LADM AND INTERLIS
AS A PERFECT MATCH FOR 3D CADASTRE

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Motivation

- Real word is 3D
- vertical development is a trend that will continue

Legal ≠ physical reality
- Standards

Stoter et al., 2012

https://www.pinterest.com/Storpweber/
Literature Review of Related Work

- Current Best Practices
- LADM country profiles
- INTERLIS language and software packages
- The role of constraints
- Semantics & code lists

Implementation and first findings

- INTERLIS in Switzerland
- INTERLIS in Greece
- INTERLIS in Colombia
Standardization in Land Administration

Cognitive Legal Spaces

Land Administration Domain Model

Physical Spaces

CityGML
BIM
IFC
IndoorGML

Legal/ Physical Integrated Approaches

CityGML ADEs
LandInfra/ InfraGML
3D CDM
Integrated BIM model
LADM OWL
MODELLING LEGAL SPACES

LADM
ISO 19152
LADM Design is based on
common pattern of “people – land” relationships

- ISO spatial domain standard - 19152
- abstract conceptual schema
- Model Driven Architecture
- 2D & 3D registrations
- explicit relationships with physical models

Adaptable and adoptable in local conditions

[Leemmen Ch., 2012]
MODELLING PHYSICAL SPACES

INTERLIS 2
SN 312031
INTERLIS concept

- Swiss Standard
- Conceptual Schema Language
- Object Relational modeling language
- Neutral Transfer Format (XML-based)
- Formal specification of constraints
- Automated quality control of the data
- Long-term availability (archiving data)
- Interoperability between information systems
INTERLIS Duality

LADM Specification

mapped to

INTERLIS models

generate

XML Transfer Rules

XML

DB schema
LADM/INTERLIS

- LADM in INTERLIS
- Greece
- Colombia
LADM in INTERLIS

Core of LADM

ISO_Base → Family of ISO_191xx → LADM_Base → LADM → LADM_country_profiles

- LADM_CH
- LADM_NL
- LADM_GR

SWISS LAND MANAGEMENT Foundation
LADM/INTERLIS in Greece
Legal Model LADM-based in INTERLIS

... 

CLASS GR_SpatialUnit (ABSTRACT) EXTENDS LADM.Spatial_Unit.LA_SpatialUnit =
dimension (EXTENDED): LADM.Spatial_Unit.LA_DimensionType;
area (EXTENDED): LADM.Spatial_Unit.LA_AreaType;
surfaceRelation: LIST {0..1} OF GR_SurfaceRelationType;
hasTopographicMap: Boolean;
KAEK: CharacterString;
label: CharacterString;
insideMap: Boolean;
volume (EXTENDED): LADM.Spatial_Unit.LA_VolumeValue;
END GR_SpatialUnit;

CLASS GR_Level (ABSTRACT) EXTENDS LADM.SpatialUnit.LA_Level =
name(EXTENDED): CharacterString;
register: GR_RegisterType;
structure: LADM.SpatialUnit.LA_StructureType;
type: MANDATORY GR_LevelContentType;
END GR_Level;

...
Physical Model in INTERLIS

CONTRACTED MODEL CITYMODEL_3D

CLASS CityObject =
  id: MANDATORY int;
  startDate: MANDATORY INTERLIS.XMLDateTime;
  endDate: MANDATORY INTERLIS.XMLDateTime;
  geometry: ISO19107.GM_Object;
END CityObject;

CLASS Building EXTENDS CityObject =
  geometry (EXTENDED): MANDATORY ISO19107.GM_Solid;
  name: string;
  MANDATORY CONSTRAINT
  ILIFunction.validateSolidGeometry(geometry);
END Building;

CLASS BuildingParts =
  geometry: MANDATORY ISO19107.GM_Solid;
  theme: MANDATORY string;
  MANDATORY CONSTRAINT
  ILIFunction.validateSolidGeometry(geometry);
END BuildingParts;

3D CityModel from Paper "A methodology for modelling of 3D spatial constraints"
LADM/INTERLIS in Colombia

- Peace Accords
- Post-Conflict Preparations
- National Development Plan 2014-2018

Support Modernization of Land Administration in Colombia

new National Multipurpose Cadastre
Steps towards implementation
Semantically Enriched Code Lists & Enumerations

**CODE LISTS**

```
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, courtof_appeal);
END GR_PartyRoleType;
```

**ENUMERATION TYPES**

```
LA_StructureType = (point, line, polygon, other);

COL_StructureType EXTENDS LA_StructureType = (other
  (text, topological, drawing, unstructured));
```
**Constraints**

<table>
<thead>
<tr>
<th>HARD</th>
<th>SOFT</th>
</tr>
</thead>
</table>
| - Should *always* be TRUE  
- If NOT the transaction should be cancelled | - May NOT always be True  
- If they are *Not True* they can be included in an exception list |

**SOFT constraint + exception list = HARD constraint**

**FALSE OR presence at the exception list = TRUE**
FUNCTION no_overlaps(
Objects: OBJECTS OF ANYCLASS;
SurfaceAttr: ATTRIBUTE OF @ Objects
RESTRICTION (SURFACE)
): BOOLEAN;

CLASS CO_Terrain EXTENDS LA_SpatialUnit =
Geometry: MANDATORY GM_Surface2D;
SET CONSTRAINT no_overlaps(ALL, >> geometry);
END LA_BAUnit;
Validation

Transfer file
- BROWSE 0096_L1.xtf, 0096_L1_test_fabian.

Use custom .ili model
- BROWSE ISO19107_V1_LV03.ili, LADM_CH.

Validation results:
- Download 0096_L1.xtf validation errors
- No errors during 0096_L1_test_fabian.xtf validation
Cross-Model Constraints

Physical model

Constraint violated!

Legal & physical model

Legal model

Ownership Party A

Common Space

Ownership Party B
3D Data types

Proposed Structure

```pascal
STRUCTURE GM_Surface3DListValue =
    value: MANDATORY GM_Curve3D;
END GM_Surface3DListValue;

STRUCTURE GM_Solid EXTENDS GM_Object =
    geometry: LIST {1..*} OF GM_Surface3DListValue;
END GM_Solid;

FUNCTION validateSolidGeometry(solid:ISO19107.GM_Solid):BOOLEAN;

```

Implemented Structure

```pascal
STRUCTURE GM_MultiSurface3D =
    geometry: LIST {1..*} OF GM_Surface3DListValue;
END GM_MultiSurface3D;

ISO 19107
need for more explicit relationships between LADM and physical models (BIM, IFC, LandXML, IndoorGML)

LADM/INTERLIS approach can be implemented in any LADM-based model to get a platform-independent exchange format linked to the conceptual model

LADM/INTERLIS approach: a solution for legal and physical integration in a controlled manner by specifying (spatial) constraints

modularity of LADM/INTERLIS approach & ability to structure country profiles

core model that can be extended by thematic/regional models of land administration realm
ISO TC211: LADM 2nd edition → LADM implementation

INTERLIS can be used as an external validating mechanism for LADM models

Further tools will be developed in order to support a holistic LADM/INTERLIS approach

- Translations of standards (CityGML, LandXML, InfraGML IndoorGML) to INTERLIS
- Development of tools for 3D volumetric primitive validation
- Development, maintenance and improvement of the tool chain
Thank you!

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INTERLIS Language for Modelling Legal 3D Spaces and Physical 3D Objects by Including Formalized Implementable Constraints and Meaningful Code Lists
Eftychia Kalogianni, Efi Dimopoulou, Wilko Quak, Michael Germann, Lorenz Jenni and Peter van Oosterom
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