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3D Cadastre GIS –
Geometry, Topology and other Technical Considerations

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Agenda

- Introduction – 2D & 3D Cadastre in Israel
  - The existing legal cadastre in Israel
  - Spatial sub-parcel solution
  - Relationship between surface and spatial parcels
  - Status of 3D cadastre
- 3D Cadastre GIS Project - Objectives
- 3D cadastre GIS – Geometry, Topology and Visualization
  - Possible definitions for a 3D parcel
  - Cadastre processes
  - Single vs. multilayer model
  - Visualizing a 3D GIS
- Summary

The Existing Legal Cadastre in Israel

- Introduced in 1928
- Based on Torrens principles (Registration of Title)
- Two-Dimensional
- Surface properties
- Ownership rights - The “cone” model

The Existing Legal Cadastre in Israel

- No solution for a multilayer activities related to land parcels
- The Israeli government decisions to improve the efficiency of the land use:

“... arrangement of conditions for exploitation of land parcel for several uses, above and below the surface …”

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The R&D 3D Cadastre Project

- In 2002 a two years R&D project
- Geodetic, Cadastral, Planning, Engineering and Legal solutions, for utilizing above and below surface spaces

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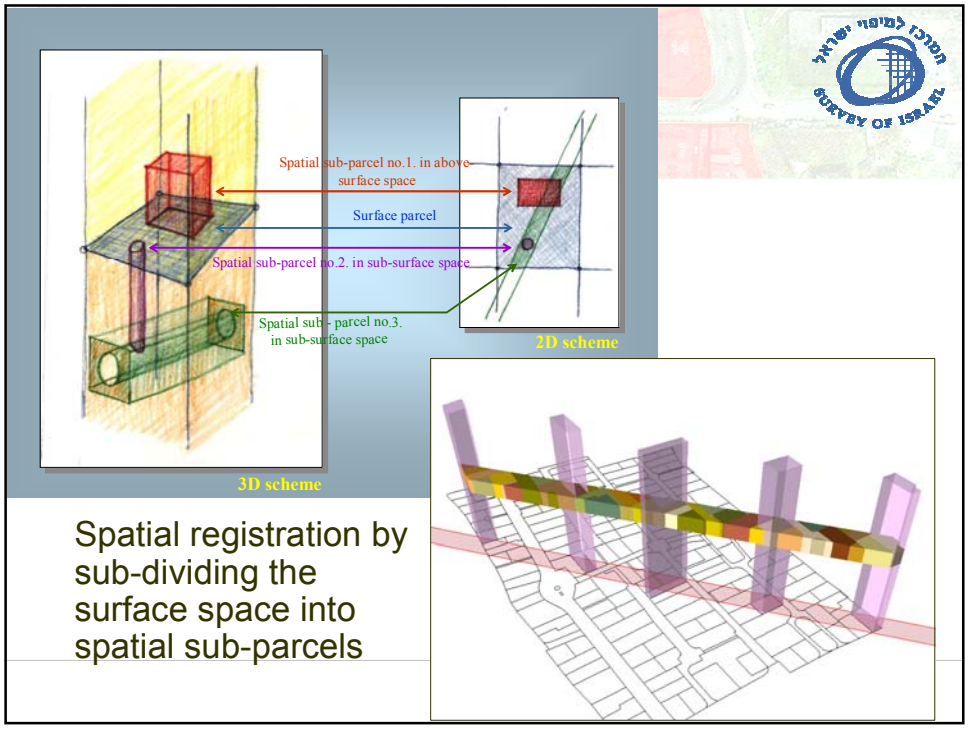
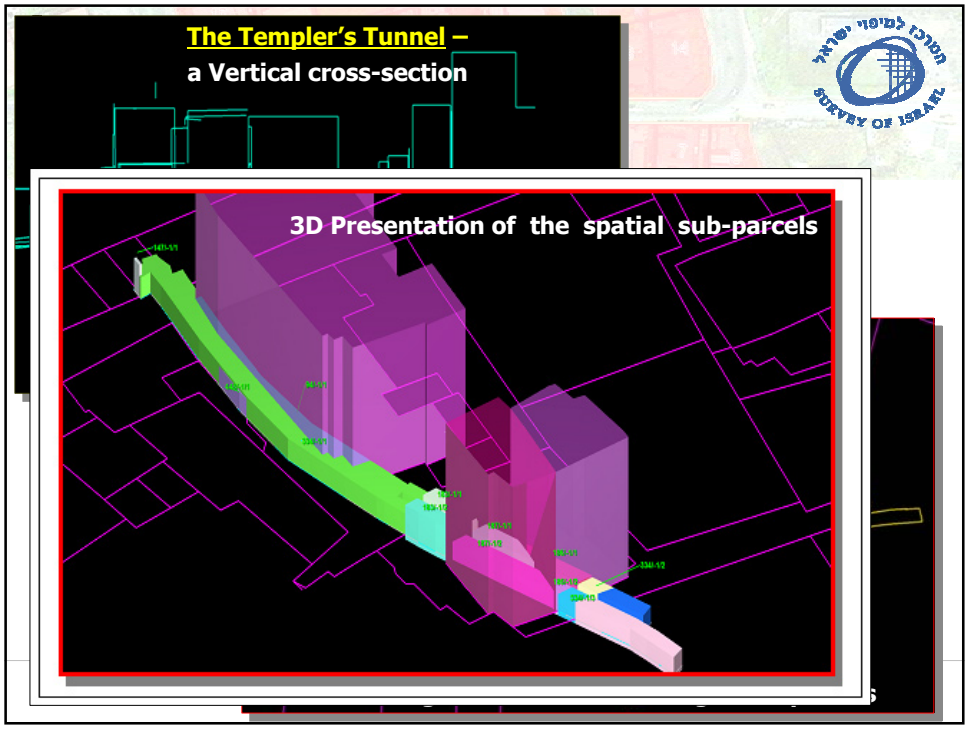
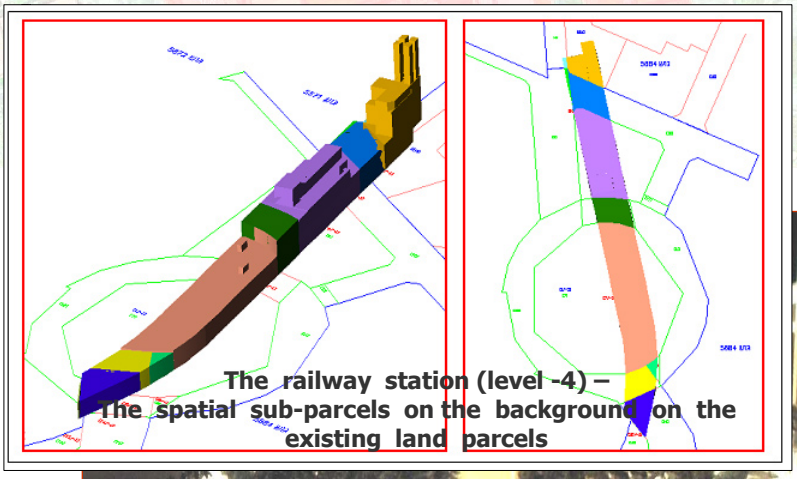
"Spatial Sub-Parcels" Solution

- Spatial registration by sub-dividing the surface space into spatial sub-parcels
- Spatial sub-parcel - a final volume object
- The spatial sub-parcel will be included in the block as a part of the surface parcel
- The existence of spatial sub-parcel will be noted also in the Title register
- No Changes in definition of the surface parcel
- Continuity of the existing registration method



Spatial registration by sub-dividing the surface space into spatial sub-parcels





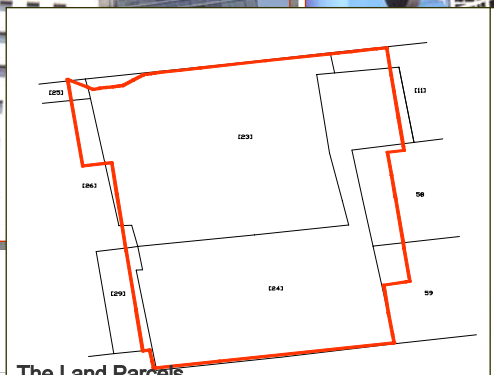
The railway station (level -4) –
The spatial sub-parcels on the background on the existing land parcels

The Main Town Center of Modi'in –

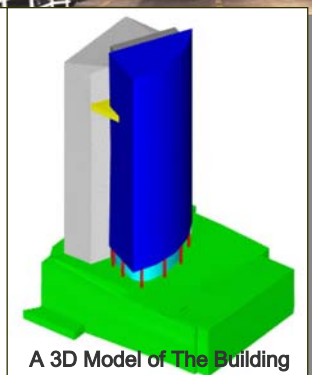
9

(*By courtesy of Mr. Ronen Grinstein*)

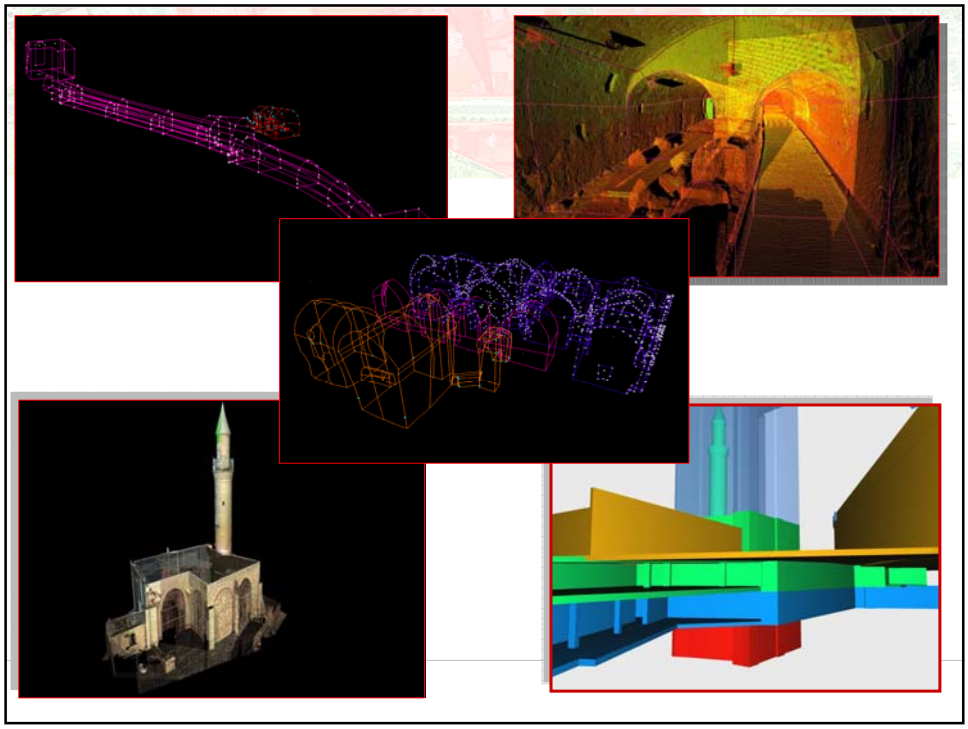
A Multistory building



The Land Parcels
Regarding to The Parking



A 3D Model of The Building
and The Parking



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Surface and Spatial Parcels Relationship

	Surface parcel	Spatial parcel
Surface parcel	- No intersection or overlapping between parcels - No gaps between parcels	- There is always a vertical overlap - Spatial parcel can exceed a surface parcel - 0, 1, or more spatial parcel in its area
Spatial parcel		- No intersection or penetration between parcels - Vertical overlapping is allowed - Vertical & horizontal gaps are allowed
Boundaries and volume	- 2D boundaries using x, y points - Height is a property, relatively to sea level, no legal significance - Volume in infinite, but can be expropriated	- 3D boundaries defined using x, y, z points - Height is part of entity definition and has legal significance - Finite volume
Ownership right	yes	yes
Geometry shape	2D polygon	3D shape

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Cadastre Processes

- 2D Cadastre processes
  1. Horizontal division
  2. Horizontal unification
- 3D cadastre processes
  1. Vertical division of a surface parcel (creation of a new spatial parcel)
  2. Horizontal division of both surface and spatial parcels
  3. Unification of two (or more) surface parcels with spatial parcel in their area
  4. Horizontal unification of two (or more) spatial parcels
  5. Horizontal division of a spatial parcel
  6. Vertical division of a spatial parcel
  7. Vertical unification of two (or more) spatial parcels
  8. Vertical unification of a surface parcel with a spatial parcel

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The Implementation of 3D Cadastre in SOI

- R&D project (2002-2004)
- Modification of the Survey Regulations
- Production of a spatial registration plan
- Complementing 2D Cadastre with elevation data
- Measurements, data processing and mapping in 3D
- Documentation of the whole 3D Cadastre procedure

The Implementation of 3D Cadastre in SOI

- Master plan for underground space development (2009)

- A model for global 3D Cadastre database, relating to the national GIS environment
- 3D Visualization of the 3D Cadastre database
- Topology definition between land parcels to the spatial parcels

3D Cadastre GIS project (2008-2009)

3D Cadastre GIS

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3D Cadastre GIS Project - Objectives & General Comments

- Main objective: examine the requirements and the design of a GIS system that support 3D cadastre
- Considerations: data structure, layers, processes, topology and visualization
- Existing GIS platforms do not fully support a 3D cadastre
- Open issues are complex and interdisciplinary

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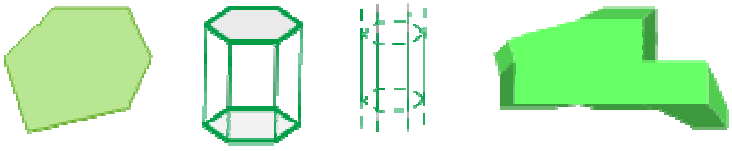
Possible Definitions for a 3D Parcel

- Simple vs. complex shapes
  - 2D shape, 2.5D shape, full 3D shape



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Possible Definitions for a 3D Parcel

- Object representation: B-rep vs. CSG
  - > Boundary representations 
  - > Constructive solid geometry 
  - – Selection of a modeling technique may influence the layer model, the database structure, flexibility, performance and more
  - – Preference of a modeling technique depends on the criteria used for evaluation
  - – Optionally consider different modeling technique for different types of objects (pipe vs. train station)

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Single vs. Multilayer Model

- Optional models
  - – Single 2D layer
  - – Single 3D layer
  - – **Multilayer with 2D for surface parcels and 3D for spatial parcels**
  - – Multilayer with 2.5D for surface parcels and 3D for spatial parcels
  - – 2D for surface parcels with projection of spatial parcels boundaries and pointer to more information
- Many considerations may influence the selection of a layer model
  - – cost, software and technical continuity, complexity, flexibility, software lifetime, usability and more.
  - – For SOI we recommend the use of a multi layer with 2D and 3D parcels

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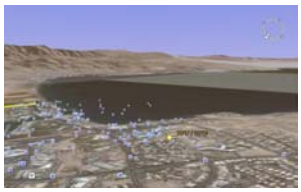
General 3D Visualization

- Visualizing the terrain
  - Wide spread
  - Uses 2.5D and not full 3D
  - Large area performance and accuracy is usually poor



Eilat & Aqabah (© Google Earth)

- Visualizing 3D single shape
  - Available in many commercial products
  - Different challenges in large area with different entities

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Visualizing 3D GIS Cadastre

- Challenges
  - Large areas
  - Many objects (large number of points in heterogeneous density)
  - Need for precision
- Principles
  - Combined surfaces (terrain and human made objects)
  - Data streaming and Quad tree data structure
  - Use of Level of Details (LOD)

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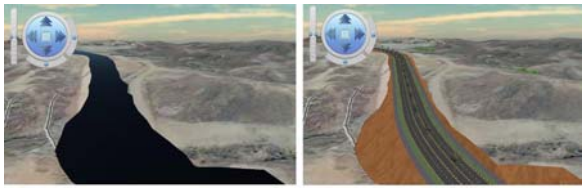
Visualizing 3D GIS Cadastre

- A solution for modeling combined surfaces by Sivan Design
  - Pictures taken from Civil Simulate©
  - Creation of holes in topography to avoid surface overlapping and with it problems of surface visibility



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Summary

- The future cadastre in Israel will be analytical, three-dimensional (3D) , multilayer and will be incorporated into the national GIS system and will be managed by GIS means.
- The spatial registration will be achieved by sub-dividing the surface parcel space into spatial sub-parcels.
- Necessary amendments will be made in the relevant laws and the Survey Regulations.

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