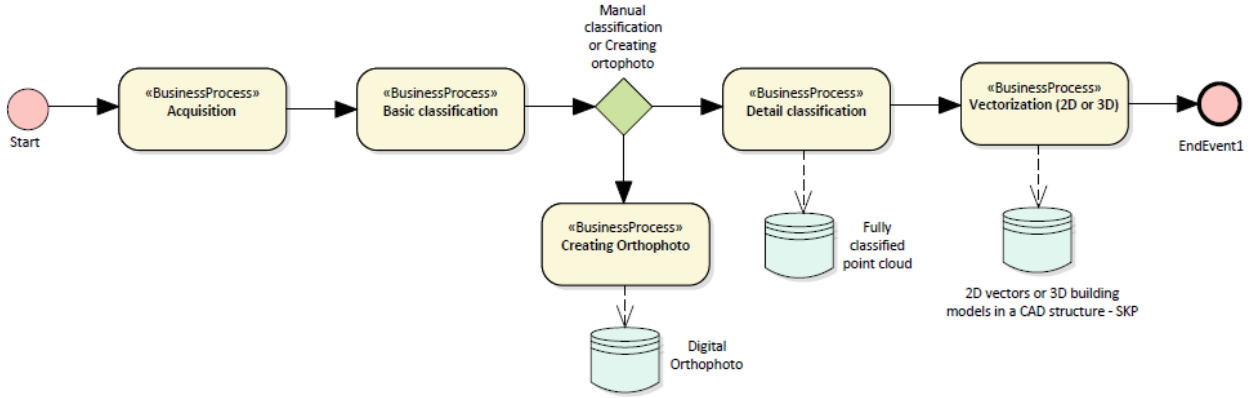
Point cloud classification and 2D and 3D vectorization

- After LiDAR scanning, as a first step orthophoto images and a georeferenced point cloud have been created.
- After that, initial classification, detail classification, 2D and 3D vectorization was done using classified LiDAR data and according to the relevant rules in the Republic of Serbia.
- List of all layers:

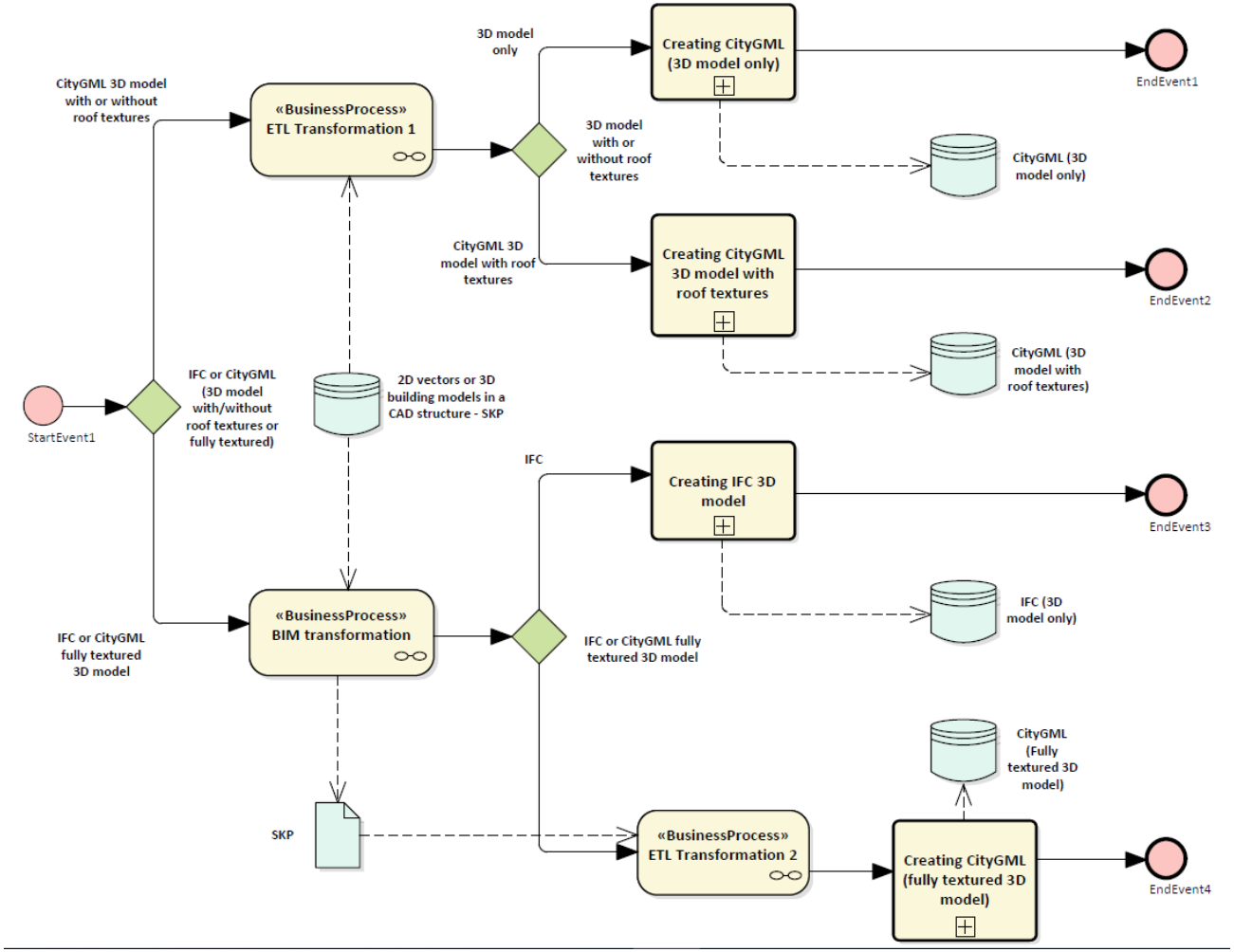
2D CAD/Vector Layers	3D CAD/Vector Layers
Asphalt road, field road, pedestrian road, forest, park, isolated trees, bush, terrace, river, stream, water, canal, fence, railway, bridge, parking, bench, bus stops	House, building, residential and commercial building, auxiliary building, lighting, pole, power lines, traffic sign

Basic processing steps

- Results of these basic processing steps were a fully classified point cloud, and a file containing 3D building models in a CAD structure.



The defined workflow of the data transformation process



Data transformation results

- As a result of the data transformation, the CityGML model of 1204 of the city buildings of LoD2 with photorealistic elements of the roofs and in an appropriate coordinate system were created
  - Case study 1 – Novi Sad city center, campus and Petrovaradin Fortress
- One of the main advantages of mass LiDAR surveying and processing and automatic classification of point cloud data is results of classification and possibility to connect results with features defined by the CityGML standard.

CAD layers which have been transformed into 3D model defined by the CityGML standard

- Table shows an overview of all CAD layers, which have been transformed into GML format by ETL transformation into features defined by the CityGML standard.

CAD Layers	CityGML Features
House, building, auxiliary object, residential and commercial object	Building, RoofSurface, WallSurface
Breaklines, grid	TINRelief
Forest, thicket	PlantCover
Road, field road, pedestrian road	Road
Parking, other	LandUse
Water	WaterBody

View of the 3D model with the corresponding features in accordance with the CitiGML standard displayed in the Cesium JS Web Map Client – case study 1 Novi Sad

Case Study 2 – Novi Pazar

- The second case study uses the procedure to obtain 3D city database developed based on UAV data and terrestrial LiDAR for the city of Novi Pazar.
- For this purpose, for arial images DJI MAVIC PRO with camera CMOS with effective pixels:12.35 M, and for terrestrial scanning Leica ScanStation P20 was used.
- Flight control and planning was performed from the Pix4Dcapture mobile application, and total of 3 flights are planned at an altitude of 80 meters and one at an altitude of 40 meters.
- The total number of photos collected from altitude of 80 m is 943 and from altitude 40 m is 676.

Terrestrial laser scanning

- Data processing was performed through Agisoft Metashape software.
- The area was scanned with terrestrial laser scanning during 3 days with a total of 33 stations.
- Also, total of 11 ground control points (GCP) was collected for precise georeferencing of the model.
- A cloud of dots, mesh, texture, and orthophoto was generated from both subprojects, and then merged into joint one.
- The generated point cloud at the output consists of a total of 1,184,126 points.

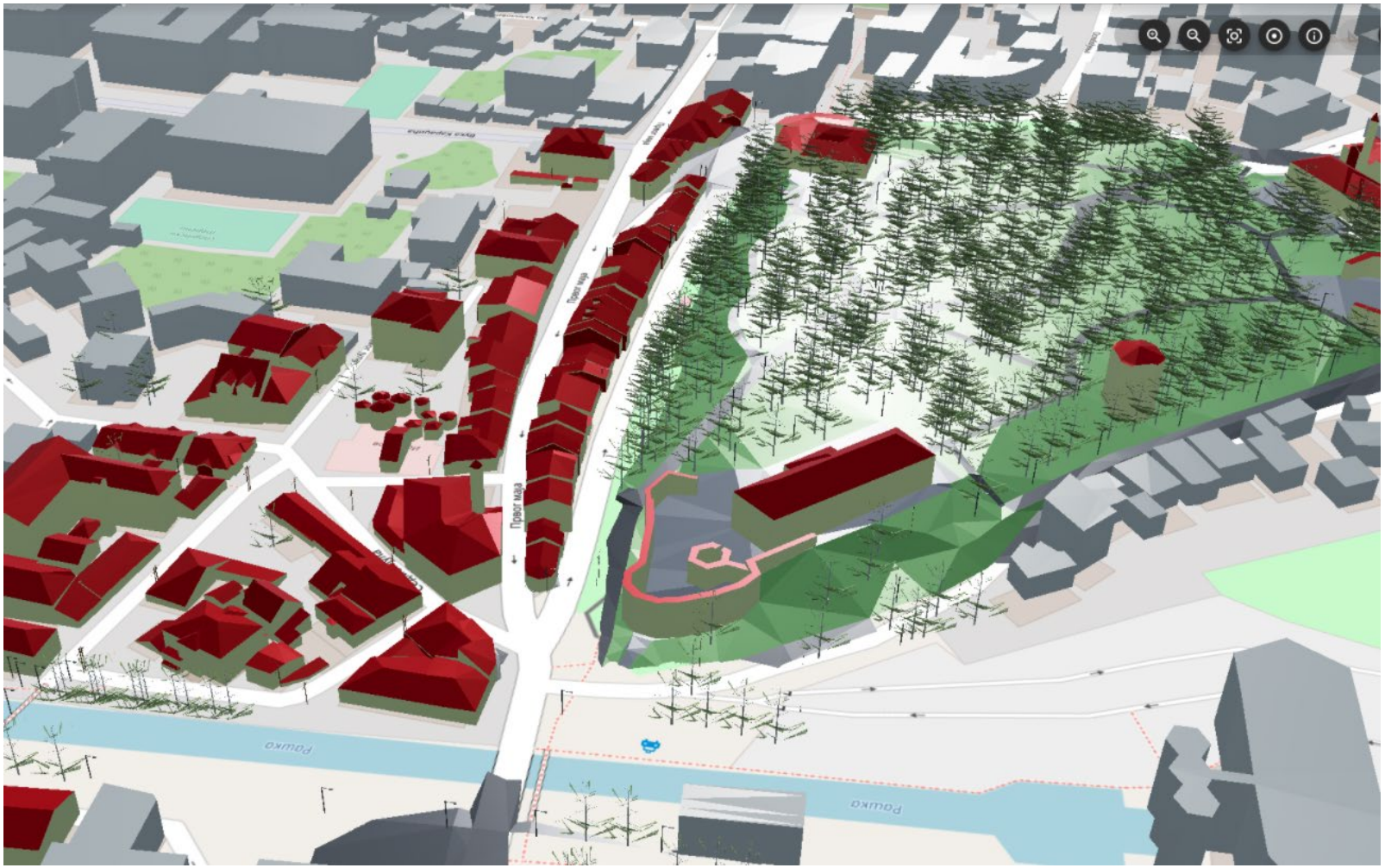
Scanning area

Stations are highlighted in red, marker positions are highlighted in green

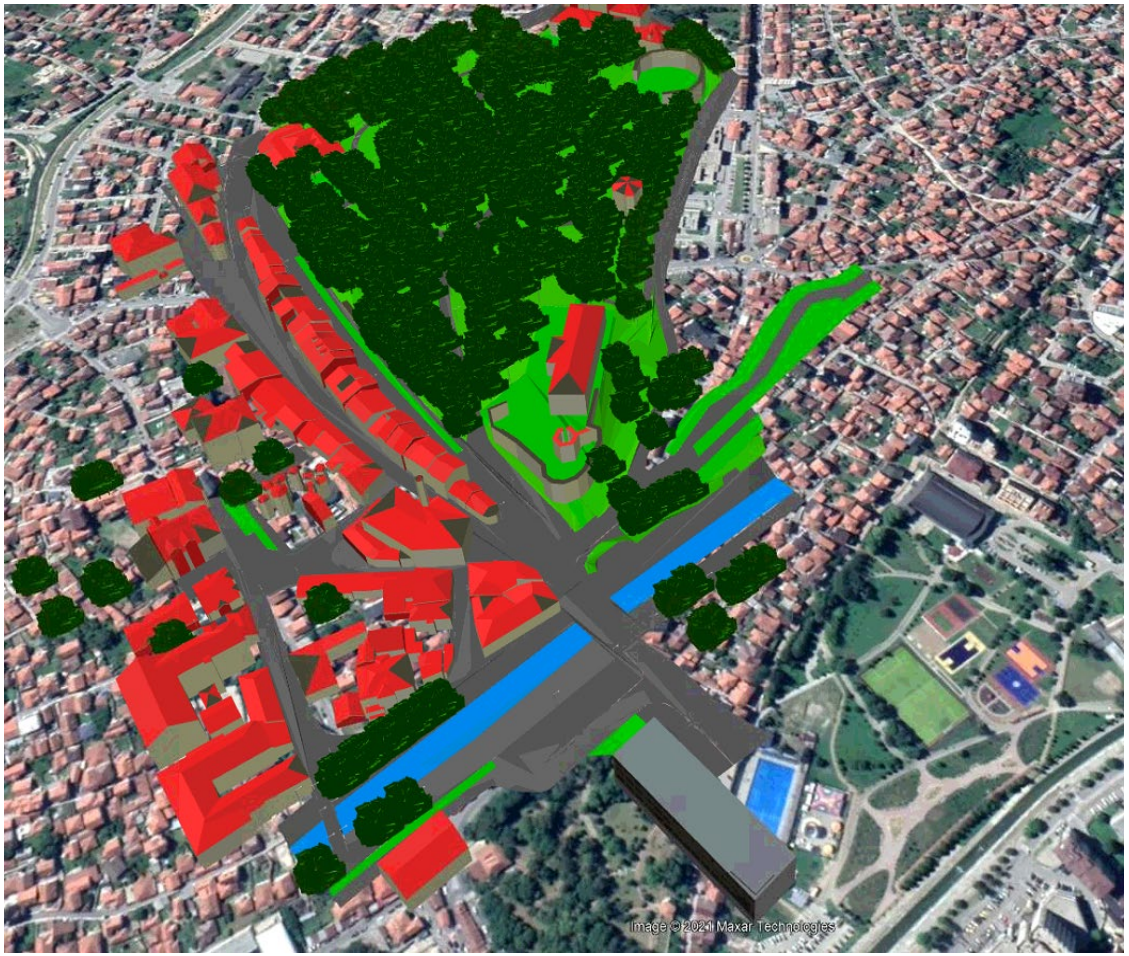
Point cloud classification and 2D and 3D vectorization

- Different type of manual and automatic points cloud classification and vectorization was done
  - 2D: Asphalt road, field road, pedestrian road, forest, park, isolated trees, bush, terrace, river, stream, water, canal, fence, railway, bridge, parking, bench, bus stops
  - 3D: House, building, residential and commercial building, auxiliary building, lighting, pole, power lines, traffic sign

View of the 3D model with the corresponding features in accordance with the CitiGML standard displayed in the Cesium JS Web Map Client – case study 2 – Novi Pazar



Novi Pazar - Case study 2 - KML



CityGML external references

- CityGML standard has anticipated a mechanism to link an object from a 3D model to a corresponding object in another information system, such as cadastral information system
- This is called an external reference represented by ExternalReference class
- The 3D city model created, in accordance with the CityGML standard, was imported into 3DCityDB database, which provides a query mechanism through SQL
- externalObject.name contains UPIN

External Reference	Name	URI
	informationSystem	https://katastar.rgz.gov.rs/eKatastarPublic
	externalObject.name	89010-1124-0-1-1

Conclusion

- We revised current practices for the spatial data acquisition and recognized the possibilities for improvements in terms of data registration in the cadastre to support collected 3D information.
- Most of the municipalities in Serbia have 2D spatial data in the form of digital cadastral map containing 2D parcel boundaries and building footprints, while building units are represented by the 2D CAD sketches of the floor plans. These boundaries are represented by the class RS_BoundaryFaceString. All this information is linked by unique property identification number (UPIN).
- With the proliferation of 3D datasets special attention is paid to spatial sources such as LiDAR (airborne and terrestrial) and UAVs for buildings and BIM/IFC for building units, and formats for representation such as CityGML, CityDB, IndoorGML, BIM/IFC.
- Similar to 2D digital cadastral map supported by sketches of indoor information, we propose 3D digital cadastral map supported by indoor information represented by 3D formats (BIM/IFC, CityGML, IndoorGML) based on available data, also linked by UPIN.
- This approach is demonstrated on two case studies in terms of data collection procedures that can be used for 3D cadastre purposes and development of 3D cadastral database. Both case studies use the procedure to obtain 3D city database, which can serve as a basis to populate cadastral database, where properties should be tagged by the UPIN.

Future work

- Future work will include further integration of cadastral datasets (CityGML and LADM based), since geometries for buildings are stored in CityGML format.
- The current analysis is based on CityGML 2.0 format since available datasets are developed in this version of the standard. However, analysis of CityGML 3.0 should also be addressed.
- Further research directions are pointed toward methods for automation of building extraction from point clouds based on the machine learning algorithms combined with extraction of 3D geometries from the point clouds based on 2D building footprints in cadastral map.
- For the indoor space and building units future research directions may be the generation of 3D indoor space based on available 2D floor plans in the cadastre or building units legal spaces mapping in IFC.

Thank you for your attention!