

LADM-v2 as Core Information Model for the Smart City 3DGI: 3D Cadastres, 3D Valuation and 3D Spatial Planning Information

Peter van Oosterom

On behalf of LADM core team: Chrit Lemmen, Abdullah Alattas,
Agung Indrajit, Eftychia Kalogianni, Abdullah Kara, Anna Shnaidman

29 August 2019
Campus FHNW, MuttENZ,
Switzerland



Overview

- Land Administration Domain Model (v2)
- 3D Cadastres
- 3D Valuation
- 3D Spatial Planning Information
- More in the revision of LADM
 - 3D Indoor
 - 3D Marine
 - Much more...

UN definition (1996, UN-ECE report)

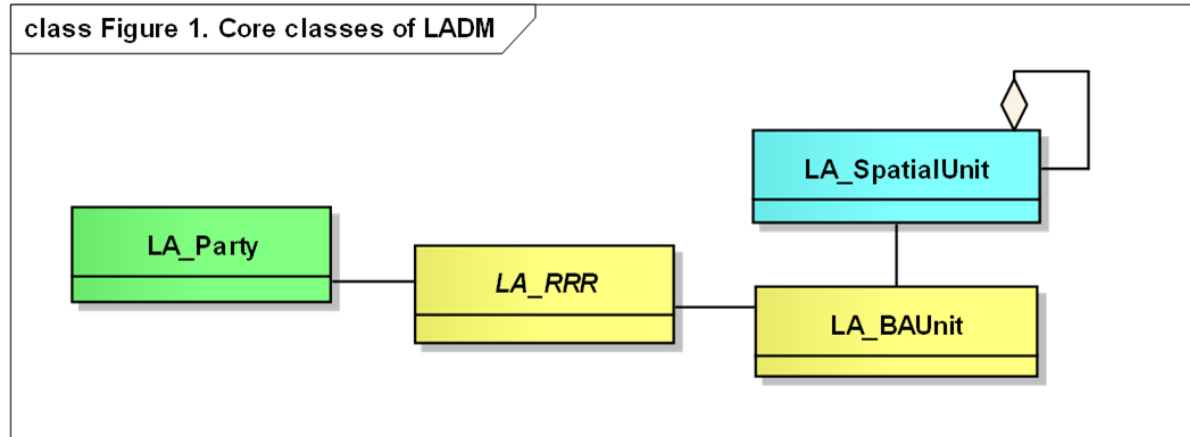
Land administration

- “.. the processes of recording and disseminating information about
- the **ownership**,
 - **value**
 - and **use** of land and its associated resources”



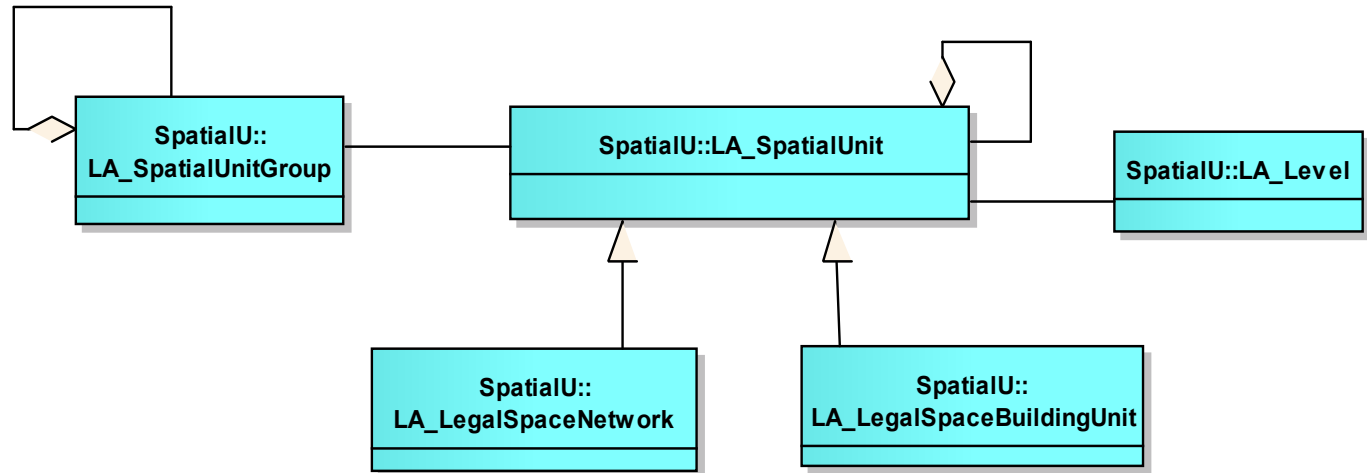
Land Administration Domain Model ISO 19152:2012 (LADM)

- It is an information model, at **conceptual** level
- It includes:
 - Spatial part (geometry, topology)
 - Extensible framework for legal/administrative part

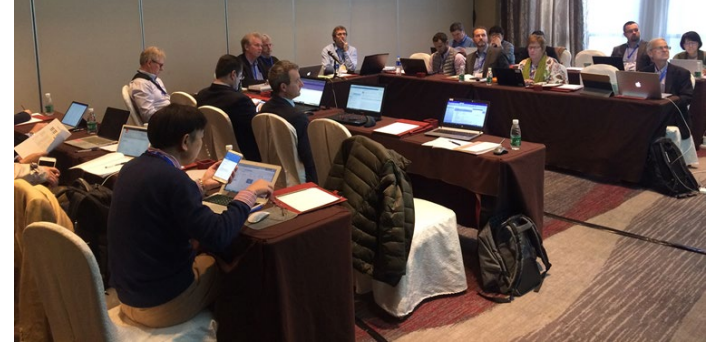


LA_SpatialUnit (alias LA_Parcel)

- LA_SpatialUnit specializations: network, building unit
- 5 types: **point, text (unstructured) line, polygon, and topology**
- 2D and 3D integrated without complicating 2D



LADM revision

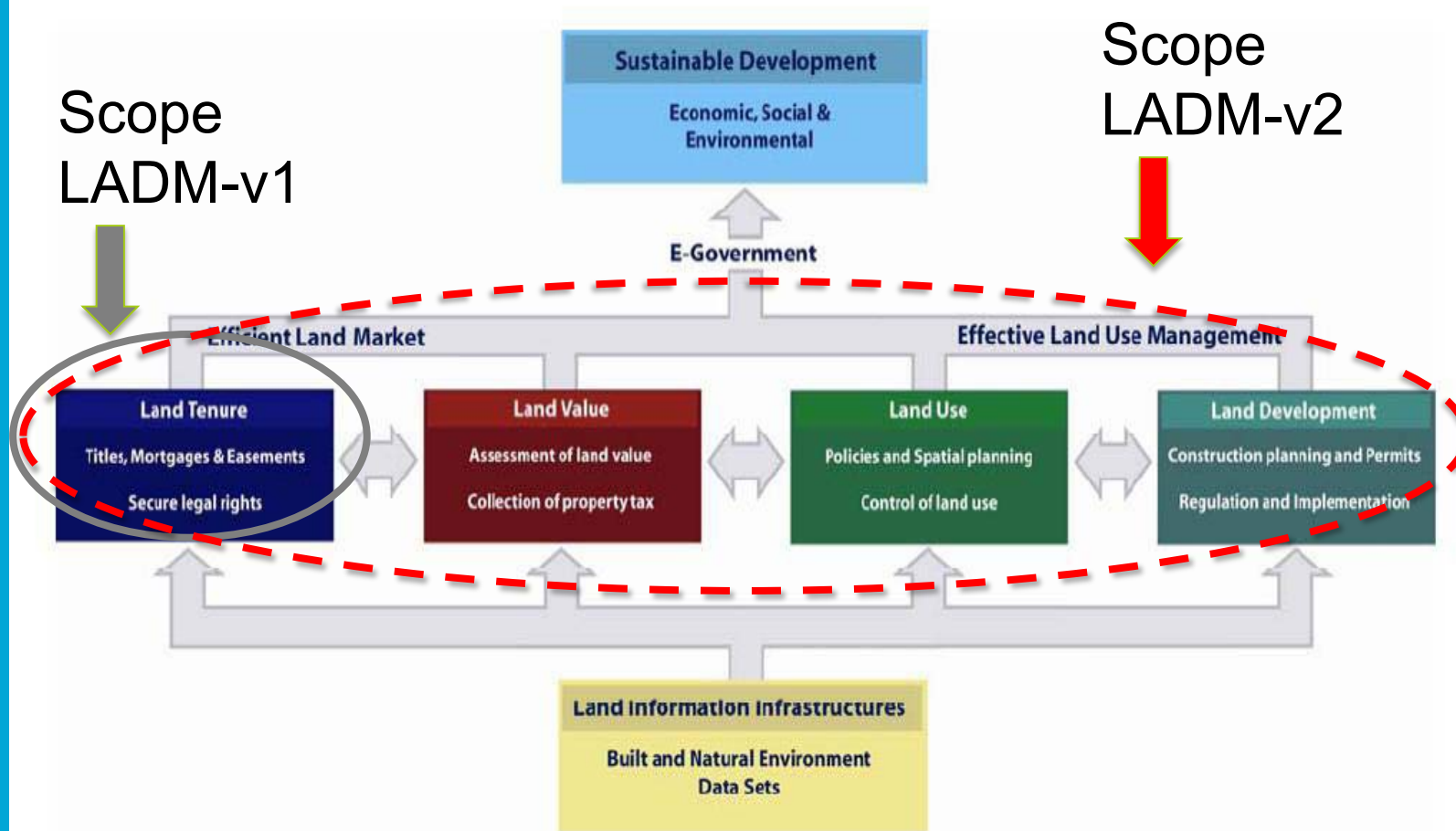


- Proposal to revise LADM 2017 after UN GGIM EGM and FIG LADM Workshop in Delft NL
- LADM Workshops in Zagreb 2018 and **Kuala Lumpur 2019**
- ISO/TC 211 Meetings Copenhagen 2018, Wuhan 2018, Maribor 2019 and **Omiya 2019**
- Initiate Stage 0 to gather all requirements from a diverse group of organisations

Enemark (2006)

Scope
LADM-v1

Scope
LADM-v2





ISO process

```
graph TD; 00[Preliminary 00] --> 10[Proposal 10]; 10 --> 20[Preparatory 20]; 20 --> 30[Committee 30]; 30 --> 40[Enquiry 40]; 40 --> 50[Approval 50]; 50 --> 60[Publication 60]; 60 --> 90[Review 90]; 90 --> 10; 90 -- Confirm --> 60; 90 --> 95[Withdrawal 95];
```

The ISO process flowchart illustrates the stages of standard development:

- Preliminary 00**: Preliminary work item "Stage 0"
- Proposal 10**: New work item proposal (NWIP)
- Preparatory 20**: Working Draft(s) WD
- Committee 30**: Committee Draft(s) CD
- Enquiry 40**: Draft International Standard (DIS)
- Approval 50**
- Publication 60**: International Standard
- Review 90**: Confirm (leads back to Publication 60)
- Withdrawal 95**

The ISO logo is visible in the top right corner.

Nominated experts → Switzerland?

- Australia (SA): 1. Mohsen Kalantari, 2. Sudarshan Karki
- Canada (SCC): 3. Jean-François Beaupré
- China (SAC): 4. Wenchao Liu
- Czech Republic (UNMZ): 5. Karel Janecka
- Finland (SFS): 6. Tarja Myllymäki
- Japan (JISC): 7. Yoko Horie
- Republic of Korea (KATS): 8. Yong Ho Lee
- New Zealand (NZSO): 9. Peter Smith, 10. Mike Judd, 11. Richard Murcott
- Norway (SN): 12. Olaf Østensen
- South Africa (SABS): 13. Dinao Tjia
- Spain (UNE): 14. Amalia Velasco, 15. Arturo Aranguren
- Sweden (SIS): 16. Magnus Linnér, 17. Jesper Paasch
- United Kingdom (BSI): 18. John Clutterbuck
- United States (ANSI): 19. Sean Uhl, 20. Carsten Bjornsson
- FIG: 21. Christiaan Lemmen, 22. Peter van Oosterom, 23. Anna Shnaidman, 24. Agung Indrajit, 25. Eftychia Kalogianni (note liaison)

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Air Rights

22 July'19
NY Times

3D parcel

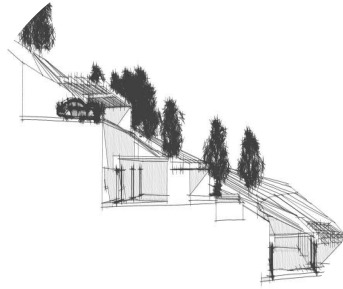
The New York Times

How Much Is a View Worth in Manhattan? Try \$11 Million

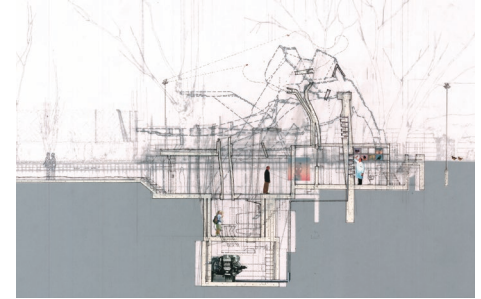
When a group of loft owners were confronted with a proposed tower that would have blotted out their views, they gave a developer \$11 million to not build.



Classification of spatial unit types



<http://www.asmecbg.com/projects.html>



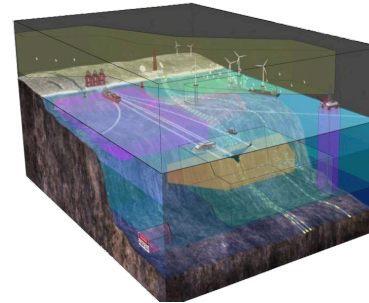
<https://www.pinterest.com/Storpweber/>



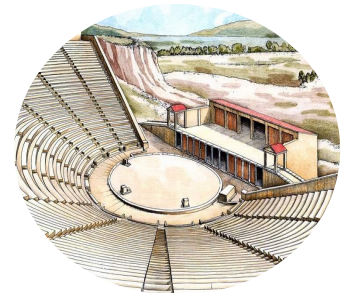
<https://www.tap-ag.com/>



Kitsakis and Dimopoulou, 2014



<https://marinecadastre.gov/>

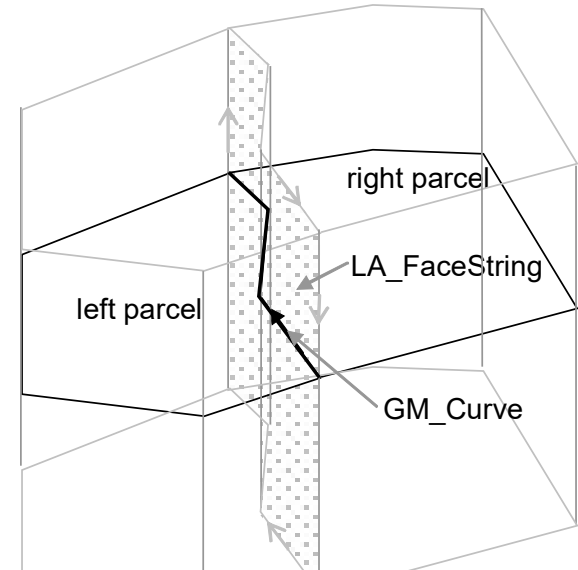
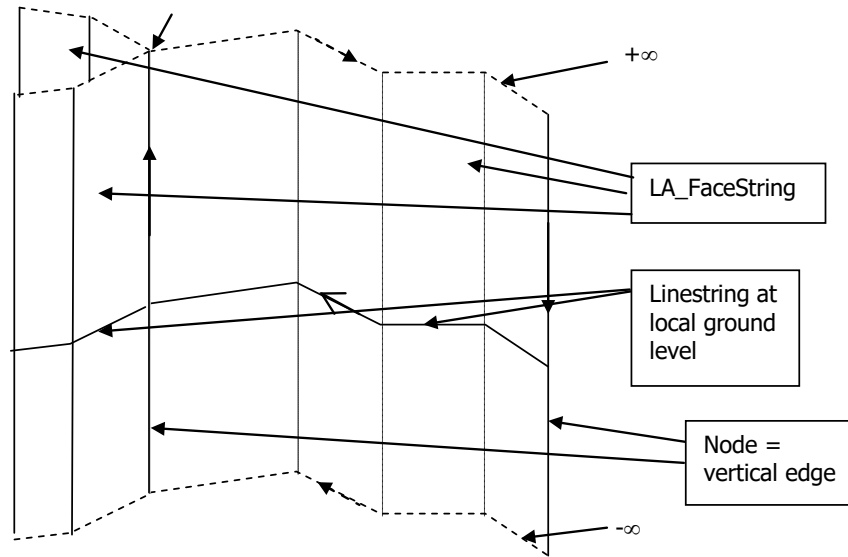


Spatial Units in 3D

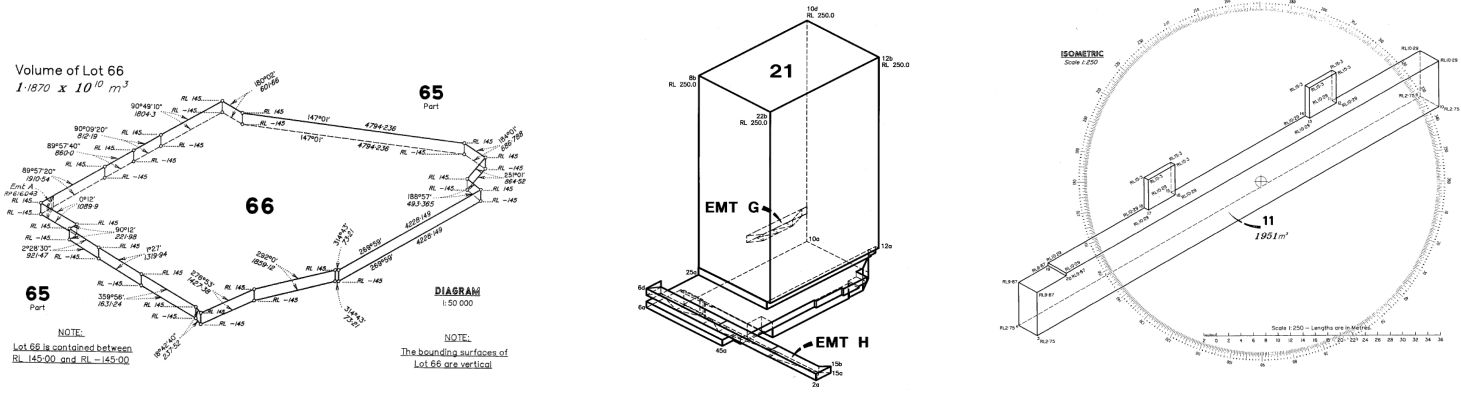
- Extend the equivalent concept from 2D to 3D
→ 3D parcels are in areas of highest land values
- Sharing of boundary surfaces between 3D parcels
where boundary lines would be shared in 2D (topology)
- point-line-area becomes point-line-area-volume
- **Challenges:**
 1. Majority of parcels is in 2D and 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), therefore alternative needed

2D parcels and their 3D interpretation

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



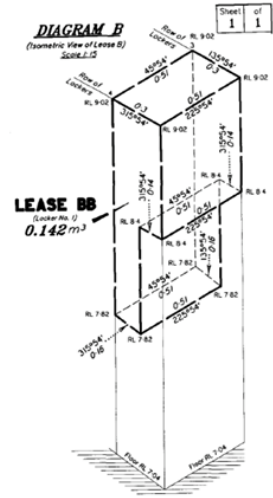
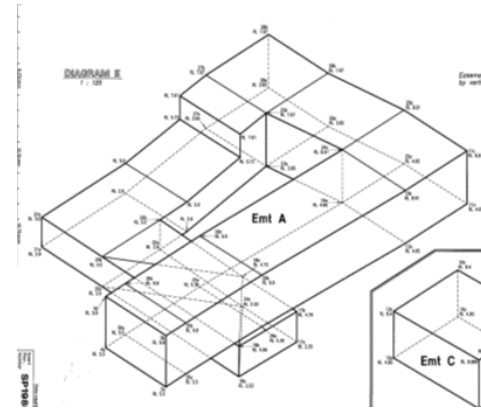
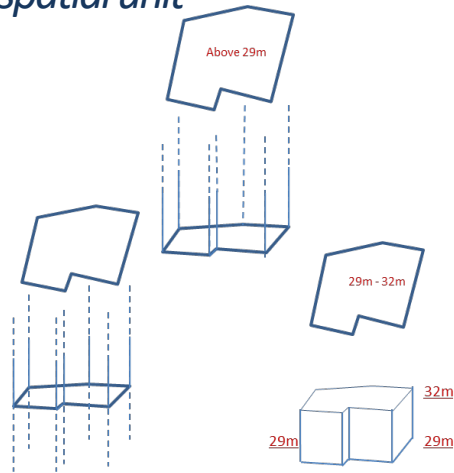
2D and 3D Representations of Spatial Units



The initial classification of 3D spatial units was provided by Thompson et al. [2015]. The defined spatial units' categories are listed on next slide in an order of growing complexity

Categorization of 3D Spatial Units

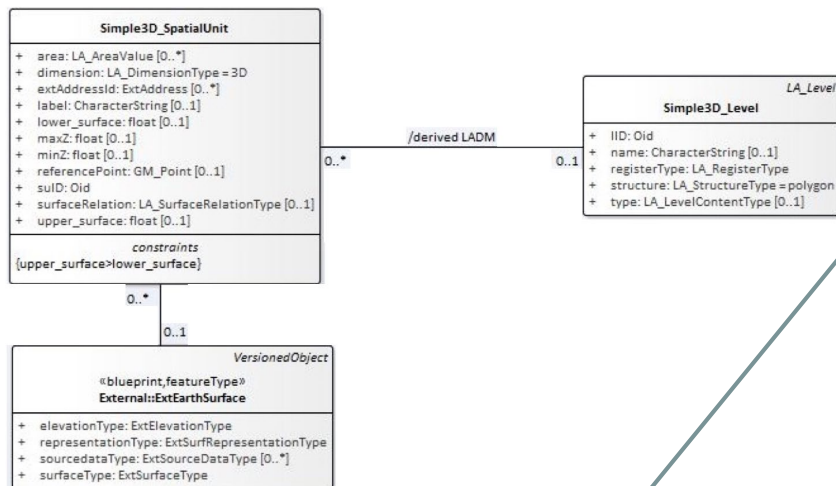
1. *Semi-open spatial unit*
2. *Polygonal slice spatial unit*
3. *Single-valued stepped spatial unit*
4. *Multi-valued stepped spatial unit*
5. *General 3D spatial unit*
6. *Building/construction format spatial unit*
7. *Balance spatial unit*



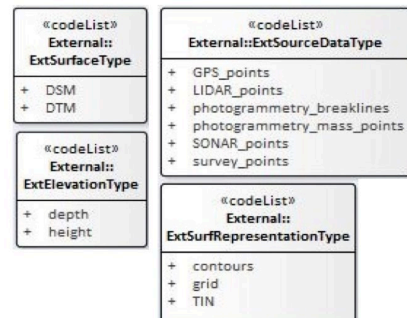
Spatial Units & Spatial Profiles

1. Simple 3D Spatial Profile: polygonal slice & semi-open spatial units

The Simple_3D profile describes 3D parcels that are encoded as 2D parcels, restricted between two horizontal, single-valued surfaces, which must not intersect or touch. Polygonal slice and semi-open spatial units can be modelled within this. It adds two attributes at the Simple3D_SpatialUnit class to define the values/heights of the upper and lower surfaces that form the polygon. New default values are used and associated constraints are imposed.



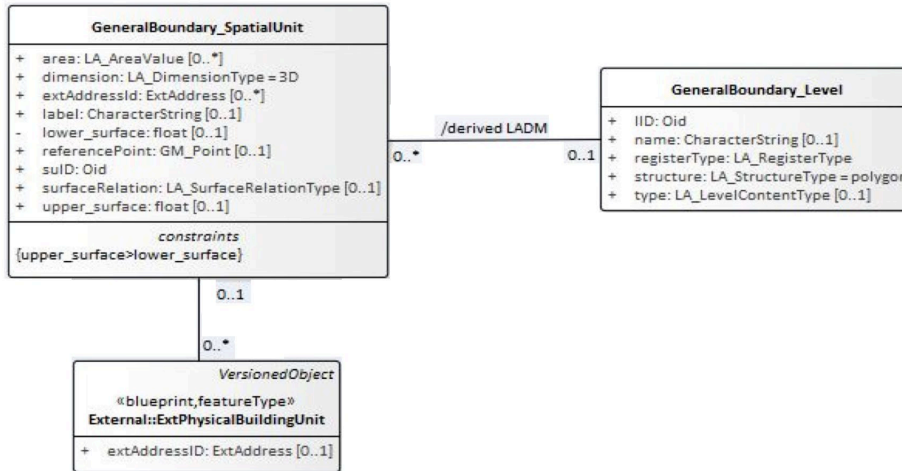
Proposed code lists
for External Class:: ExtEarthSurface*



*following the concept of the Elevation Theme of INSPIRE

2. General Boundary 3D Spatial Profile: Building/Construction format spatial units

The General Boundary Spatial Unit profile describes 3D parcels that are legally defined by the extents of an existing or planned structure that contains/will contain the unit. There are two ways to describe and spatially represent the spatial unit: by referring to a building format or by defining its actual shape by geometrical types. New attributes and default values are used and associated constraints are imposed.



A building/ construction format spatial unit is legally defined by the extents of an existing or planned structure that contains/will contain the unit.

It can be described and spatially represented by:

- referring to a building format (e.g. BIM/IFC) or
- defining its actual shape by geometrical types

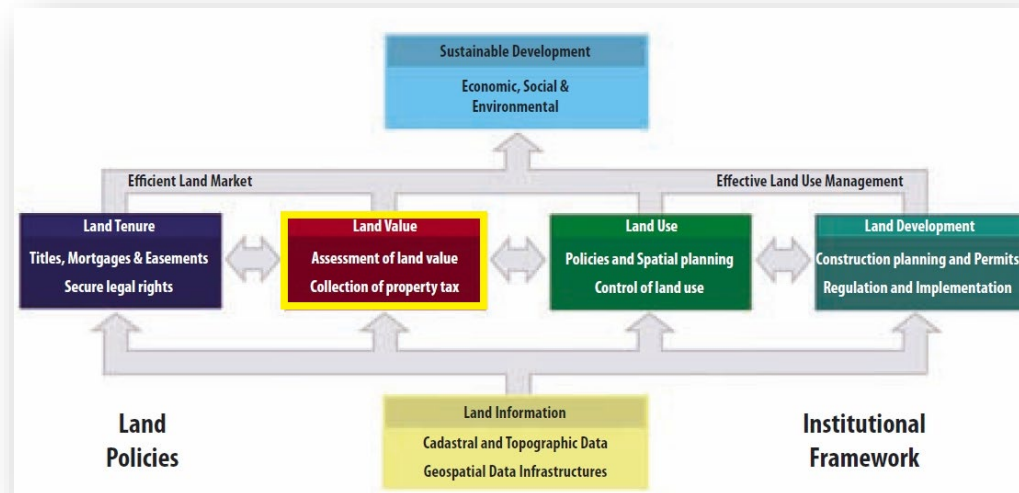
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 - 3D Marine
 - Much more...

Property Valuation

- **Land administration** is the processes of determining, recording and disseminating information about the ownership, **value** and use of land
- There is no **internationally accepted information model** that defines **semantics of property valuation inventories**

- **LADM-v2**
Valuation
Information
Package



Property Valuation Information Model

VM_Valuation defines input and output data used and produced within single or mass appraisal processes such as valuation method, value type.

VM_MassAppraisal specifies mass appraisal-related information. (e.g. statistical method, analysis type).

VM_ValuationUnit represents basic recording units of valuation registries (e.g. Land, building).

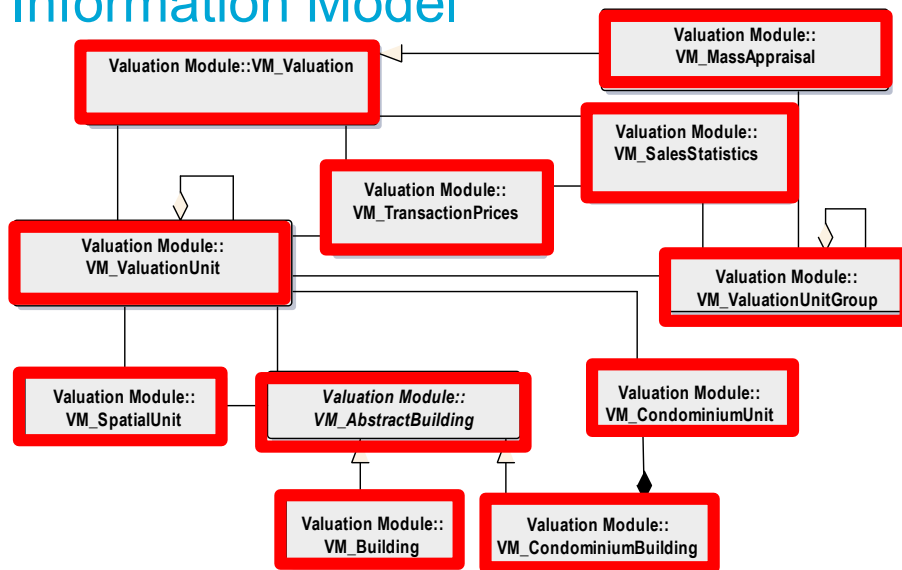
VM_ValuationUnitGroup clusters valuation units according to zones that have similar characteristics.

VM_SpatialUnit specifies cadastral parcels, and sub-parcels (collection of a number of parcels and their land use types).

VM_AbstractBuilding, **VM_Building**, **VM_CondominiumBuilding**, **VM_CondominiumUnit** specifies physical aspects of buildings, building parts (condominium units).

VM_TransactionPrices defines information content of transaction contracts or declarations provided by parties.

VM_SalesStatistics represents information related to price statistics produced through analysis of transaction prices.



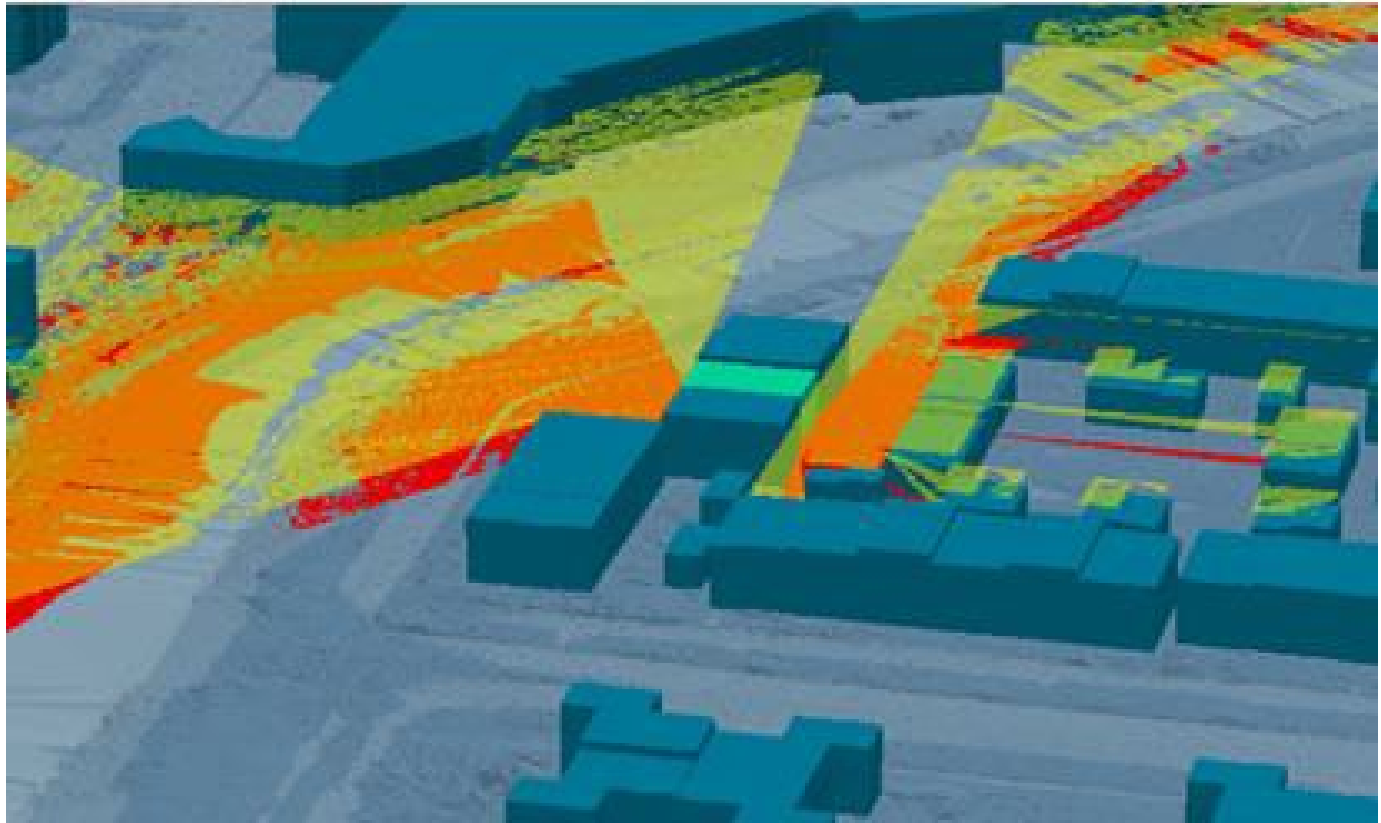
- (1) LADM → A continuum of rights and spatial units, Valuation → Rights attached to land are required.
- (2) The other standards are maximally reused when developing the model.

The **LADM VM** extension consists of 11 main classes, 7 data types and 18 code lists

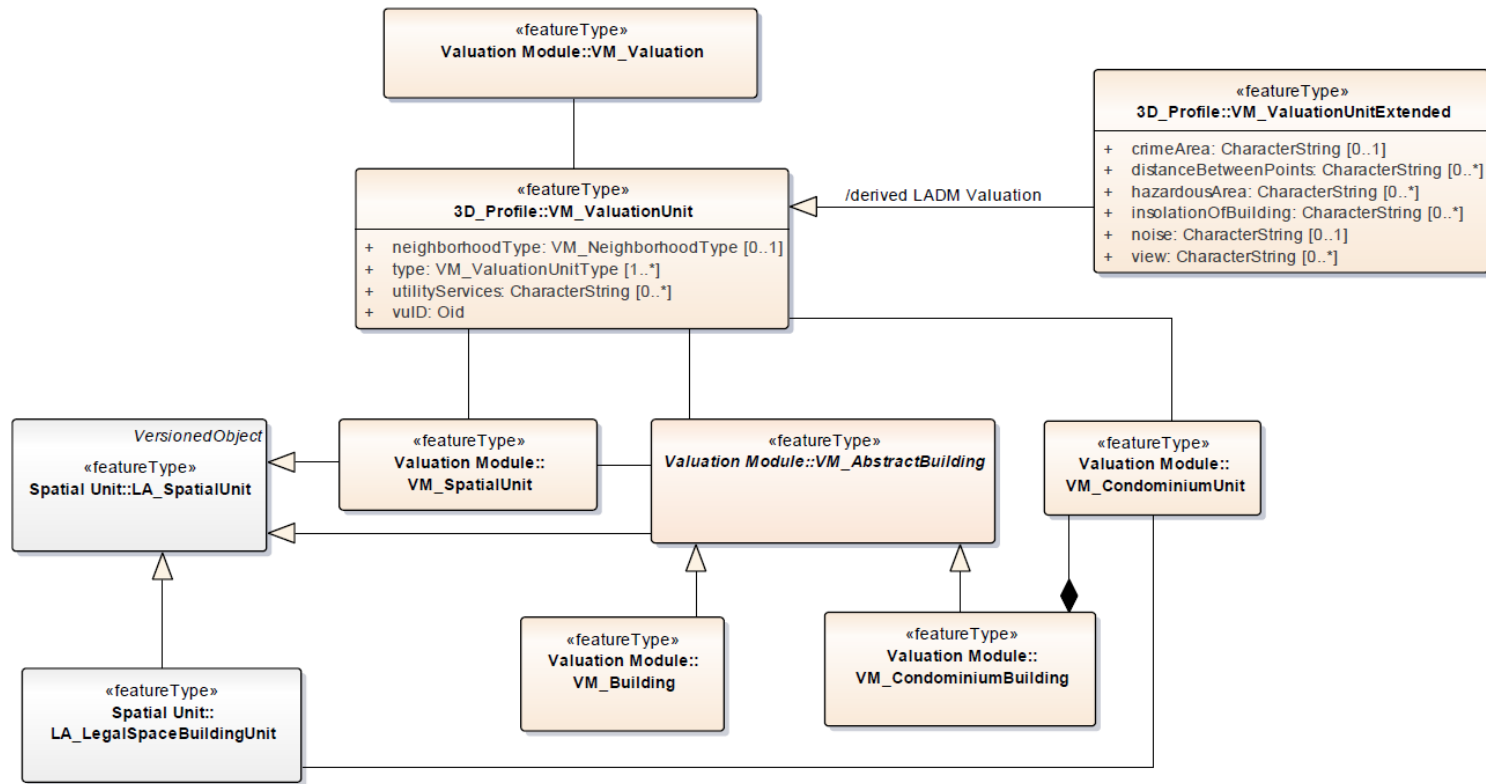
3D for property valuation

- 3D RRRs (legal) and 3D physical objects
- **3D view analysis** (lake, ocean, golf and mountain view)
- 3D noise analysis (e.g. airport and neighborhood noise) (Wilhelmsson, 2000; Cohen and Coughlin, 2008)
- 3D hazard analysis (Ghanbarpour et al., 2014)
- 3D crime analysis (Wolff and Asche, 2009)
- 3D insolation analysis (sunlight and daylight analyse) (Helbich et al., 2013)
- 3D distance to points of interest (central business district, metro station, busy road, beach, waste, school, ...)

Viewshed polygons for two levels:
yellow=top, red=one level lower



Proposed 3D valuation unit profile



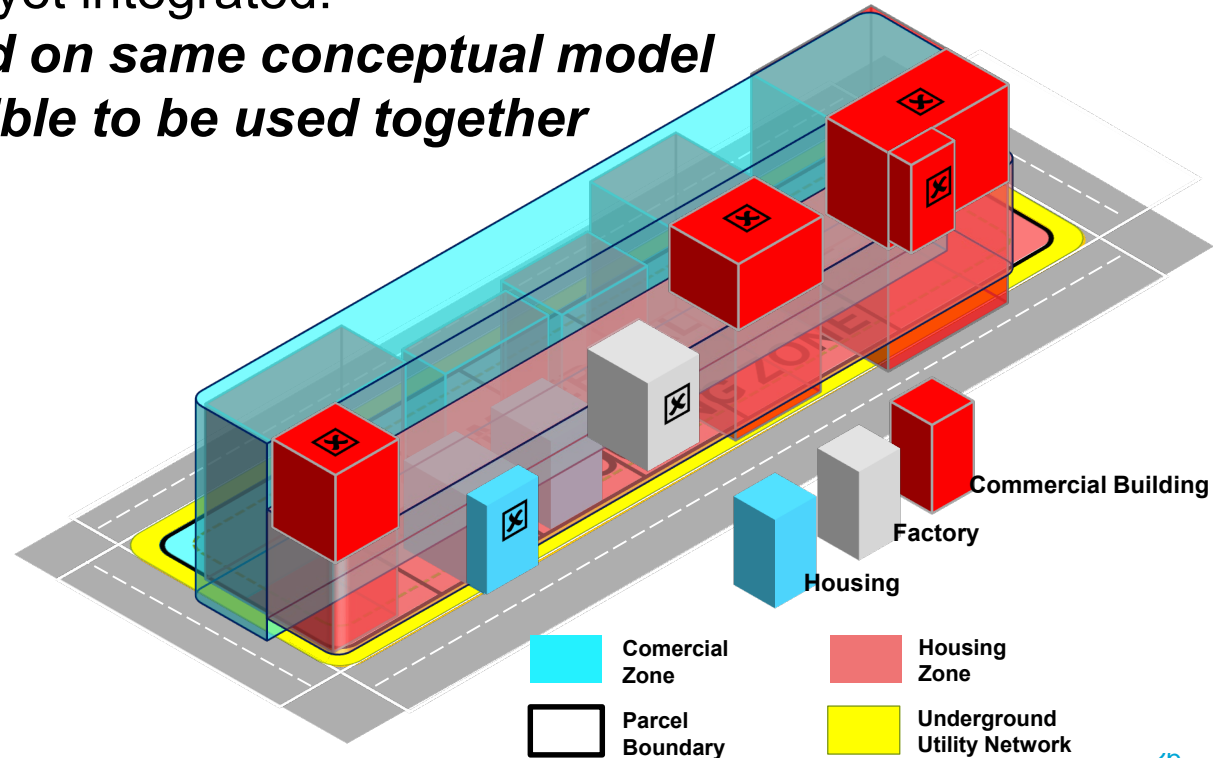
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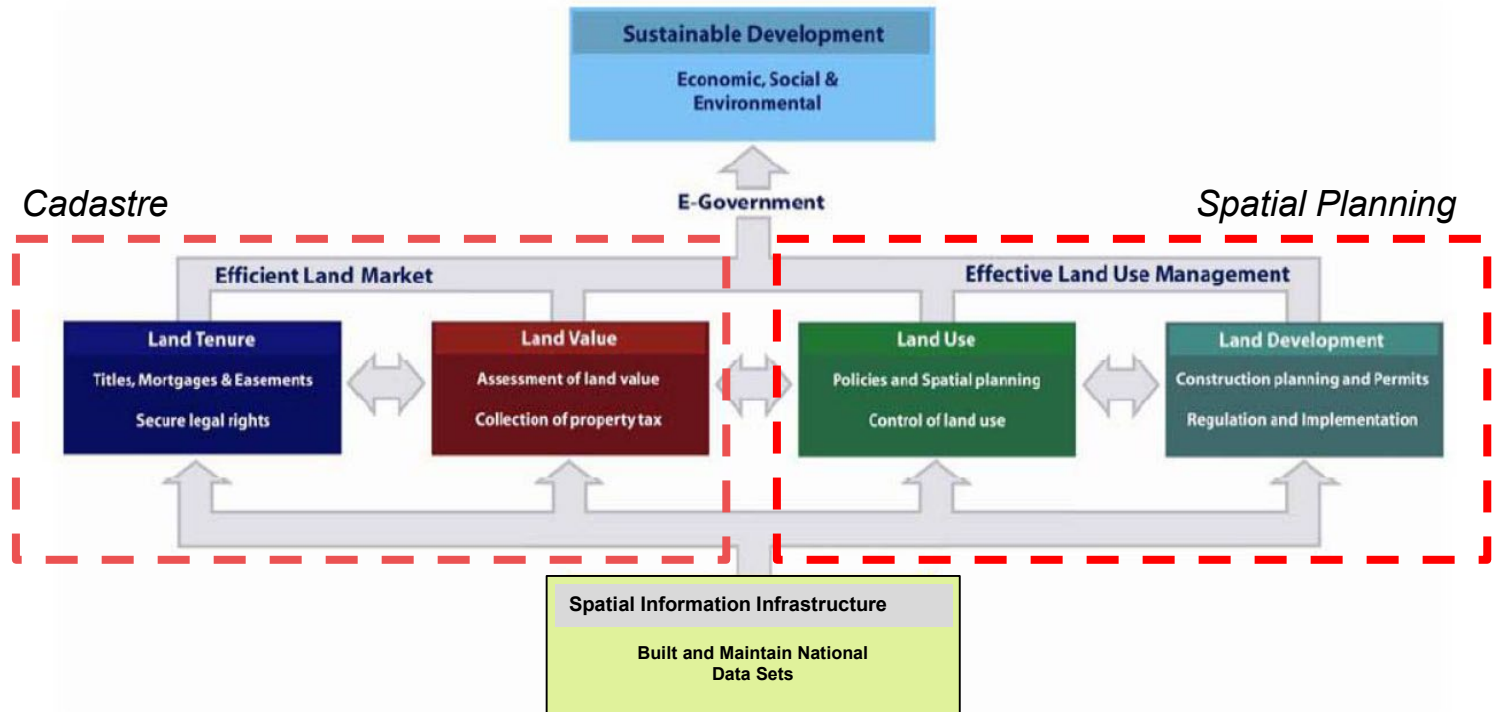
Today's mismatch

Land registry and planned land use information is today not yet integrated:

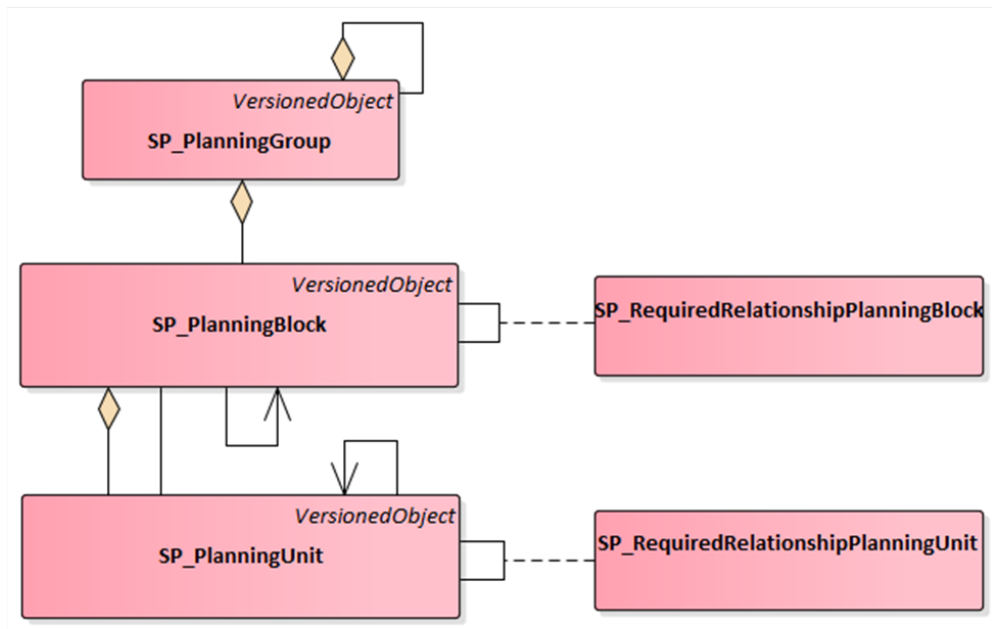
- 1. not based on same conceptual model***
- 2. not possible to be used together***



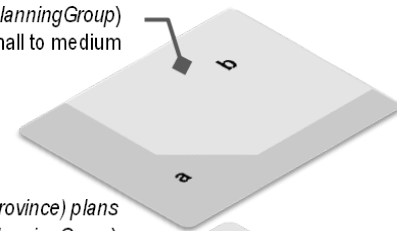
Integrated Information is needed



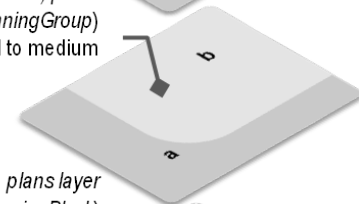
Added to LADM-v2: Spatial Planning Information Package



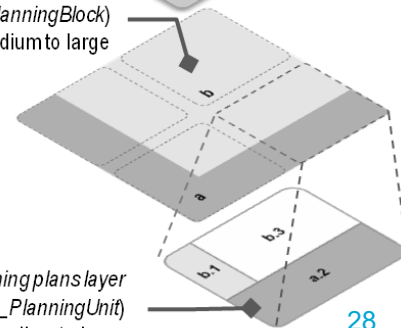
Spatial (national) plans
(SP_PlanningGroup)
Map scale: small to medium



Spatial (province) plans
(SP_PlanningGroup)
Map scale: small to medium



Spatial (city) plans layer
(SP_PlanningBlock)
Map scale: medium to large



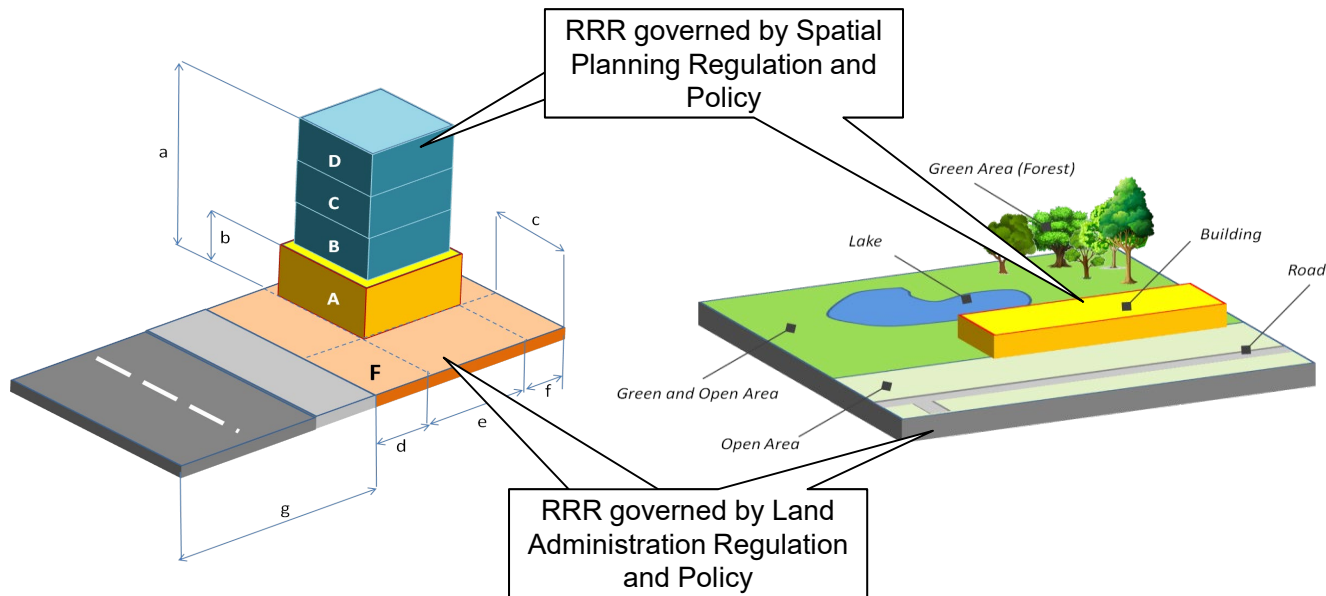
Zoning plans layer
(SP_PlanningUnit)
Map scale: medium to large

Adapted from Indrajit et al. (2018)

Definitions of new concepts

Proposed Classes (Modified from INSPIRE and Plan4All Project)	
<i>SP_PlanngBlock</i>	Represents Planned Land Use (PLU) that corresponds to spatial plans, defined by spatial planning authorities, depicting the possible utilization of the land in the future. Planned land use is regulated by spatial planning documents elaborated at various levels of administration. Land Use regulation over a geographical area is in general composed of an overall strategic orientation, a textual regulation and a cartographic representation.
<i>SP_PlanngUnit</i>	A featuretype that consist of polygons that is mutually exclusive. The SP_PlanningUnit is part of SP_PlanningBlock that represents zoning arrangement with regulation regarding the Potential Land Use development. SP_PlanningBlock contains the SP_PlanningUnit to express the planned land use defined by the authority via SP_SpaceFunction attribute. SP_PlanningUnit have several specific attributes to accomodate Rights, Restrictions and Responsibilities.
<i>SP_PlanngGroup</i>	The administrative hierarchy of spatial planning.
<i>SP_RequiredRelationshipPlanningUnit</i>	Represents instances of relationship between two or more zoning plans according to location or time
<i>SP_RequiredRelationshipPlanningBlock</i>	Represents instances of relationships between spatial plans.
<i>LA_LegalOpenSpaceUnit</i>	The class represent spaces within a land parcel that are not allowed to be built on.

Spatial planning information as part of Complete land administration



Spatial planning regulates total height of a building on a parcel

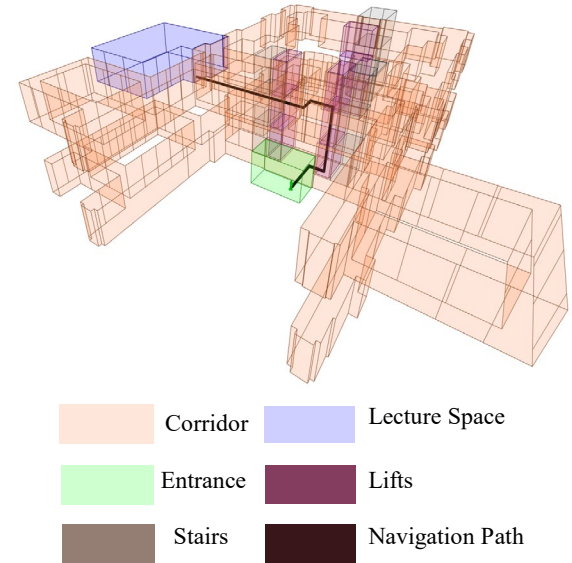
Spatial planning regulates ratio of the land use over an area

Overview

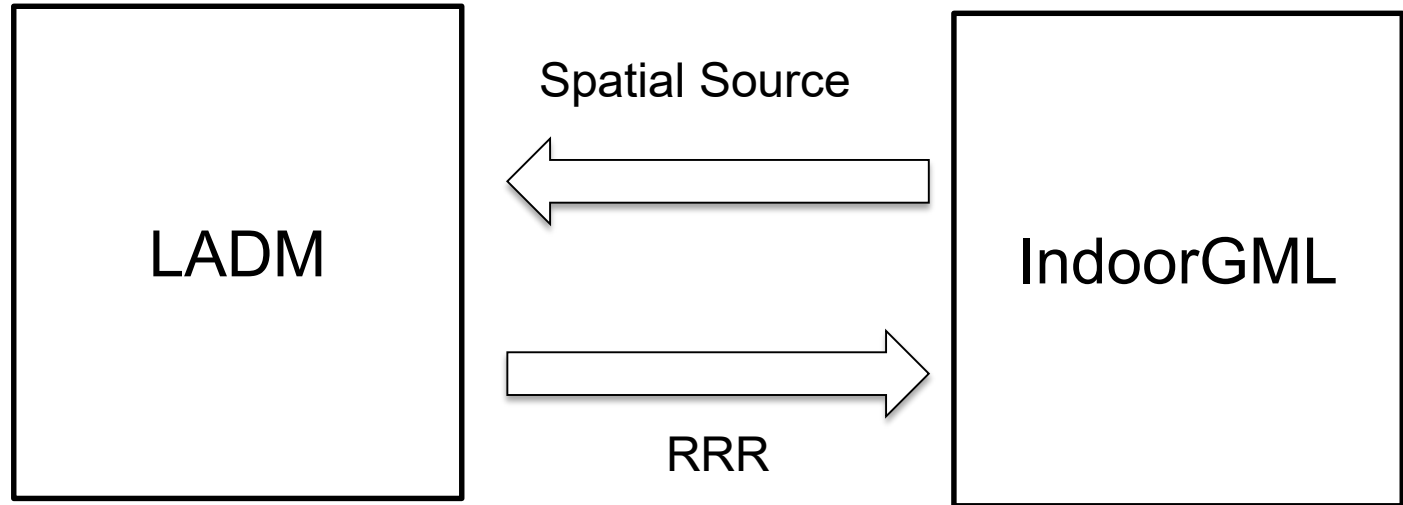
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 - 3D Legal spaces/physical objects (BIM) links
 - Much more...

LADM and (OGC's) IndoorGML

- The indoor environments of buildings are very rich of Rights for individuals or groups of people, so the representation of these Rights are going to improve the use of these environments
- The different types of environments require a better understanding of the relationship between the indoor spaces and the users according to the Rights, Restrictions, and Responsibilities of the environments



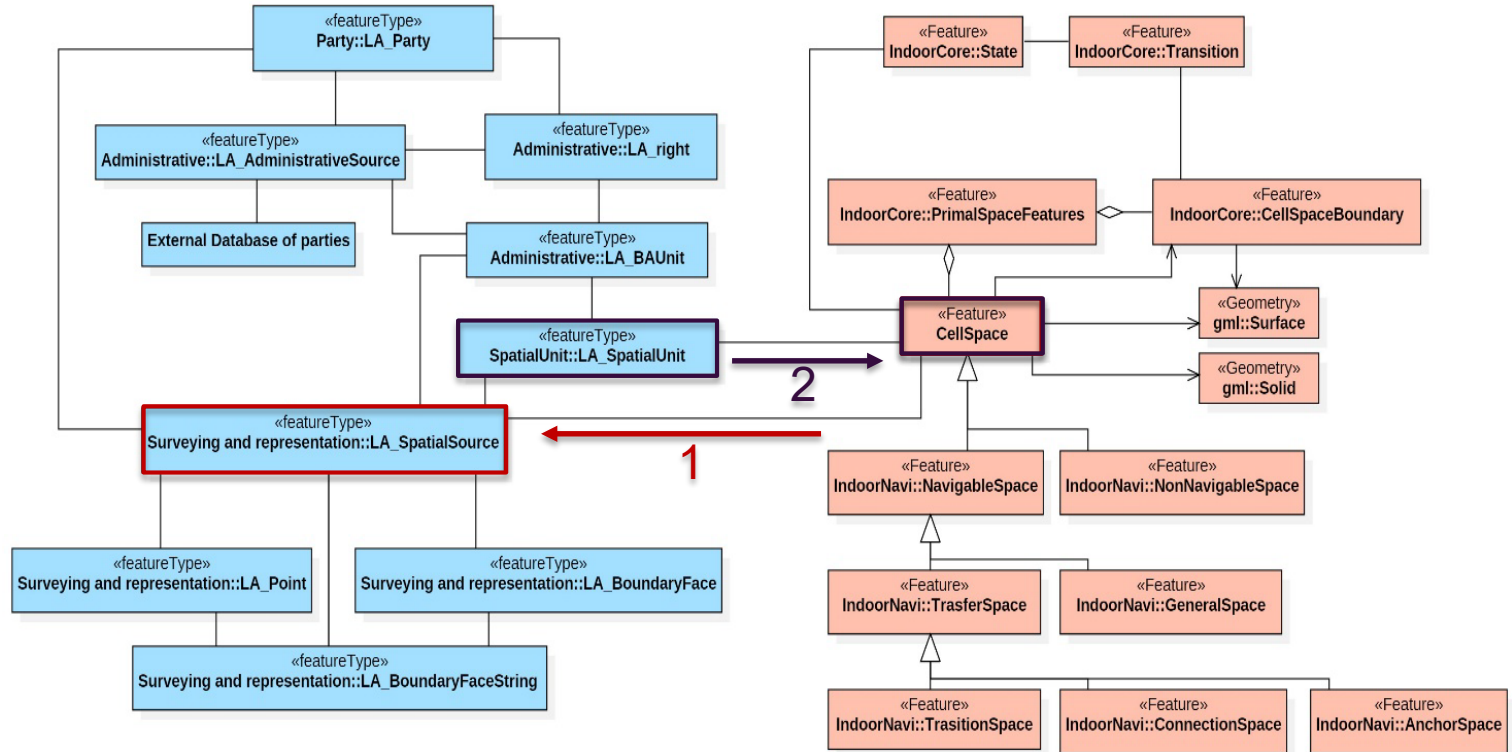
Goal: LADM and IndoorGML



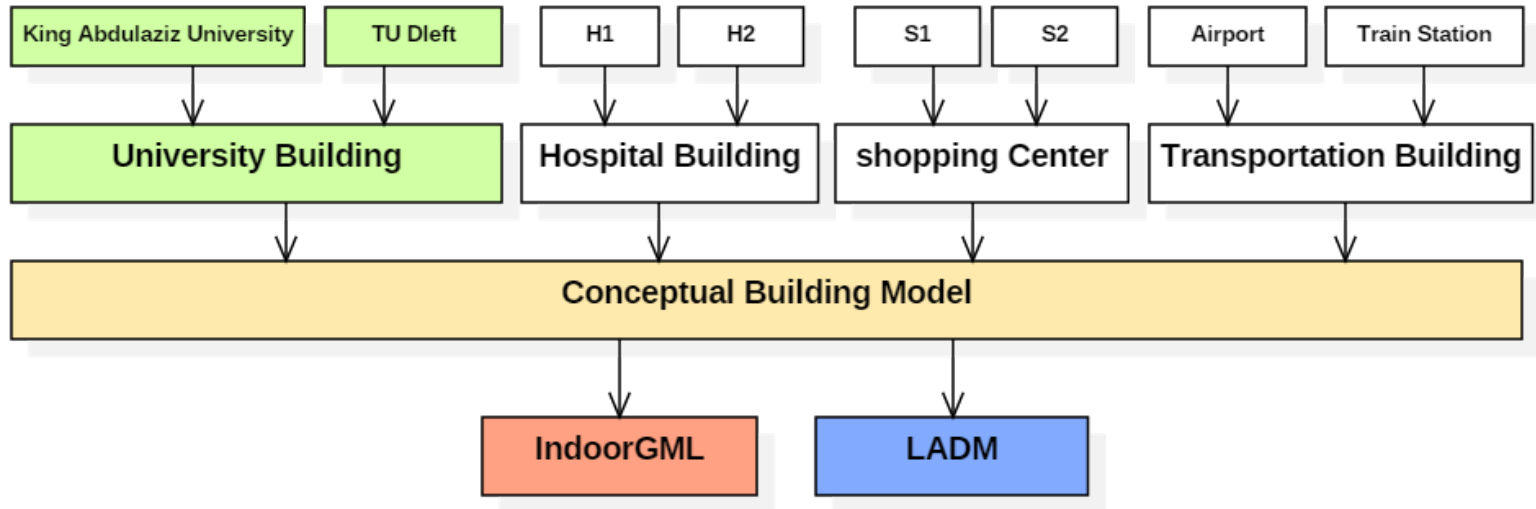
LADM (blue) and IndoorGML (red)

Rights on Spaces

Indoor Navigation



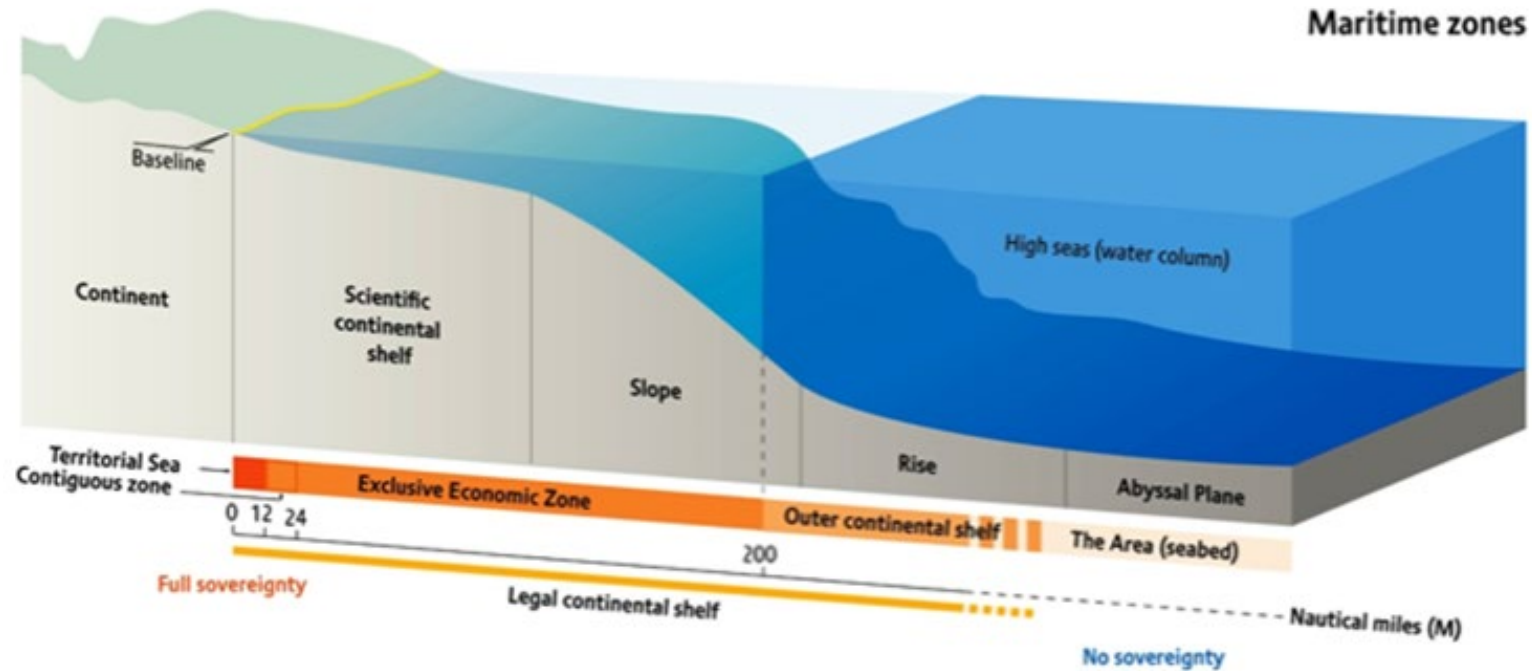
Hierarchical framework of integration model



Overview

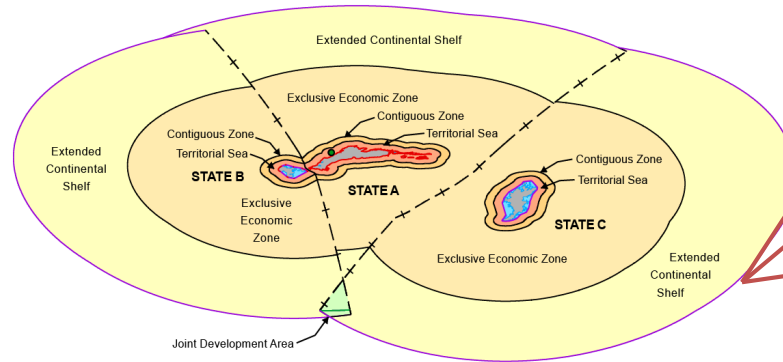
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LADM and IHO S-121



IHO S-121

S-121 DATA MODEL



USE CASES

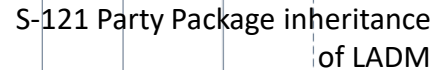
Navigation & Enforcement

Legal Declaration

Authoritative Public Data

- Description and digital representation any type of **Marine Limits and Boundaries**
- ISO 19152 and S-121 are both built on the ISO TC211 suite of Geographic Information standards
- Appendix E of IHO S-121 describes how the LADM related classes are integrated into S-121

S-121 Basic Administrative Unit
inheritance of LADM



Overview

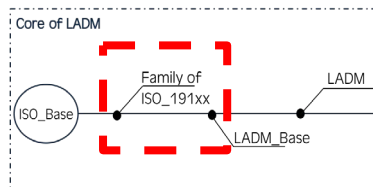
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Also in LADM-v2 (not presented)

- Sustainable development goals (SDG) Land Indicators
- Refined LADM Survey model
- **Semantically rich code lists**
- More on LA processes; e.g. transactions in blockchain ISO TC307
- Methodology for developing country profile
- Guidelines for implementation (informative)
- Technical models / encodings (**INTERLIS**, RDF, GeoJSON, BIM/IFC, InfraGML, CityGML,...)
- Correct small errors/typo's LADM v1;
see <http://isoladm.org/StandardMaintenance>

INTERLIS

- Formal specification of constraints (OCL-like language)
- Automated quality control of the data & data models
- Long-term availability (archiving data)
- System independent
- Interoperability between (geographic) information systems
- INTERLIS 3 is under development
→ soon to be proposed as international standard



ISO 19156 ili model

TYPE MODEL ISO19156 (en)

IMPORTS UNQUALIFIED ISO19115;

DOMAIN

STRUCTURE OM_Observation =

!! to do !!!

!! phenomenonTime: MANDATORY

TM_Object;

!! resultTime: MANDATORY

TM_Instant;

!! validTime: TM_Period;

resultQuality: DQ_Element;

!! parameter: NamedValue;

!! constraints

!! {observedProperty

shall be a phenomenon

}

END OM_Observation;

STRUCTURE OM_Process =

END OM_Process;

END ISO19156

ISO 19115 ili model

IMPORTS UNQUALIFIED ISO_Base;

DOMAIN

DQ_EvaluationMethodTypeCode =

other

);

CI_RoleCode = (

resourceProvider,

custodian,

owner,

user,

distributor,

originator,

pointOfContact,

principalInvestigator,

processor,

publisher,

author

);

STRUCTURE MD_Identifier =

END MD_Identifier;

STRUCTURE DQ_Result =

END DQ_Result;

END ISO19115

ISO 19107 ili model

TYPE MODEL ISO19107_V1_LV03 (en)

IMPORTS UNQUALIFIED INTERLIS;

DOMAIN

ISO 19111 ili model

TYPE MODEL ISO19111 (en)

DOMAIN

STRUCTURE SC_CRS =

!! to do !!!

END SC_CRS;

STRUCTURE

CC_OperationMethod =

!! to do !!!

END

CC_OperationMethod;

END ISO19111.

!! 2D Basic Types

GM_Point2D = COORD

480000.000 .. 850000.000 [m],

70000.000 .. 310000.000 [m],

ROTATION 2 -> 1;

GM_Curve2D = POLYLINE WITH
(STRAIGHTS,ARCS) VERTEX GM_Point2D WITHOUT
OVERLAPS > 0.001;

GM_Surface2D = SURFACE WITH
(STRAIGHTS,ARCS) VERTEX GM_Point2D WITHOUT
OVERLAPS > 0.001;

!! 3D Basic Types

GM_Point3D = COORD

480000.000 .. 850000.000 [m],

70000.000 .. 310000.000 [m],

-1000.000 .. 9000.000 [m],

ROTATION 2 -> 1;

GM_Curve3D = POLYLINE WITH
(STRAIGHTS,ARCS) VERTEX GM_Point3D WITHOUT
OVERLAPS > 0.001;

GM_Surface3D = SURFACE WITH
(STRAIGHTS,ARCS) VERTEX GM_Point3D WITHOUT
OVERLAPS > 0.001;

...

END ISO19107

Semantically rich Code lists

- **Versioned** Code list (definitions may change over time, unique URI approach)
- Code **hierarchy** (using SKOS/RDF, XML, HTML, ...)
- Proposal for hierarchical and versioned Code list management in INTERLIS, Kalogianni et al. (2017):

- (Inter)national maintenance issues/ roles when managing Code lists: run registry, conduct updates
- INSPIRE Code list register can be an example

```
STRUCTURE GR_PartyRoleType EXTENDS LADM.Party.LA_PartyRoleType =
  cID: MANDATORY Oid;
  parent_cID: Oid REFERENCE TO LADM.Party.LA_PartyRoleType.cID;
  begin_Date_Time: XMLDate;
  end_Date_Time: XMLDate;
  MANDATORY CONSTRAINT
  end_Date_Time >= begin_Date_Time
  description: CharacterString;
  !! Possible code list values:
  (lawyer,bank,notary,citizen,institution,tax_office,church,surveyor,
  insurance_organization,metropolis,parish,court,court_of_appeal,
  high_court,state_council,legislative_authority,local_authority,
  expropriation_committee,ministry, urban_planning_authority,other);
END GR_PartyRoleType;
```

LADM Edition II

Summary



New project → to meet new requirements

Multipart standard :: new modules, informative Annexes

taxation/valuation

spatial planning

land indicators

LADM country profiles
Spatial Units & LADM Spatial Profiles
LADM processes
LADM and IHO S-121
LADM and IndoorGML
LADM encodings

Enhanced 3D and 4D support

Volunteered land administration and
crowdsourcing information

INVOLVED ORGANIZATIONS

OGC®
Making location count.



UNITED NATIONS
OFFICE OF LEGAL AFFAIRS (OLA)



THE WORLD BANK
IBRD • IDA | WORLD BANK GROUP

kadaster



UN HABITAT
FOR A BETTER URBAN FUTURE

Conclusion

- Scope of LADM-v2 will cover complete land administration domain
- Land administration is the foundation of the **Geo-Information Infrastructure**
- Actual data collection, maintenance and integration will be at local level (national, city)
- Creating, using and maintaining links between 3D Legal spaces/ physical objects (BIM) by multiple organizations
- Cooperation of many different disciplines: law, surveying, valuation, spatial planning, ICT, etc.
- International standards bring global experience, benefits of scale, and basis for harmonization
- **LADM-v2 as Core Information Model for the Smart City 3DGI: 3D Cadastres, 3D Valuation and 3D Spatial Planning Information and much more!**

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