Cadastre in a digital world -Nordic and Global Perspectives
FIG Commission 7 Annual Meeting and International Seminar
24 - 28 September 2018, Bergen, Norway, Europe

National Technical University Of Athens
School of Rural and Surveying Engineering

3D Crowdsourced Cadastral Surveys – An Option for Fit-For-Purpose Registration of Urban Unregistered Properties

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Introduction

- *Current Situation:* ⇢ *A modern land administration systems (LAS) is needed*
  - Vertically growing cities
  - Complex infrastructure
  - Subdivision of three-dimensional (3D) space
  - Overlapping property rights

- Current research trends:
  - 3D / 4D Cadastre
  - Land Administration Domain Model (LADM ISO 19152)
  - adoption of automation
  - low-cost but reliable procedures
  - VGI, Crowdsourcing techniques
  - usage of modern IT tools and m-services

  Smartphones **à** *Multi-sensor systems*

VGI / Crowdsourced geo-data-future

VGI in Real World Mapping Applications

§ *OpenStreetMap (OSM)*

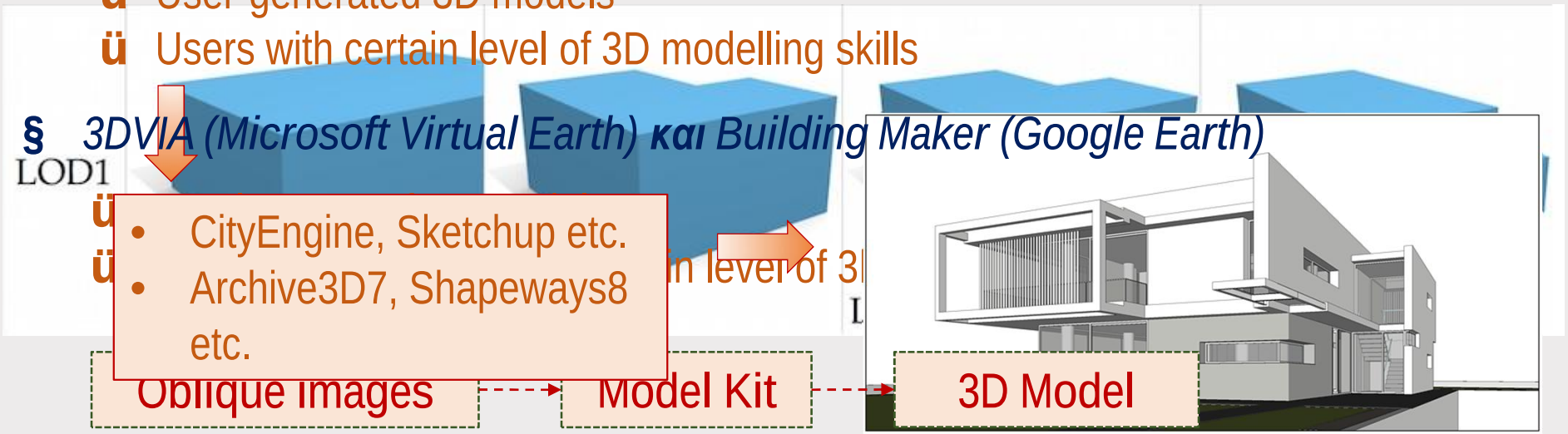
- ü 3D data capturing
- ü Huge potential **à** CityGML LoD1
- ü 3D projects **à** OSM-3D, OSM Buildings, Glosm, OSM2World etc.

§ *Google 3D Warehouse (shared repository)*

- ü User-generated 3D models
- ü Users with certain level of 3D modelling skills

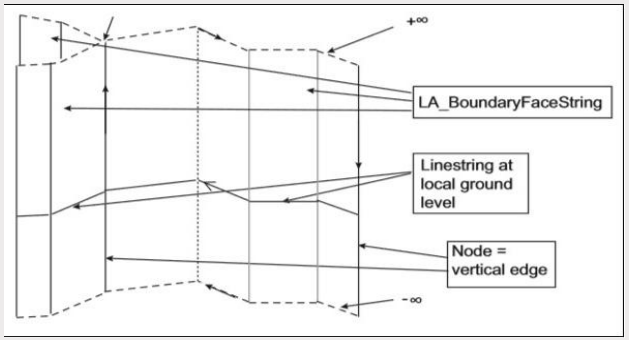
§ *3DVIA (Microsoft Virtual Earth) **και** Building Maker (Google Earth)*

- ü
- ü in level of 3



3D Aspect of LADM (1/2)

- *LADM ISO 19152*
  - Spatial domain standard
  - flexible conceptual schema for 2D/3D Cadastres
  - based on a Model Driven Architecture (MDA)



- *3D LADM-based country profiles:*
  - Russian Federation, Poland, Korea, Malaysia, etc.

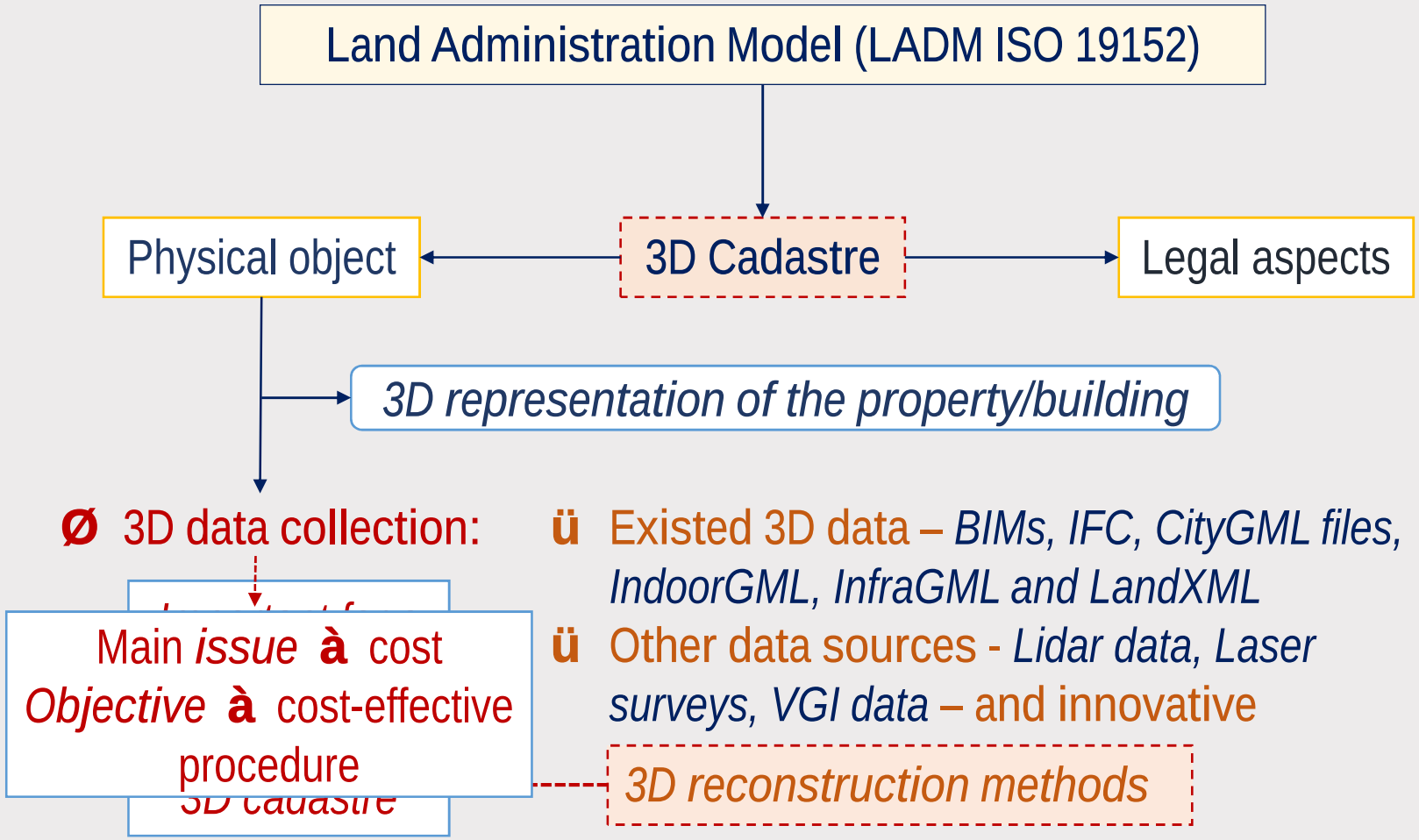
- *Linking LADM with physical models:*

Legal data model ⟷ *Physical data model*

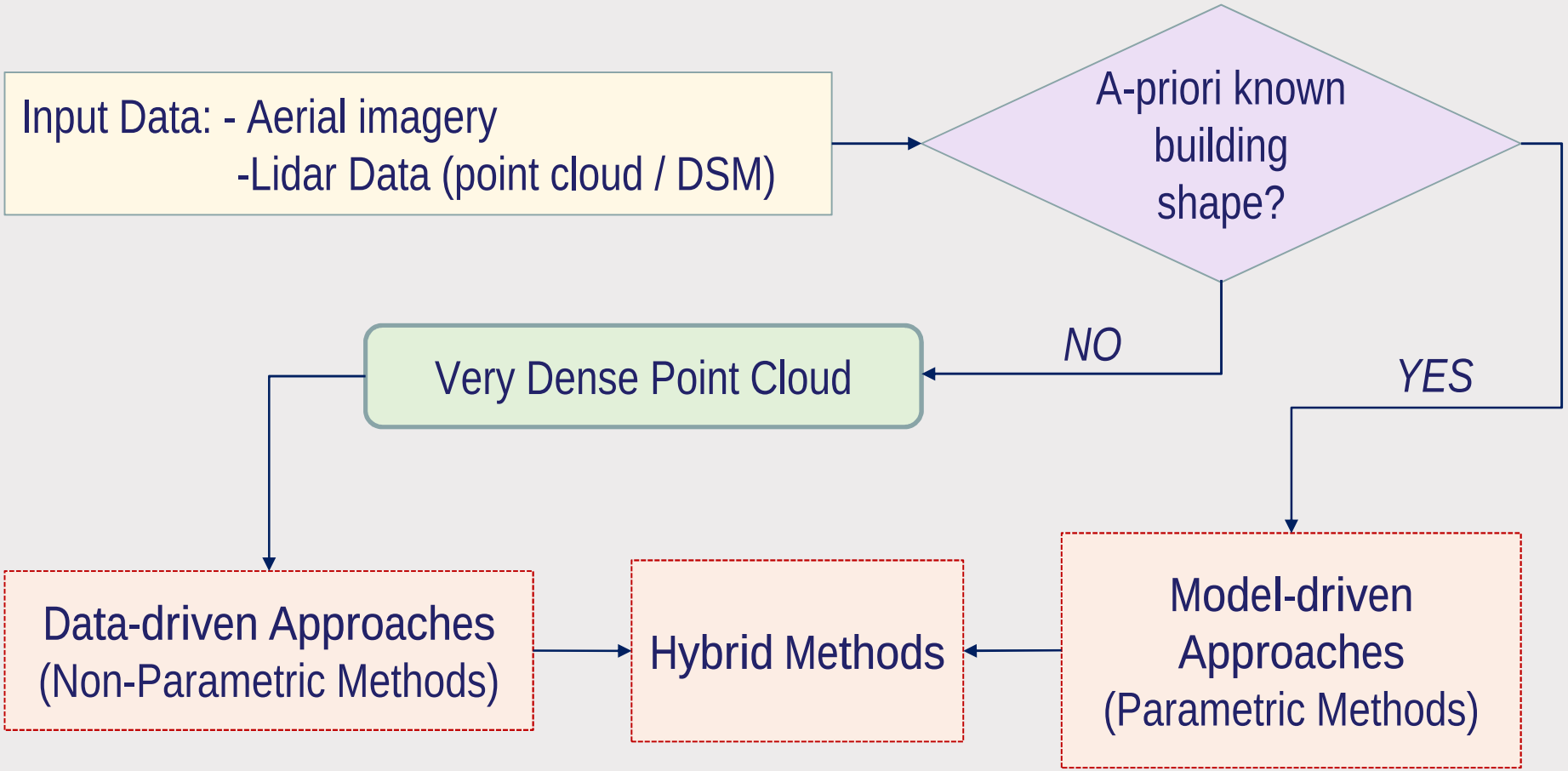
- *Application schemas*
- *Technical models*

(CityGML, IndoorGML, BIM/IFC, LandXML, InfraGML, etc.)

3D Aspect of LADM (2/2)



VGI / Crowdsourced Data and Reconstruction Techniques for 3D Cadastre



The potential use of crowdsourcing for 3D cadastral surveys

Model-driven Methods:

- ü robust
- ü high computing speed
- ü cost effective
- ü topologically correct model output
- ü less sensitive to noise
- ü no need for specific 3D modelling skills
- ü prior information about building shape
- ü Limited model library

Data-driven Methods:

- ü flexible - no need prior knowledge about building structure
- ü textured models
- ü very dense point cloud
- ü high computational cost
- ü sensitive to noise
- ü require specific 3D modelling skills
- ü Topological errors

VGI data – Main Error
Occlusions

→

3D Cadastre - Key Element
Volumes of buildings – preserve property rights

→

Best fitted solution - Model-Driven Methods

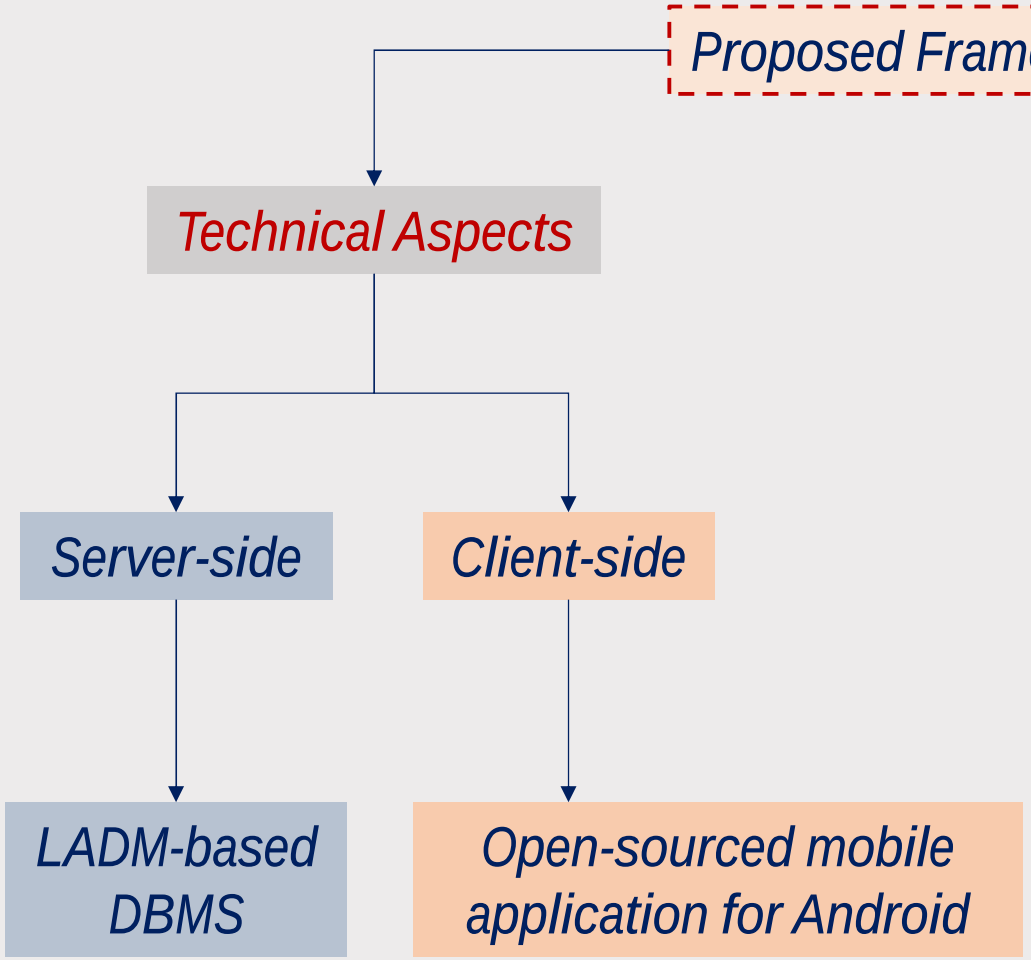
Proposed Framework (1/2)

- Innovation:
  - ü Low-cost equipment & IT tools
  - ü Crowdsourcing techniques
  - ü Mobile services (m-services)
  - ü Web services
  - ü Open-source software (OSS)
  - ü LADM ISO 19152

Active participation of the right holders minimize surveys cost and time

A fit-for-purpose 3D crowdsourced cadastral surveying approach based on standardized data model as LADM, might be of significant value to speed up processes for establishing 3D cadastres

Proposed Framework (2/2)

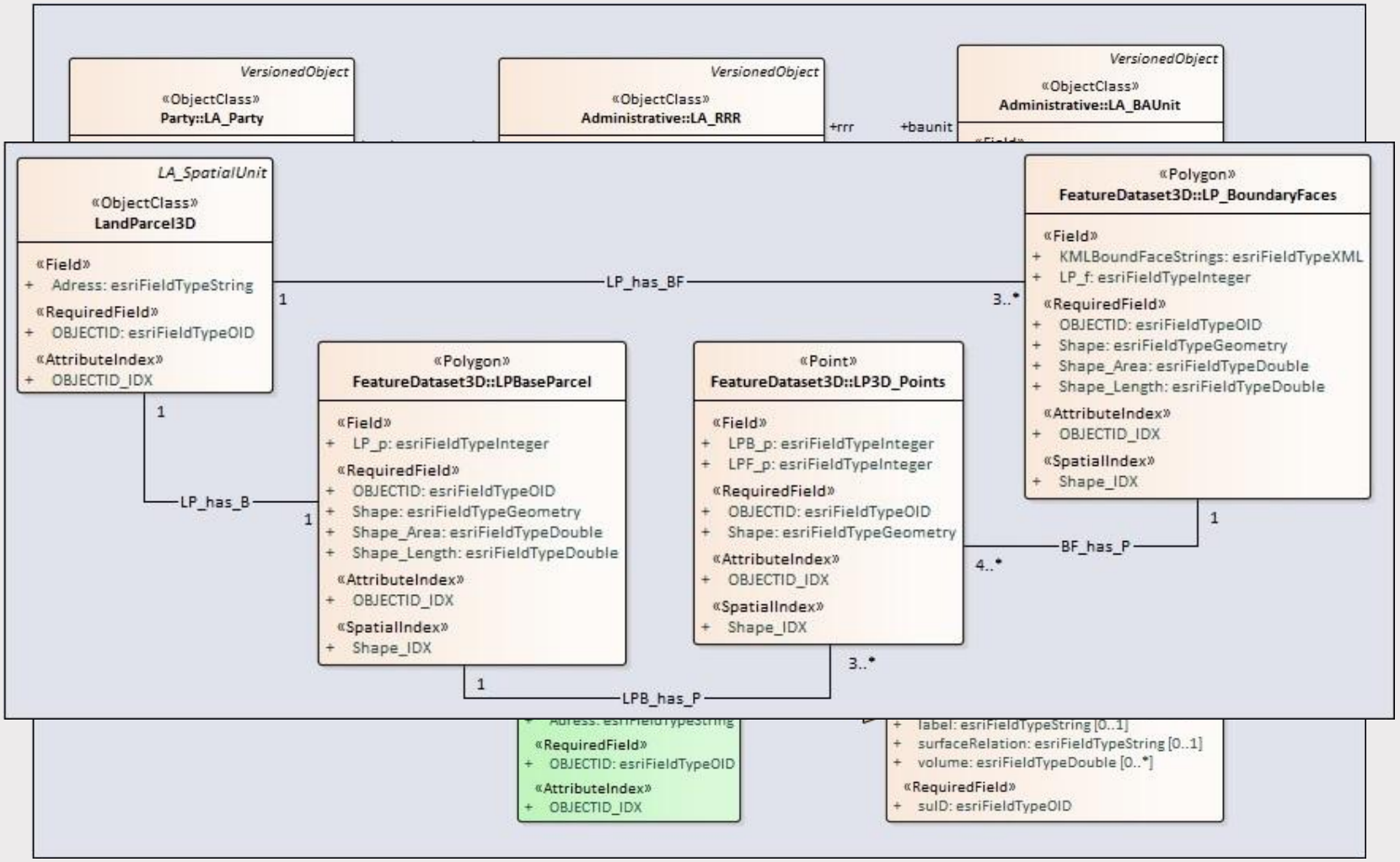


- *Cost-effective LADM-based technical solution*
  - Acquisition
  - Registration
  - 3D modelling
  - Visualization

Database Management System (DBMS)

Server-side (3D land parcel)

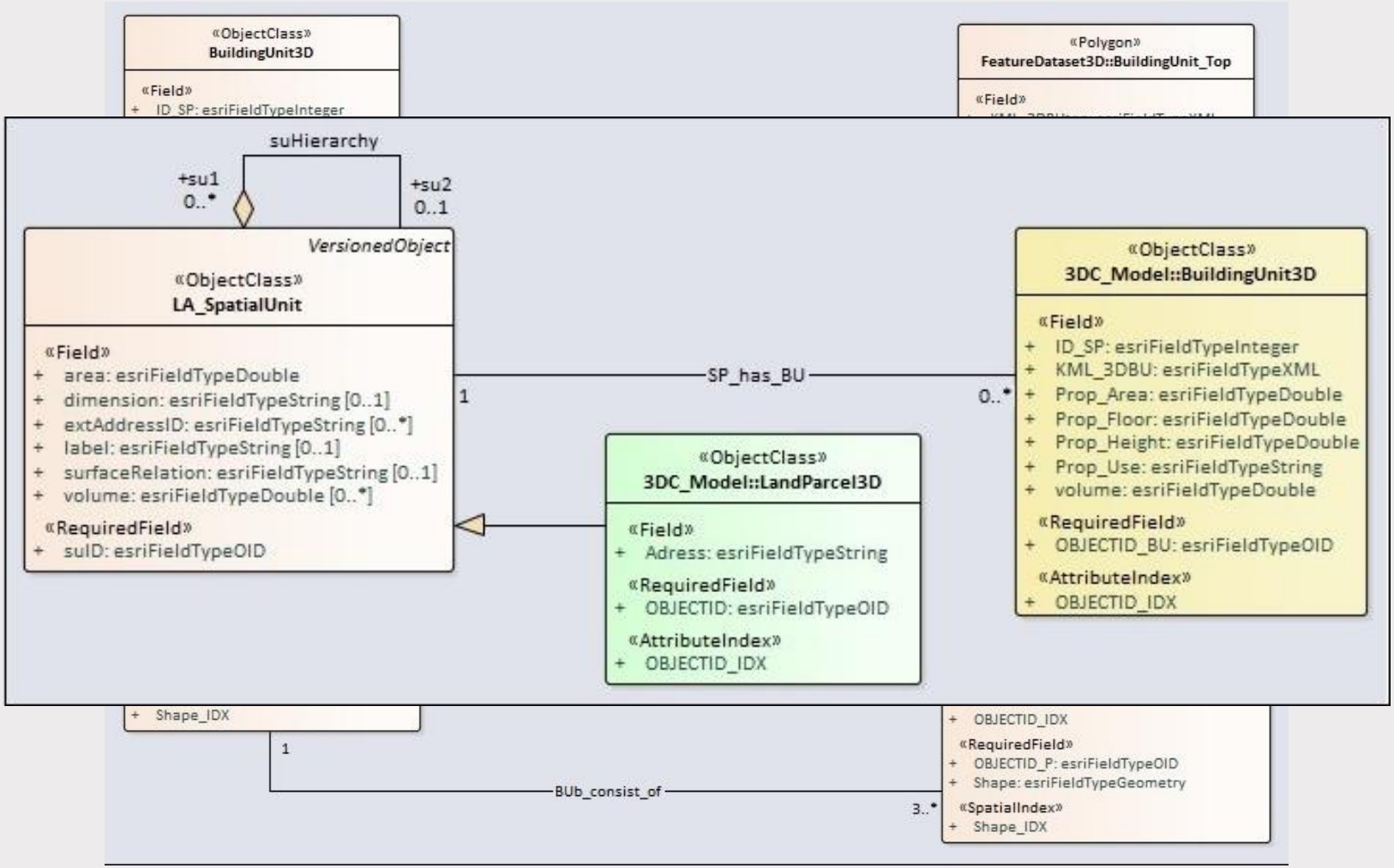
Enterprise Architect UML modeling tool
– ArcGIS Geodatabase



Database Management System (DBMS)

Server-side (3D building unit)

Enterprise Architect UML modeling tool – ArcGIS Geodatabase

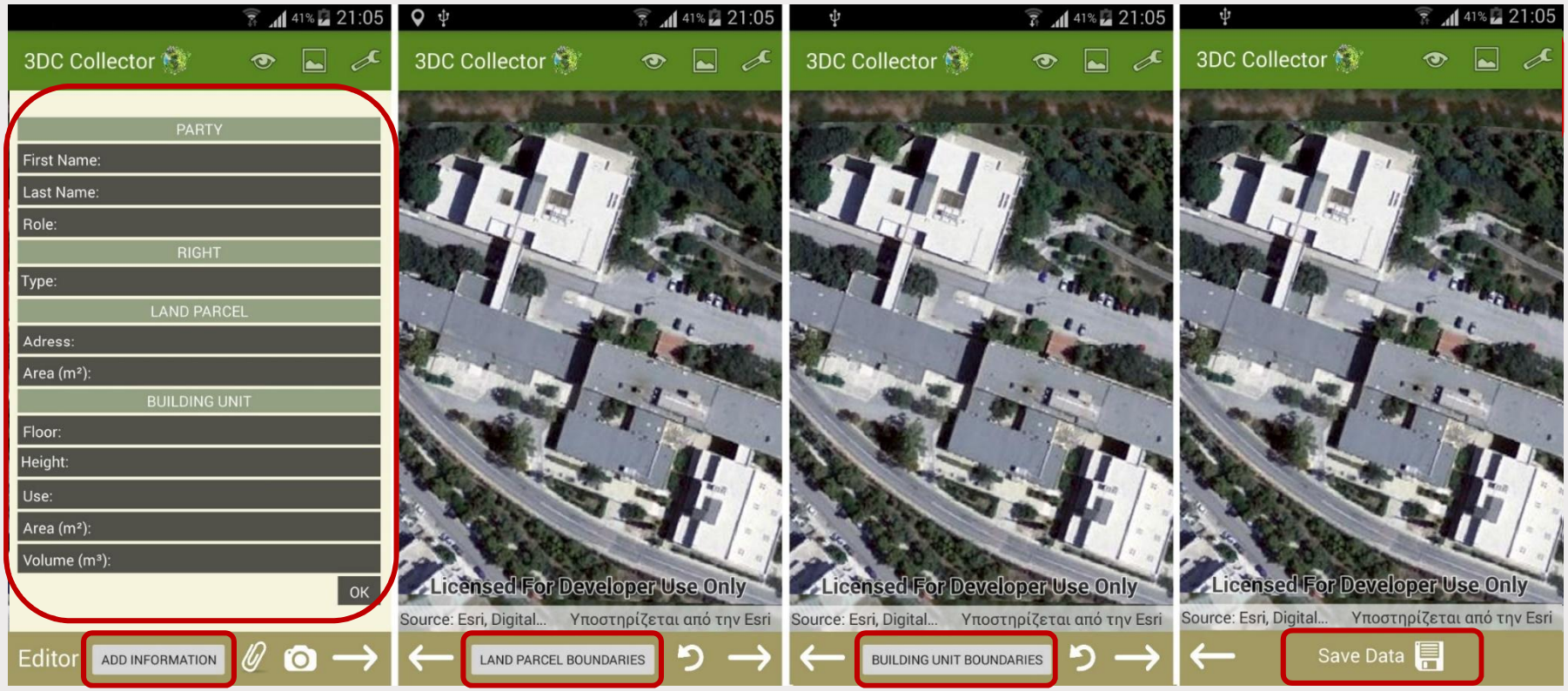


3D – Crowdsourcing Self-developed Mobile Application

Client-side

- *Self-developed open-sourced* Mobile Application
  - 3D cadastral data acquisition
  - 3D modelling of real properties (LoD1)
    Land Parcel & Property Unit **à** *Model-driven approach*
  - 3D visualization above & below the terrain
- *Software tools*:
  - Visual Studio 2013 (IDE)
  - Oracle JDK 8 (Java Development Kit)
  - Android SDK Manager (for API level 19),
  - add-in ArcGIS Runtime SDK for .NET (100.0.0) of ESRI
  - add-in Xamarin 4.5.0
  - the SharpKML library
  - the programming language of C#,
  - the Server of ArcGIS Online (Cloud of ESRI)

3D – Crowdsourcing Self-developed Mobile Application (2/2)



Proposed Procedure for 3D Cadastral Surveys (1/2)

Ø Provision of the available basemap with the areas under cadastral survey

ü recent orthophoto overlaid with buildings floor plans **à** *Higher geometric accuracy*

or

ü Orthophoto or aerial photo with the areas under cadastral survey **à** *Lower geometric accuracy*

Ø Crowdsourced 3D cadastral information/data acquisition

Cadastral Mobile Application

- ü Demarcation / digitization of the property boundaries
- ü Insertion of additional geometric information: building height, floor
- ü Insertion of additional descriptive information: rights holder's personal data, type of rights, etc.
- ü Verification images and legal documents
- ü 3D Parametric reconstruction of the building

Proposed Procedure for 3D Cadastral Surveys (2/2)

Ø Crowdsourced 3D cadastral information/data acquisition

Cadastral Mobile Application →

Help needed?

ü Provided either by volunteers or by professionals

ü Demonstration videos of the mobile/web applications by NCMA

Ø Data evaluation and control by the cadastral service

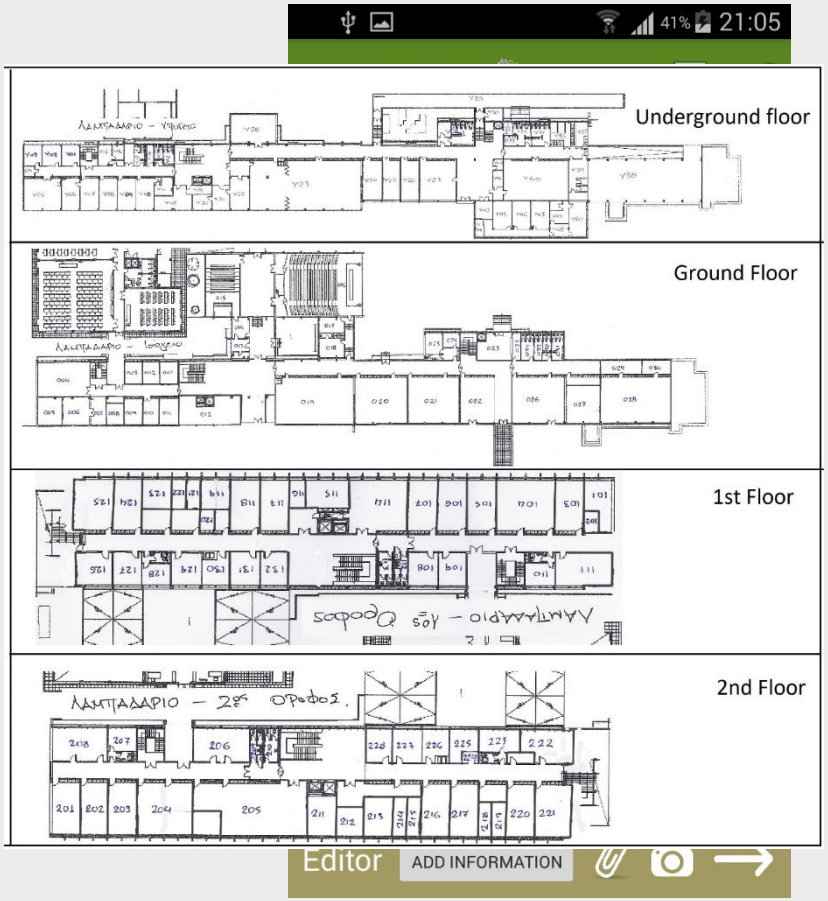
Incomplete Data?

Submission of missing data by the right holders

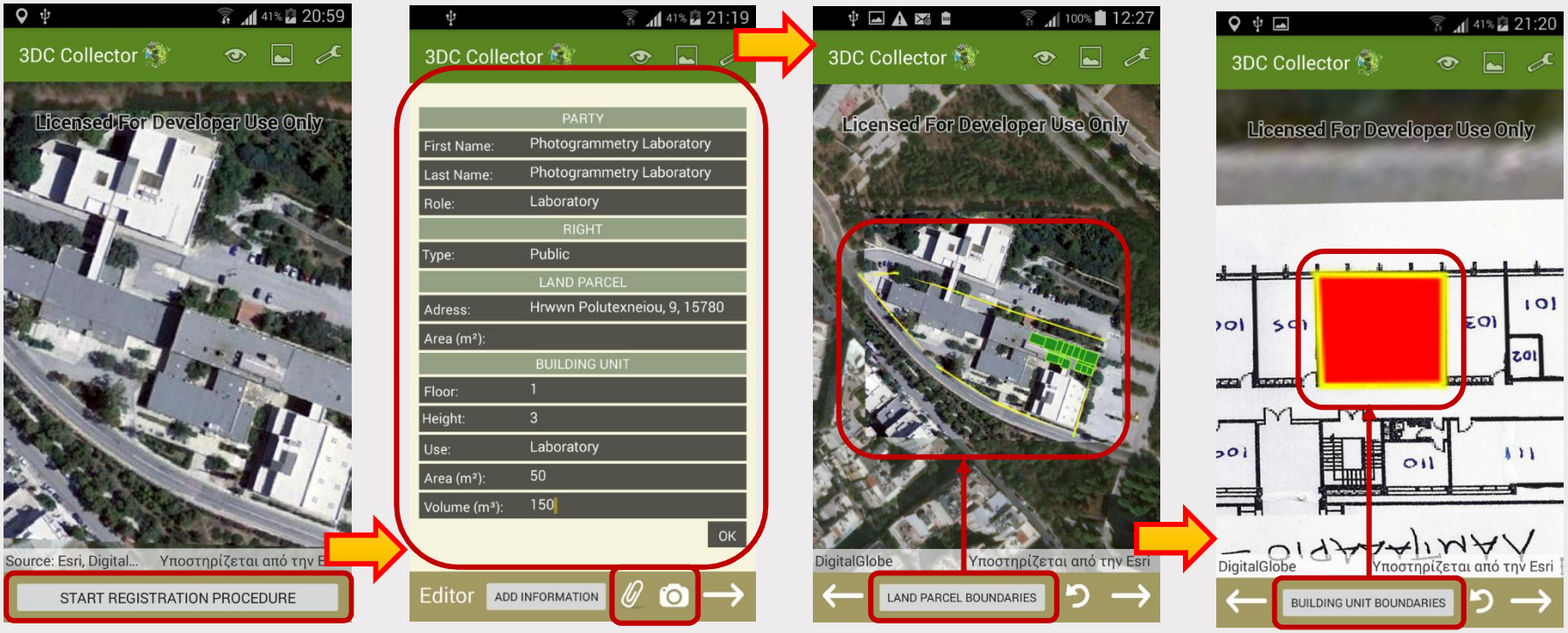
Ø Compilation of preliminary crowdsourced 3D building models by right holders

Case Study: Building of the School of Rural&Surveying Engineering NTUA

- Acquisition of Crowdsourced 3D cadastral information/data:
  - The *room-outline* coordinates
  - The building *area code, address*
  - The room holder *name, role, type of rights*
  - The room *floor, height, use, area size, volume*
- Basemaps:
  - Orthophoto at the scale of 1:1000
  - Floor plans, at a scale of 1:200, of
    - the underground floor
    - the ground floor
    - the first and
    - the second floor

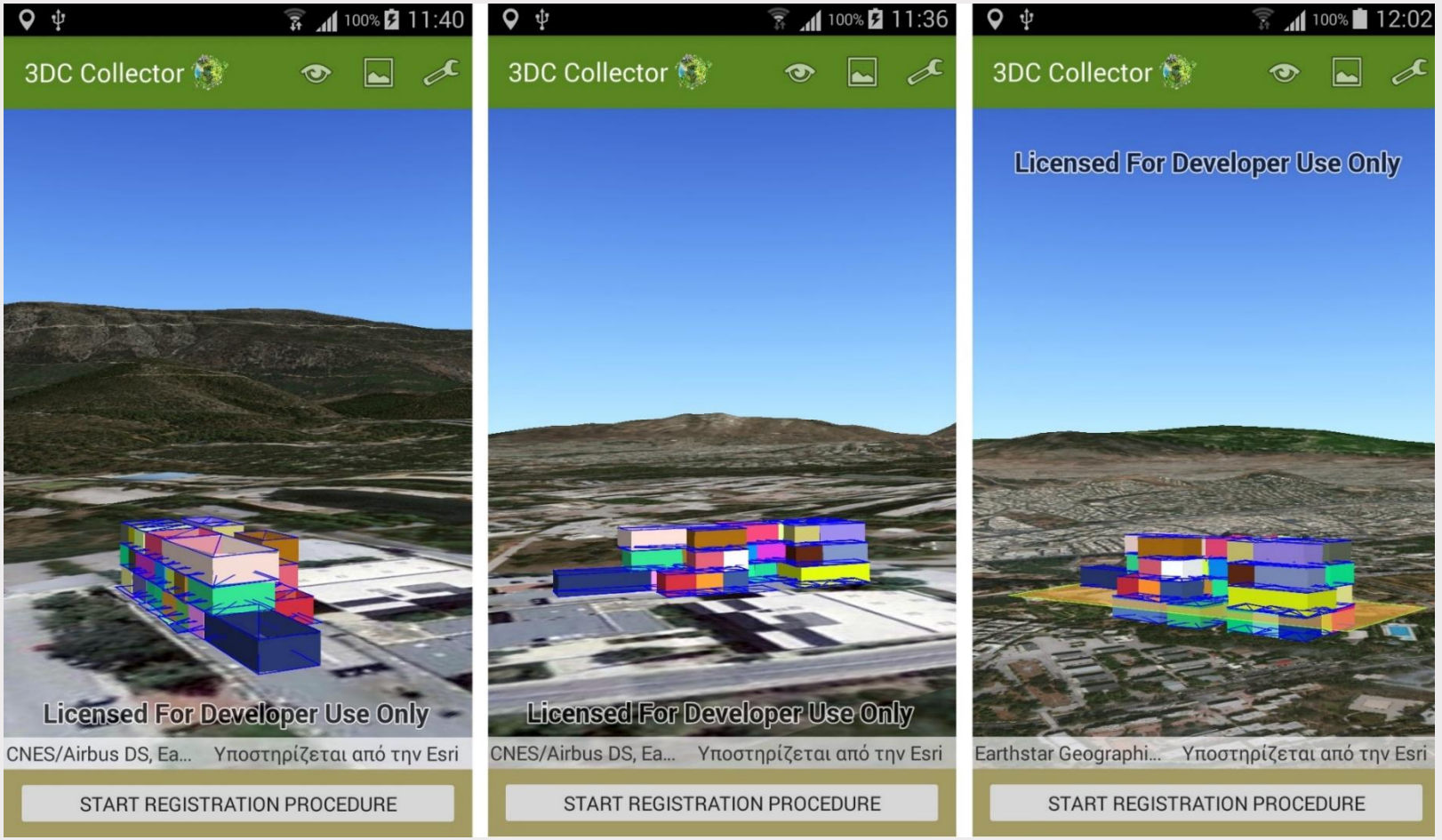


Case Study (2/4)



Case Study (3/4)

3D Visualization of the declared properties
- *LoD1 (Parametric Modelling)*



Case Study (4/4)

- Result evaluation :
  - Comparison with the reference data:
    - Maximum deviation: 0.49m
    - Minimum deviation: 0.03m
    - Average deviation: 0.17m
  - Qualitative 3D models
    - *correct 3D position*
    - *small shape defects*
  - Recording time per property:
    - 5-7 min fast
  - *Easy-to-use*

Conclusions

- *Modern Approach - 3D Cadastral Surveys:*
  - *3D Crowdsourcing Techniques* - Citizens' participation – *gross errors minimization*
  - *Cost and time effective solution / automation* usage of modern *low-cost IT tools, m-services, parametric modelling techniques*
  - *Land Administration Domain Model (LADM ISO 19152)*
  - *Available cartographic infrastructure*

Technical framework for the initial registration of 3D crowdsourced cadastral data and the creation of a standardize cadastral database

Conclusions

A cost effective solution is required for the initial implementation of a EU desired 3D Cadastre

Ø Advantages:

- ü Efficient and Transparent system
- ü Reliability
- ü Guaranteed protection of properties
- ü Reduction of financial resources
- ü Management of complex areas – multi-dimensional overlapping property rights
- ü Citizens participation to the data collection procedures

Thank you for your attention!

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