Survey of Israel
המרכז למיפוי ישראל

3D Cadastres

9-2-2014

Peter van Oosterom, based on joint work with:
Chrit Lemmen, Jantien Stoter, Henrdrik Ploeger

Meeting on 3D Cadastre at the Survey of Israel
Tel Aviv, 9 February 2014

Content overview

→ TU Delft background

- Introduction
- FIG working group, international overview
- 3D in ISO 19152
- Deep integration 3D and time
- Netherlands developments
- Some other countries

Delft University of Technology
Key Figures 2011

Number of students

Total student body
19.500

of which bachelors
10.900

of which masters
6.300

of which PhD students
2.300

Staff

Total staff
5.655

Academic staff
3.375

of which Professors
437

Support staff
2.280

Output

PhD theses
319

Scientific publications
5.840

Master's degrees awarded in 2011
1.989

Bachelor's degrees awarded in 2009
1.902

Some history

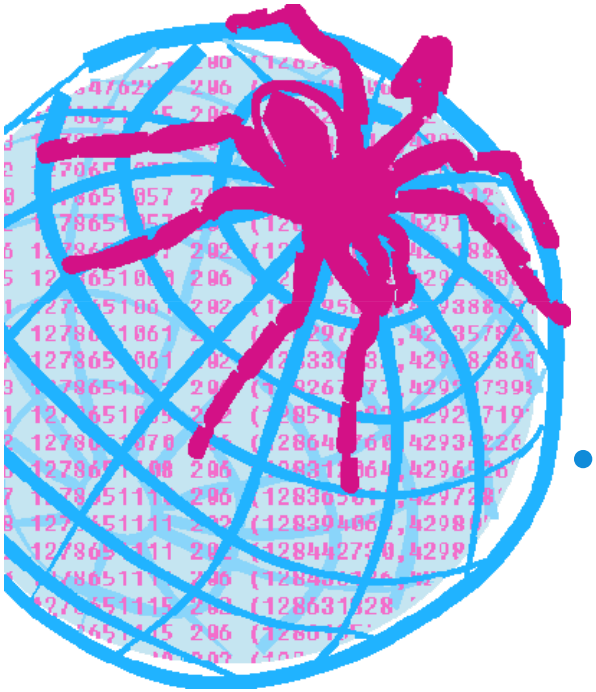
- 1842: Founded by King Willem II as 'Royal Academy'
- 1864: 'Polytechnic school' status, with Lewis Cohen Stuart first professor-director (chair Mathematics-Geodesy)
- 1926: Wim Schermerhorn, professor Surveying, Leveling & Geodesy first prime minister after World War II, and established ITC (International Training Centre for Aerial Survey) in Delft
- 1937: Felix Vening Meinesz part-time lector Gravity Measurements (1939 he became extraordinary professor Geodesy)

- 1948: Start Geodesy education (before Surveying part of Civil Eng)
- 2002: Converted to MSc (no own BSc)
- 2005: MSc Geodetic Engineering renamed to MSc Geomatics
- 2012: New - MSc Geomatics (for the Built Environment)
  - Track Geoscience and Remote Sensing in CE/AES

International Rankings: Times Higher Education (THE)

- THE Rankings 2013, overall:
  TU Delft #69 (Technion #201)
- THE Rankings 2013, Engineering and Technology:
  TU Delft #23 (Technion #69)
- World Reputation Rankings 2013:
  TU Delft #51 (Technion not in top 100)
  First in Netherlands, third in continental Europe
- Source: http://www.timeshighereducation.co.uk

Scientific/technological focus of the GIS technology research



- Central research topic geo-DBMS/ 5D super model as 'glue' between:
  - 3D spatio-temporal modeling
  - Computational geometry (generalization)
  - Distributed GI processing
  - Mobile GIS (LBS)
  - Knowledge engineering
- Geo-ICT 'tool research' confronted with 2 application themes:
  - Crisis Management (leader Sisi Zlatanova)
  - Spatial Information Infrastructure (leader Jantien Stoter)

Ambition: top 1(3) geo-DBMS University in the world

Geo-Database Management Center

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Ir. Martijn Meijers
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OTB room 2.240

Wiebke Tegtmeier, MSc

External PhD researchers

João Paulo Hespanha, MSc

External researchers

Dr. Rod Thompson,
Dip. Computer Sc., M. Eng. Sc.

Guest researchers

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OTB room 2.220

Project manager

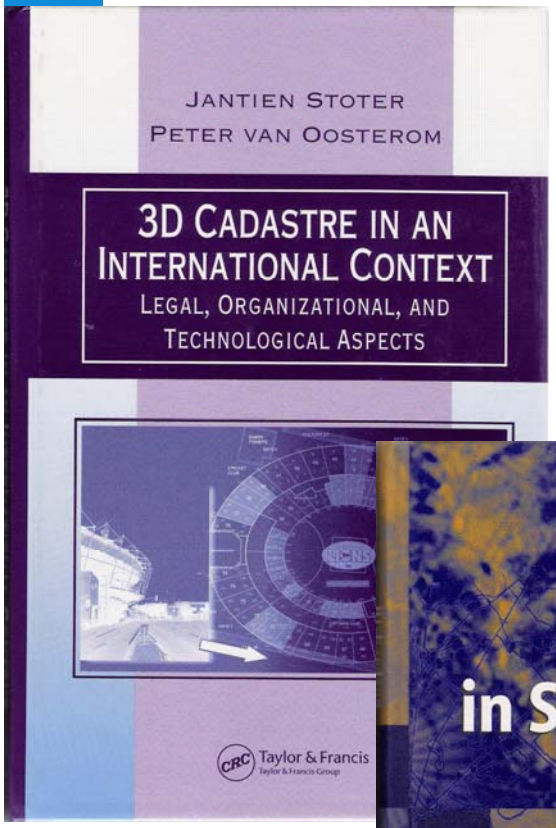
Elfriede Fendel
Phone: +31 (0)15 27 84548
OTB room 2.270

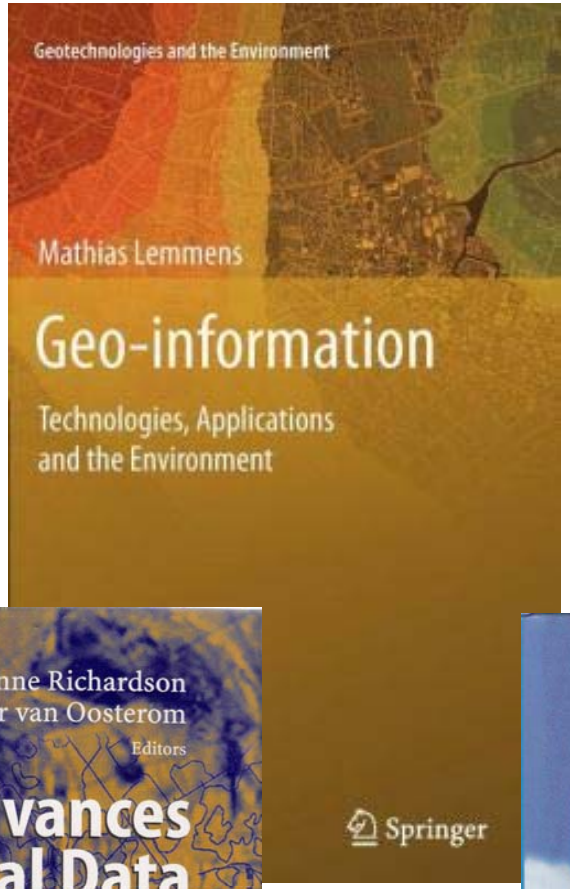
International activities, besides projects

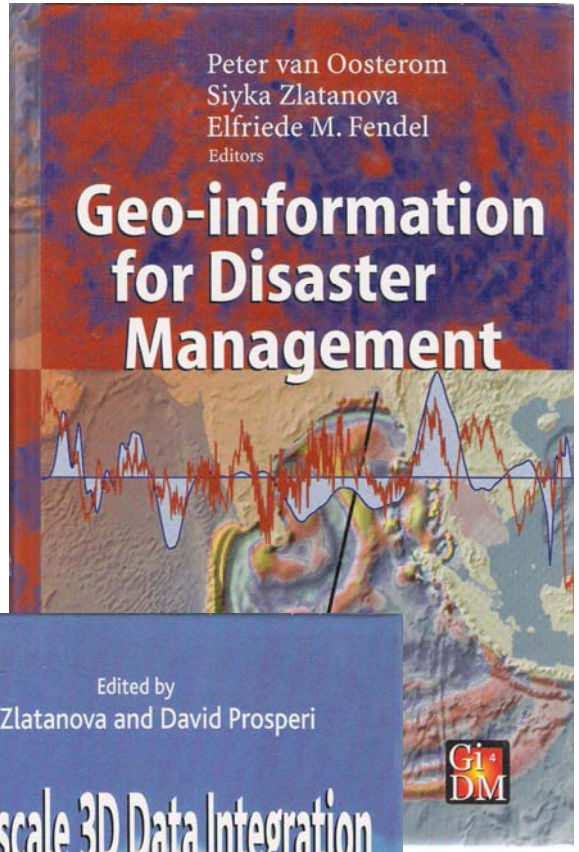
- INSPIRE: member of drafting team data specification (DT DS) and thematic working group Cadastral Parcels TWG CP→ implementing rules finished (others nearly finished; e.g. land-use)
- INSPIRE concerns 34 types of data sets, 27 countries with 22 languages (and more influence; e.g. Iceland, Norway and Switzerland are also involved)

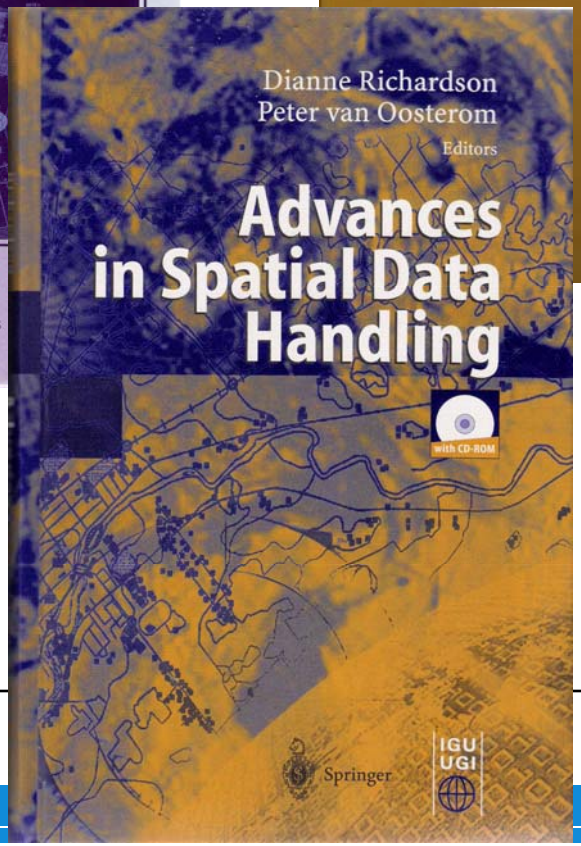
- ISO TC211: founder/editor of ISO 19152 Land Administration Domain Model (LADM) with Chrit Lemmen/Harry Uitermark
- Chair of the 2010-2014 Joint working group (WG) of FIG commissions 3 and 7 on 3D Cadastres
- International Society for Photogrammetry and Remote Sensing (ISPRS), Chair of WG IV/7, 3D Indoor Modelling and Navigation
- Open Geospatial Consortium (OGC), Chair of IndoorGML
- Global Spatial Data Infrastructure Association (GSDI), Chair of WG Legal and Socio-economic Issues
- Chair of EuroSDR commission Data Specifications

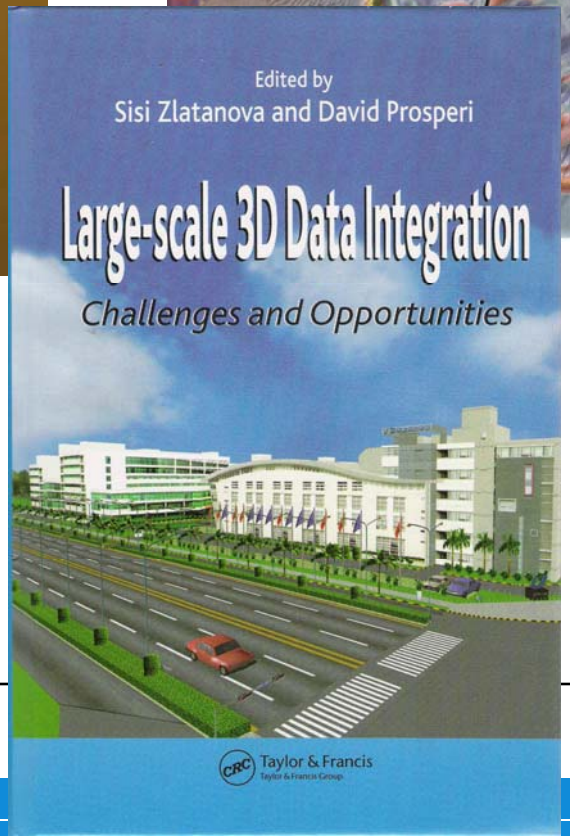
Books…


JANTIEN STOTER
PETER VAN OOSTEROM
3D CADASTRE IN AN INTERNATIONAL CONTEXT
LEGAL, ORGANIZATIONAL, AND TECHNOLOGICAL ASPECTS
Taylor & Francis

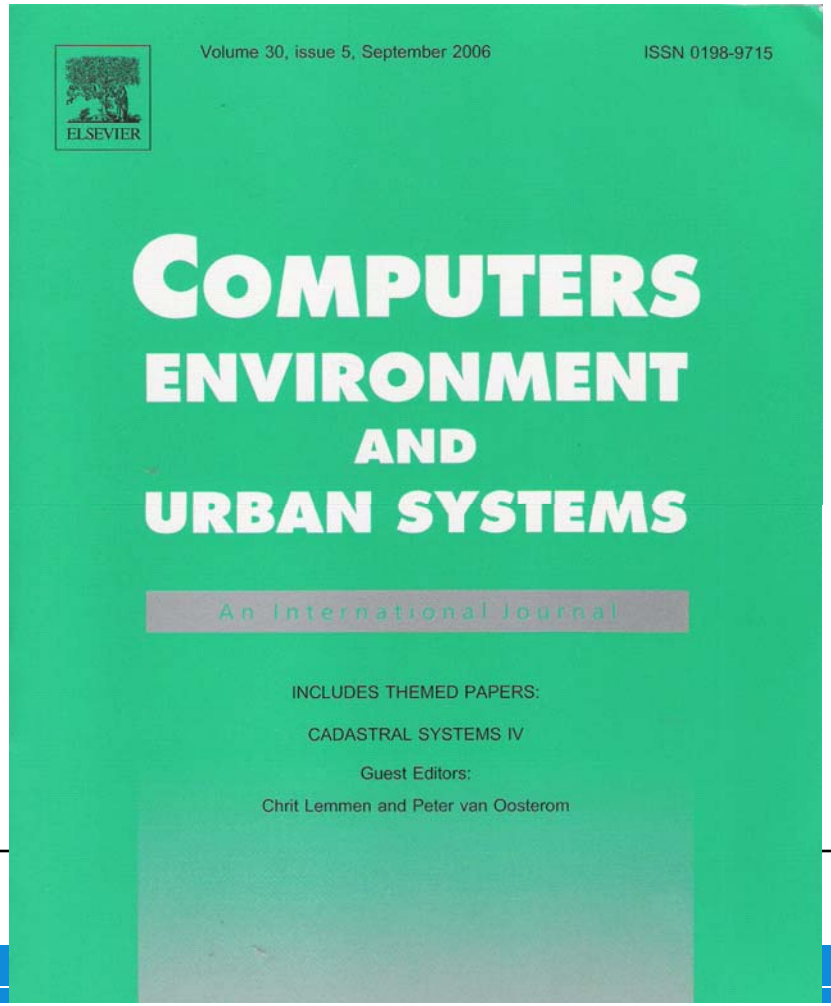

Geotechnologies and the Environment
Mathias Lemmens
Geo-information
Technologies, Applications and the Environment
Springer

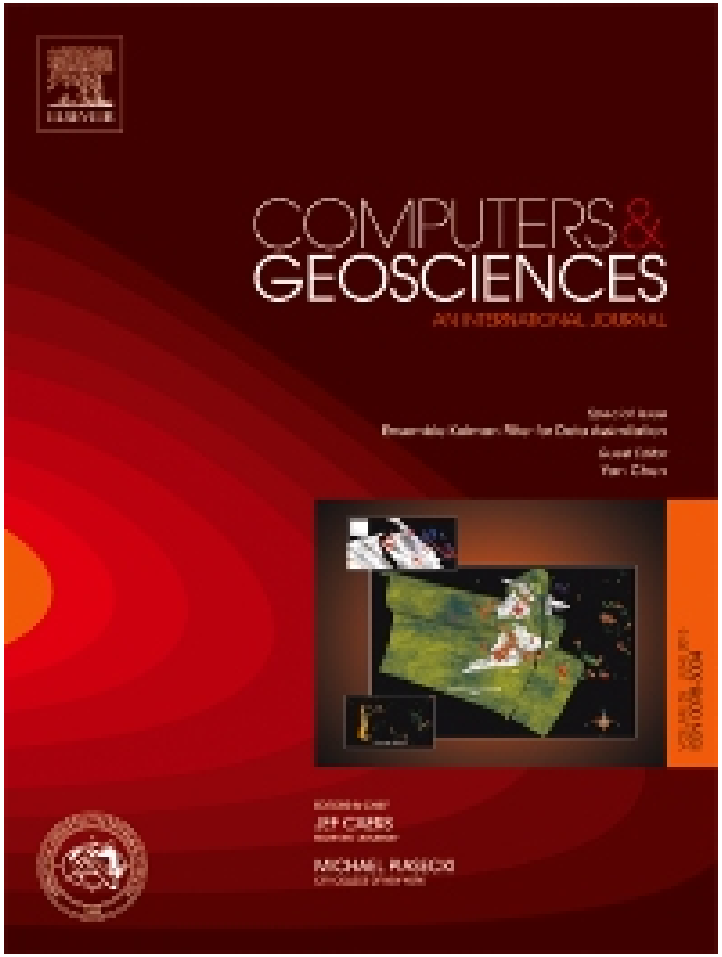

Peter van Oosterom
Siyka Zlatanova
Elfriede M. Fendel
Editors
Geo-information for Disaster Management
GI4DM


Dianne Richardson
Peter van Oosterom
Editors
Advances in Spatial Data Handling
with CD-ROM
Springer
IGU
UGI


Edited by
Sisi Zlatanova and David Prosperi
Large-scale 3D Data Integration
Challenges and Opportunities
Taylor & Francis

Journals (various editor roles)





Geo-information Education TU Delft

- Bachelor Education
  1. National geo-information minor (half year part of Bachelor)

- Master Education
  1. MSc Geomatics (for the Built Environment)
  2. MSc GIMA (Geo-Information Management and Applications) by four NL Univ's: Delft, Wageningen, Utrecht, Twente (ITC)
  3. Track Geoscience and Remote Sensing in Civil Engineering (and also in Applied Earth Sciences)

- PhD Education (all GI research directions, among which)
  1. Geo-information technology
  2. Geo-information governance

2012: MSc Geomatics (for the Built Environment)

Core programme:

GM.1 Sensing Technology for the Built Environment
GM.2 Geographical Information Systems and Cartography
GM.3 Positioning and Location Awareness
GM.4 3D Modelling of the Built Environment
GM.5 Spatial Decision Support for Planning and Crisis Management
GM.6 Geo DataBase Management Systems
GM.7 Geo Web, Sensor Networks and 3D-GeoVisualisation Technology
GM.8 Geo Datasets and Quality
GM.9 Geo-information Organisation and Legislation

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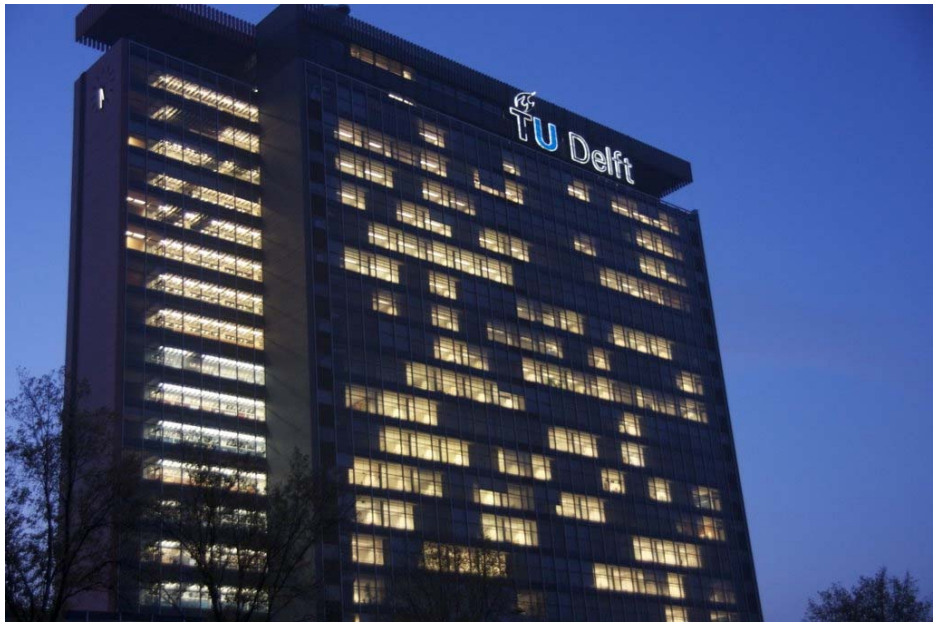
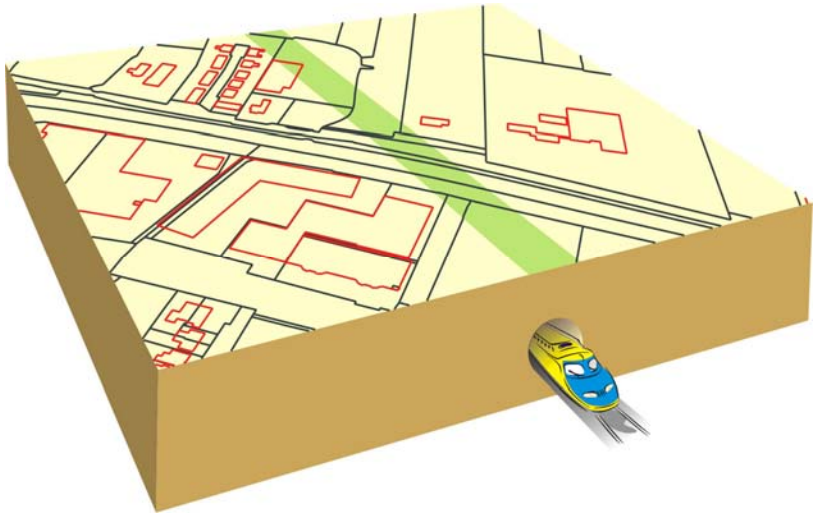
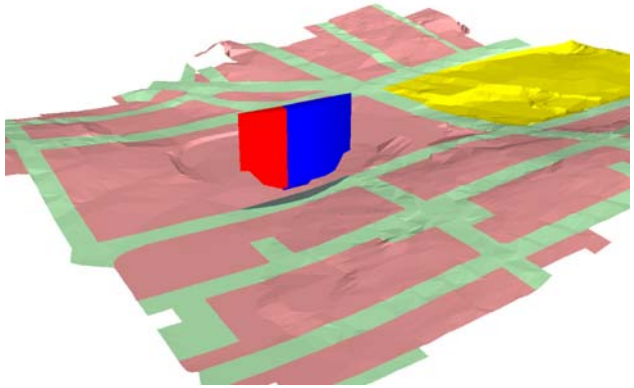
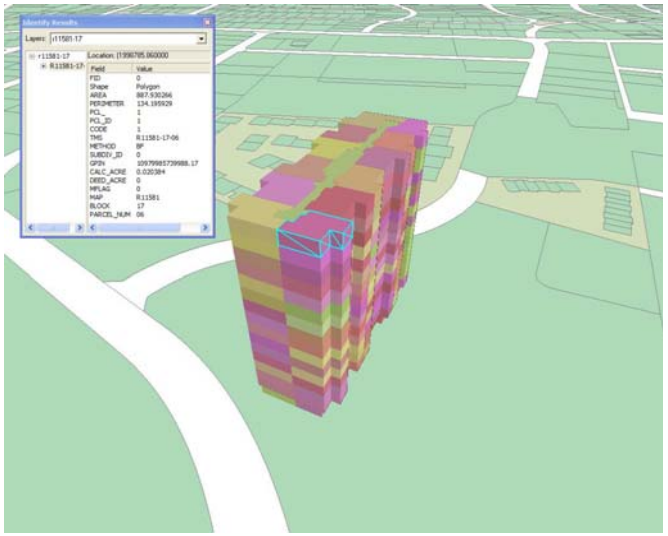


Introduction







2D registration for a 3D world?

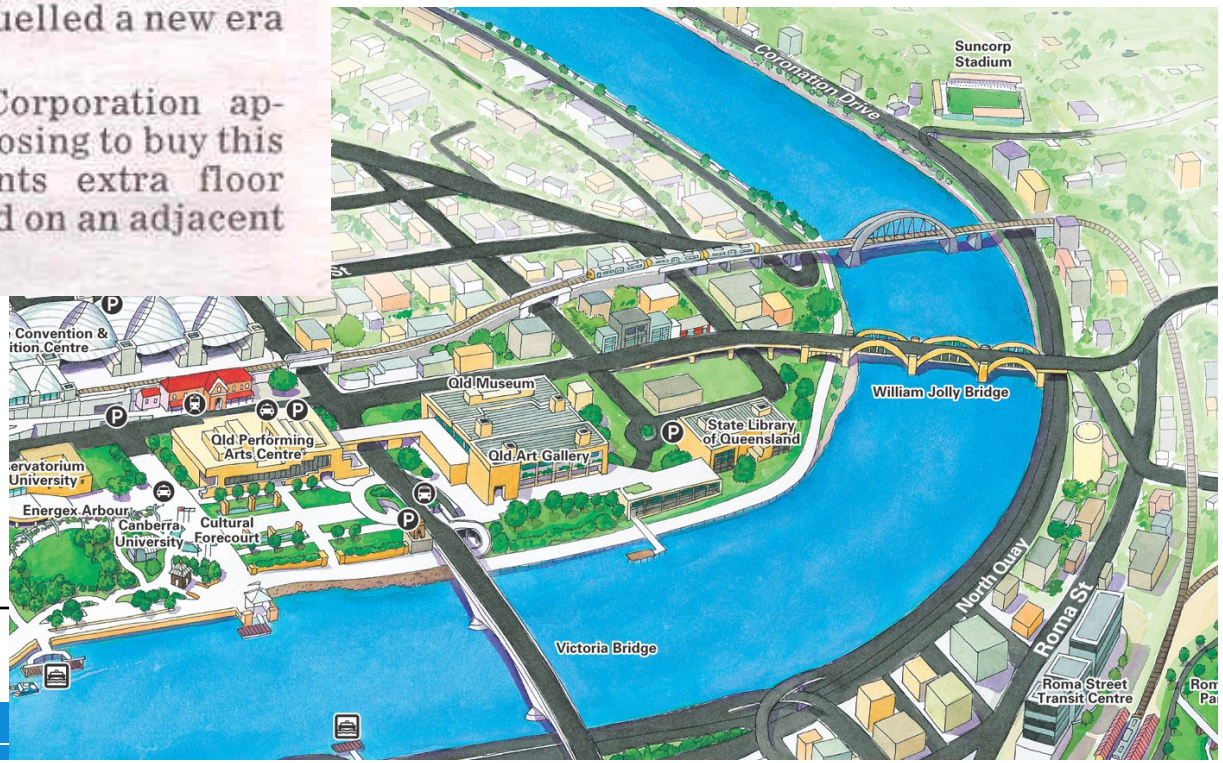
Today's practice:
Queensland Australia

Airspace sold

STATE cabinet has approved the sale of airspace over the South Bank rail corridor, which will allow planned offices to extend over the rail lines.

Premier Peter Beattie and Transport Minister Steve Bredhauer said the sale fuelled a new era in Brisbane city development.

"Mirvac and South Bank Corporation approached the Government proposing to buy this airspace because Mirvac wants extra floor space for offices it plans to build on an adjacent lot," Mr Beattie said.



Happening in Singapore…

Upward looking Singapore looks below for room to grow

NOVEL SOLUTION: It may build interconnected cities with shopping malls and transport hubs, writes *Calvin Yang*

Singapore ***has been building upward, with apartment structures reaching as high as 70 stories****, but the demand for land is* ***pushing it to build underground****.*

SINGAPORE, with a little less land mass than New York City, is running out of room for its 5.4 million people.

The city-state has built upward — with apartment buildings reaching as high as 70 stories — reclaimed underused properties for housing and pushed out coastlines for more usable land.

But as one of the world's most crowded cities, and with projections for 1.5 million more people in the next 15 years, Singapore's options are as limited as its space.

So Singapore is considering a novel solution: building underground to create an extensive, interconnected city, with shopping malls, transport hubs, public spaces, pedestrian links and even cycling lanes.

"Singapore is small, and whether we have 6.9 million or not, there is always a need to find new land space," said Zhao Zhiye, the interim director of the Nanyang Center for Underground Space at Nanyang Technological University. "The utilisation of underground space is one option for Singapore."

Height restrictions imposed on areas around air bases and airports have prevented developers from building taller projects. And there is a limit to how much land can be reclaimed from the ocean — so far it accounts for a fifth of Singapore's space, but it is vulnerable to rising sea levels caused by climate change.

The squeeze has led to the closing of several old estates and military camps to make way for residential and industrial development.

Building underground is not new in Singapore. About 12km of expressways and about 80km of transit lines are below ground. Underground drainage systems and utility tunnels are common features beneath the urban landscape.

Now Singapore is going further, beginning work on a huge underground oil bunker called Jurong Rock Caverns. When this is completed, it will free up about 60ha of land, an area equivalent to six petrochemical plants.

Another project on the drawing board is the Underground Science City, with 40 interconnected caverns for data centres and research and development labs that would support the biomedical and life sciences industries. The science centre, with an estimated 20ha to be situated 30 stories below a science park in western Singapore, would house as many as 4,200 scientists and researchers.

"A lot of facilities can go underground if you fully utilise the underground space," Zhao said.

"In the beginning there might be a psychological issue, but as long as we have proper lighting and proper ventilation, gradually people can overcome the idea of working and living underground."

Subterranean projects can be three to four times as costly as surface projects because of higher construction costs and the need for extensive soil investigations.

In a recent blog post, Khaw Boon Wan, Singapore's national development minister, pointed to extensive pedestrian passageways and shopping malls in Japan and Canada.

He cited the possibilities in Singapore "of creating underground transport hubs, pedestrian links, cycling lanes, utility plants, storage and research facilities, industrial uses, shopping areas and other public spaces here".

"The earlier we begin this process, the faster we will learn and the easier it would be for us to realise these plans." NYT

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4. Deep integration 3D and time
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International Federation of Surveyors

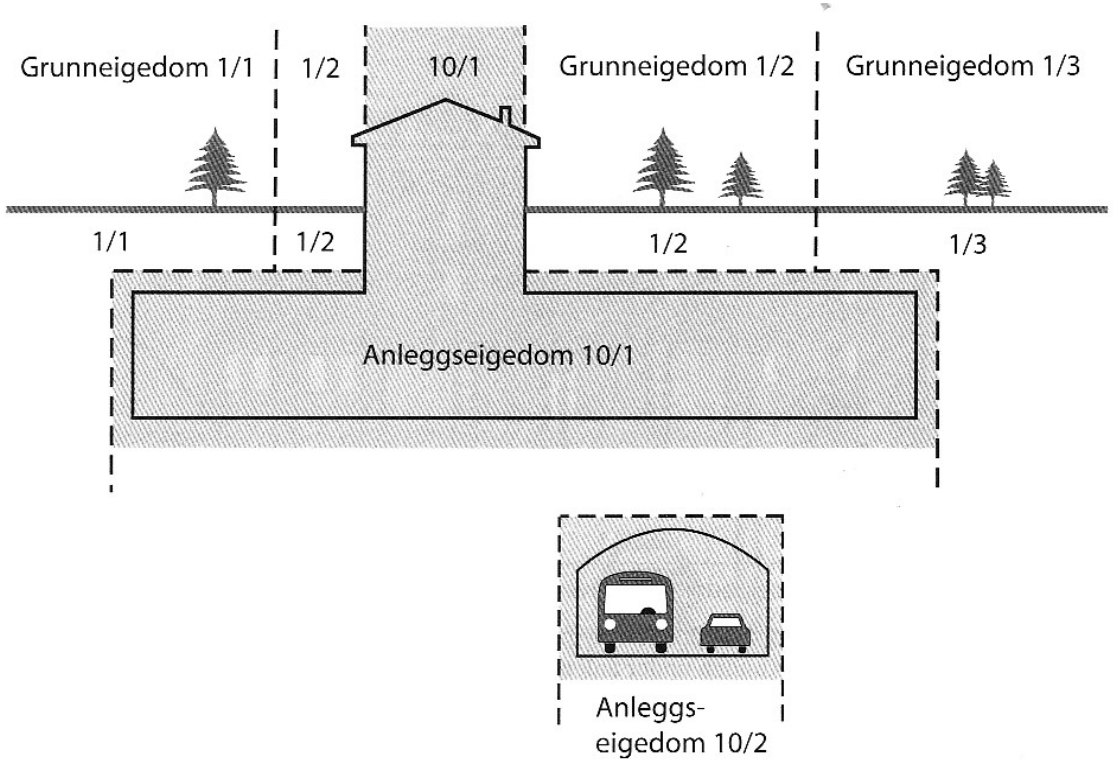
- Initial FIG working group 3D Cadastres 2002-2006 (International Federation of Surveyors, founded 1878 NGO)
- 3D Cadastres sessions at every FIG WW or congress since

- Working group 3D Cadastres 2010-2014, scoping questions:
  1. What are the types of 3D cadastral objects?
     Related to (future) constructions (buildings, pipelines, tunnels, etc.)
     any part of the 3D space, both airspace or subsurface?
  2. 3D Parcels for infrastructure objects, such as long tunnels, pipelines, cables: divided by surface parcels or one object?
  3. For representation of 3D parcel, has legal space own geometry or specified by referencing to existing topographic objects

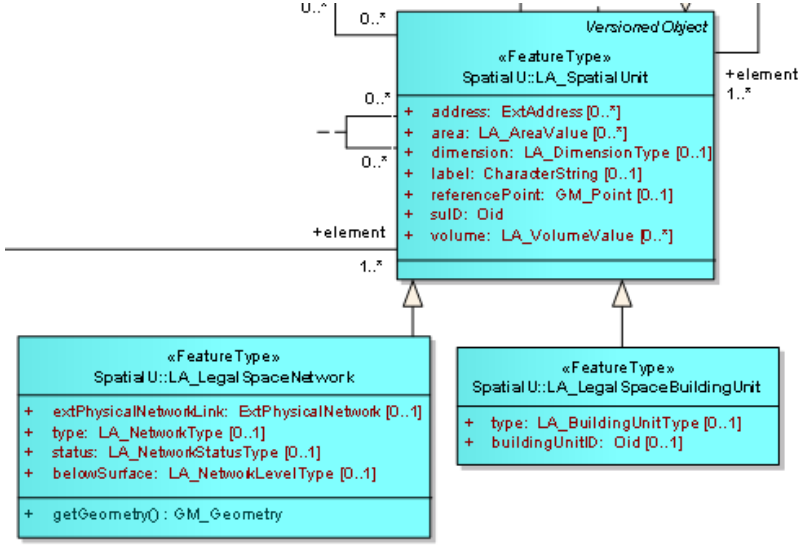
FIG Working group objectives

- Common understanding of terms and issues involved; ISO 19152 Land Administration Domain Model: LADM with 3D
- Guidelines/checklist for implementation of 3D-Cadastres: 'best practices' legal, institutional and technical aspects

Note: 3D Parcels in broadest sense: land & water spaces, both above & below surface.



Topics



- 3D-Cadastres and models: role of earth surface, 3D parcels open at top and bottom, topology structure, relative height,…
- 3D-Cadastres and SII: legal objects (cadastral parcels and associated rights) and their physical counterparts (buildings or tunnels) result into two different, but related registrations
- 3D-Cadastres and time: partition of legal space into 4D parcels: no overlaps or gaps in space of time
- 3D-Cadastres and usability: graphic user interface (GUI) for interacting with 3D cadastral data; e.g. Google Earth

Deliverables

- 2010: creation of web-site and interest-group www.gdmc.nl/3DCadastres (inc. literature)
- 2010: initial questionnaire status 3D Cadastres
- 2011: 2nd workshop on 3D-Cadastres (16-18 nov, Delft)
- 2011-13: 3D Cadastres session at FIG working weeks
- 2012: 3rd workshop on 3D-Cadastres (25-26 oct, Shenzhen)
- 2014 : final questionnaire status 3D Cadastres
- 2014: presentation of the results FIG-congress

FIG

FIG joint commission 3 and 7 Working Group on 3D Cadastres - Work plan 2010-2014

Home
Objectives
Topics
Scope
Realization
Deliverables
Operation
Timetable
Participants
Organization
Literature

Workshop 2012
Workshop 2011
Workshop 2001

Questionnaire
Please fill in

Literature

This page lists a number of (important) publications and other documents related to 3D Cadastres.
Click on the title to download or view the corresponding PDF file.

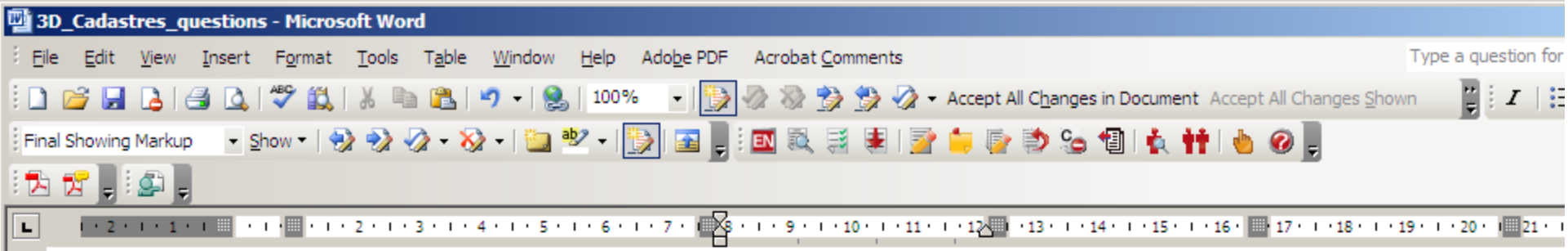
2012 | 2011 | 2010 | 2009 | 2008 | 2007 | 2006 | 2005 | 2004 | 2003 | 2002 | 2001

2012

Diego Alfonso Erba
Application of 3D Cadastres as a Land Policy Tool
In: Land Lines, the quarterly journal of the Lincoln Institute of Land Policy, April 2012, pp. 8-14

FIG Working Week 2012, Rome, Technical Programme
3D (Cadastre): p. 12, p. 14, p. 19

Chengxi Bernad Siew and Alias Abdul Rahman
Compression Techniques for 3D SDI
FIG Working Week 2012, Rome, 18 p.



General/applicable 3D real-world situations

1		Australia/Queensland 2010	The Netherlands 2010	Your Jurisdiction 2010	Your Jurisdiction 2014
1.1	Are all 3D parcels constrained to be within one surface (2D) parcel?	Yes, but this is not guaranteed for all time	Rights referring to the use of a limited space will be registered in the cadastre on a 2D parcel. However the right registered might refer to a construction or space on several 2D parcels. Yes		
1.2	Are ambulatory[2] boundaries permitted?	Theoretically they are, because 3D parcels are broken at surface parcel boundaries. Theoretically the limit of a unit at ground level may be bounded by a physical (ambulatory) feature	Theoretically they are, because the database representation may become invalid when a situations have been like that (i.e. in conflict what is registered) for many years.	Questionnaire	
1.3	Is it allowed to have 3D parcels not related to physical constructs or objects?" (e.g. airspace, subsurface volumes)	Yes	Normally the rights to establish 3D parcels (apartment rights; right of superficies;		

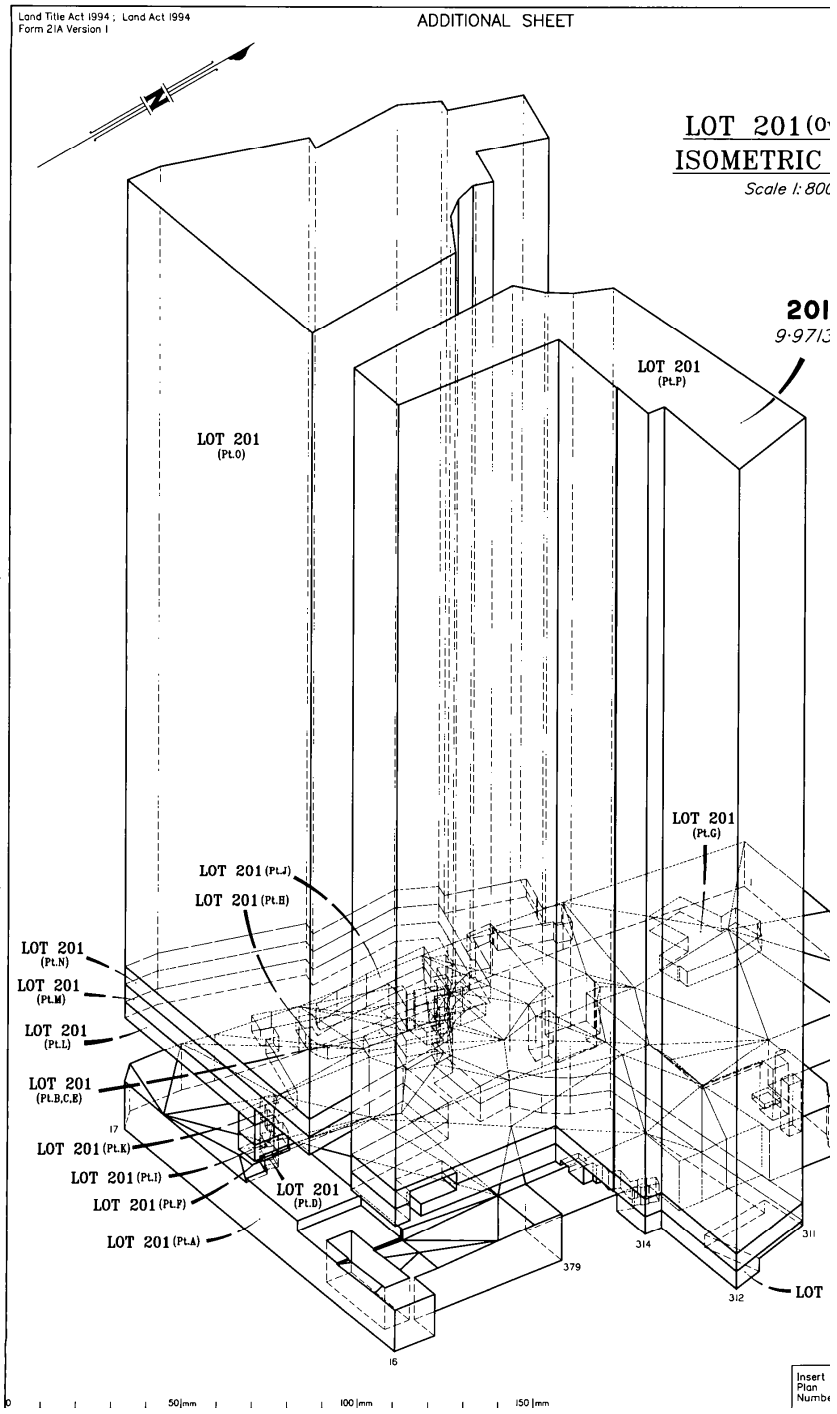
[2] An ambulatory boundary is a boundary of a land parcel which follows the movements of a natural feature such as a river. Its position determined at points of time (when survey is carried out), but between such "fixes", the definition of the property is the position of the real world natural feature.

Design of questionnaire

- Difficult to design clear questionnaire for abstract topic 3D Cadastres (quite abstract, everybody has own interpretation)
- Questionnaire starts with introduction notes, including formal and informal definition of 3D parcel: 'spatial unit against which (one or more) unique and homogeneous rights (e.g. ownership right or land use right), responsibilities or restrictions are associated'
- Important distinction between 3D physical and 3D legal object
- Questions grouped into 9 thematic blocks (next slide)
- Two blank columns: status 2010 and expectation 2014
- Two example set of answers (Queensland/Australia, Netherlands)
- Questionnaire distributed among members of FIG working group 3D Cadastres (via commissions 3 and 7) and still open

Thematic blocks of questions

1. General/applicable 3D real-world
2. Infrastructure/utility networks
3. Construction/building units
4. X/Y Coordinates
5. Z Coordinates/height repr.
6. Temporal Issues
7. Rights, Restrictions & Responsib.
8. DCDB (Cadastral Database)
9. Plans of Survey, incl. field sketch



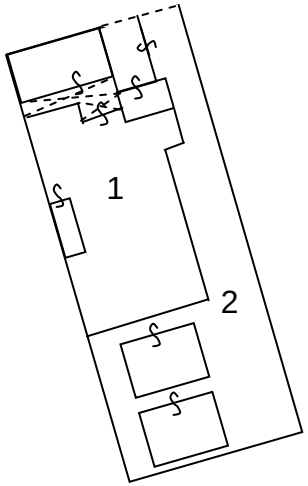
Analysis of responses

- 37 FIG completed questionnaires received (Argentina, Australia, Austria, Bahrain, Brazil, Canada, China, Croatia, Cyprus, Denmark, Finland, France, Germany, Greece, Hungary, India, Indonesia, Israel, Italy, Kazakhstan, Kenya, Macedonia, Malaysia, The Netherlands, Nepal, Nigeria, Norway, Poland, Russia, South Korea, Spain, Sweden, Switzerland, Trinidad and Tobago, Turkey, and United Kingdom) → on website www.3dcadastres.nl

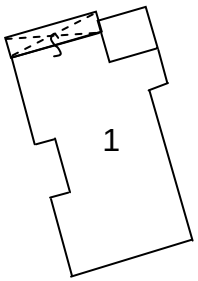
- Nearly all jurisdictions (except Poland & Nepal) allow registration of 3D parcels, in practise often (limited to) apartments
- Despite efforts concept '3D cadastre/parcel' still ambiguous
- Hardly any responses for 2014, some exceptions: Switzerland, Denmark, Israel, Bahrain, Russian Federation,…
- Completed questionnaires give overview of the different systems: organizational, legal, technical

Registration of 3D parcel in cadastral database

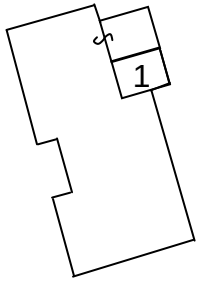
- Did not exist in any country in 2010…
- 'Floor plans' boundaries per floor and are in public register
- Reference to 3D parcel from 2D map Australia, Cyprus, Croatia, Norway and Sweden
- Italy has separate 'Cadastre of Buildings' with 3D
- Spain converts floor plans to 3D parcels (with 3m height)



Ground



1st floor

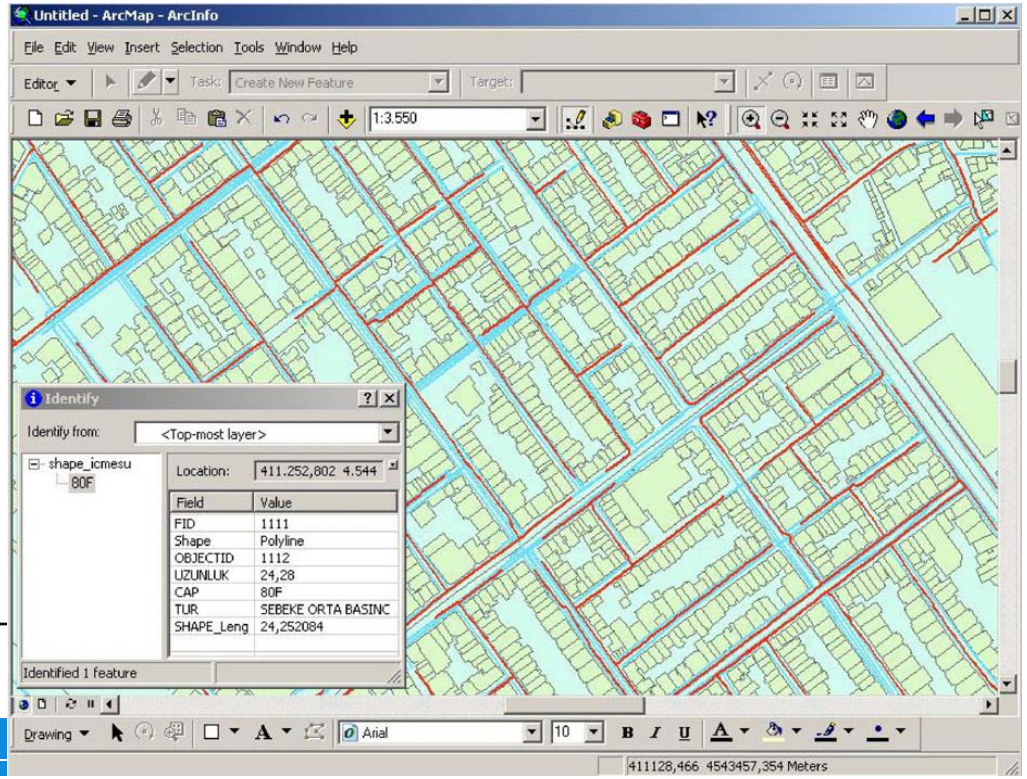


Terrace

Cable and pipeline networks

- Specific type of 3D object: below/above over several land parcels
- Netherlands, Switzerland, Kazakhstan, Russia (limited practise) and Canada allow registration of right spaces related to networks
- Others are developing this: Denmark, Hungary, Israel and Italy
- Some countries have separate 'utility' maps/ registrations (Victoria/Aus, Croatia)

- Last group: no registration or very limited registration; e.g. in Turkey only high voltage power lines (but other networks at level of municipality; e.g. Istanbul →



Third International FIG Workshop on 3D Cadastres - Mozilla Firefox

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www.cadastre2012.org/eProgramme.aspx

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深圳市规划和国土资源委员会
Urban Planning, Land and Resources Commission of Shenzhen Municipality

PAIRC

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3D Cadastres

FIG

Draft Programme

Wednesday 24 Oct. 2012 Registration

Thursday 25 Oct.2012

8:30-8:40	Welcome and opening
8:40-10:20	Legal Aspects
8:40-9:05	Designing a Title Certificate for the Chinese 3D Cadastre Changbin Yu, Lin Li, Shen Ying, Biao He, Zhigang Zhao, and Yuan Wan
9:05-9:30	Swedish 3D Property in an International Comparison Jenny Paulsson
9:30-9:55	Legal Aspects of 3D Property Rights, Restrictions and Responsibilities in Greece and Cyprus Efi Dimopoulou and Elikkos Elia

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1. Introduction
2. FIG working group, international overview
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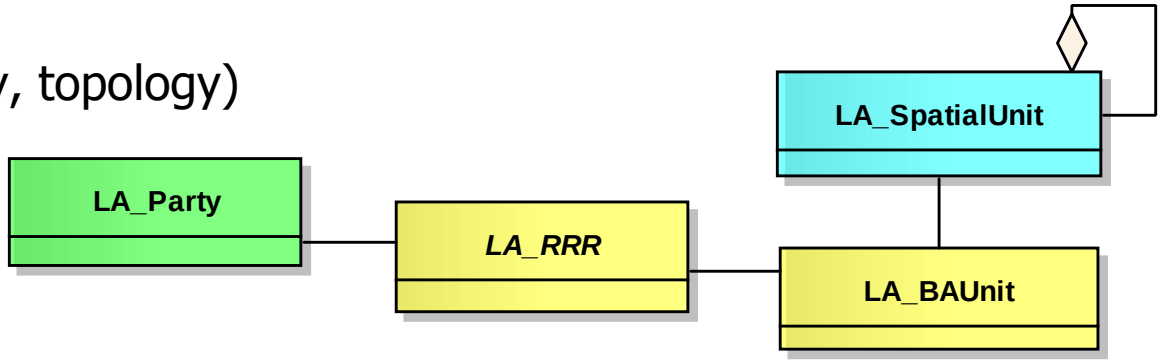
5. Netherlands developments
6. Some other countries

Land Administration Domain Model ISO 19152 (LADM)

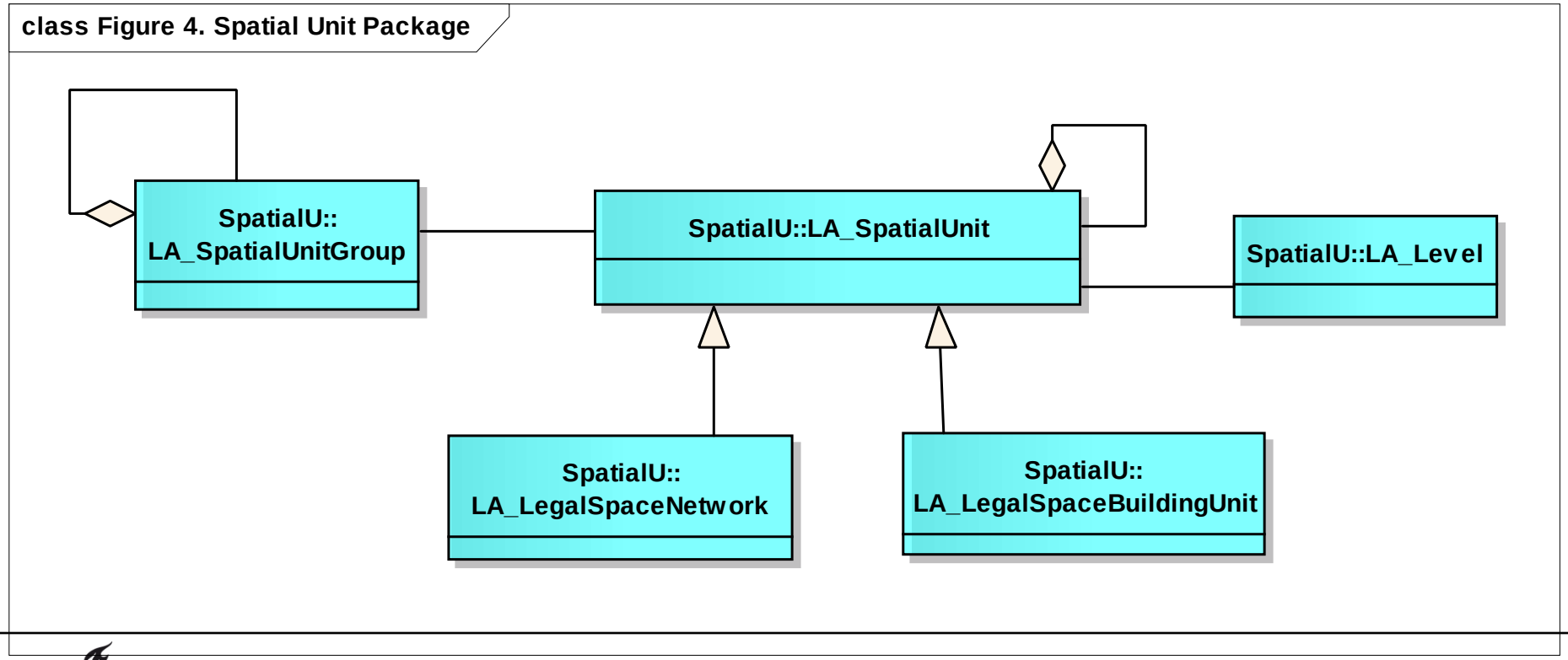
- Model includes:
  - Spatial part (geometry, topology)
  - Extensible frame for legal/admin parts

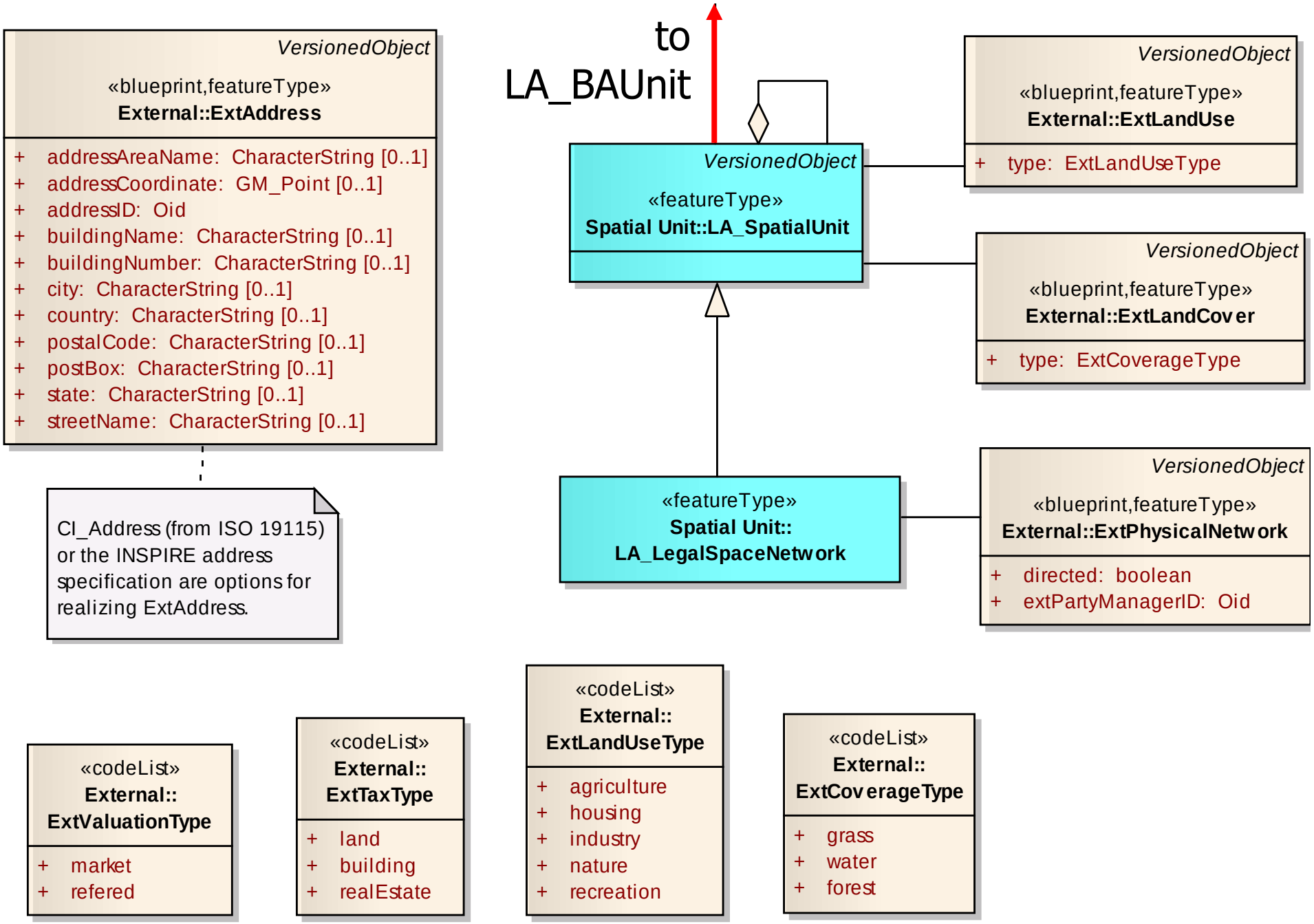


- Stared within the FIG in 2002
- FIG proposed LADM to ISO/TC211, January 2008 (parallel voting in ISO TC211 and CEN TC287)
- Includes integrated 2D and 3D support

LA_SpatialUnit (alias LA_Parcel)

- LA_SpatialUnit specializations: network, building unit
- organized in LA_Level based on structure or content
- 5 types: point, text (unstructured) line, polygon, and topology
- 2D and 3D integrated without complicating 2D




VersionedObject
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External::ExtAddress
+ addressAreaName: CharacterString [0..1]
+ addressCoordinate: GM_Point [0..1]
+ addressID: Oid
+ buildingName: CharacterString [0..1]
+ buildingNumber: CharacterString [0..1]
+ city: CharacterString [0..1]
+ country: CharacterString [0..1]
+ postalCode: CharacterString [0..1]
+ postBox: CharacterString [0..1]
+ state: CharacterString [0..1]
+ streetName: CharacterString [0..1]
CI_Address (from ISO 19115) or the INSPIRE address specification are options for realizing ExtAddress.
to LA_BAUnit
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«featureType»
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VersionedObject
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+ refered
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+ building
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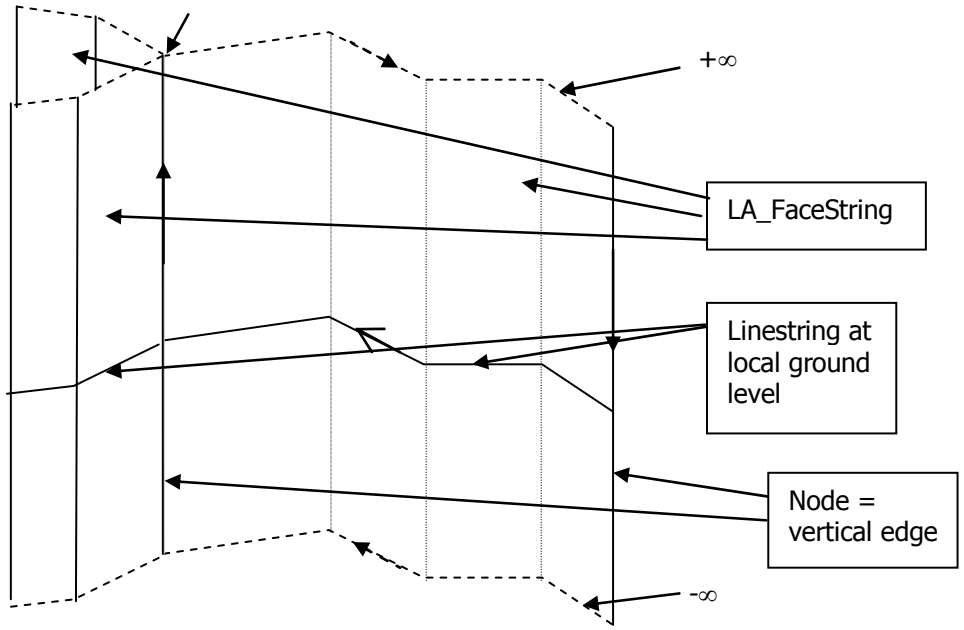
ExtLandUseType
+ agriculture
+ housing
+ industry
+ nature
+ recreation
«codeList»
External::
ExtCoverageType
+ grass
+ water
+ forest

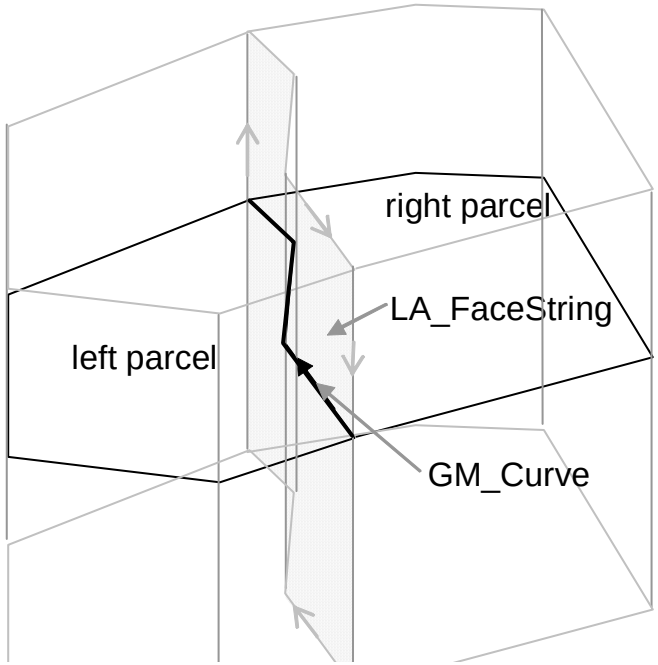
Spatial Units in 3D

- Extend the equivalent concept from 2D to 3D
  → 3D parcels are in areas of highest land values
- Sharing of surfaces between 3D parcels
  where lines would be shared in 2D
- point-line-area becomes point-line-area-volume
- Challenges:
  1. Majority of parcels is in 2D and should not be lost
     → integrate 2D/3D
  2. 3D parcels can be unbounded (up/down) according to National law
     → does not fit in ISO 19107 (spatial schema), so alternative needed

2D parcels and their 3D interpretation

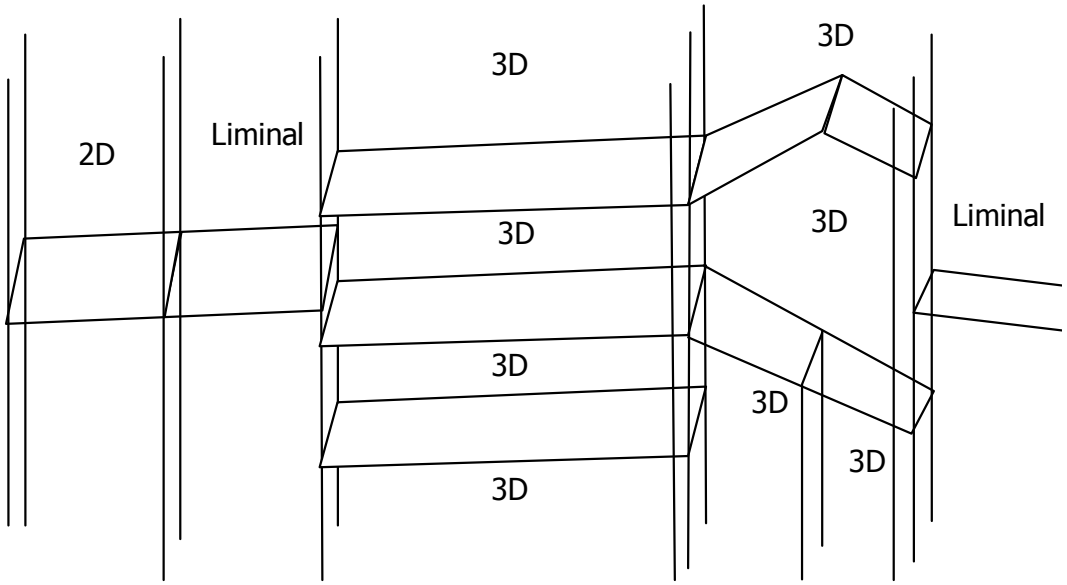
- Observation: 2D description implies 3D prismatic volume
- 2D polyline (GM_curve) implies string of vertical faces





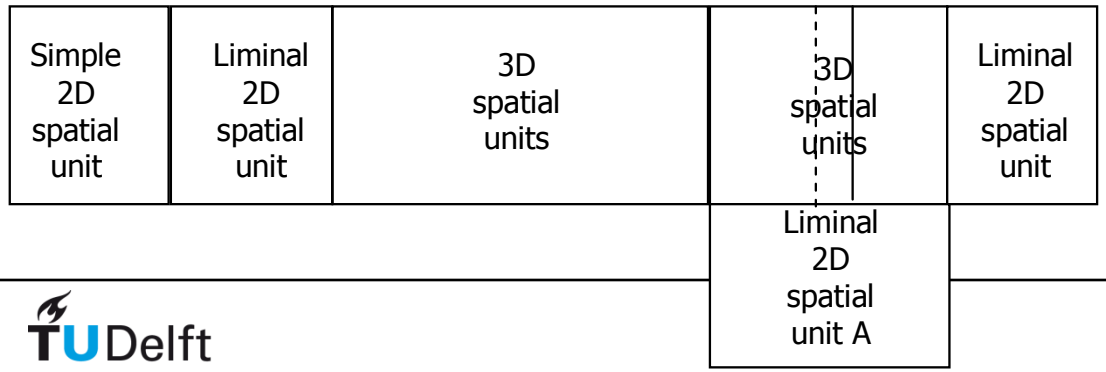
2D and 3D Integration

- between 2D and 3D spatial unit transition via liminal spatial units



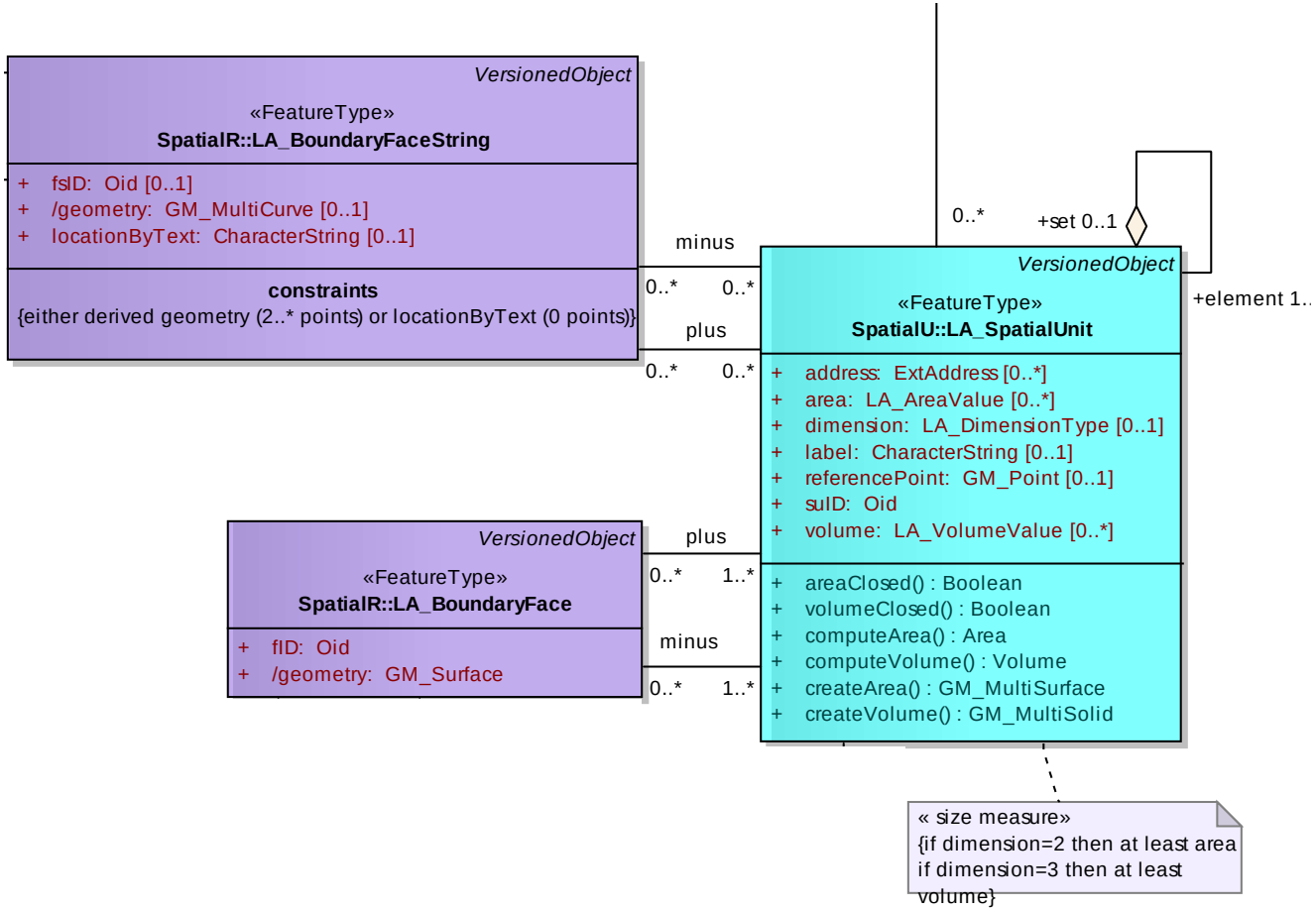
- Liminal spatial units are 2D parcels, but are stored as 3D parcels

- Liminal spatial units are delimited by a combination of LA_BoundaryFace and LA_BoundaryFaceString objects



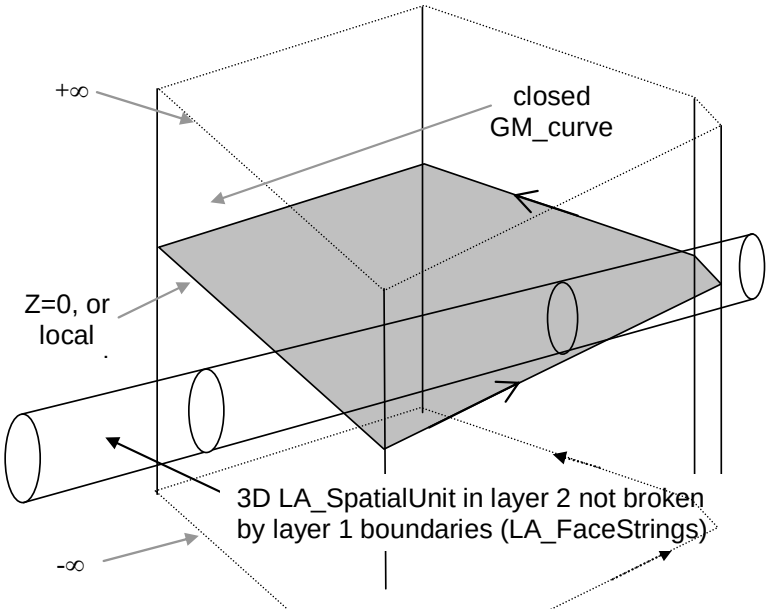
2D and 3D integration

- 2D polyline (GM_curve) implies string of vertical faces: LA_BoundaryFaceString
- true 3D described with arbitrary oriented faces: LA_BoundaryFace



The 3D use of LA_Level

- organization based on content or structure:
  - example 1, content-based: one layer with 'primary' (strongest) rights, another layer with rights that can be added/subtracted (e.g. restrictions)
  - example 2, structure-based: one layer with topologically structured parcels (one part of the country), another layer with (unstructured) line based parcels (other part of country)
- can also be used in 3D context: one layer 'normal' parcels, another layer with subtracted 3D parcels
- based on independence principle
- each country design own levels



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Deep integrating 3D space and time: 4D Cadastre Example

Partition: no gaps or overlaps in the parcelation on which the rights (e.g. ownership) are based

2D: a planar partition of the surface

3D: a partition of space with no overlaps or gaps

4D: no overlaps or gaps in the rights, not only in space but also in parallel the time dimension

3D Tunnel registration in Queensland

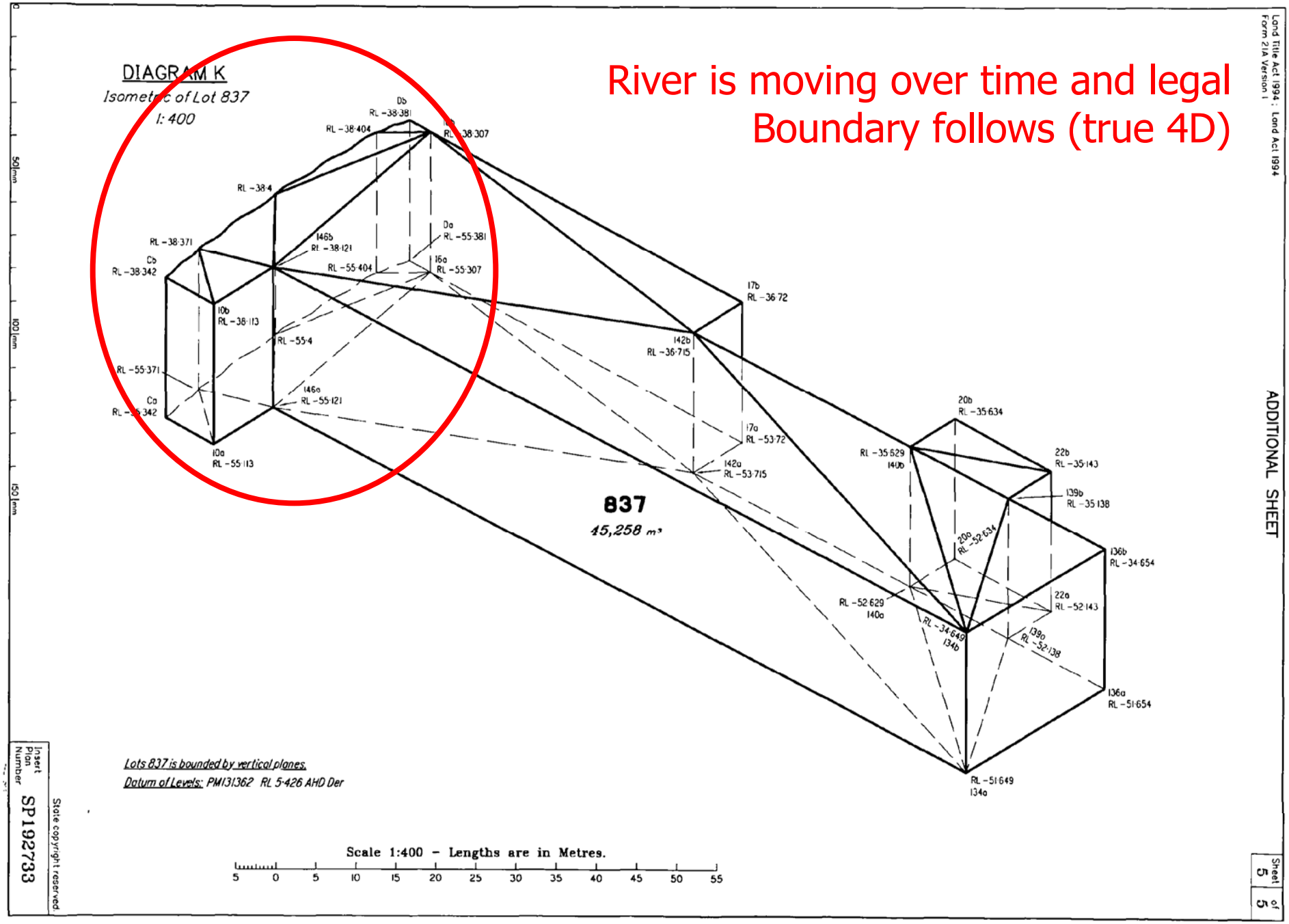
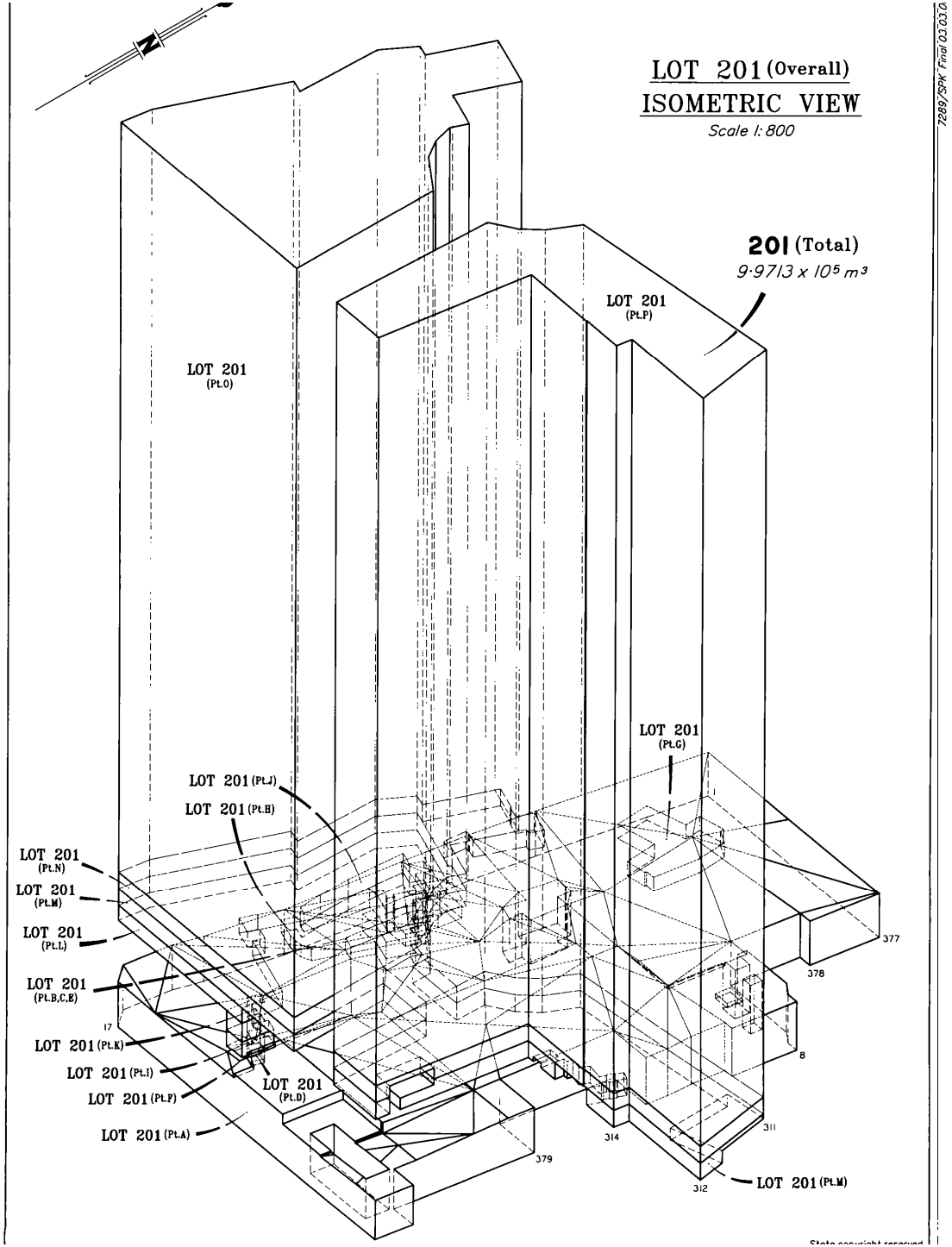


DIAGRAM K
Isometric of Lot 837
1: 400
River is moving over time and legal Boundary follows (true 4D)
837
45,258 m²
Lots 837 is bounded by vertical planes.
Datum of Levels: PM131362 RL 5·426 AHD Der
Scale 1:400 – Lengths are in Metres.
5 0 5 10 15 20 25 30 35 40 45 50 55
Land Title Act 1994 : Land Act 1994
Form 21A Version 1
ADDITIONAL SHEET
Insert Plan Number
SP192733
State copyright reserved
Sheet 5 of 5

More cases: Timesharing

- 3D volumetric survey plan (apartments)
- Timesharing of 40 units/week: 40*52 shares
- Timeshare can be traded, mortgaged, etc.
- 3D+time=4D



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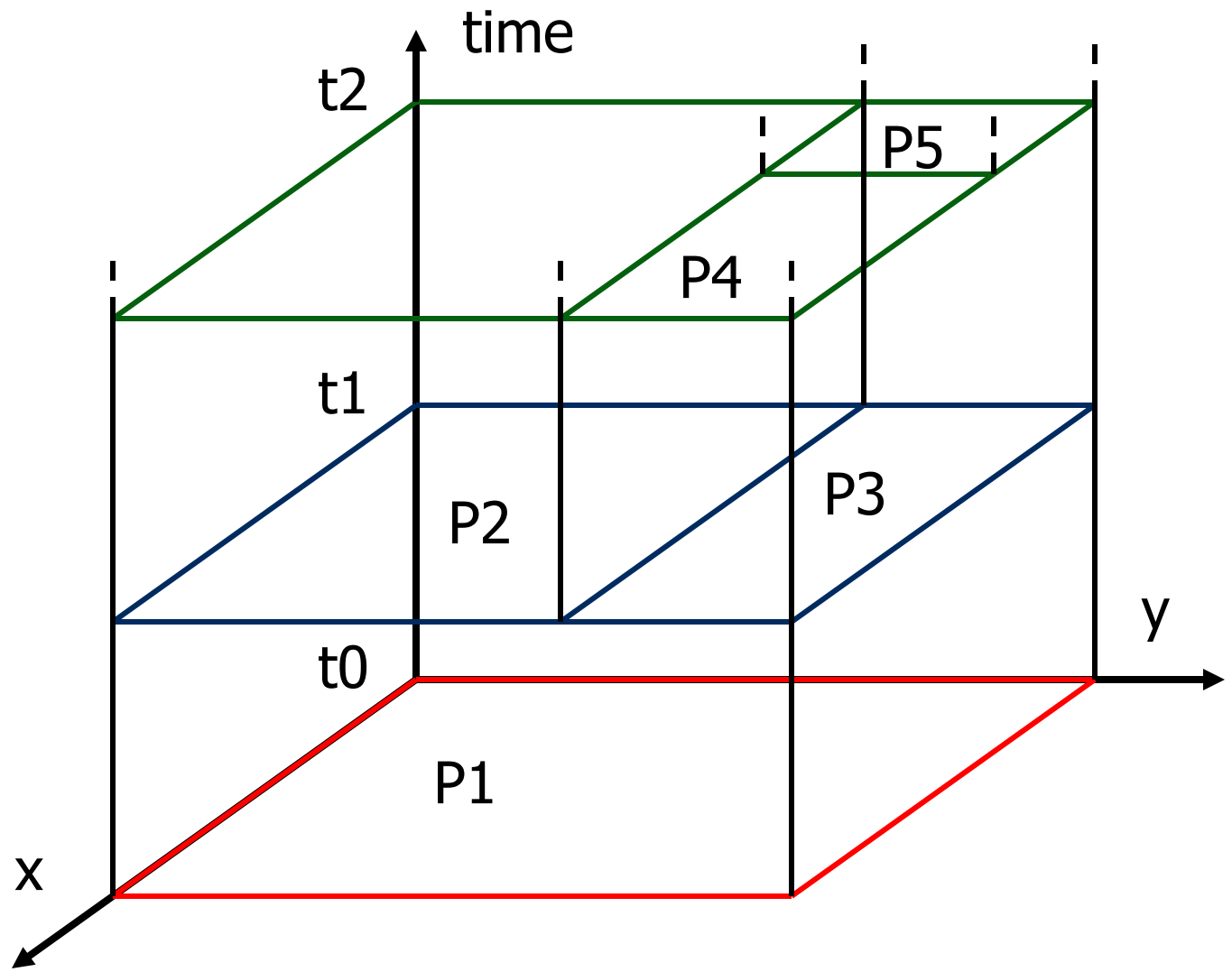
4D cadastre: separate space and time or an integrated attribute?

- Advantages of separate attributes:
  1. Already able to represent all cases
  2. Supported by state-of-the art technology
  3. Temporal aspect is more than just one dimension

- Advantages of integrated 4D data type:
  1. optimal efficient 4D searching
  2. Parent-child becomes topology neighbor query in time

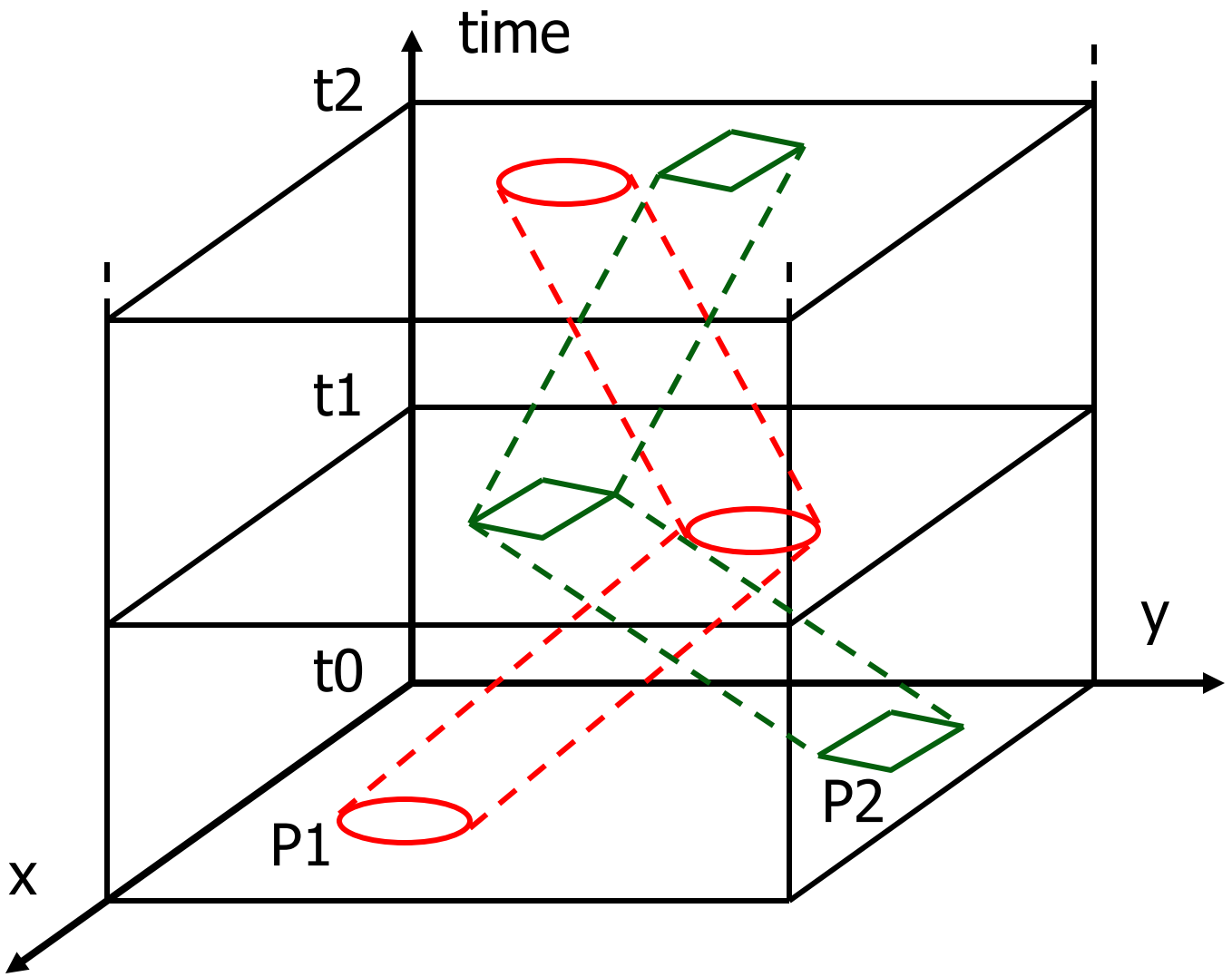
Subdivision of parcels



4D data type advantages (cont.)

- Advantages of integrated 4D data type:
  1. optimal efficient 4D searching
  2. Parent-child becomes topology neighbor query in time
  3. Foundation of full (4D) partition: no overlaps or gaps in space and/or time
  4. 4D analysis: do two moving cattle rights have spatio-temporal overlap/touch

Moving cattle



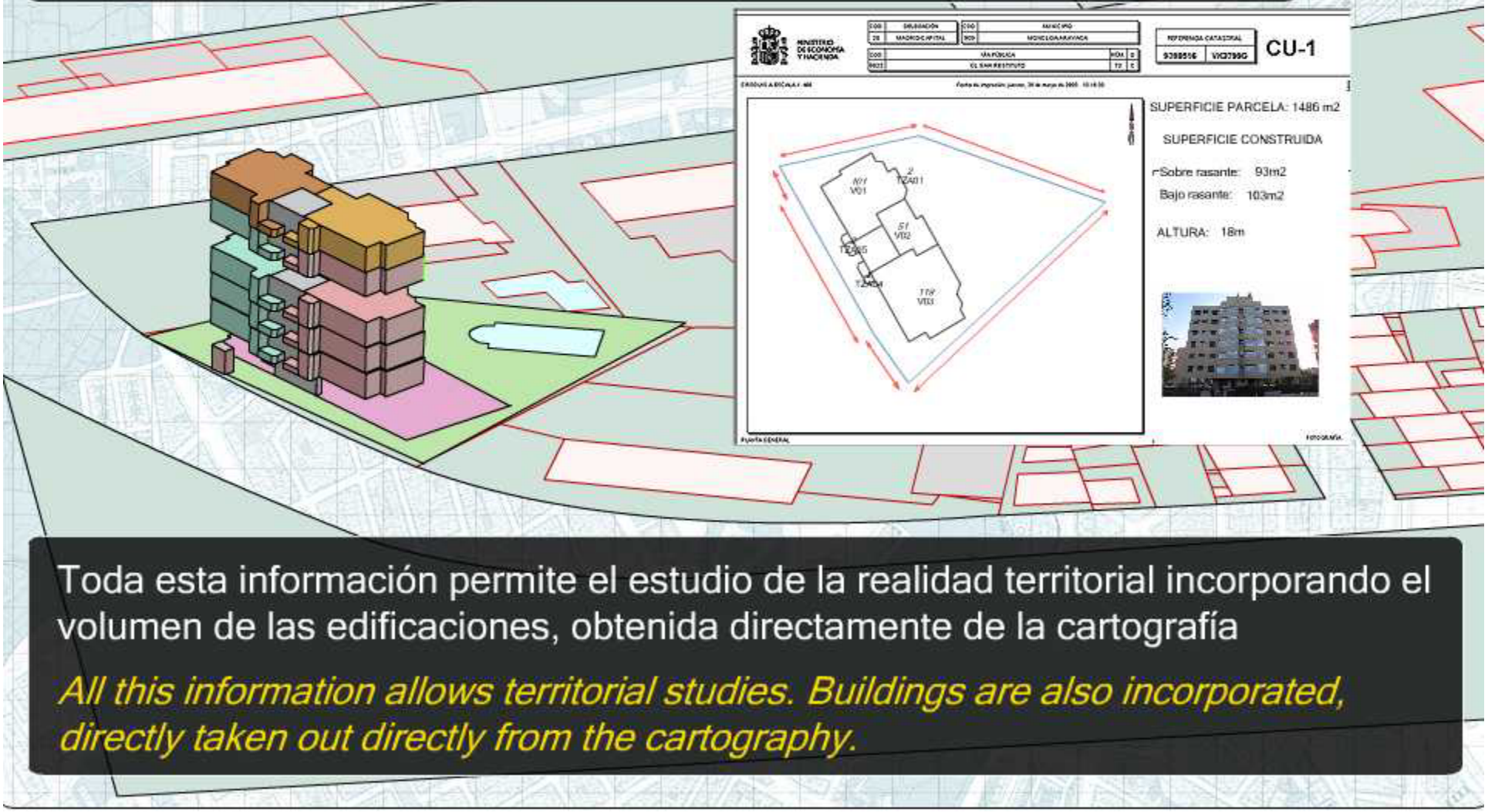
MINISTERIO DE ECONOMÍA Y HACIENDA

SECRETARÍA DE ESTADO DE HACIENDA Y PRESUPUESTOS

DIRECCIÓN GENERAL DEL CATASTRO

El e-catastro 4D
actualizado diariamente

Localización, Altura de edificios, croquis por planta, Datos catastrales, fotografías de fachada.
Real state location, buildings height, floor sketches (CU1), Cadastral data, front photographs.



Toda esta información permite el estudio de la realidad territorial incorporando el volumen de las edificaciones, obtenida directamente de la cartografía

All this information allows territorial studies. Buildings are also incorporated, directly taken out directly from the cartography.

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3D Cadastre in the Netherlands

- Several studies have been carried out in the past decade
- Now actual implementation
  within legal, institutional, organisational context

Why now?

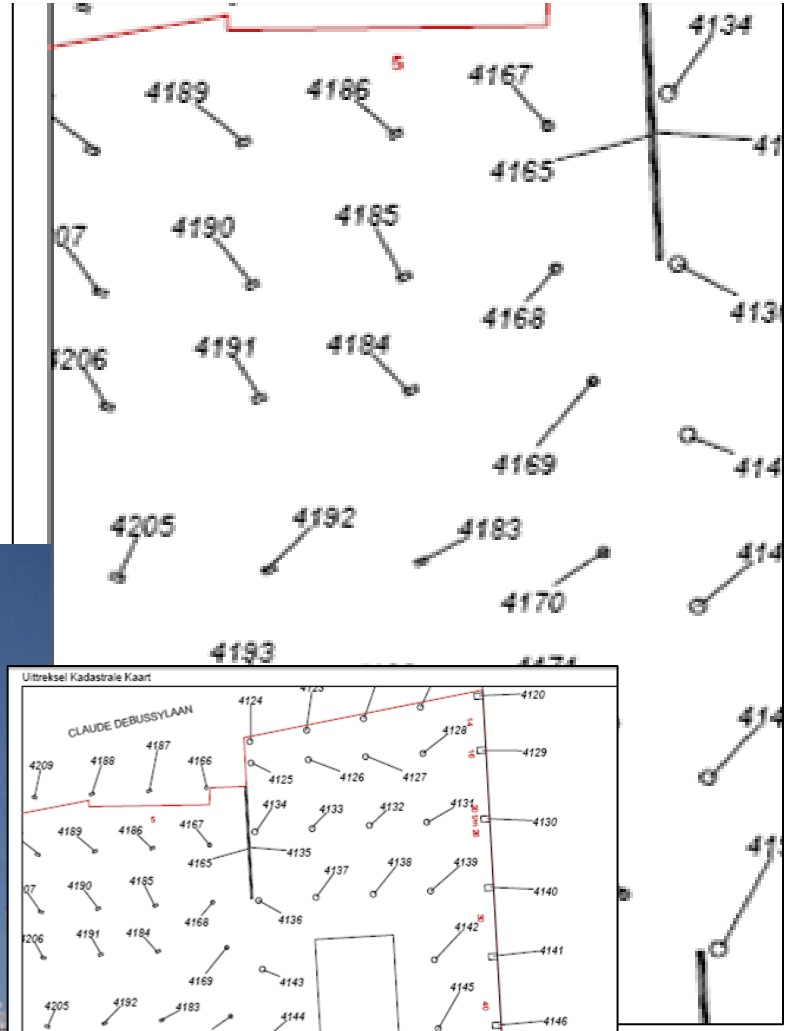
- Technically it has become possible to accept 3D drawings
- Practice has asked for support

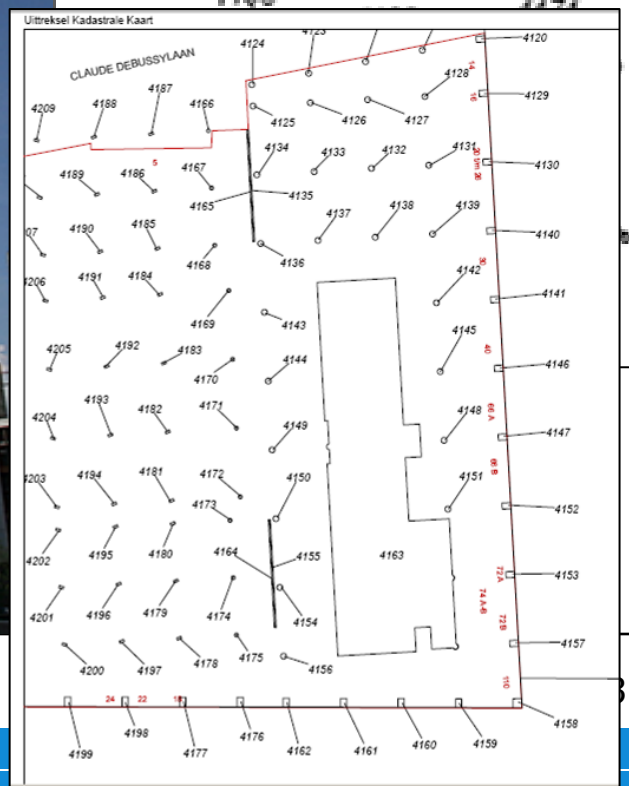
Background

- Main registration entity is 2D parcel
- Although it is possible to establish property rights with 3D boundaries
- Case 1: one object, superficies
- Note parcel fragmentation

Case 2

- Land by municipality
- Two 3D objects, long lease:
  1. Parking garage
  2. Office tower on 80 pillars
- Note again parcel fragmentation





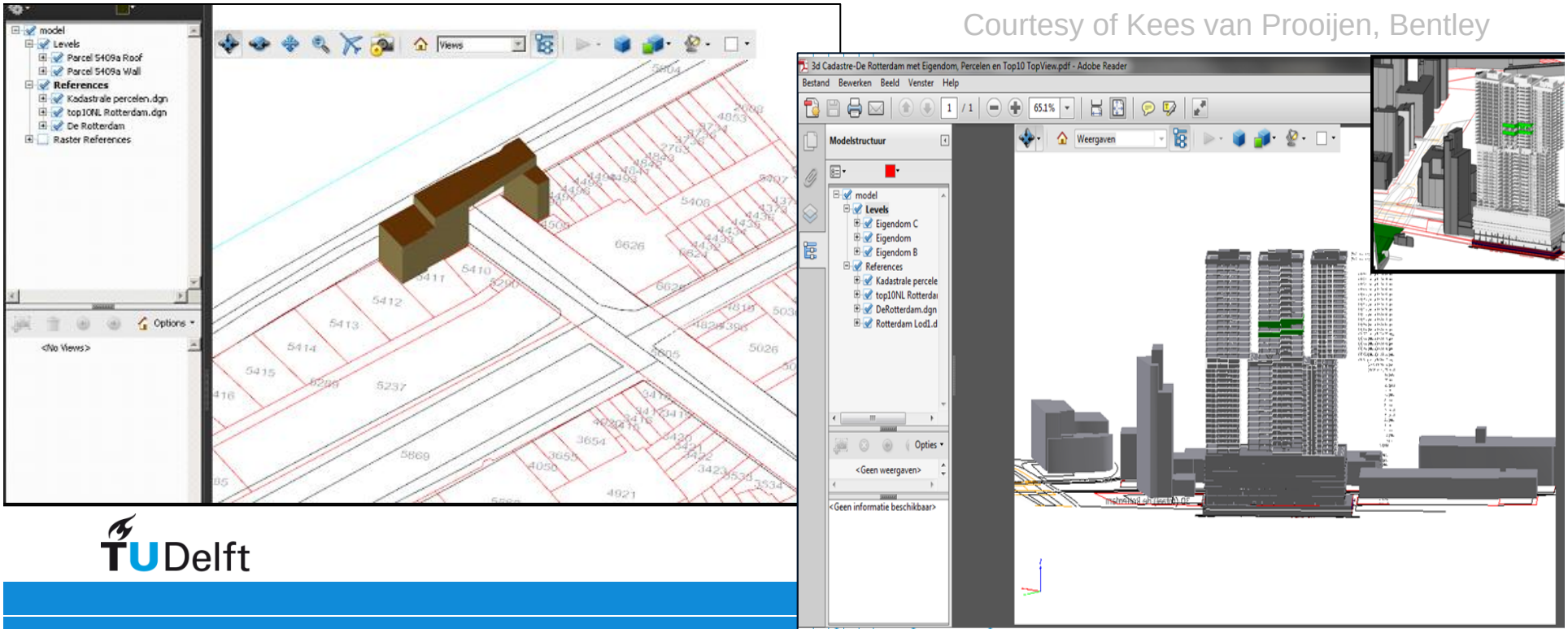
Findings from the case studies (many more than now presented)

- Registration and publication of rights on 3D property is possible with the traditional 2D approach

- But:
  1. Registration is not clear:
     Hard to understand if more than one object/part is involved
  2. Objects are divided over several parcels:
     Hard to maintain

Phase I

- No dramatic change
- Principle: refuse "fragmented parcel creation"
- Require a registration of 3D representation that reflects the space to which right applies
- 3D PDF (is already possible!)



Courtesy of Kees van Prooijen, Bentley

TU Delft

Phase I in more detail

- Notification of 3D registration in cadastral map
- Projection 3D representation in separate layer (LA_Level)
- Link to 3D drawing
- Original 2D parcels can be kept (have own LA_Level)
- No 3D parcel in a 3D cadastral map
- Requirements/guidelines for 3D drawing

Requirements for 3D PDF

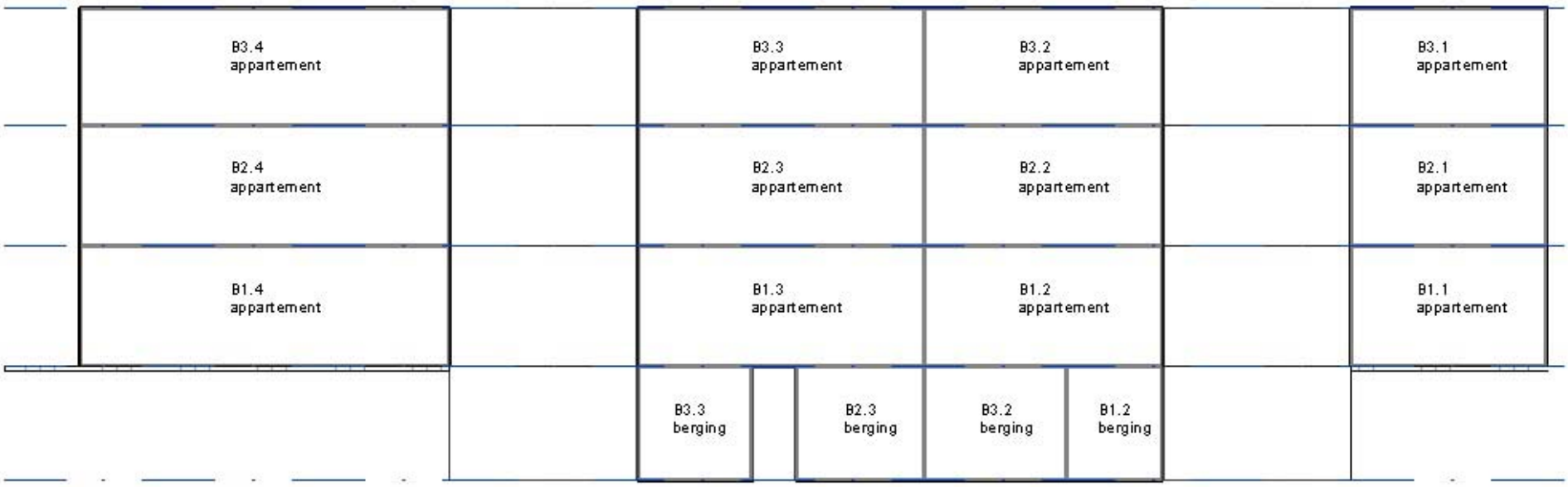
- 2D ground parcels that overlap with legal volumes
- 3D (graphical) description of legal space:
  - 3D extent and overlap with ground parcels

- Legally required 2D cross sections with accompanying annotations
- Objects needed for reference/orientation in 3D environment:
  - large scale topography
  - 2D geometry of buildings
  - 3D constructions and earth surface (with ground parcels) as reference

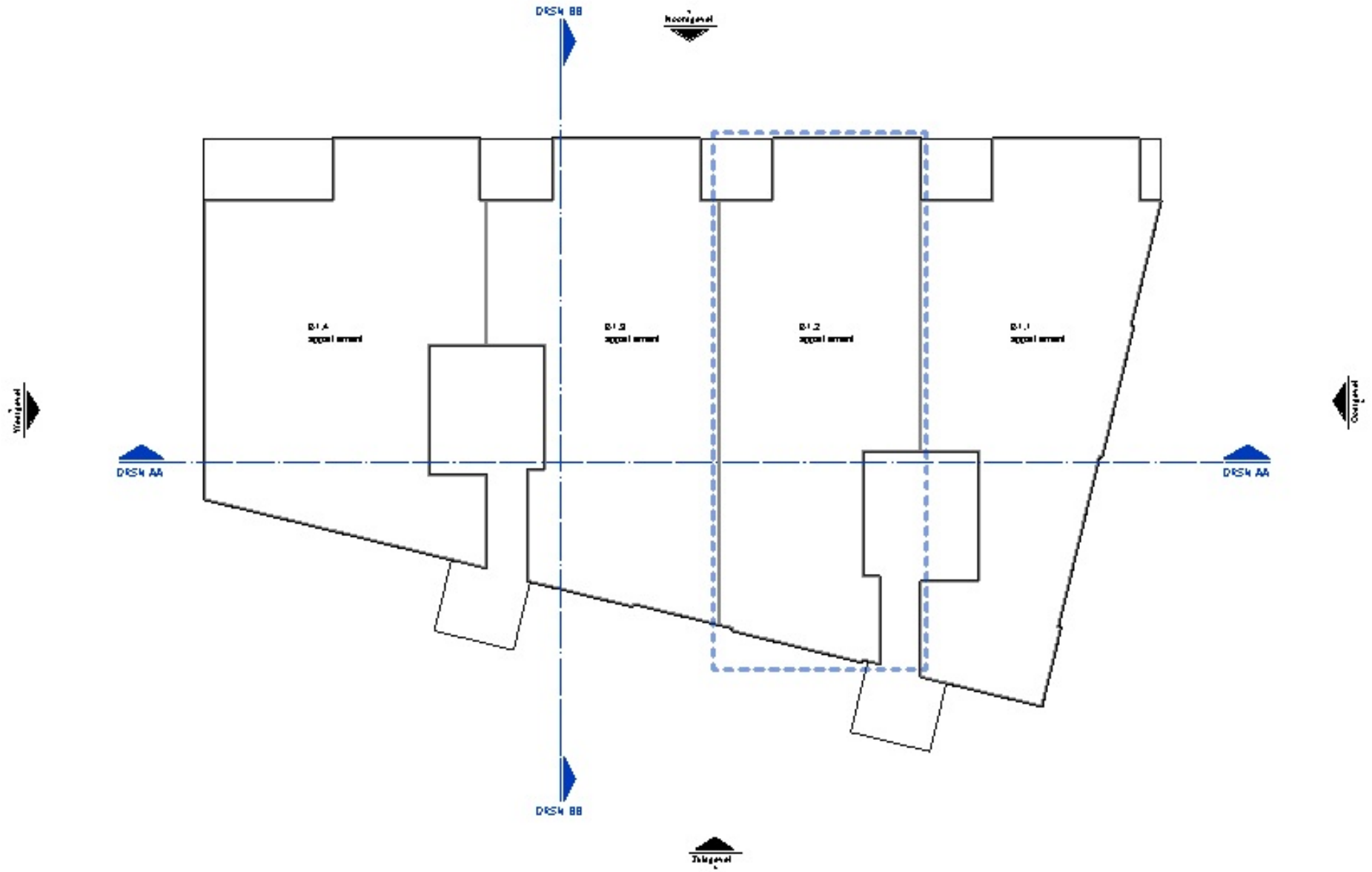
- Length/area measures of the legal space
- Volume of the legal space
- Z: 3D PDF should identify origin in local coordinates (and relate this to national height datum)

Example 3D PDF by a company: VDNDP Bouwingenieurs

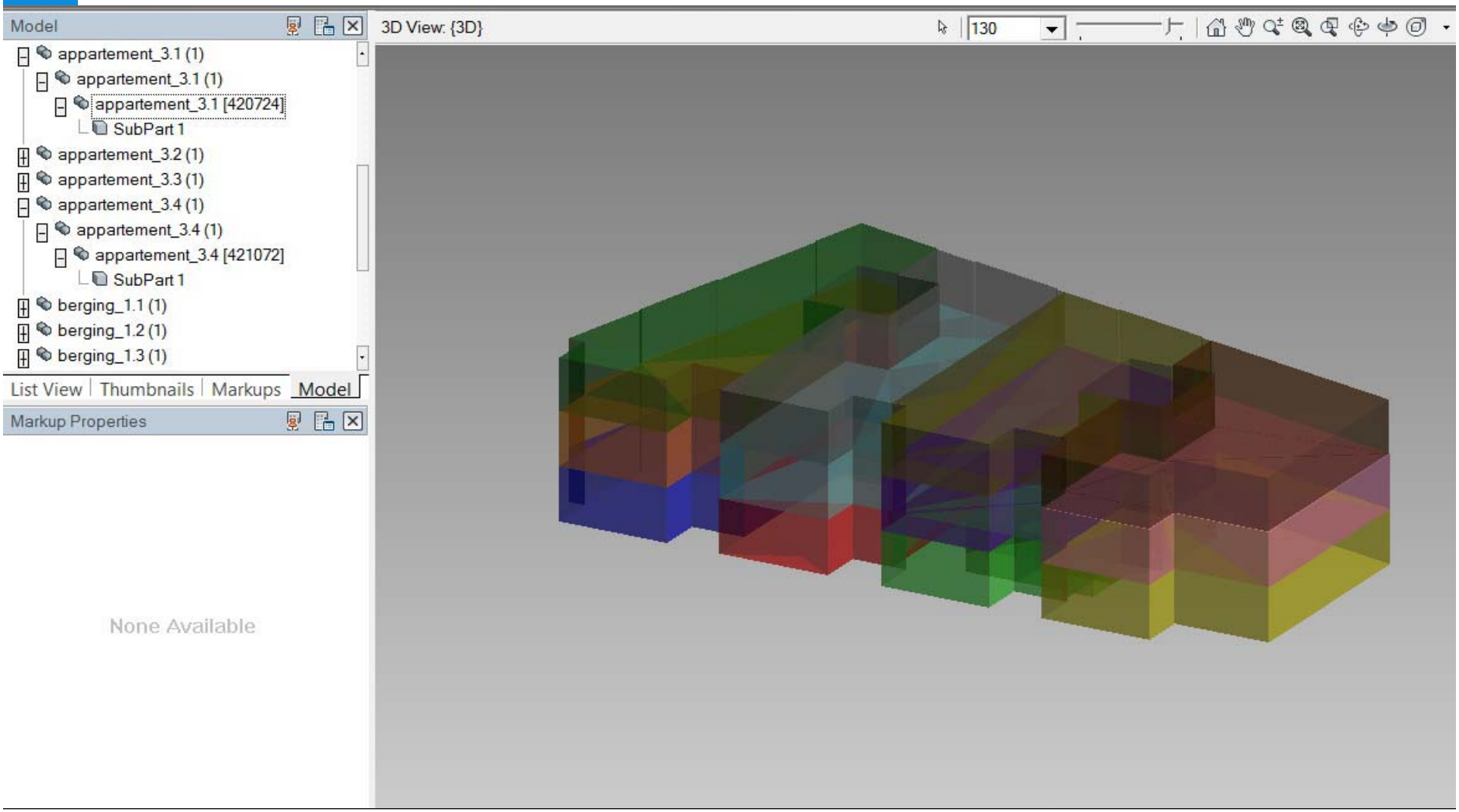
Vertical cross section



Floor plan of 1st floor



3D legal spaces



Additional requirements, phase I

- Footprint and projection on earth surface in cadastral map
- Unique identification is not possible, therefore preliminary id's
- No 3D data can be submitted for registration:
  1. as long as the 3D space can be visualised in a 3D PDF, the representation is accepted
  2. topological structure not possible, but one 3D PDF could show separate legal volumes; e.g. neighbours in apartment complex
  3. quality of the 3D representations cannot be checked

Next, Phase II

- Obligatory in specific situations
- Still related to one or more ground parcels
- A 3D graphical representation is always required
- based on ISO standard LADM and full integration 2D/3D (LA_BoundaryFace and LA_BoundaryFaceString)

- 3D data itself: XML-encoding (CityGML, LandXML, IFC?)
- Kadaster checks on geometry, topology, overlap:
  - Requirements for allowed geometries

- Possible to establish legal space that overlaps several ground parcels with own identification

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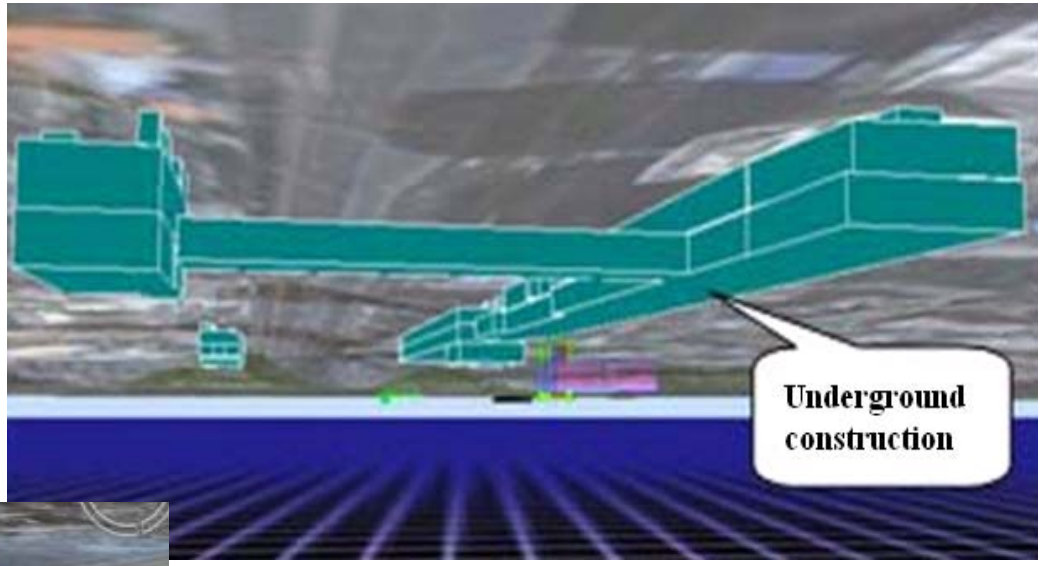
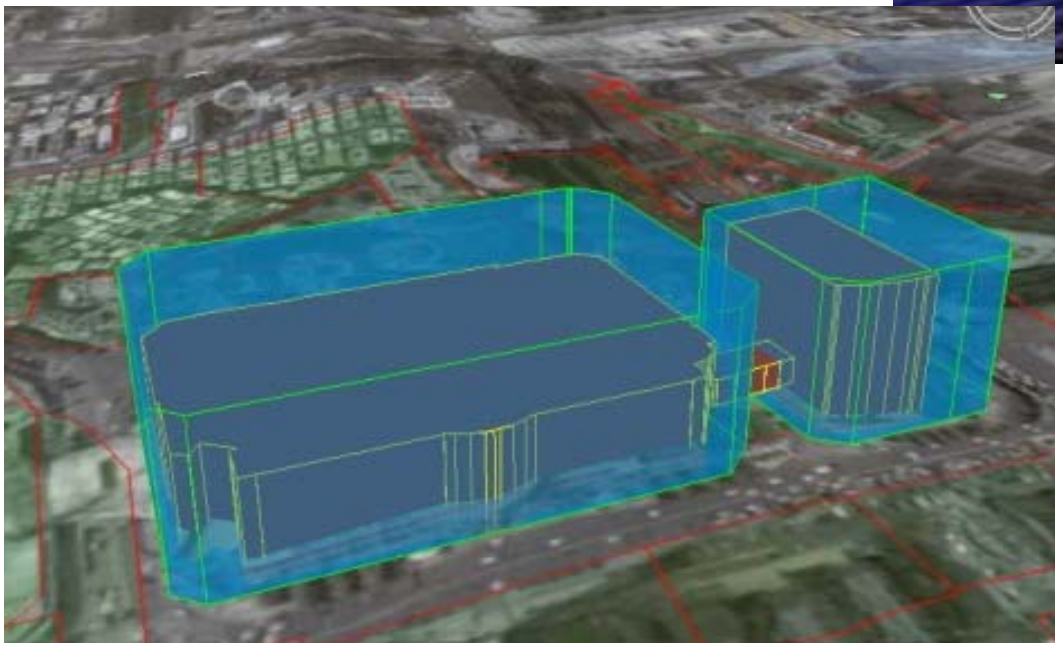
Some other countries

- China
- Russian Federation
- Malaysia
- Australia (operational, but in DCDB)
- Scandinavian countries (operational, but in DCDB)
- Switzerland (ongoing study)
- Bahrain (being constructed)
- Singapore (tender on-going)

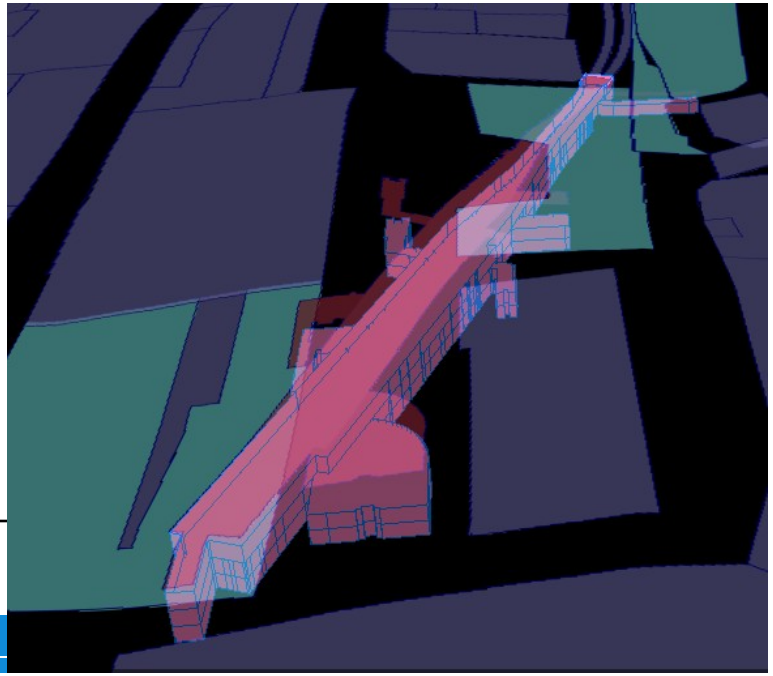
Shenzhen China



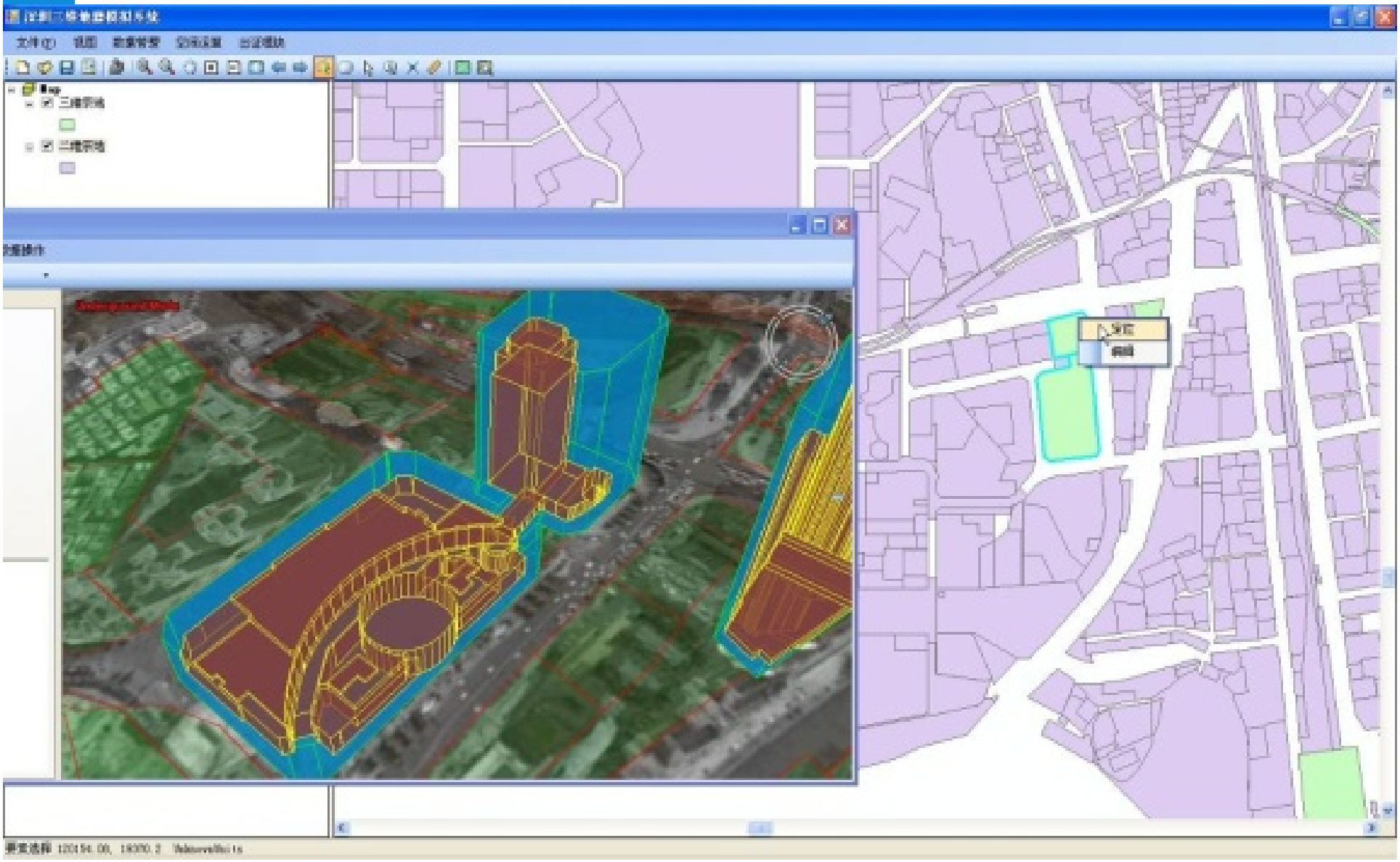


Legal space (blue), buildings (brown)

Subsurface metro, 3 levels



2D and 3D Cadastral data (Shenzhen)



Demo's of 3D Cadastre, 2012 workshop Changchun and Shenzhen

Relevant publications

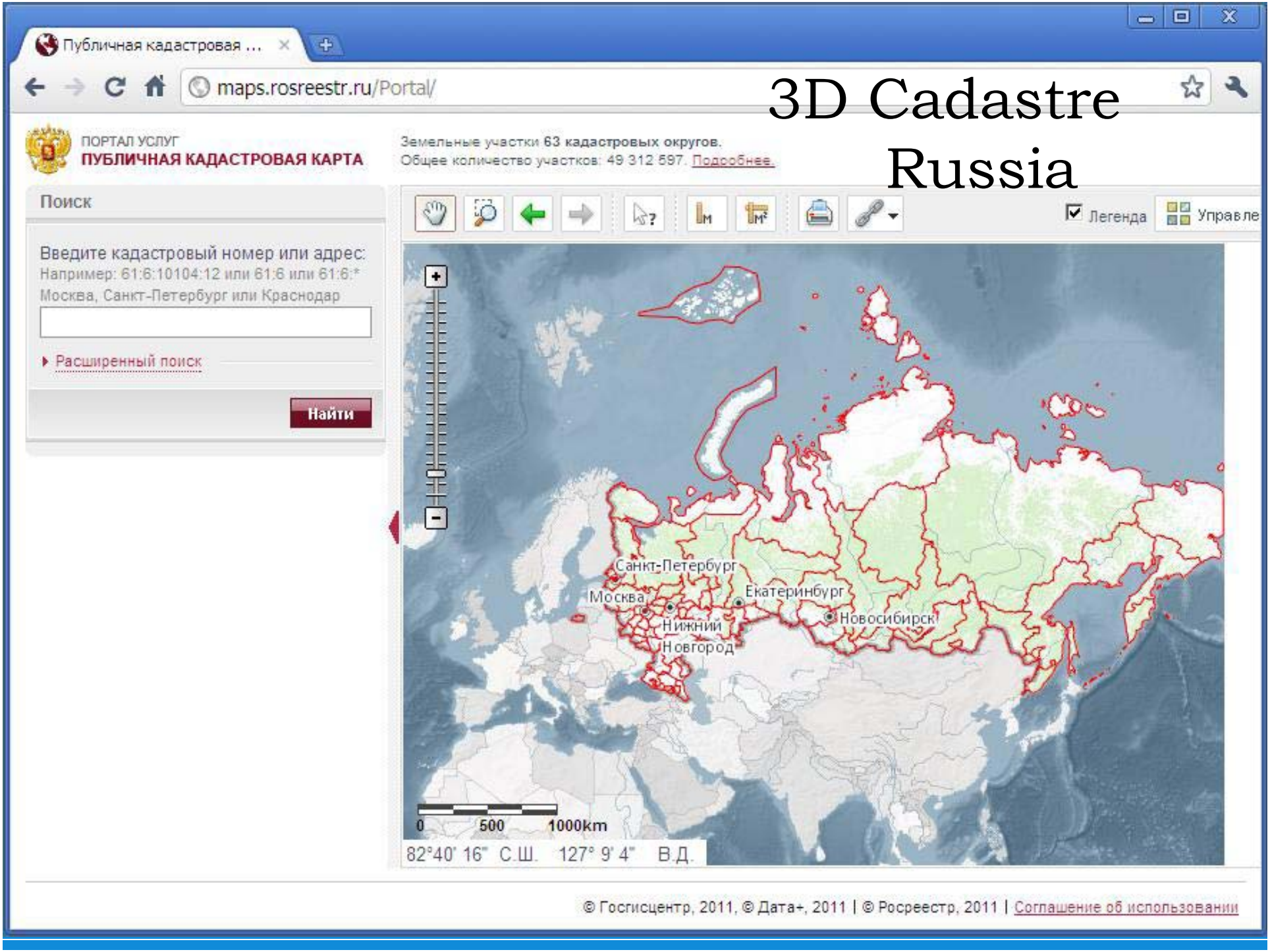
3D Cadastre, Shenzhen (in FIG 3D Cadastres 2011 workshop):

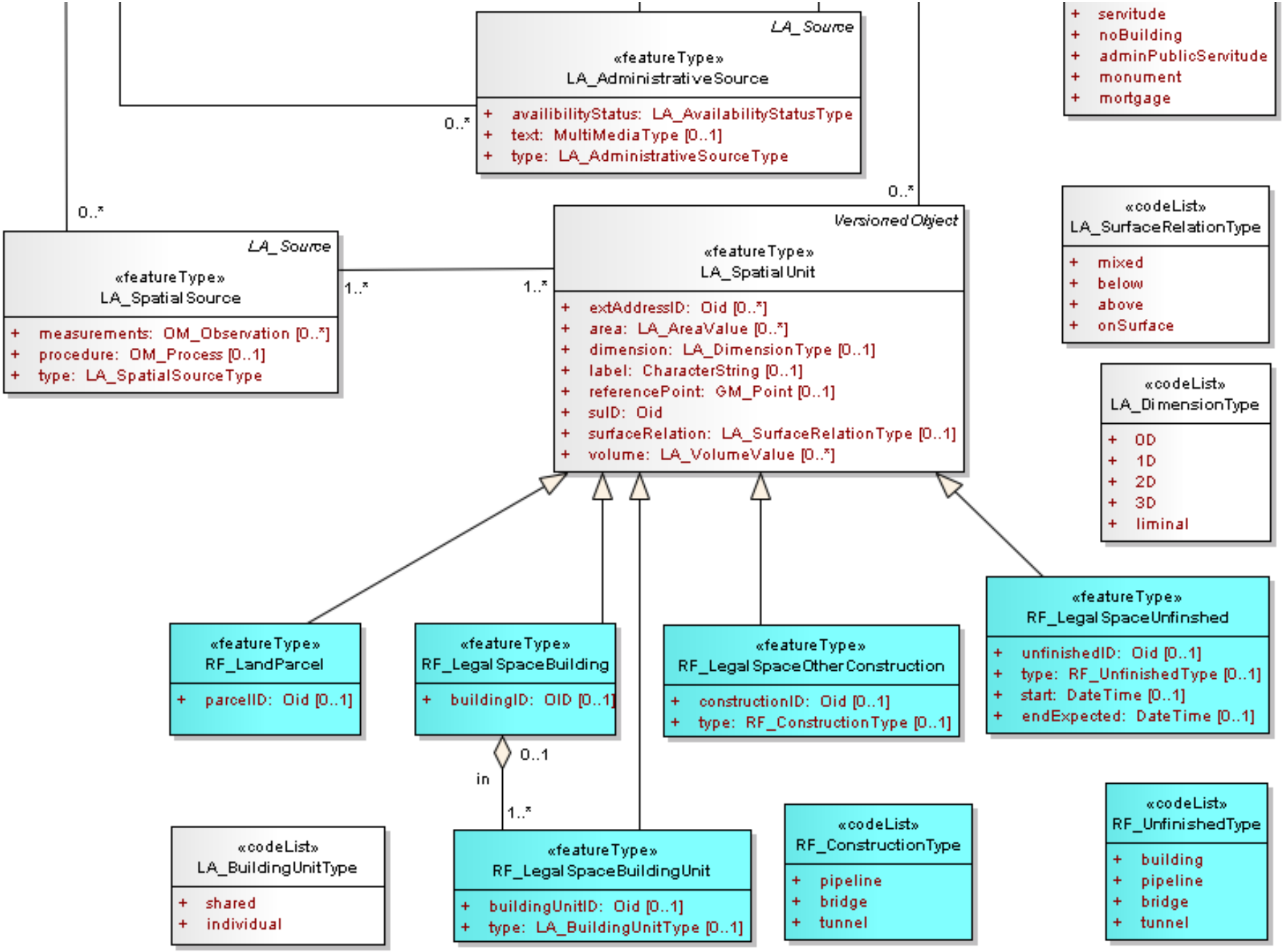
- A Multi-jurisdiction Case Study of 3D Cadastre in Shenzhen, China as Experiment using the LADM (by Renzhong Guo, Shen Ying, Lin Li, Ping Luo and Peter van Oosterom)
- Design and Development of a 3D Cadastral System Prototype based on the LADM and 3D Topology (by Shen Ying, Renzhong Guo, Lin Li, Peter van Oosterom, Hugo Ledoux and Jantien Stoter)

LADM:

- Integration of Land and Housing in China: First Analysis of Legal Requirements for LADM Compliance (by Yuefei Zhuo, Zhimin Ma, Christiaan Lemmen and Rohan Bennett), FIG LADM 2013 workshop

3D Cadastre Russia

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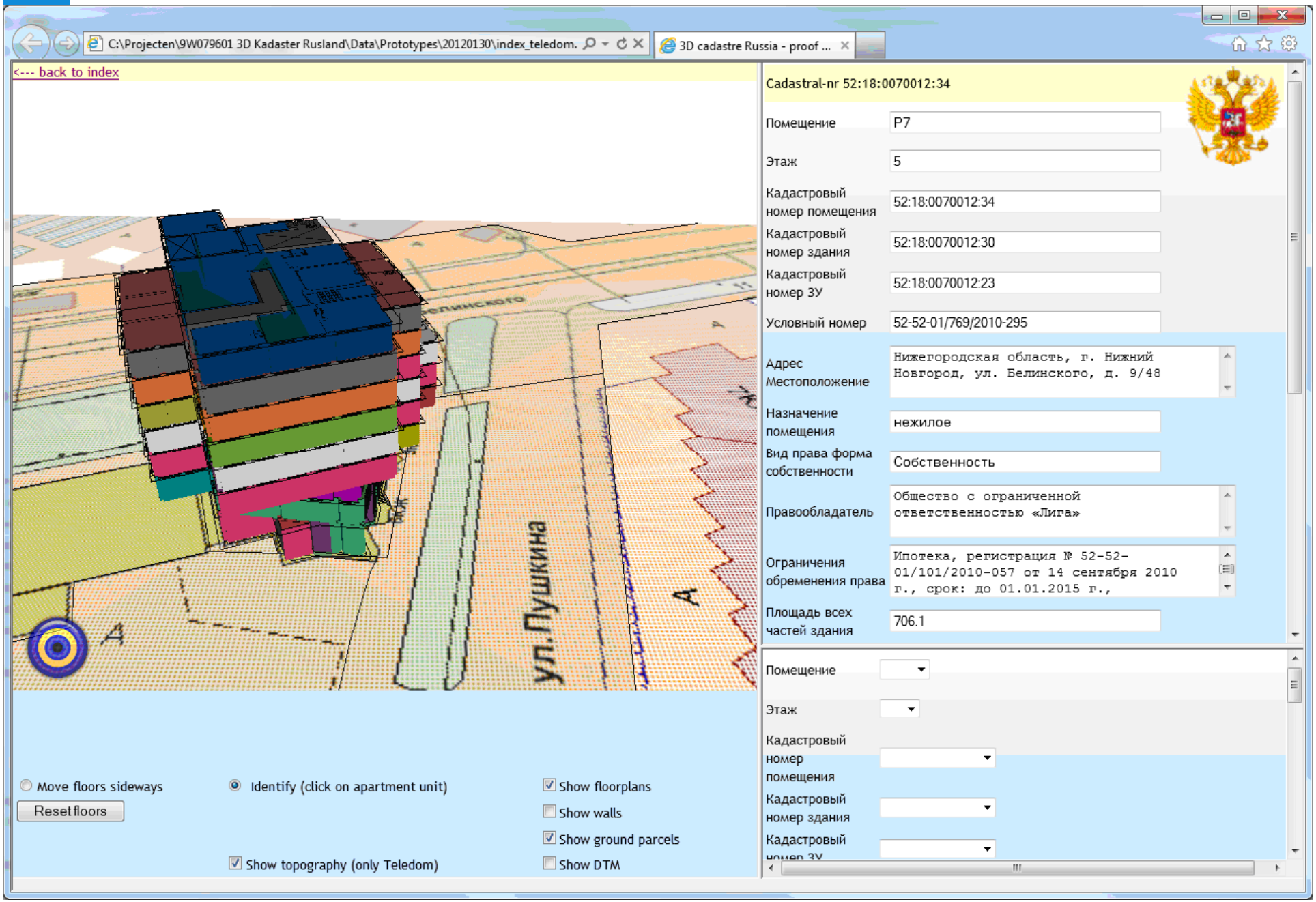
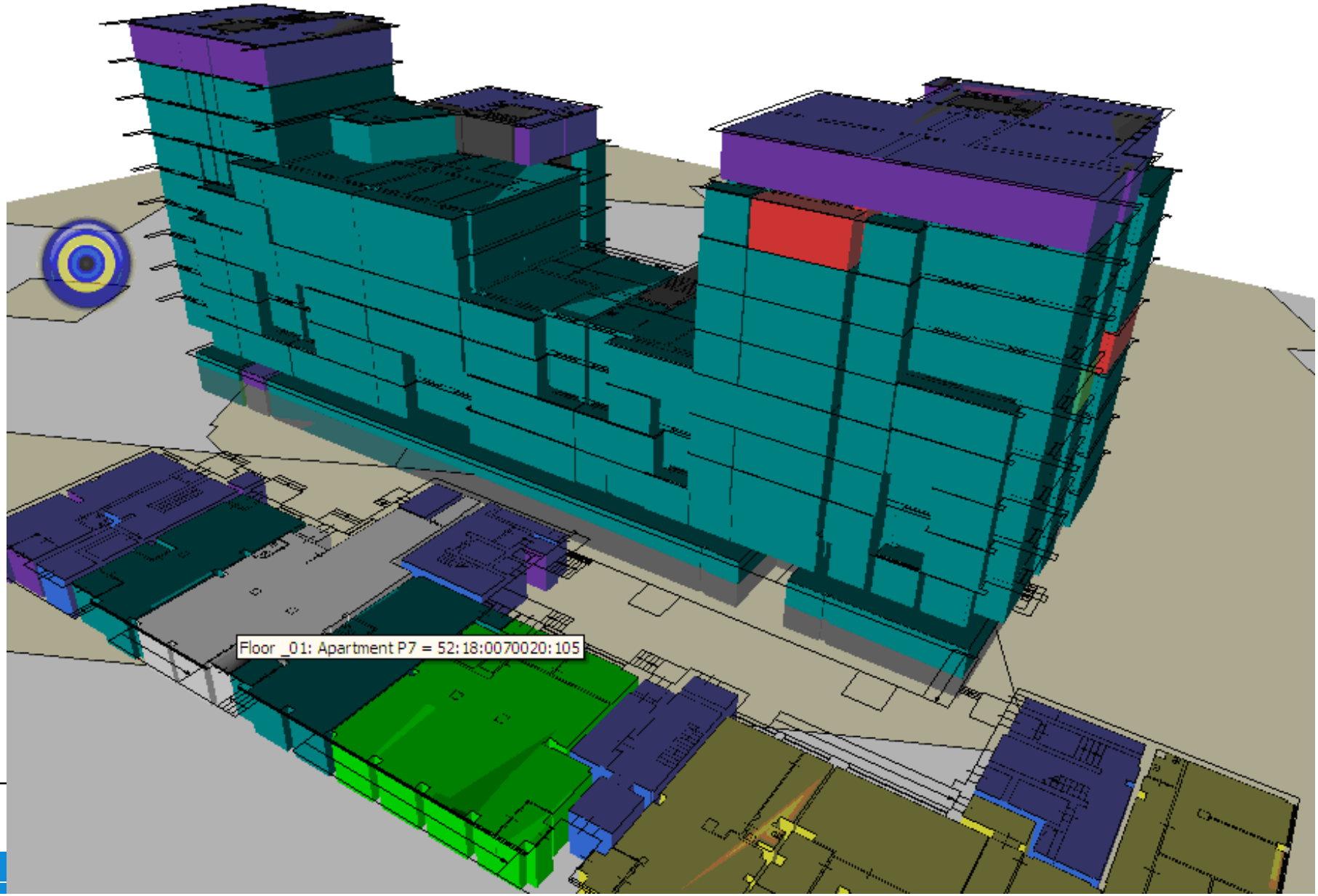
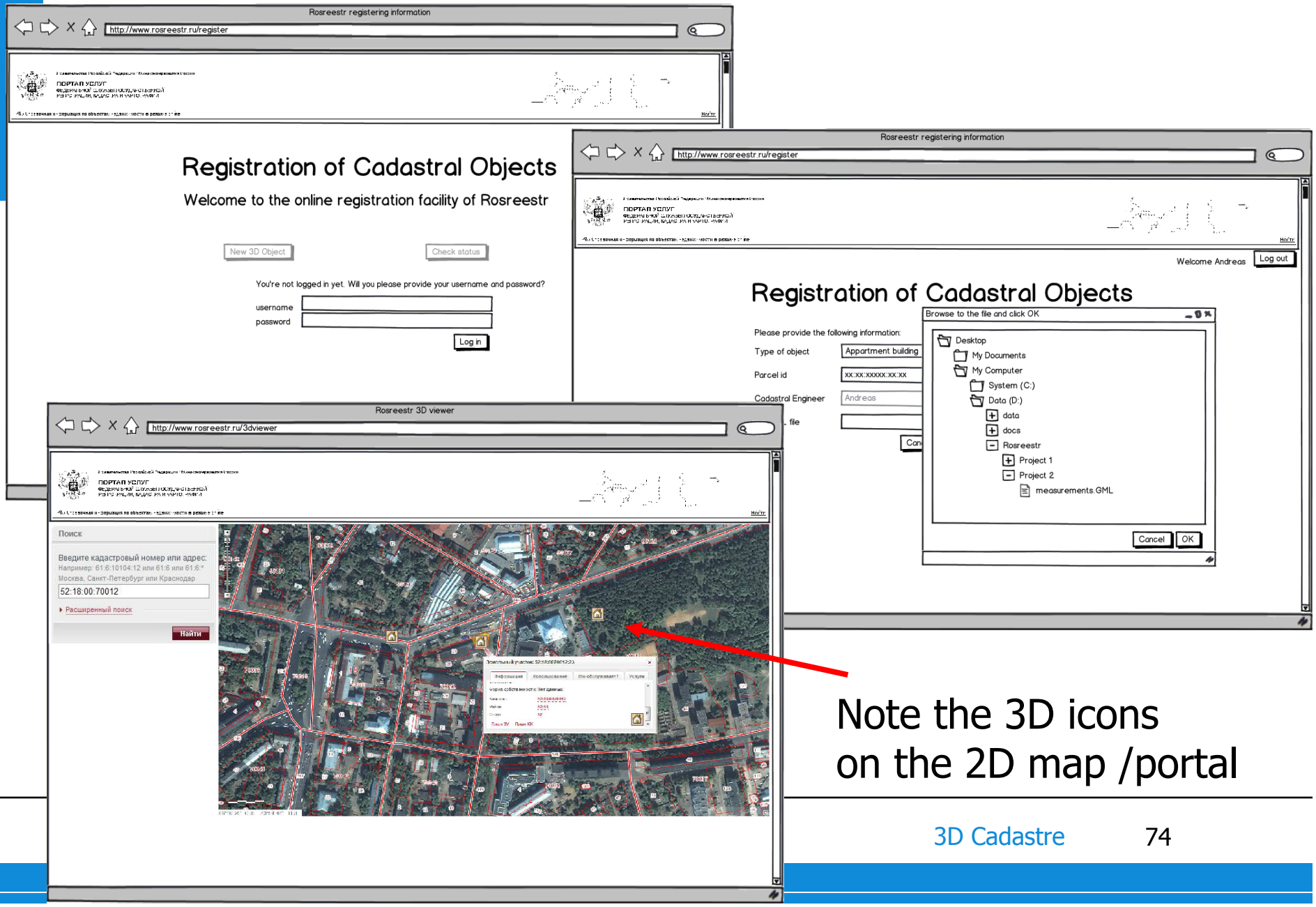
+ building
+ pipeline
+ bridge
+ tunnel


C:\Projecten\9W079601 3D Kadaster Rusland\Data\Prototypes\20120130\index_teledom.
3D cadastre Russia - proof ...
<--- back to index
Cadastral-nr 52:18:0070012:34
Помещение
P7
Этаж
5
Кадастровый номер помещения
52:18:0070012:34
Кадастровый номер здания
52:18:0070012:30
Кадастровый номер ЗУ
52:18:0070012:23
Условный номер
52-52-01/769/2010-295
Адрес Местоположение
Нижегородская область, г. Нижний Новгород, ул. Белинского, д. 9/48
Назначение помещения
нежилое
Вид права форма собственности
Собственность
Правообладатель
Общество с ограниченной ответственностью «Лига»
Ограничения обременения права
Ипотека, регистрация № 52-52-01/101/2010-057 от 14 сентября 2010 г., срок: до 01.01.2015 г.,
Площадь всех частей здания
706.1
ул. Пушкина
Move floors sideways
Identify (click on apartment unit)
Reset floors
Show floorplans
Show walls
Show ground parcels
Show topography (only Teledom)
Show DTM
Помещение
Этаж
Кадастровый номер помещения
Кадастровый номер здания
Кадастровый

Slide-out interface (look inside)



Registration mock-up



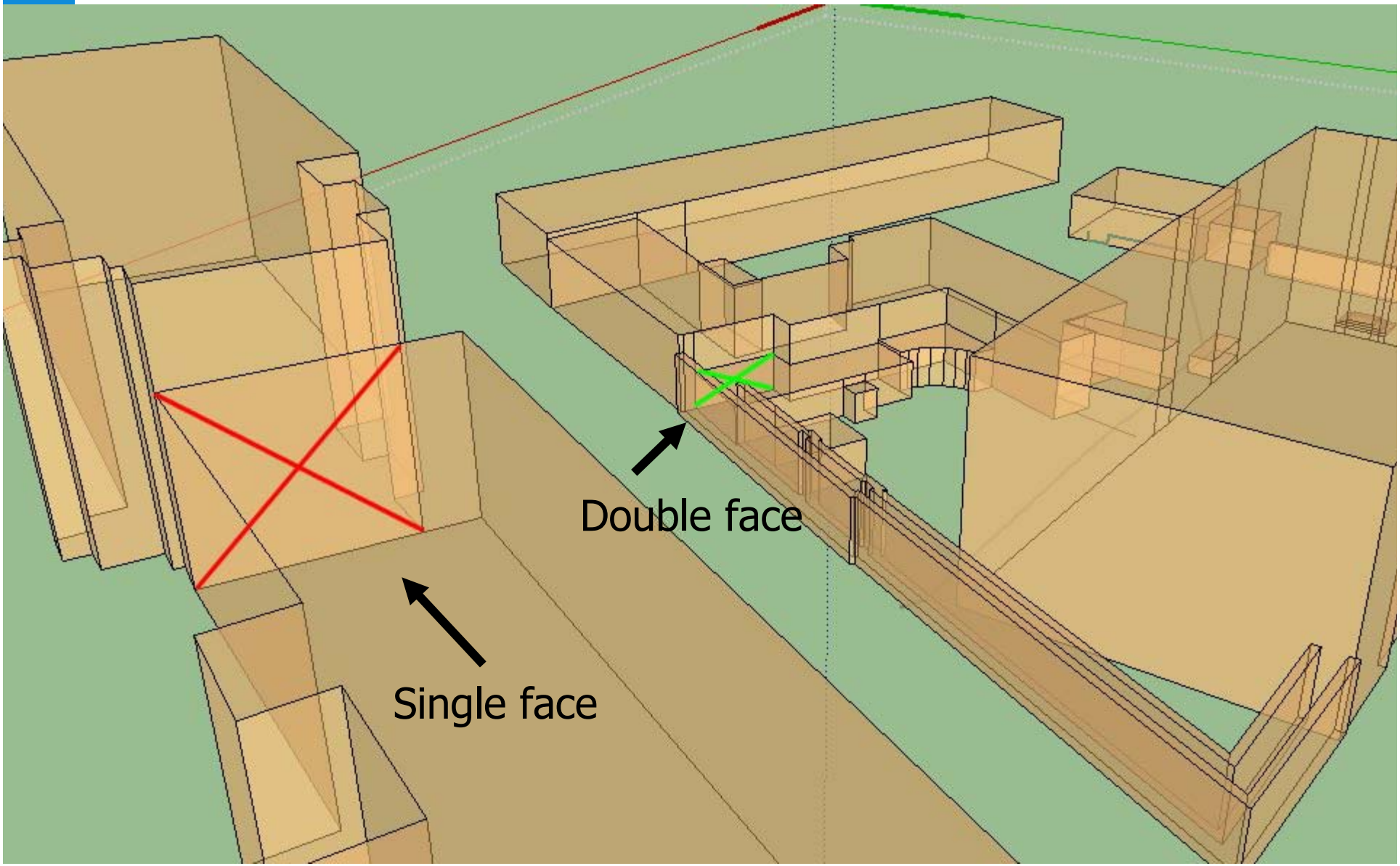
Note the 3D icons
on the 2D map /portal

Russian 3D cadastre prototype

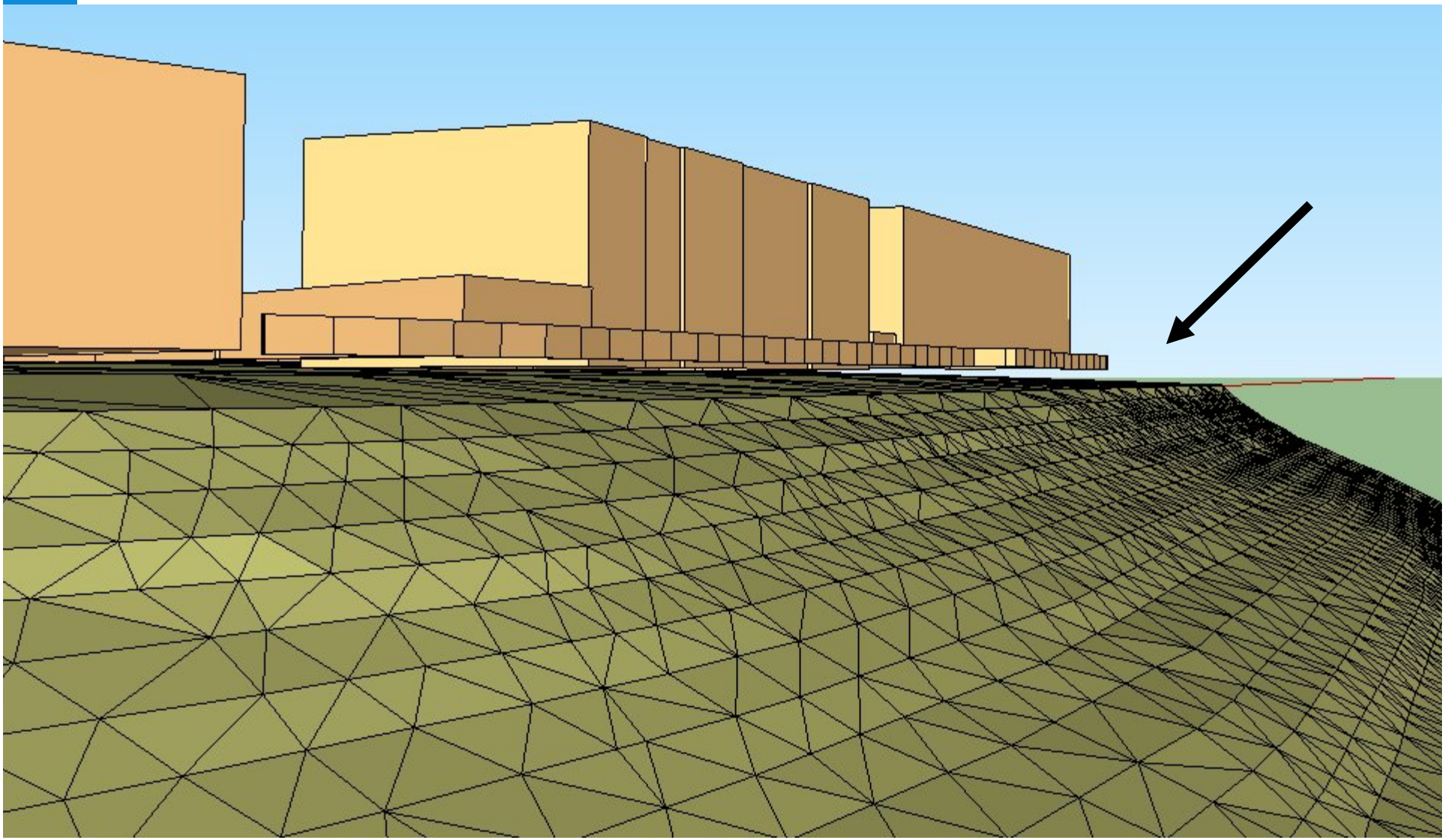
- Prototype focused on
  - Visualization of the three selected cases
  - Web dissemination of 3D cadastral objects and related admin
  - Added reference objects DTM, walls of buildings, scanned map,…
  - Spatial interaction with data in 2D/3D environment
  - Selection based on admin conditions

- Excluded from prototype/pilot, but needed:
  1. Initial registration (use of required format)
  2. Data validation (check input data quality)
  3. Data storage and management (in DBMS)

3D cadastral objects not in solid group
→ non-trivial to correct



Buildings partially floating in air (case gas pipeline)

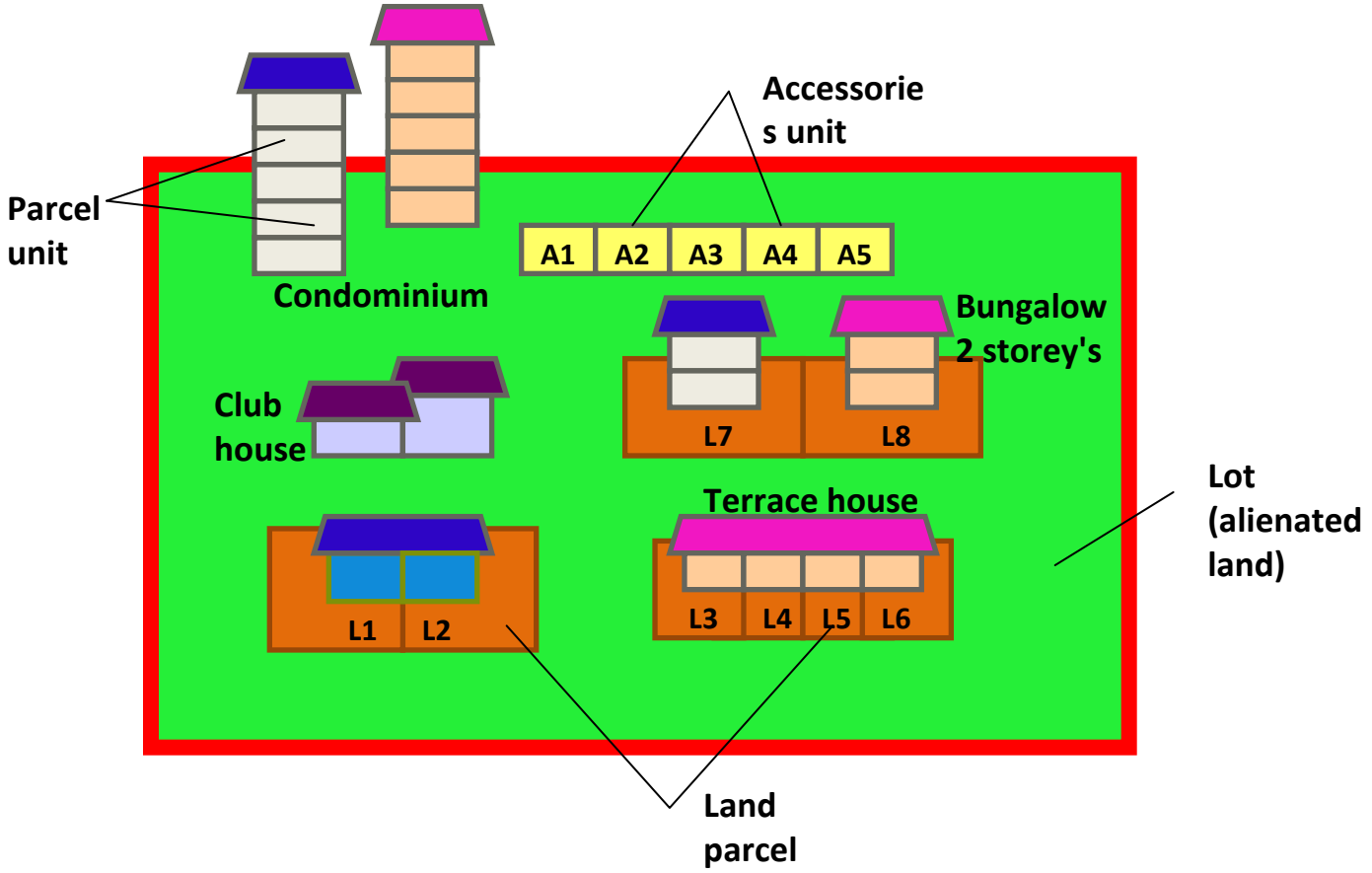


Validator

- (Automatic) check 3D cadastral object before input
- Use proper data management (right data type in DBMS) during storage
- Check for potential conflicts with other 3D objects (or columns implied by 2D surface parcel)
- Should 3D cadastral objects be connected (indirectly) to earth surface, i.e. must be reachable

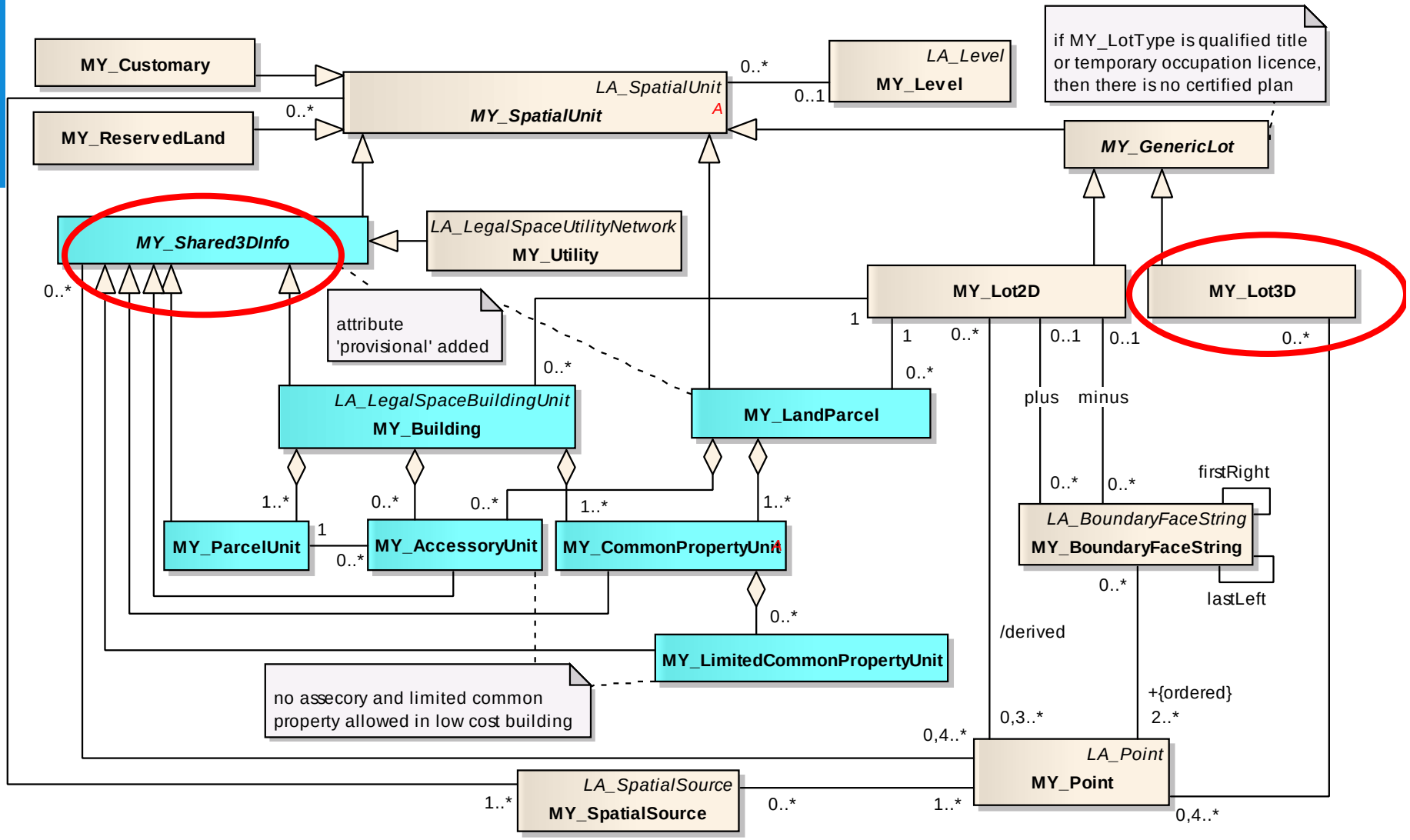
- Check spatial aspects (flat faces, partition of space)
- Check consistency between spatial – legal/admin data
- Check legal/admin attributes, proper transfer of rights between involved parties

Malaysia: integrated 2D and 3D



Various cadastral objects related to strata titles in context of one lot

Spatial data modelling based on LADM

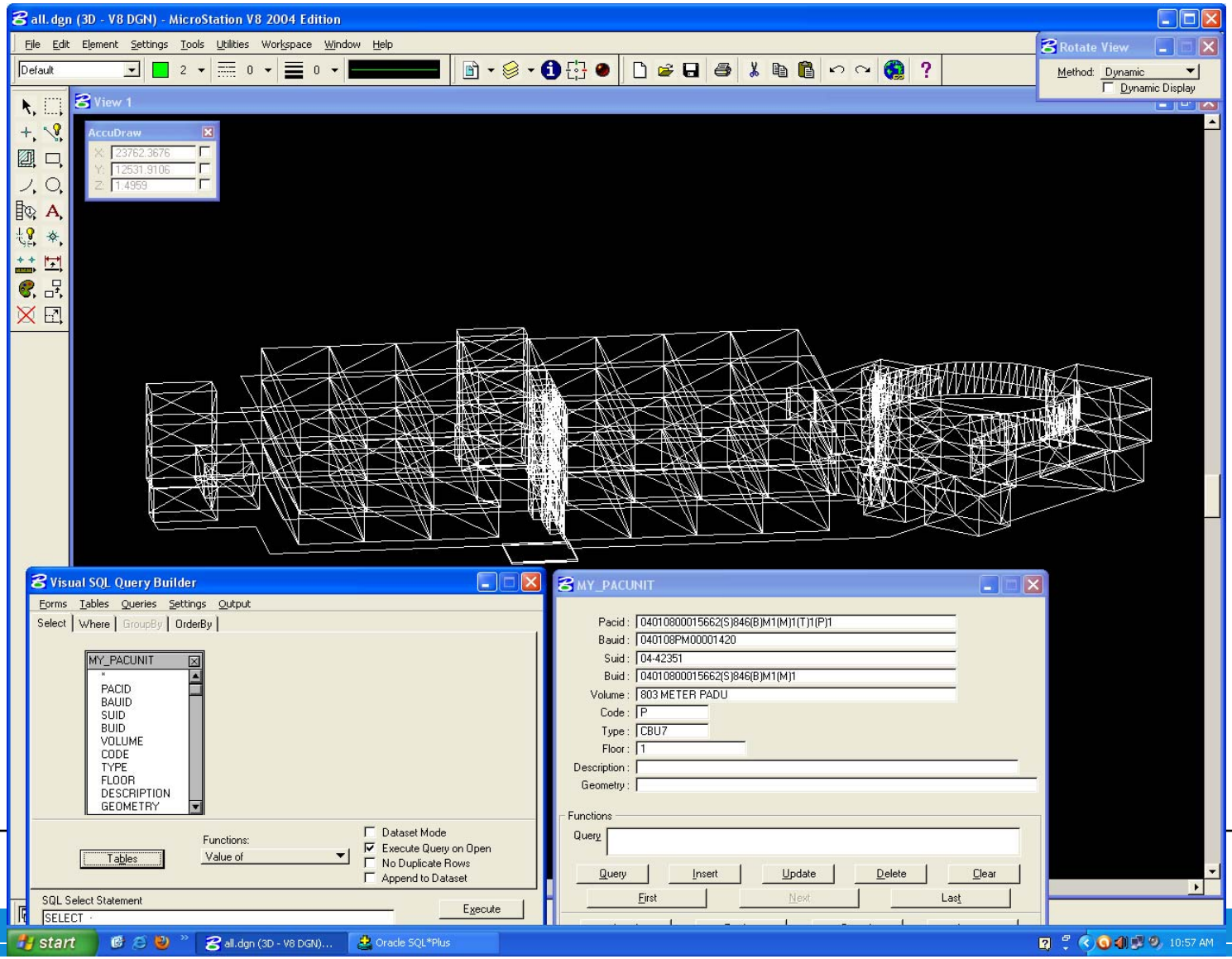


Implementation

- Convert conceptual model (UML class diagram) into technical model, decide on indexing, exact data types, references/id's, topology, history/versions,…

- Database Oracle spatial: MDSYS.SDO_GEOMETRY type
- Malaysian country profile: 2D topology structure for land parcel
- Managing 2D and 3D spatial object, Oracle Spatial supports storage for 3D points, lines and polygons
- MY_BoundaryFaceString represent 2D cadastral object
  → polyline, GTYPE=2002
- MY_Shared3DInfo represent 3D cadastral objects
  → multipolygon method, GTYPE=3007

3D Cadastral object



TU Delft

FIG 2014 congress, unofficial programme 3D Cadastres

- Transition of Property Registration from Paper to 2D to 3D – A Case Study from Bahrain (Kashram Ammar et al.)
- 3D Laser Scanning to Detect Property Encroachment (Khoo Victor H. S. et al., Singapore)
- Developing a 3D Digital Cadastral System for New Zealand (Gulliver Trent et al.)
- Let's Talk About land and property information in 3D: What Should The Future Look Like? (Rajabifard Abbas et al., Australia)
- Germany on the Way to 3D-Cadastre (Gruber Ulrich et al.)
- Development of Structure-based Topology of 3D Spatial Databases for Storing and Querying 3D Cadastre Cases (Aditya Trias, Indonesia)

FIG 2014 congress, continued…

- Developing Infrastructure Framework to Facilitate the Malaysian Multipurpose 3D Cadastre (Liat Choon Tan et al.)
- The Development of 3D City Model for Putrajaya MPC Database (Chee Hua Teng et al., Malaysia)
- Review and Assessment of Current Cadastral Data Models for 3D Cadastral Applications (Aien Ali et al., Australia)
- A Geometric-Topologic Exemplification for 3D Cadastre (Duncan Edward et al., Malaysia)
- Towards Malaysian LADM Country Profile for 2D and 3D Cadastral Registration System (Zulkifli Nur Amalina et al.)
- Integration of Data from Real Estate Cadastre, Register of Utility Networks and Topographic Database Based on LADM and CityGML Standards (Góźdź Katarzyna et al., Poland)

Content overview

1. Introduction
2. FIG working group, international overview
3. 3D in ISO 19152
4. Deep integration 3D and time
5. Netherlands developments
6. Some other countries

→ Conclusion

Conclusion

- Besides legal and technological aspects, 3D Cadastre implementation in specific country requires communication with stake holders (surveyors, notary, banks, government agencies, public), and taking (scoping) decisions

- Educate future data providers, help them with practical rules/ guidelines and tools for proper description of 3D cadastral objects:
  - What to do with wall or ceilings?
  - What horizontal and vertical reference system to use?
  - What to do with pipelines crossing multiple parcels?
  - What to do with curved surfaces (non-horizontal/vertical)?
  - What to do with partial (un)bounded objects
  - When can 3D Cadastral Unit exist (specific rules or not; e.g. relation to construction or connection to Earth surface)?

Cost of realizing 3D Cadastral system

- Some cadastral organizations estimate limited cost for realization as often: 3D data will originate from outside
- But registration guidelines are crucial

- Possible sources:
  1. Survey in 3D
  2. Old floor plan upgraded to 3D volumes
  3. New architecture design (CAD) directly in 3D

- In all cases:
  1. Agree on submission format (LADM, encoding CityCML/LandXML/..)
  2. Rules for valid 3D objects
  3. Automated checking as much as possible

Intention often more than 3D Cadastre
…full life cycle in 3D

Involved steps (order differs per country):

1. Develop and register zoning plans in 3D
2. Register (public law) restrictions in 3D
3. Design new spatial units/objects in 3D
4. Acquire appropriate land/space in 3D
5. Request and provide (after check) permits in 3D
6. Obtain and register financing (mortgage) for future objects in 3D
7. Survey and measure spatial units/objects (after construction) in 3D
8. Submit associated rights (RR)/parties and their spatial units in 3D
9. Validate and check submitted data (and register if accepted) in 3D
10. Store and analyze the spatial units in 3D
11. Disseminate, visualize and use the spatial units in 3D

Further development

- 3D Cadastre is here to stay and #implementations increase
- Often renewal in combination with LADM conformance
- In 3D even more need to connect to other registrations via SDI: buildings, tunnels, cables/pipelines, terrain elevation, etc. (physical and legal 3D objects should be aligned)

- FIG 3D cadastres working group continues for term 2014-2018
- Most of the earlier topics remain
- However, emphasis on following topics:
  1. Experiences of operation 3D Cadastral systems (law, organization, technology)
  2. 3D Cadastre in mega-cities, often in Latin-America (Brazil, Mexico), Asia (China, Malaysia, Korea, Singapore) and Africa (Nigeria)
  3. 3D Cadastre usability studies, web-dissemination and 3D cartography

Next 3D Cadastres workshop

- 4th International FIG 3D Cadastre Workshop, 9-11 November 2014 (in cooperation with the 3D GeoInfo Conference, 11-13 November 2014)

- Tentative timetable:
  1. 30 June 2014: Extended abstract (500-1000 words)
  2. 7 September 2014: Author notification
  3. 9 October 2014: For accepted submissions, final version full paper
  4. 9-11 November 2014: Workshop

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Questions?

Peter van Oosterom