ΓΓΕΤ ISR_3013

5DMuPLIS
5 Dimensional Multi-Purpose Land Information System

3D Cadastral System Functionalities for 5D Multi-Purpose LIS

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ΕΥΔΕ - ΕΤΑΚ

Outline

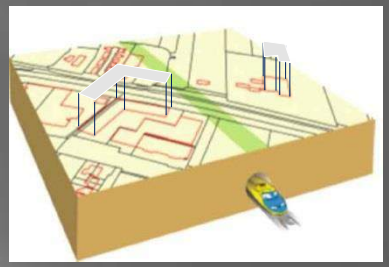
- 5DMuPLIS Project
- 2D and 3D Cadastre
- Processes
- Functionalities
- Summary

5DMuPLIS Project

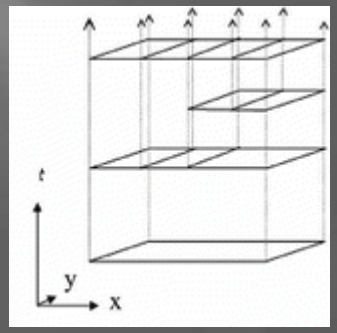
Expanding 2D cadastral GI system capabilities with:

- Height dimension
- Temporal dimension
- Scale dimension

3D

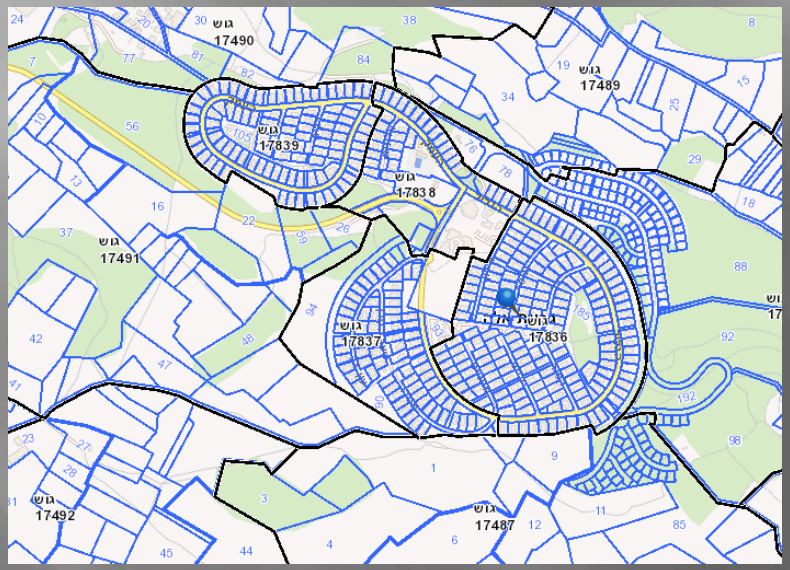


4D

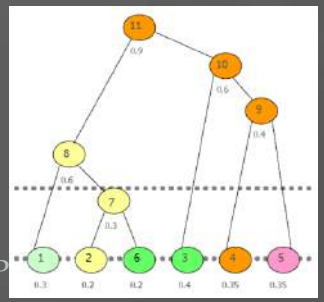


Now
State t_2 to now – 4 parcels
t_2
State t_1 to t_2 – 3 parcels
t_1
State t_0 to t_1 – 1 parcels
t_0

2D



5D



5DMuPLIS Project

- Design and develop 5D cadastral GIS (=LIS) supporting the public sector and private organizations
- 3D GIS (in the cloud) enabling the support of 5D land and property management: location (X,Y,Z), time and scale
- First phase:
  - Defining functionalities of 3D cadastral GIS
  - Design and develop 3D spatial database to support and store 3D Cadastral data

2D and 3D Cadastre

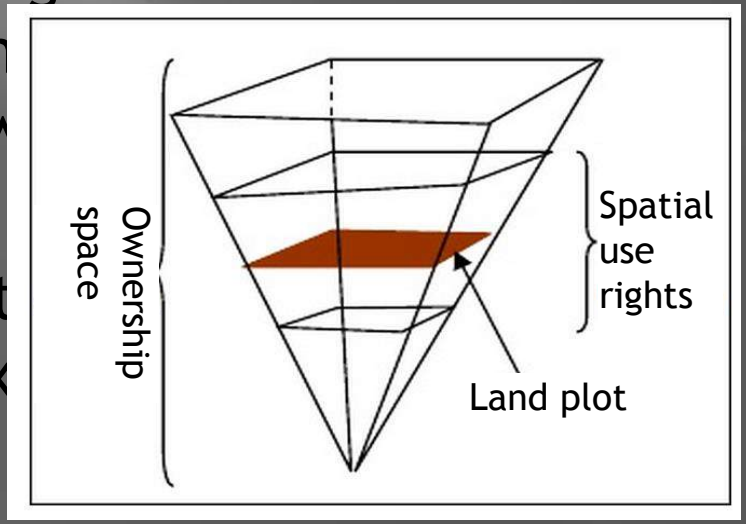
		Cadastral Data		
		2D	3D	Integrated
Aspects	Geometric	•	•	•
	Cadastral	•	•	•
	Topologic	•	•	•

- 2D cadastral maps
- 2D mutation plans (before and/or after integration onto the 2D cadastral maps)
- 3D parcel data (defined as “spatial sub-parcels”)
- Detailed outline maps

2D and 3D Cadastre

Basic principles:

- The landowner's ownership is concurring to the volume of the pyramid volume created and defined by the 2D land parcel (projection on earth) that origins at the center of the earth to the space above it.
- So far (in 2D) no concern was given to the pyramidal structure and to th
the parcel boundaries - below
ground (surface).
- In 2D it is not possible to vert
ownership and land rights (ex
registration of apartments ->
non-spatial registration).

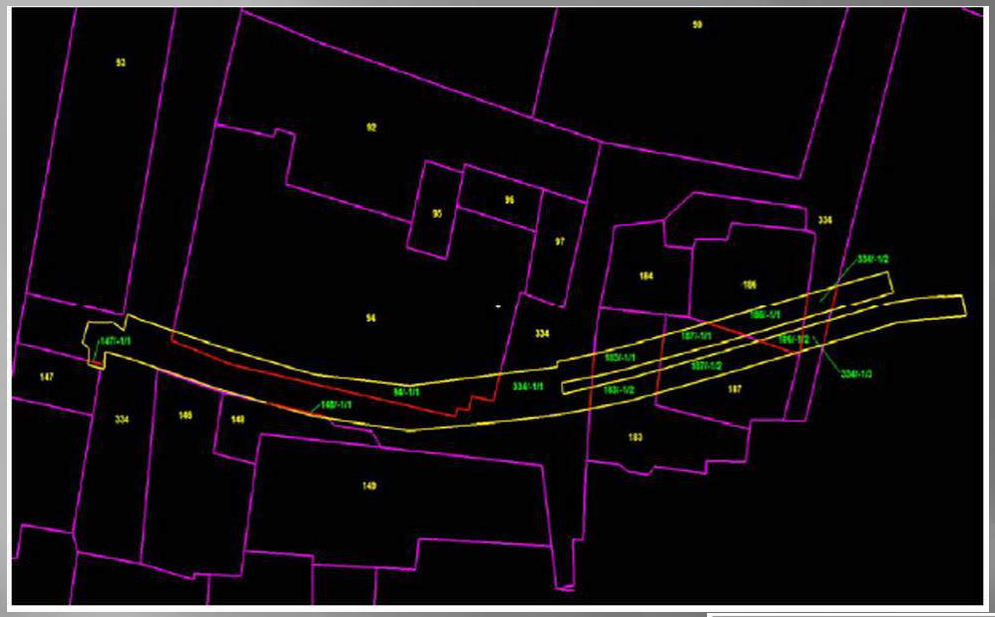


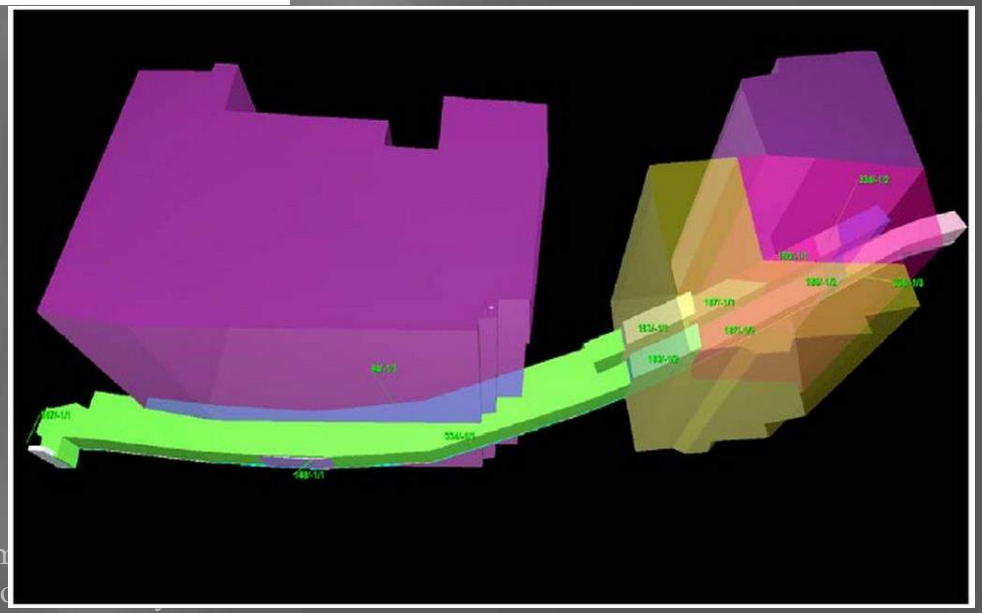
2D and 3D Cadastre

Basic principles (continued):

- 3D objects require new examinations and implications analysis derived by non-parallel vertical facades/faces.
- These are a function of the horizontal distance between facades (width and length of parcel borders), and the vertical distance from the ground (up or down).
- Correspondences and dependencies of sub-parcels (3D) to the “higher-level” (2D) parcels.

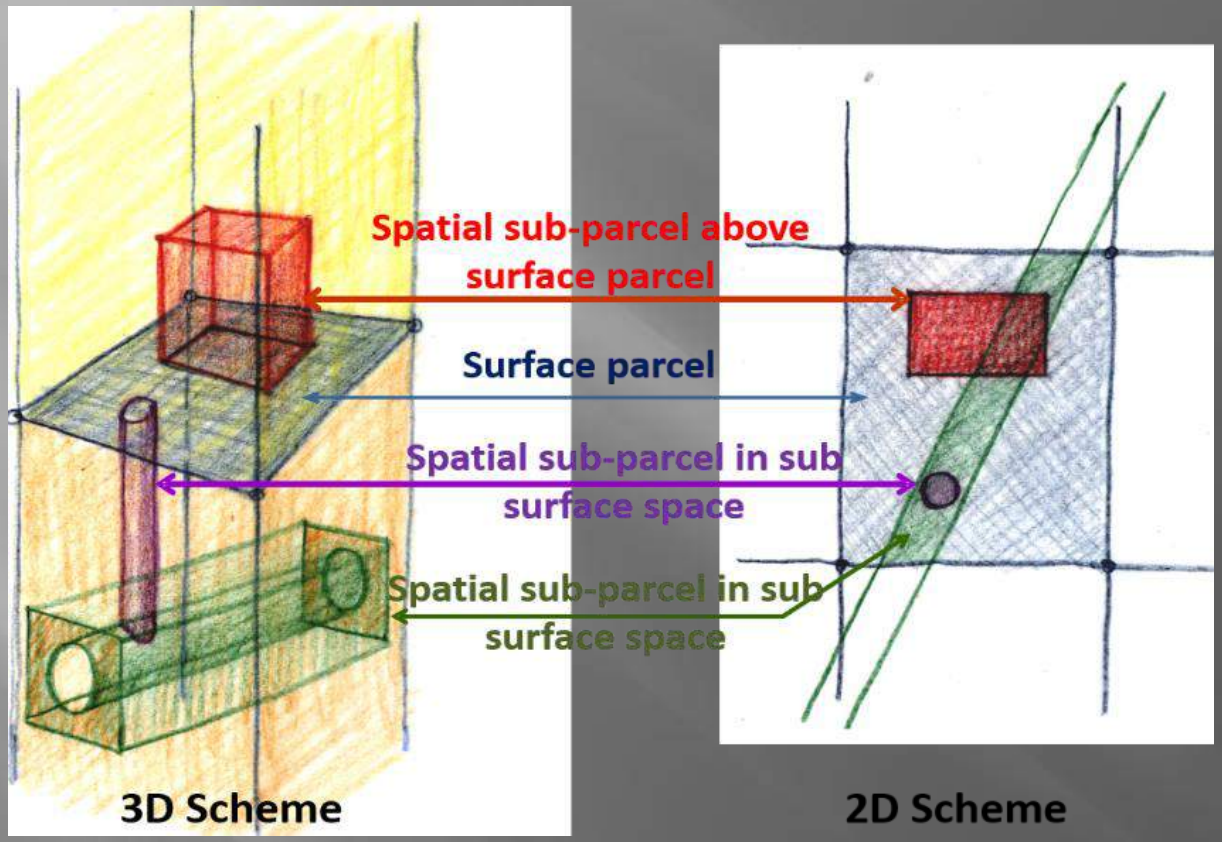
2D and 3D Cadastre





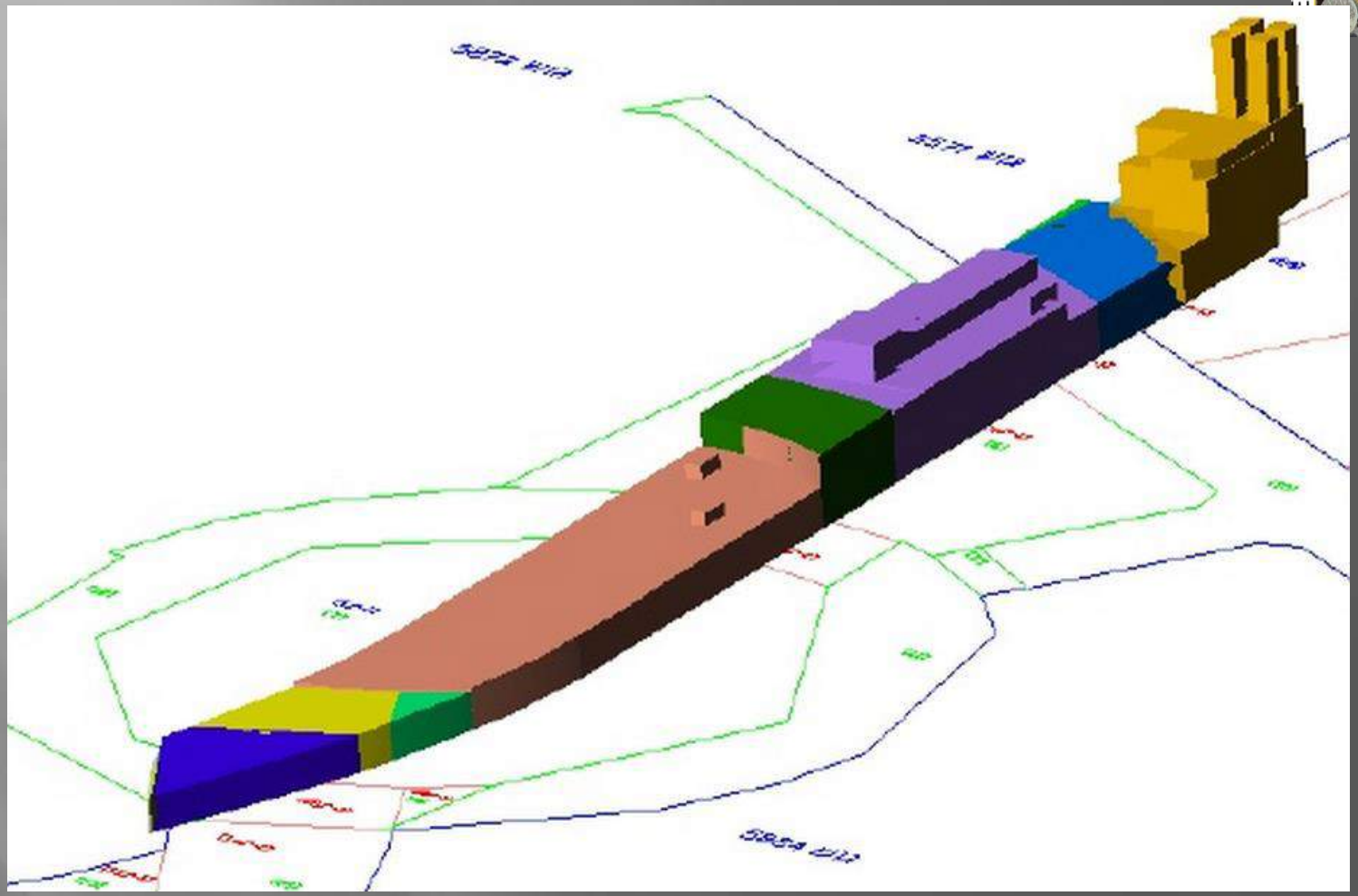
Survey of Israel, 2004

2D and 3D Cadastre



Survey of Israel, 2004

2D and 3D Cadastre



Survey of Israel, 2004

Requirements of 3D System

- Support:
  - land planning
  - infrastructure development and maintenance
  - environmental protection and resource management
  - emergency services
  - social service programs
- In terms of land records, the system is required to serve as means to:
  - acquire
  - manage
  - retrieve
  - analyze
  - display

Processes

Partial list

- Linkage of data:
  - 2D-parcel to 3D sub-parcels
  - adjacent 2D parcels
  - above- and sub- surface
- Display on request:
  - current shape components (length, area, volume)
  - position (coordinates, datum, RS)
  - identity and relationship of land parcels (ownership, history, tax, value,…)
  - 2D and 3D parcels – above- and sub- surface
- Manage and retrieve cadastral changes in a timely and accurate manner.

Processes

Partial list

- Present impact of changes:
  - 2D and 3D (overlap, continuity, ambiguity, ownership, tax,…)
  - changes derived from new/past land arrangements:
    - subdivision/split
    - consolidation/union
    - transfer (between lots)
    - expropriation
- Provide with information:
  - land ownership, value
  - timely land registration operations (also on-demand planned)

Processes

Partial list

- Relating "legal" and “fiscal” description of property to coordinate-based systems:
  - interests of land
  - land ownership records
  - extent (spatial, temporal)
  - property rights
- Analyze transformation and conversion:
  - legal description to mathematical coordinates
  - reference points
  - tax parcel maps
- Data quality analysis:
  - Description and retrieval
  - computation of quality/accuracy of data (date, collection means, propagation-of-error)

Functionalities

Specific geometric and topologic functionalities integrated in the system:

- Spatial intersection
- Spatial overlap / overlay
- Spatial buffer / extrusion
- Spatial union / merge
- Spatial proximity / nearness
- Spatial clip / extract / select
- Spatial split
- Spatial delete / erase
- Distance calculation
- Area / projection calculation
- Volume calculation
- Integrity examination

Functionalities

Intersection - the calculation of the relative spatial condition and status among spatial objects (entities).

2D and 3D objects:

- Examination of the spatial condition/position of a 3D object (sub-parcel, body, feature) and a 2D cadastral parcel.
- Similar examination to the above, only a 2D lot in a detailed outline map/plan.

Functionalities

Intersection 2D and 3D objects

Input data: 2D closed polygon(s) and 3D object(s)

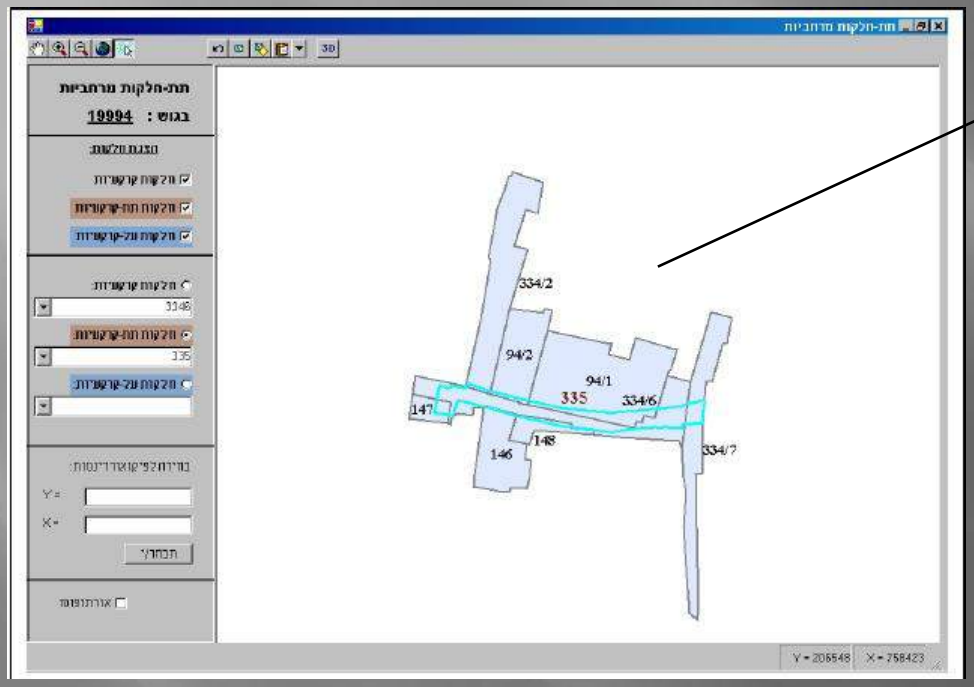
Output:

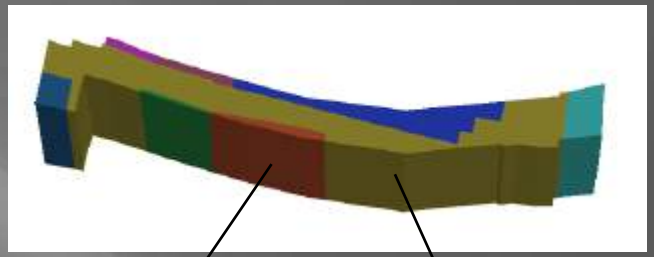
- no-intersection:
  - 3D feature falls outside the vertical limits (projection)
- fully-contained:
  - 3D feature is contained completely (falls inside) the vertical limits
- Partial-intersection:
  - 2D polygon enclosing part of the 3D feature that falls inside the vertical limits
  - 3D feature defining the portion of the 3D feature positioned under/above the 2D polygon area

Functionalities

Intersection 2D and 3D objects

Input data: 2D closed polygon(s) and 3D object(s)





ID = 457/8
Volume = 235.3 m^3
Surface area = 125.8 m^2
Ownership_code = 0
Upper_height = 5.68 m
Lower_height = -2.35 m
Land_parcel_ID = 457

ID = 457/11
Volume = 3275.3 m^3
Surface area = 1025.8 m^2
Ownership_code = 0
Upper_height = 5.68 m
Lower_height = -2.35 m
Land_parcel_ID = 457

Survey of Israel, 2004

Functionalities

Intersection 3D objects

Examination of corresponding spatial condition between 3D objects (a new entity added to the system in relation to previous version)

Input data: 3D object(s)

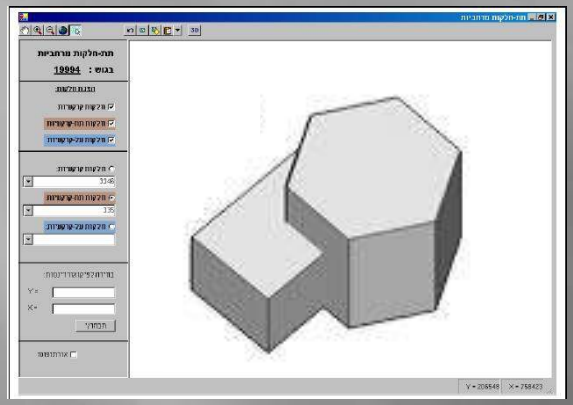
Output:

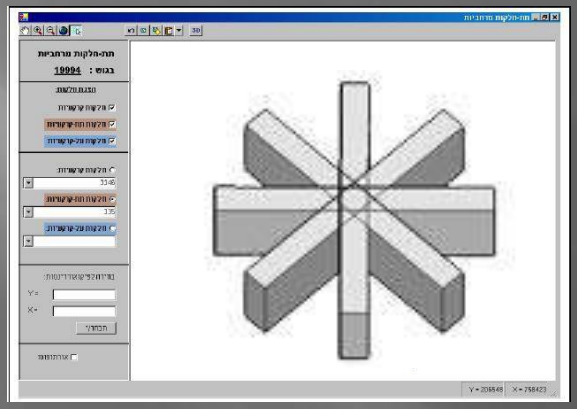
- no-intersection
- fully-contained:
  - one 3D feature is contained – or contains - completely the other 3D object.
- Partial-intersection:
  - volumetric polyhedron defining the mutual volume of the original 3D objects.

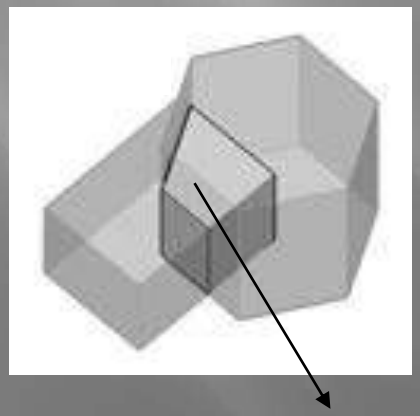
Functionalities

Intersection 3D objects

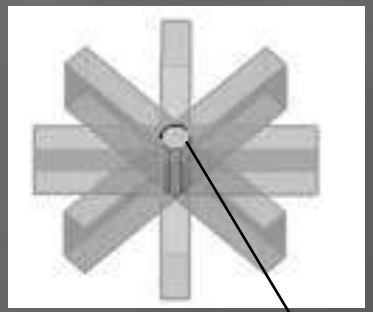
Input data: 3D object(s)







Volume = 235.3 m^3
Surface area = 125.8 m^2
Upper_height = 5.68 m
Lower_height = -2.35 m
Sub_parcel_IDs = 457/2, 457/8



Volume = 12.2 m^3
Surface area = 27.8 m^2
Upper_height = 0.68 m
Lower_height = -15.51 m
Sub_oarcel_IDs = 1045/3, 1045/11,…

Functionalities

Overlap/overlay – find spatial correspondence of 3D objects in various geometric perspectives ('directions') (without full spatial intersection computation).

- 3D object obscures in-full or in-part other 3D bodies.
- Mostly vertical and horizontal.
- Oblique perspective mostly not relevant.

Functionalities

Overlap/overlay - Horizontal plane

3D bodies are projected unto the horizontal plane (X-Y); calculation of the bodies' exterior convex polygons (maximum horizontal extent.

Input data: 2D convex polygons

Output:

- No-overlap.
- Maximum-overlap:
  - one polygon is contained – or contains - the other polygon.
- Partial-overlap:
  - compute the overlapping area of both polygons.

Functionalities

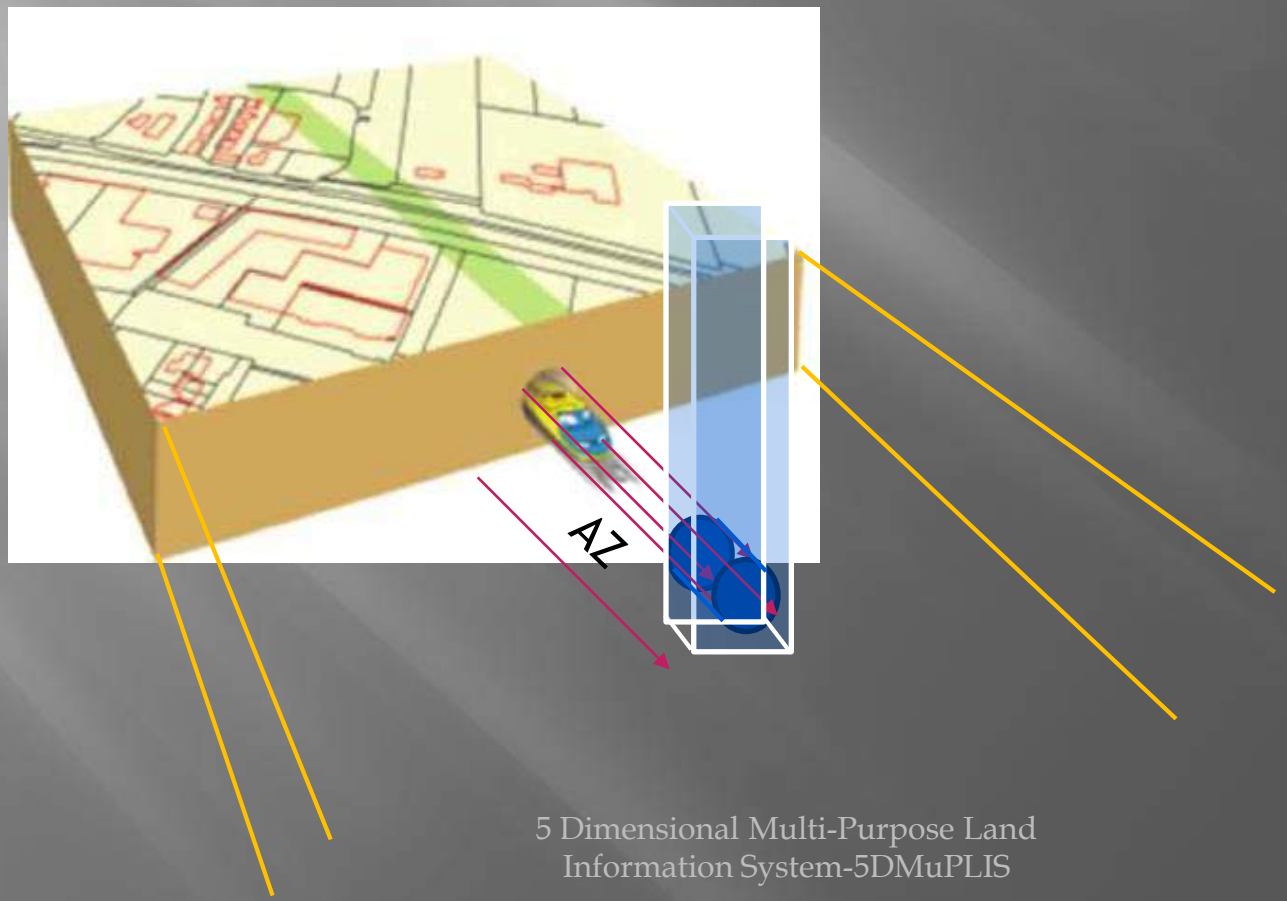
Overlap/overlay - Vertical plane (according to axes or other - designed cadastral plan).

- Projection on X-Z plane (or Y-Z plane).
- Overlap computation of the plane perpendicular to azimuth view (AZ) (e.g., tunnel extending in AZ, looking for the overlap of the projection of the tunnel on a different 3D body).
- Coordinate system is rotated from X-Y-Z to U-V-Z (relative to X-Y in an AZ angle).

Functionalities

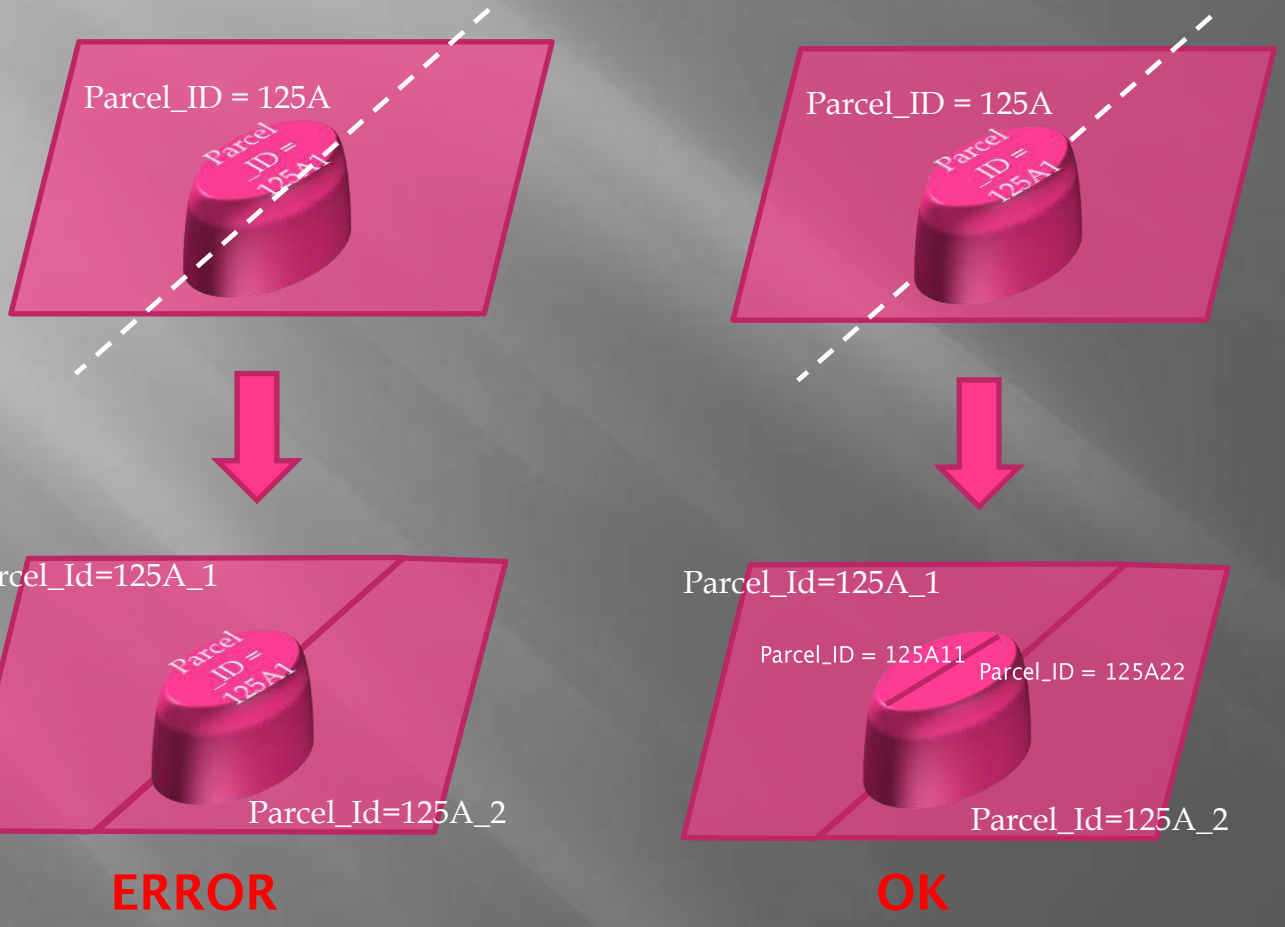
Overlap/overlay - Vertical plane

Input data: 3D object(s)



Functionalities

Subdivision



Summary

- Cadastre has been shifting in the past decades from the traditional analogue era (2D printed cadastral maps and charts) to the digital era of (still) 2D Digital Cadastre.
- Present change of the last decade is the trend of transition from 2D Cadastre to 3D Cadastre.
- The required 3D cadastral functionalities have been defined in the 5DMuPLIS research.
- The next phase is the designing of the spatial DB, to support 3D cadastral data and operations.
- The Greece-Israel research, focusing, inter alia, on integration of 3D Cadastre in the 5DMuPLIS system, will enable to establish an operative system to efficiently handle the urban environment.

Thank you for listening

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