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A multi-dimensional Land Information System for upgrading urban settlements

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European Union
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HELLENIC REPUBLIC
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HELLENIC REPUBLIC
MINISTRY OF ECONOMY
INFRASTRUCTURE, MARITIME AFFAIRS & TOURISM
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OPC II
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regions at the centre of development
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5DMuPLIS
5 Dimensional
Multi-Purpose Land
Information System

We are expected to provide solutions:
functional, reliable, affordable, inclusive & fit-for-purpose

To satisfy a world that cannot wait!

Best Use of Urban Land

energy efficiency; vital green spaces;
utility services
Health; Transport
Increased urban densities
3d city modeling
....

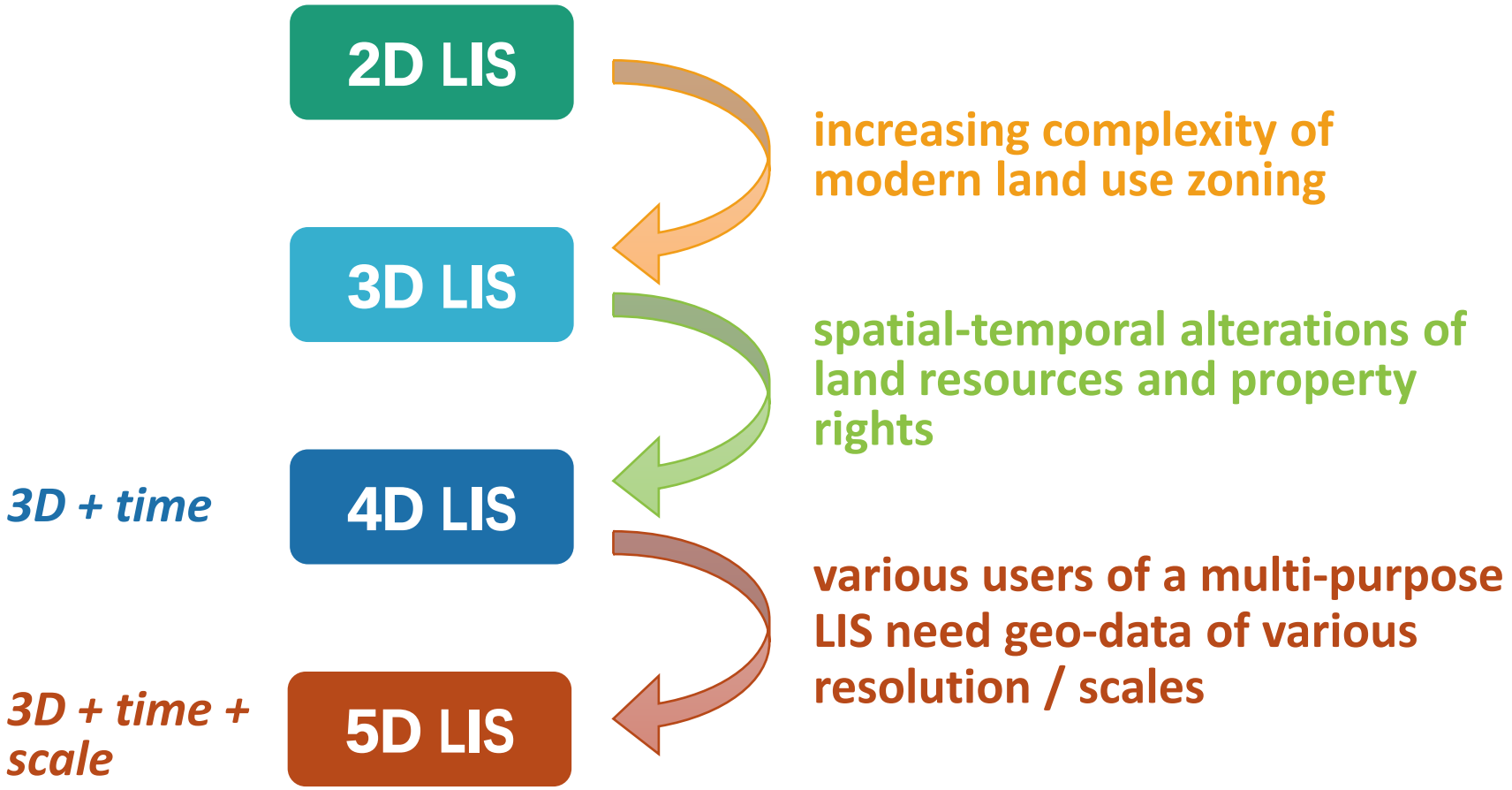
Urban land readjustment
Self financed & small projects

Voluntary participation

Fair property valuation &
Redistribution of property rights

Involvement of private sector
Affordable housing provision

The Evolution of Land Information Systems



Objectives of this project

To develop a **technical tool** that :

- Will serve urban land management purposes, land policies & reforms (property registration in 4d, property valuation, planning & land readjustment, affordable housing, etc) with transparency
- Will be applicable in various geographical regions (e.g., developed and/or developing, formal, informal urban settlements, etc)
- Will serve both public & private sectors (state authorities, municipalities, professionals, etc)
- Will operate for desktop applications
- easy to be improved or modified according to the needs

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Affordable housing: encompasses a wide spectrum of housing types, prices and occupants

- Rental housing
- For-sale housing
- Government-subsidized housing
- Public social housing ?
- Policies usually speak of affordability as:

Low-income rental housing : Subsidies for production or for occupants (object grant/subject grant) or both to make it affordable to low- (50-80% of median income) and very-low-income (50% of median income) households

Affordable ownership housing: market-rate unsubsidized housing for moderate-income (80-95%) households, first-time buyers, and subsidized ownership housing for low- and moderate-income buyers

Funding mechanisms

Financial aid can be granted as:

- extra payment (without refunding) or
- it can be granted as credits, e. g. loans with low interest or loans with public securities.

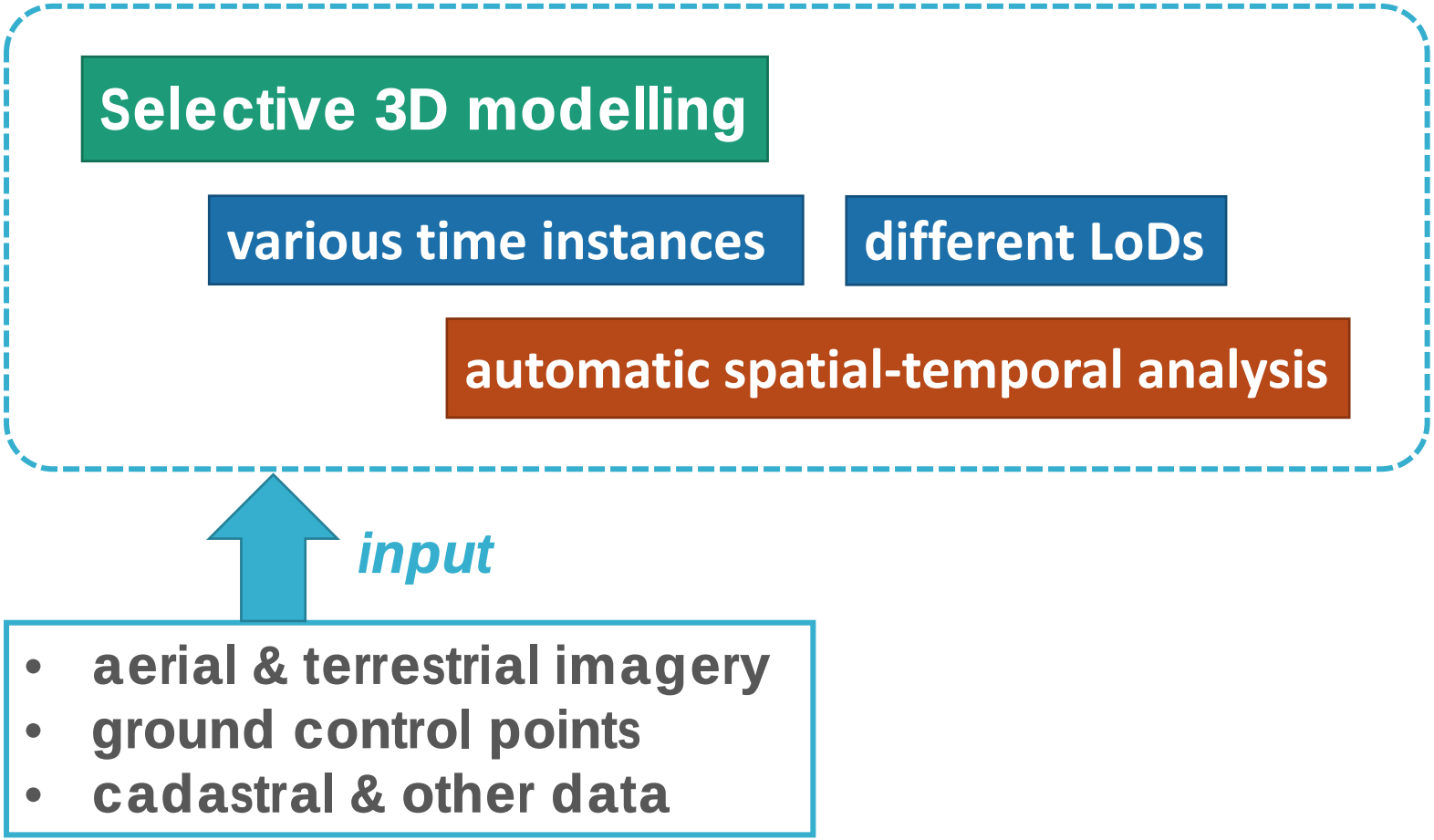
Supply of dwellings:

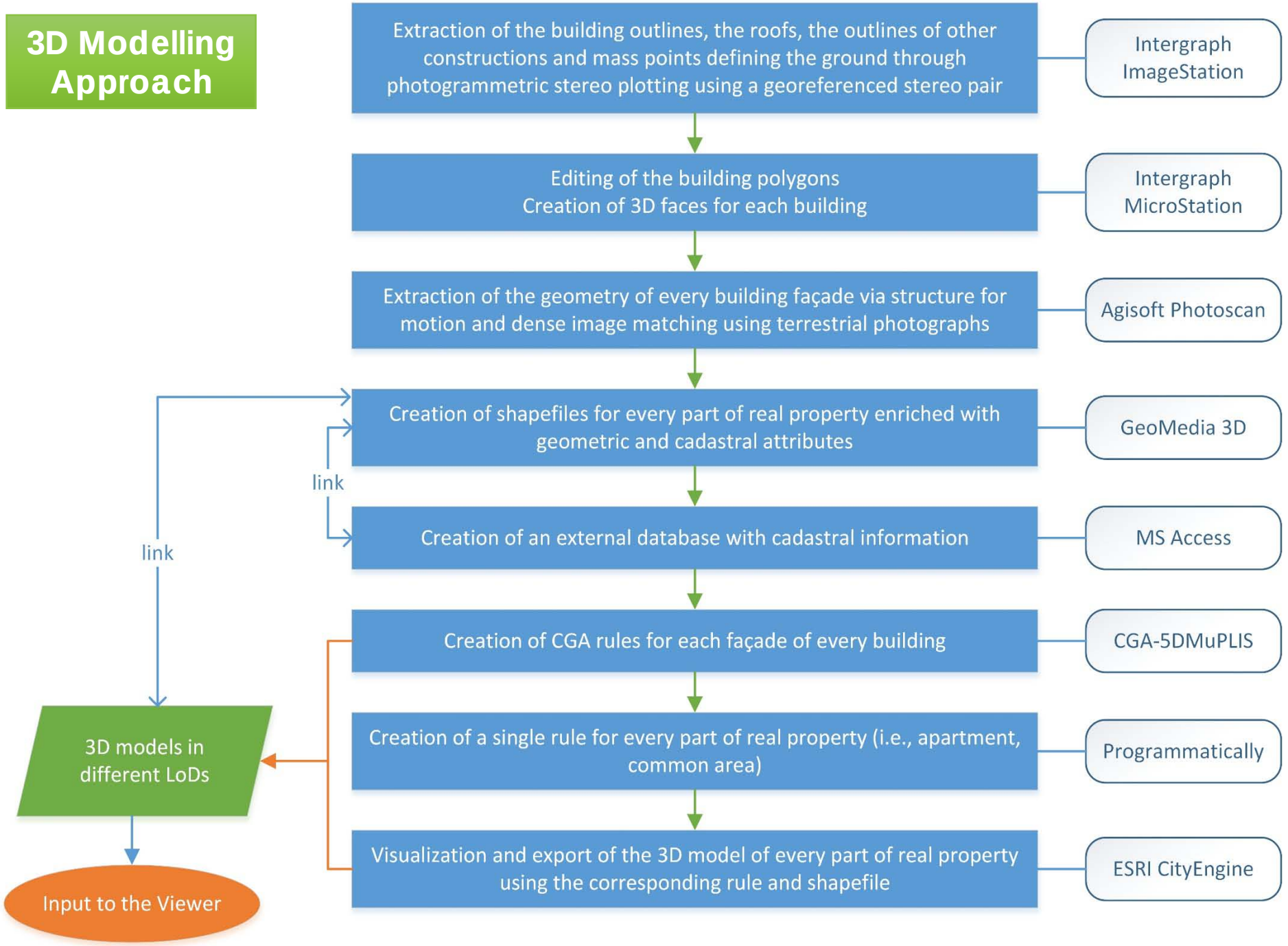
- New apartments
- the modernization of housing stock
- offering state-owned land for affordable housing to reduced prices; the investors are obliged to reflect the reduced land price in reduced rents for target group households, etc

Procedure to provide private or state land for a small scale urban land re-adjustment

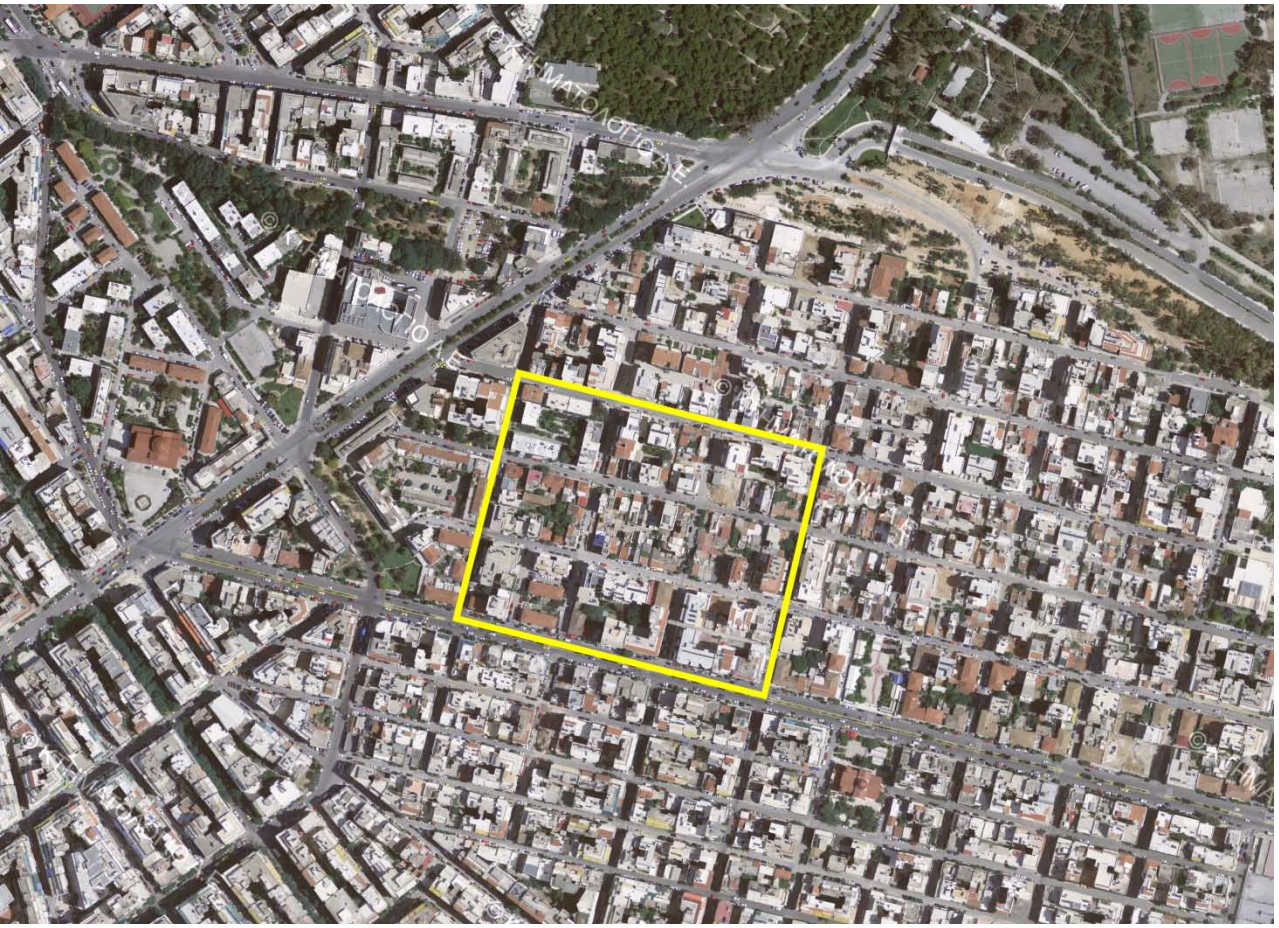
- Adjudication of the existing property rights and rights to use
- 3D cadastre and planning at a certain time t_1
- Collection of all necessary spatial data about the valid land use regulations at t_1
- Calculation of the value of each property at t_1
- Implementation of new regulations, parcel merging and construction of new buildings at t_2 with increased plot to building ratio; calculation of new values at t_2
- Redistribution of property rights to the old owners according to their old value plus a fair 'profit' that will cover all type of costs
- The remaining new properties at t_2 belong to the constructor to cover his expenses and profit but also to provide a small % of those to a target group for affordable housing according to the agreement with the state

Proposed 5D Modelling Framework




3D Modelling Approach
Extraction of the building outlines, the roofs, the outlines of other constructions and mass points defining the ground through photogrammetric stereo plotting using a georeferenced stereo pair
Intergraph ImageStation
Editing of the building polygons
Creation of 3D faces for each building
Intergraph MicroStation
Extraction of the geometry of every building façade via structure for motion and dense image matching using terrestrial photographs
Agisoft Photoscan
Creation of shapefiles for every part of real property enriched with geometric and cadastral attributes
GeoMedia 3D
link
Creation of an external database with cadastral information
MS Access
link
Creation of CGA rules for each façade of every building
CGA-5DMuPLIS
3D models in different LoDs
Creation of a single rule for every part of real property (i.e., apartment, common area)
Programmatically
Visualization and export of the 3D model of every part of real property using the corresponding rule and shapefile
ESRI CityEngine
Input to the Viewer

Study Area



A region consisting of **9 urban blocks** in the municipality of Kessariani, a suburb in the eastern part of **Athens**

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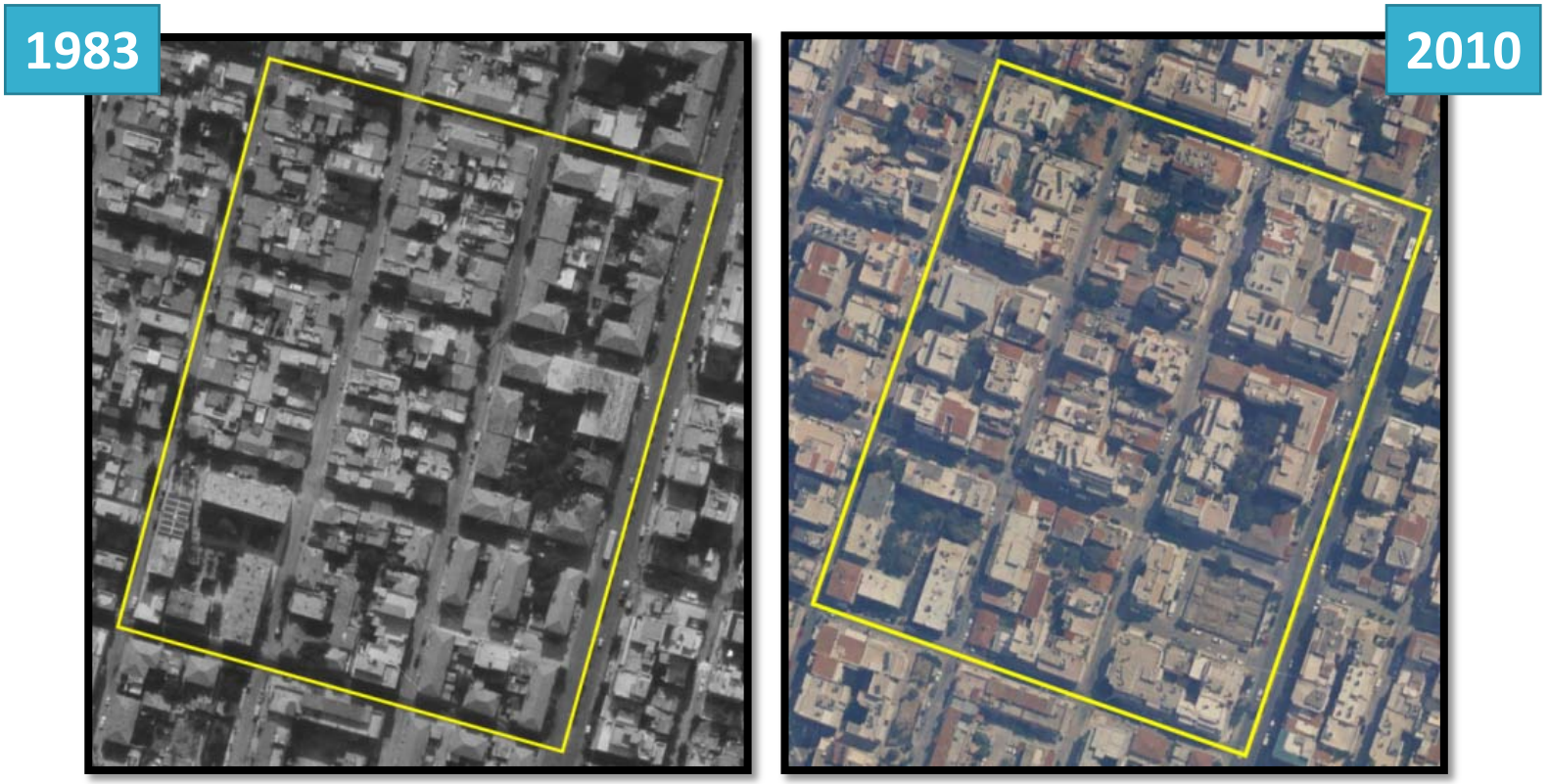
Available Datasets

Stereo pairs of aerial images from two time instances



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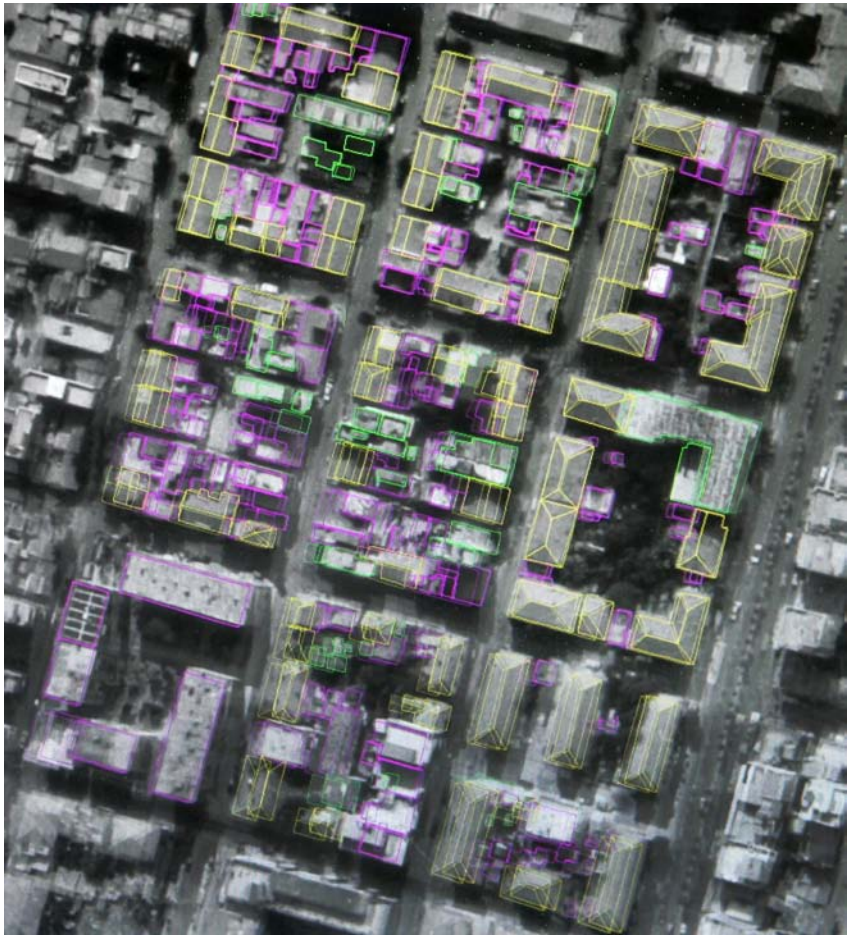
Photogrammetric Stereo Plotting



using the georeferenced stereo models of **the reference epoch**

Stereo plotting of the study area using the 1983 stereo pair

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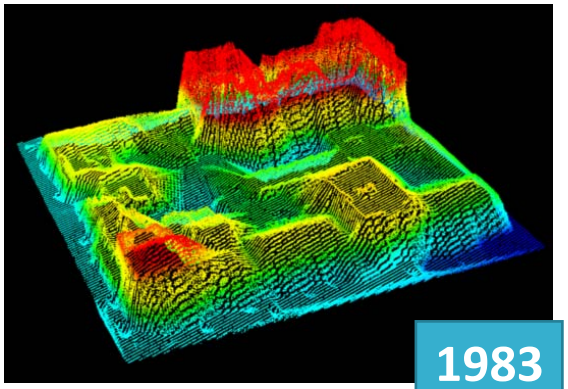
Dense Image Matching

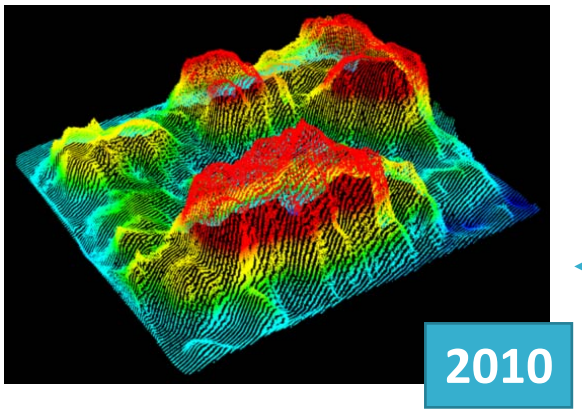
Dense image matching is applied on the stereo models of the **forthcoming time instances** for the automatic generation of 3D point clouds for the new epochs

Creation of Point Clouds of the Same Density

The point clouds vary significantly in terms of density, due to the different methodologies applied for their generation

- Transformation into meshes
- Smoothing filter on the automatically generated meshes of the new time instances (e.g., Laplace)
- New point clouds of the same density

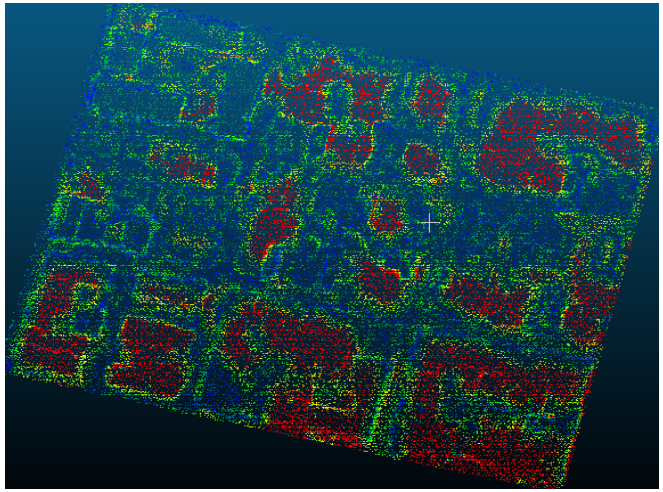




Final point clouds of an urban block

Automatic Change Detection

- The distance between each point in the reference point cloud and its nearest point in the new point cloud is computed
  - A distance threshold of 3.5 m, associated with the height of a typical floor
  - A threshold of 2.5 m above ground, to ignore cases of differences in vegetation, cars, etc
- Change maps are obtained, indicating regions that require further 3D modelling at new time instances



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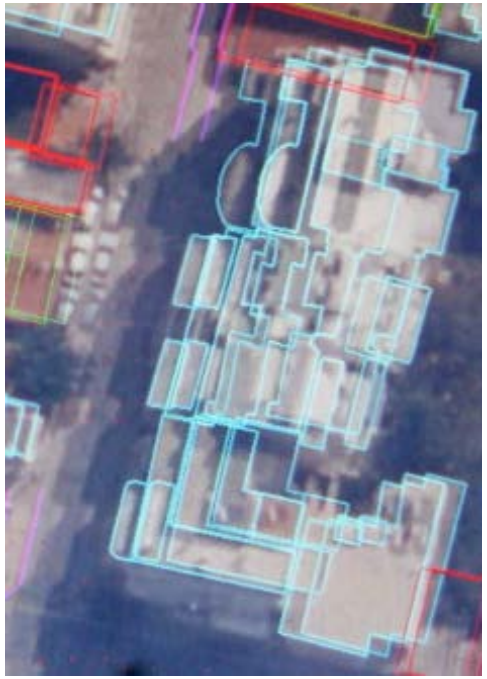
Stereo Plotting in Areas with Changes

Regions of insignificant changes remain intact.

Only regions which have undergone a significant change are modelled at new time instances.

3D building outlines are acquired through photogrammetric stereo plotting

Stereo plotting using the 2010 stereo pair



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Building Volumes

Building outlines + DTM

Building volumes for LoD1

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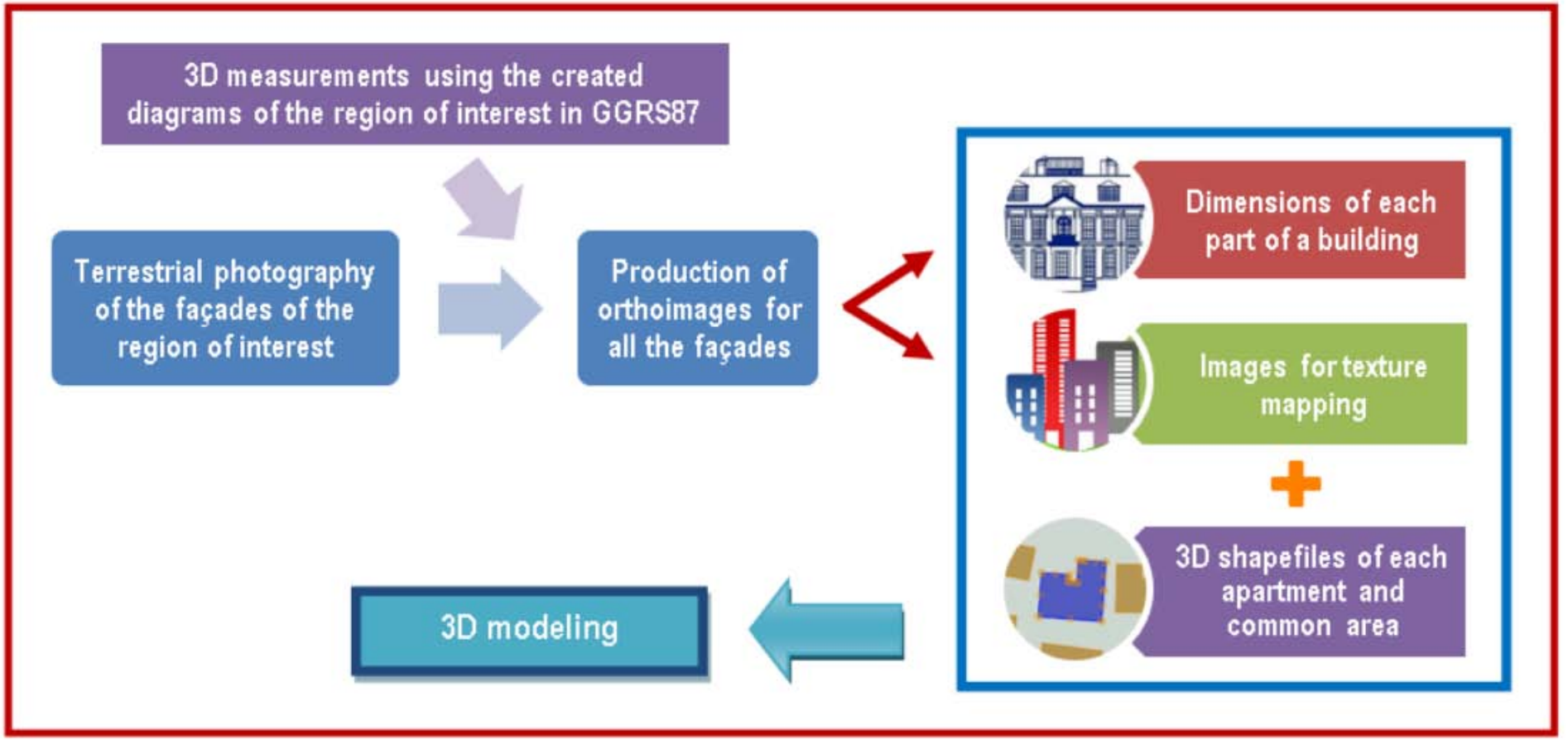
3D modelling in higher levels of detail (LoD2, LoD3)



Methodology implemented for the creation of the 3D textured models of every building

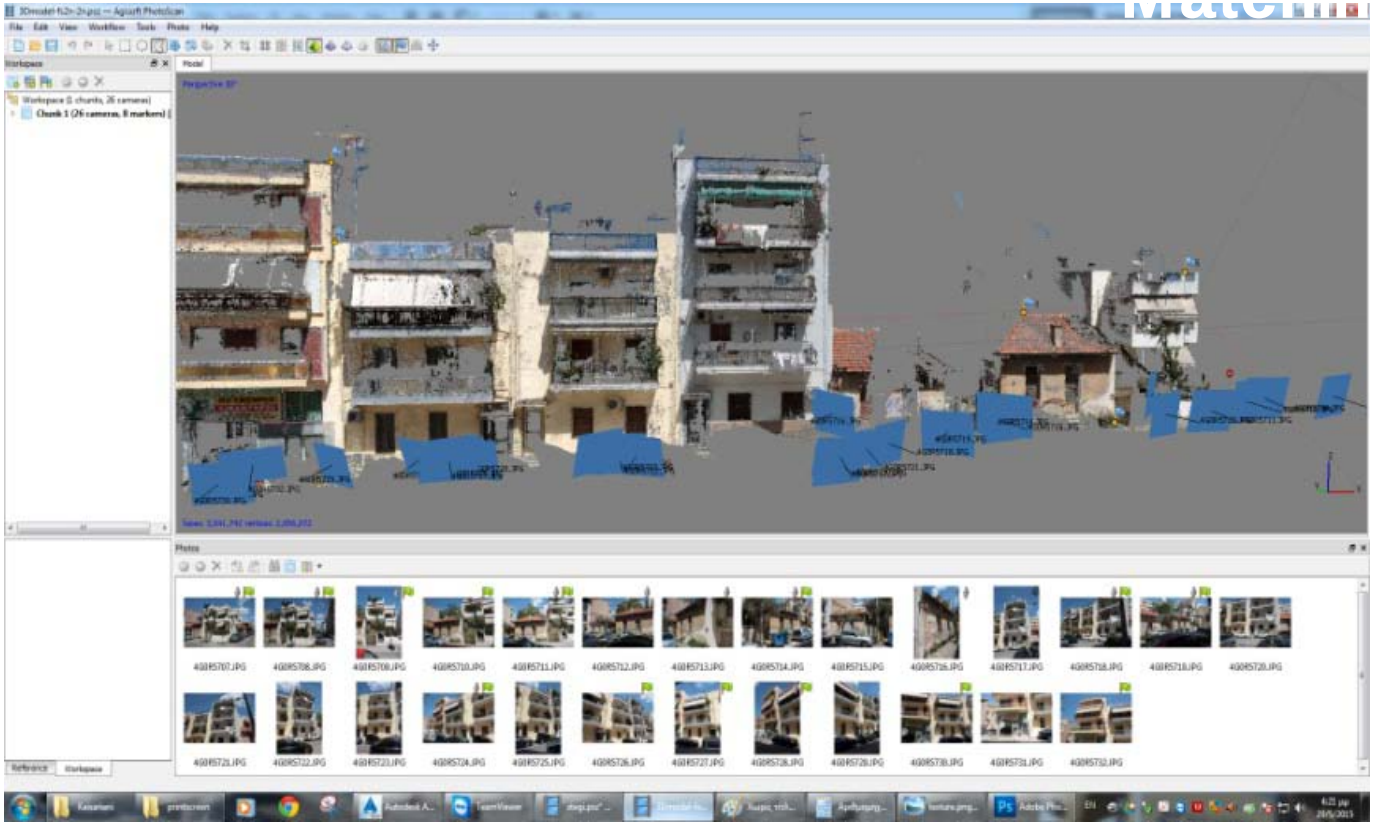
Terrestrial photography

~ 100 images per urban block were obtained using a metric calibrated camera

Each building façade is depicted at 3 images of different views at least

Extraction of dense image matching point clouds

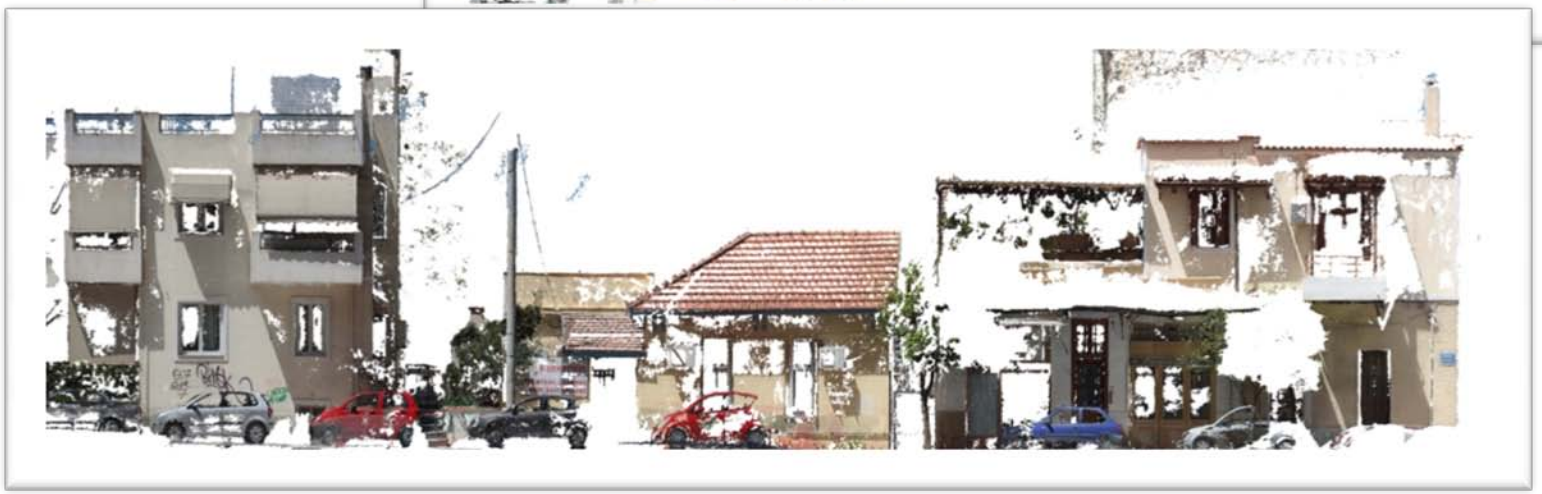
- **Structure from Motion**
- **Dense Image**



Using this technique a **dense point cloud** can be extracted using **multiple overlapping images** taken by a single camera around the object of interest

Generation of orthoimages

Orthoimages are generated (one for each side of an urban block) using the obtained optical terrestrial imagery, the GCPs and the generated dense image matching point clouds



External Database

An external database with cadastral information is created

- identifiers and categories of the persons (e.g., physical, legal, notary)
- identifiers of the documents from which rights are born (e.g., contract, court order)
- dates when documents were created
- identifiers of the rights (e.g., ownership, easement)
- percentages of ownership on parcel and/or on horizontal or vertical properties
- denominators of these percentages
- dates when rights started to exist, etc

The database is connected with the records of the shapefiles using one common field, a unique id

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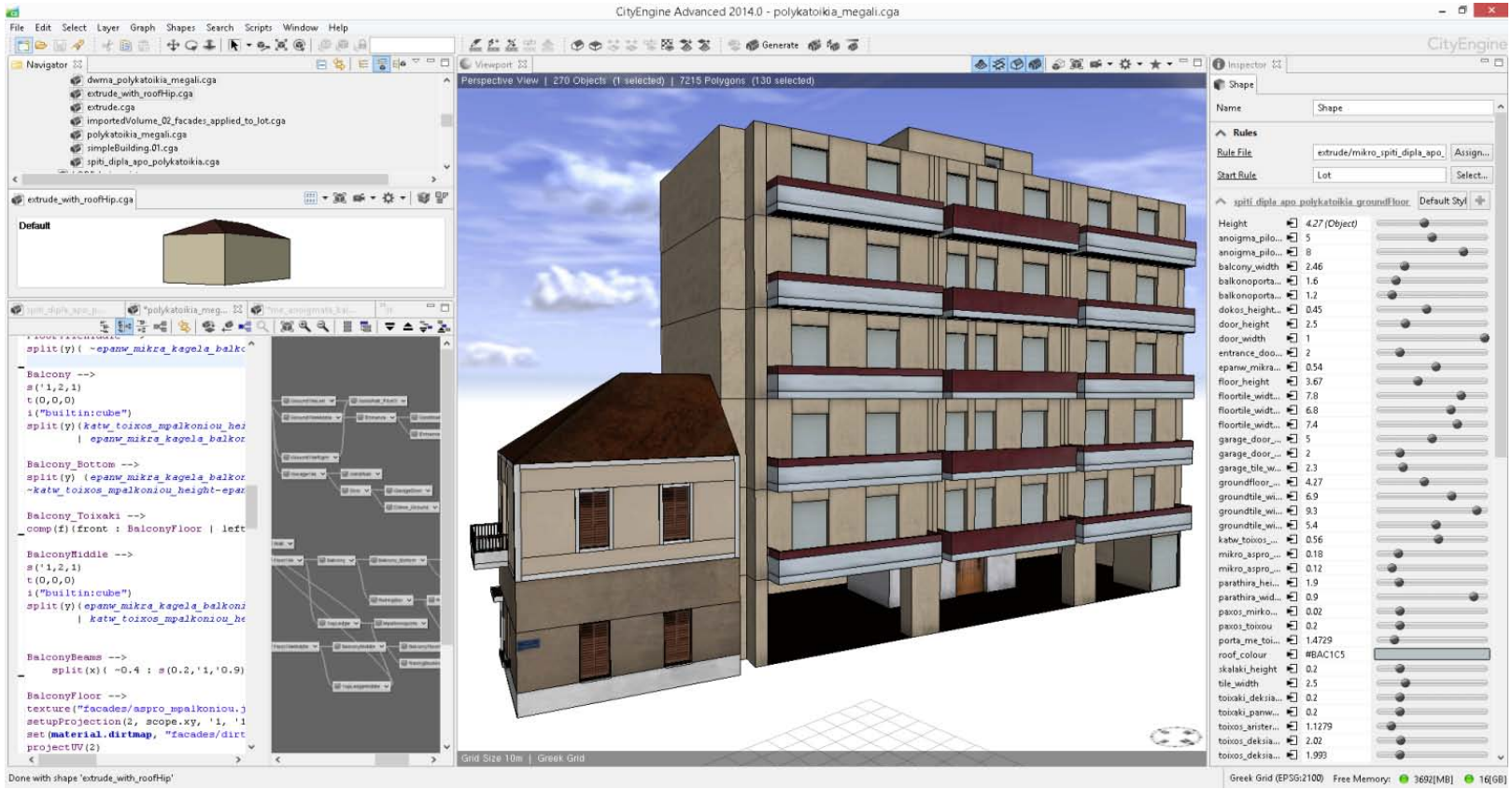
Procedural Modelling

The 3D model of each apartment or building is created through procedural modelling

- 3D content is generated using a set of rules, that is, computer code, which is applied to initial shapes to iteratively generate and refine a design by creating more details
- CGA (Computer Generated Architecture) shape grammar
- The rules enable the procedural creation of complex 3D models of buildings by firstly producing a crude volumetric model, then structuring each façade and finally adding details for doors, windows, balconies, etc., in the target level of detail
- Rapid creation and updating of 3D models, in comparison with traditional modelling techniques
- The rules are created using metric information, color and texture for the elements of each building and are applied to the footprint of each apartment or building

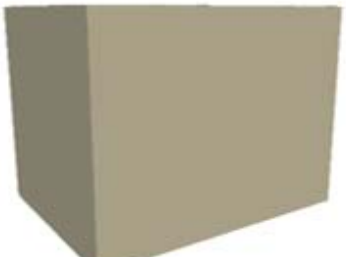
Visualization and export of the 3D models

Esri CityEngine software was used for the visualization of the generated 3D models, using the CGA rule files and the respective shapefiles, and export the models in suitable 3D formats (Collada/KML)

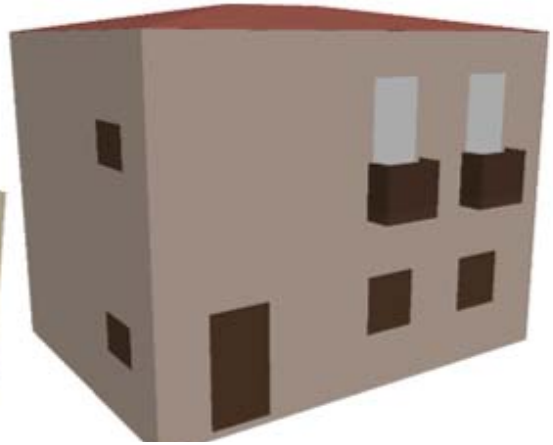


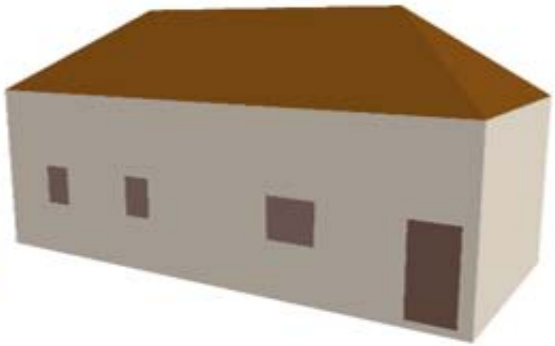
3D models in different LoDs

LoD1



LoD2





LoD3

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LoD1 LoD2 LoD3

LoD3 detail

LoD3

3D Models

1983

LoD2

LoD3

2010

3D Models

Case study for urban re-adjustment

- Voluntary merging of 5 plots, of total area 1,077 m^2, for a creation of 1 new plot, in one building block
- Urban land re-adjustment : demolition of all existing old constructions and construction of new condos, total build-up area: ~5,000 m^2
- 35% increase of the existing building-to-plot ratio

- Construction of (16) new condos for affordable housing
- Construction of(13) new condos; each of a value equal to the property value of each owner, increased by 10%, in order to ensure that all costs for resettlement are covered and the owners will voluntarily participate in the project

Case study for urban re-adjustment

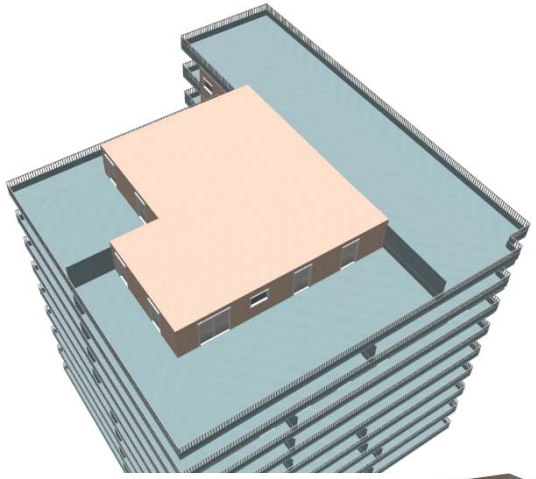
The new total build-up area: 4,378 m^2 is distributed to:

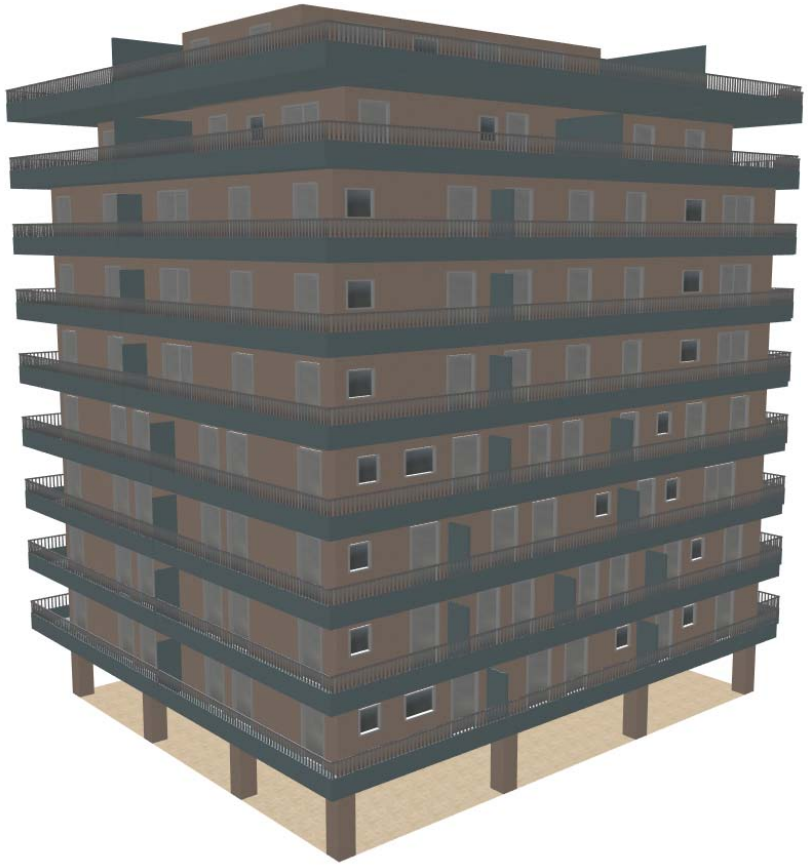
1. the old owners: 25.1% of the build-up area
   27.8% of the value
2. A target group eligible for affordable housing
   26.6% of the area
   11.0% of the value
3. The developer 48.3% of the area
   61.2% of the value,

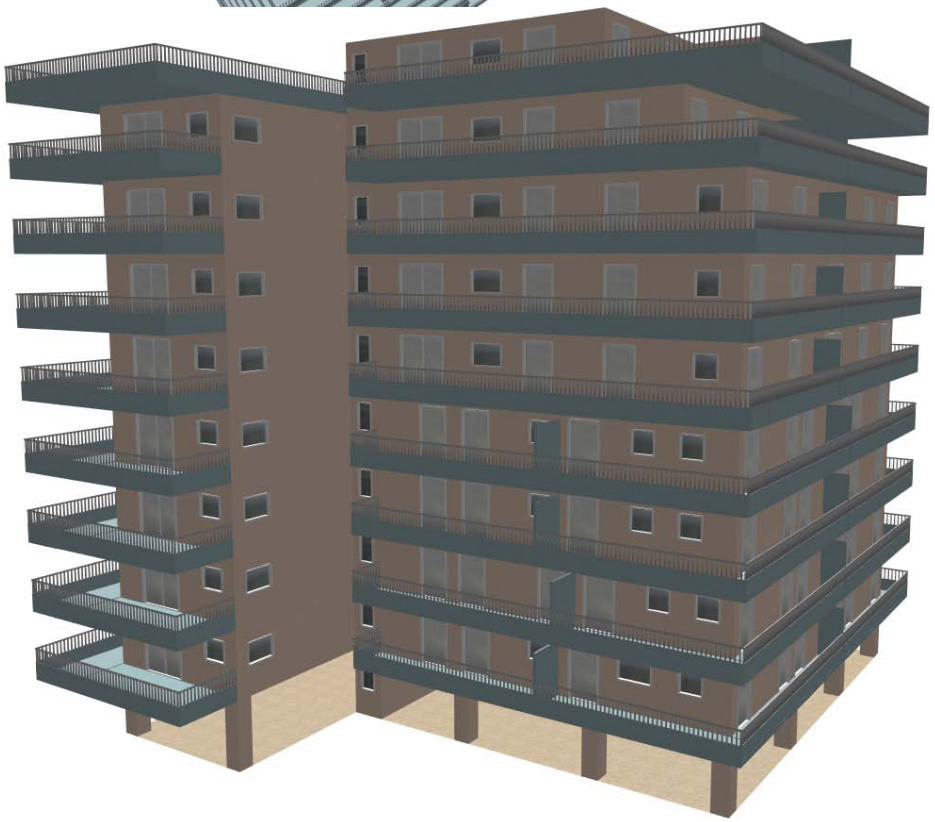
   that covers soft and hard costs,
   his profit (as it would that be prior to the increase of the building-to-plot ratio), and
   the costs for the creation of those condos offered at affordable price

Urban readjustment – redistribution of property rights

3D modelling – future scenario







2010

Future scenario

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2010

Future scenario

2010

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