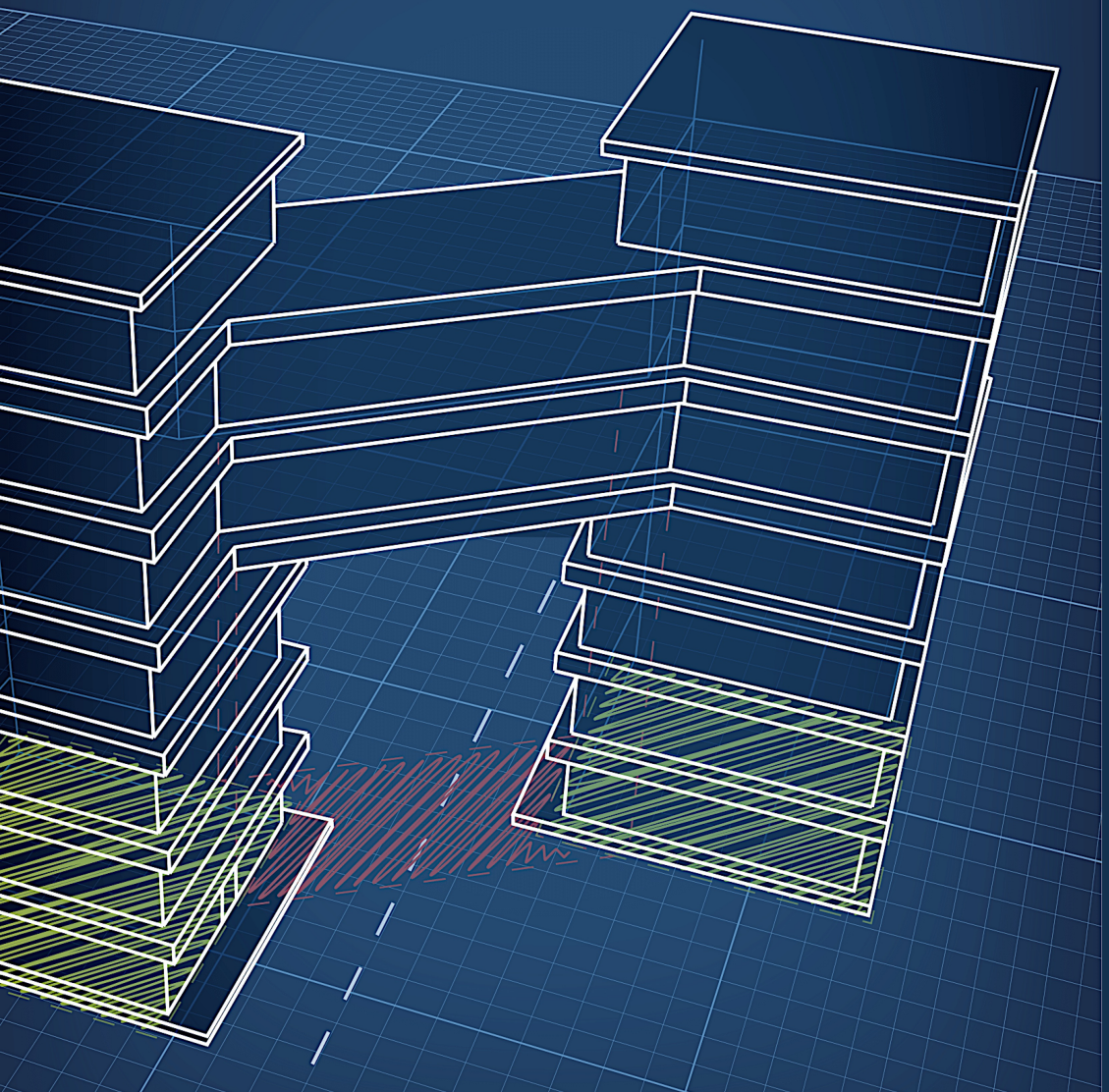
FORMALIZING IMPLEMENTABLE CONSTRAINTS IN INTERLIS LANGUAGE FOR MODELING 3D LEGAL RRR SPACES AND 3D PHYSICAL OBJECTS



Joint 3D ATHENS CONFERENCE 2016, GREECE

Eftychia Kalogianni

Efi Dimopoulou

Peter van Oosterom

Wilko Quak

OCTOBER 19, 2016

FIG 5th INTERNATIONAL FIG WORKSHOP ON 3D CADASTRES

OVERVIEW

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RESEARCH DESIGN & BACKGROUND INFO

03

LADM - CONCEPTUAL MODEL - INTERLIS - CONSTRAINTS

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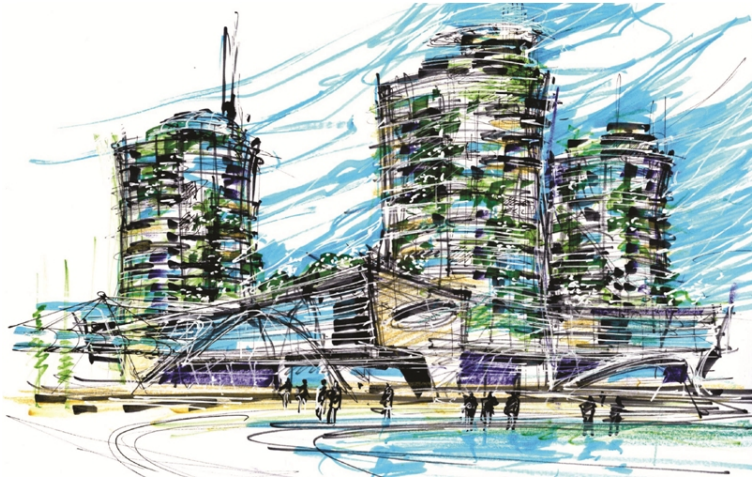
05

CONCLUSIONS & FUTURE WORK

1 INTRODUCTION

MOTIVATION

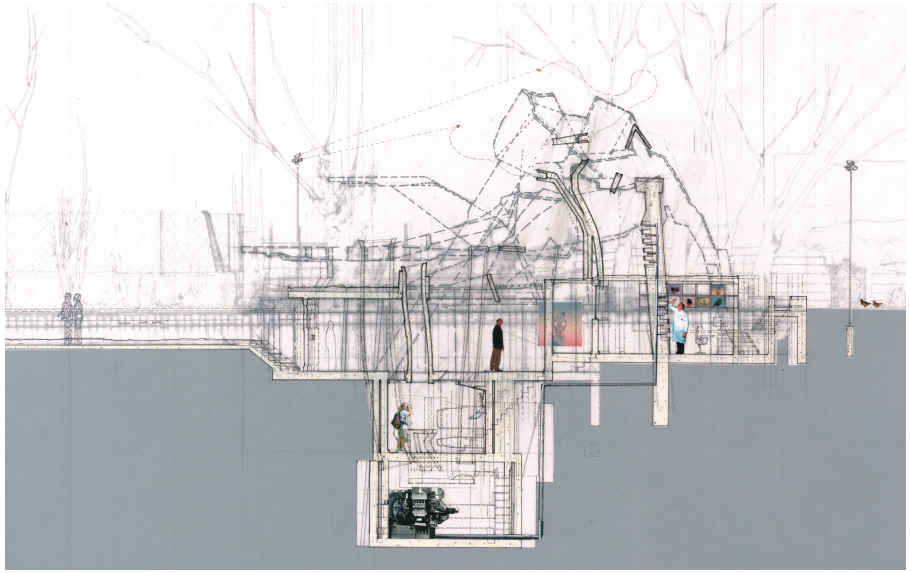
METHODOLOGY



[HTTP://WWW.ASMECBG.COM/PROJECTS.HTML]

REPRESENTING VERTICAL DEVELOPMENT

TECHNOLOGICAL OPPORTUNITIES

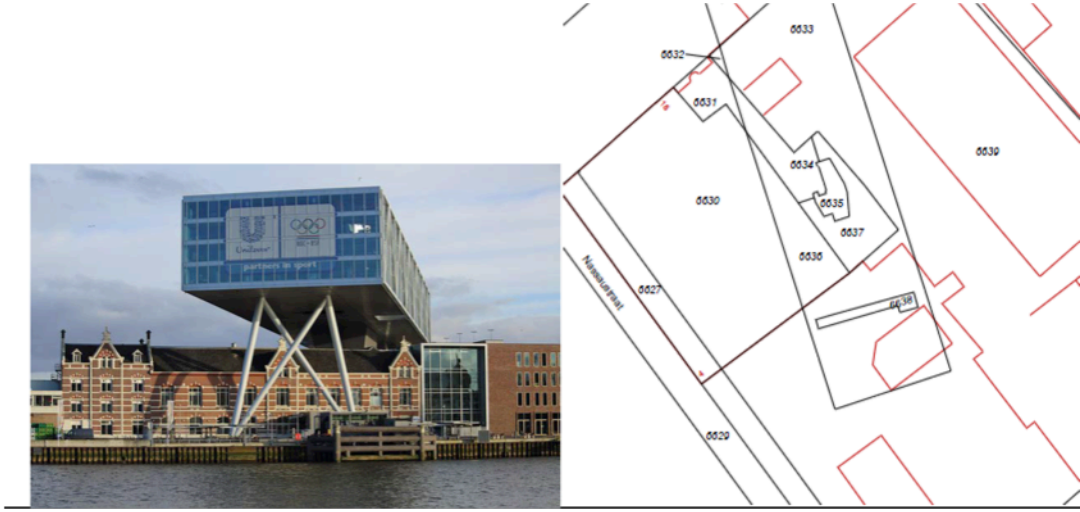


[HTTPS://WWW.PINTEREST.COM/STORPWEBER/]

INFORMATION INTEGRATION

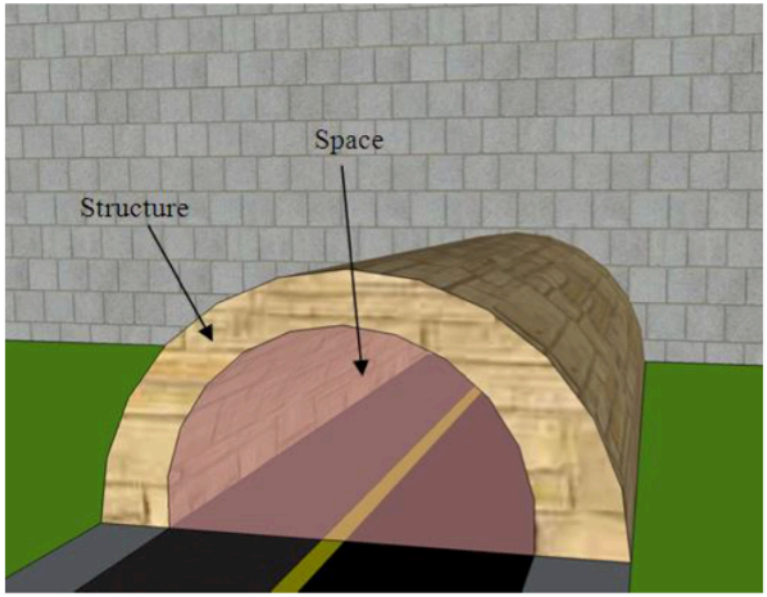
SMART DATA FOR SMART CITIES

MORE THAN 3D DATA, 4D, 5D,...



[Stoter et al., 2012]

LEGAL ≠ PHYSICAL REALITY



[Aien et al., 2015]

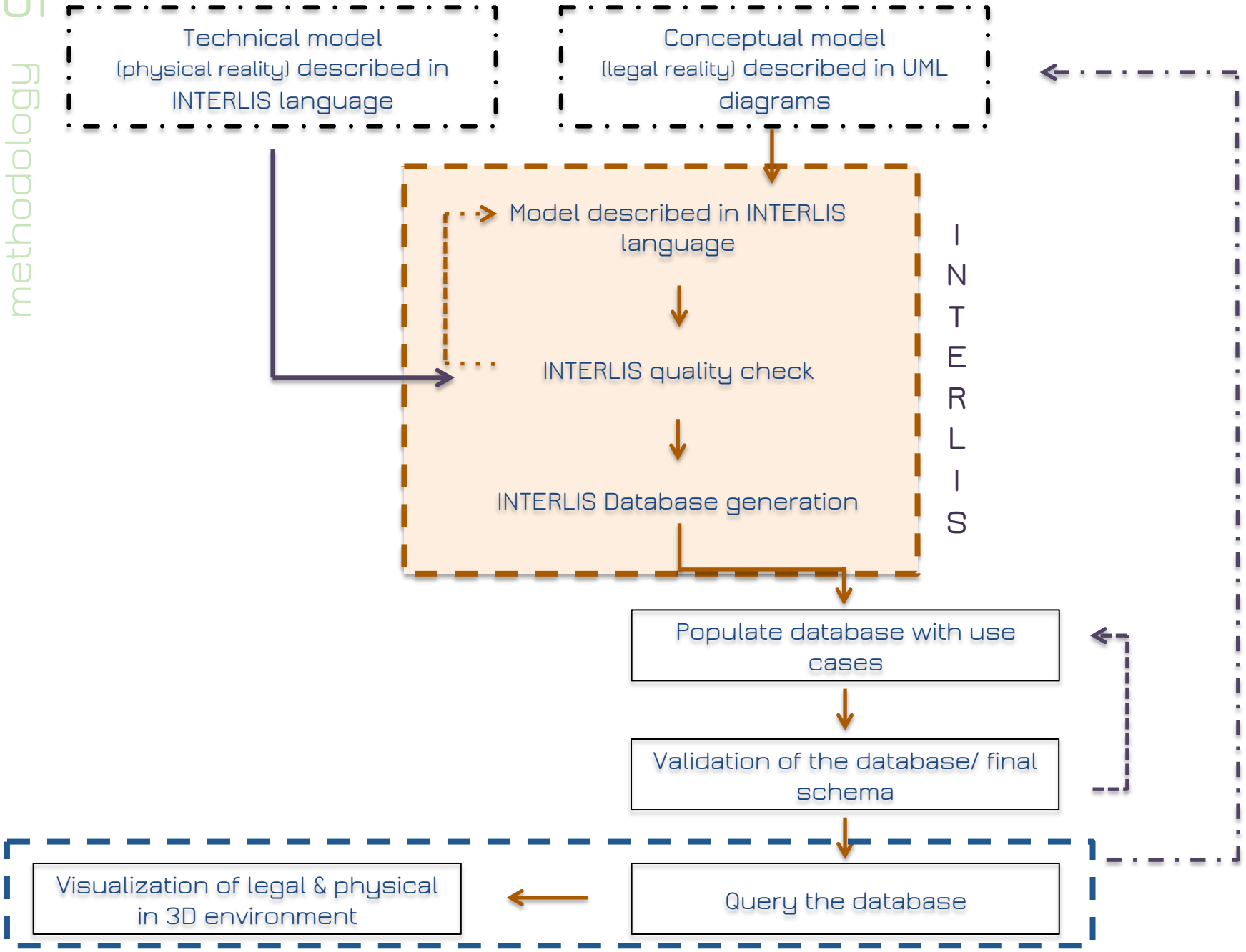
TODAY :

VISUALIZING OWNERSHIP BOUNDARIES **ALONE**

CANNOT SOLVE EXISTING AMBIGUITIES

& WILL NOT REDUCE BOUNDARY CONFUSION

AMONG OWNERS


Technical model (physical reality) described in INTERLIS language
Conceptual model (legal reality) described in UML diagrams
Model described in INTERLIS language
INTERLIS quality check
INTERLIS Database generation
INTERLIS
Populate database with use cases
Validation of the database/ final schema
Query the database
Visualization of legal & physical in 3D environment

2 RESEARCH DESIGN & BACKGROUND INFO

LEGAL & PHYSICAL REALITY

RELATED WORK

Legal Reality

Physical Reality

Cadastral data models

LADM, ePlan

3D Property &
Ownership interests

Real World

Virtual 3D City Models

CityGML, IFC

3D physical objects:
buildings, pipelines, etc.

RELATED WORK

- ✓ **3D Cadastral Data Model [3DCDM],** Aien et al. (2013)
- ✓ **CityGML Application Domain Extensions [ADE]**
  - ✓ Dsilva et al (2009) - [CityGML for cadastral purposes];
  - ✓ Çagdas (2013) - [CityGML for immovable property taxation];
  - ✓ Rönsdorf et al. (2014) - [CityGML – LADM];
  - ✓ Gozdz et al. [2014] - [CityGML – LADM];
  - ✓ Van den Brink et al. [2014] - [CityGML – IMGeo];
- ✓ **extension to Unified Building Model (UBM) for integrating IFC & CityGML** - (El-Mekawy & Östman, 2012)
- ✓ **LADM – OWL,** Soon et al. [2014]
- ✓ **IndoorGML – LADM,** Zlatanova et al. [2016]
- ✓ **3D city models – 3D cadastres: taxation, valuation,** Isikdag et al. [2014]
- ✓ **Cadastral extension IFC,** Atazadeh et al. [2016]

3 CONCEPTUAL MODEL-INTERLIS-CONSTRAINTS

LADM-3D MLAS PROPOSED FOR GREECE

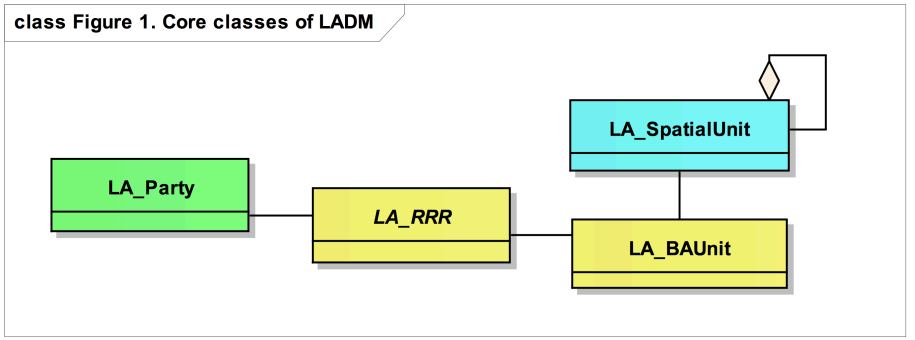
INTERLIS LANGUAGE & TOOLS

CONSTRAINTS

- The Core Cadastral Data Model (Henssen, 1995)
- FGDC (FGDC, 1996)
- ArcGIS Parcel Data Model (Meyer, 2001)
- Legal Property Object (Kalantari et al., 2008)
- E-Plan (ICSM, 2009)
- LADM – ISO19152 (Lemmen, 2012)

"The nice thing about standards is that you have so many to choose from"

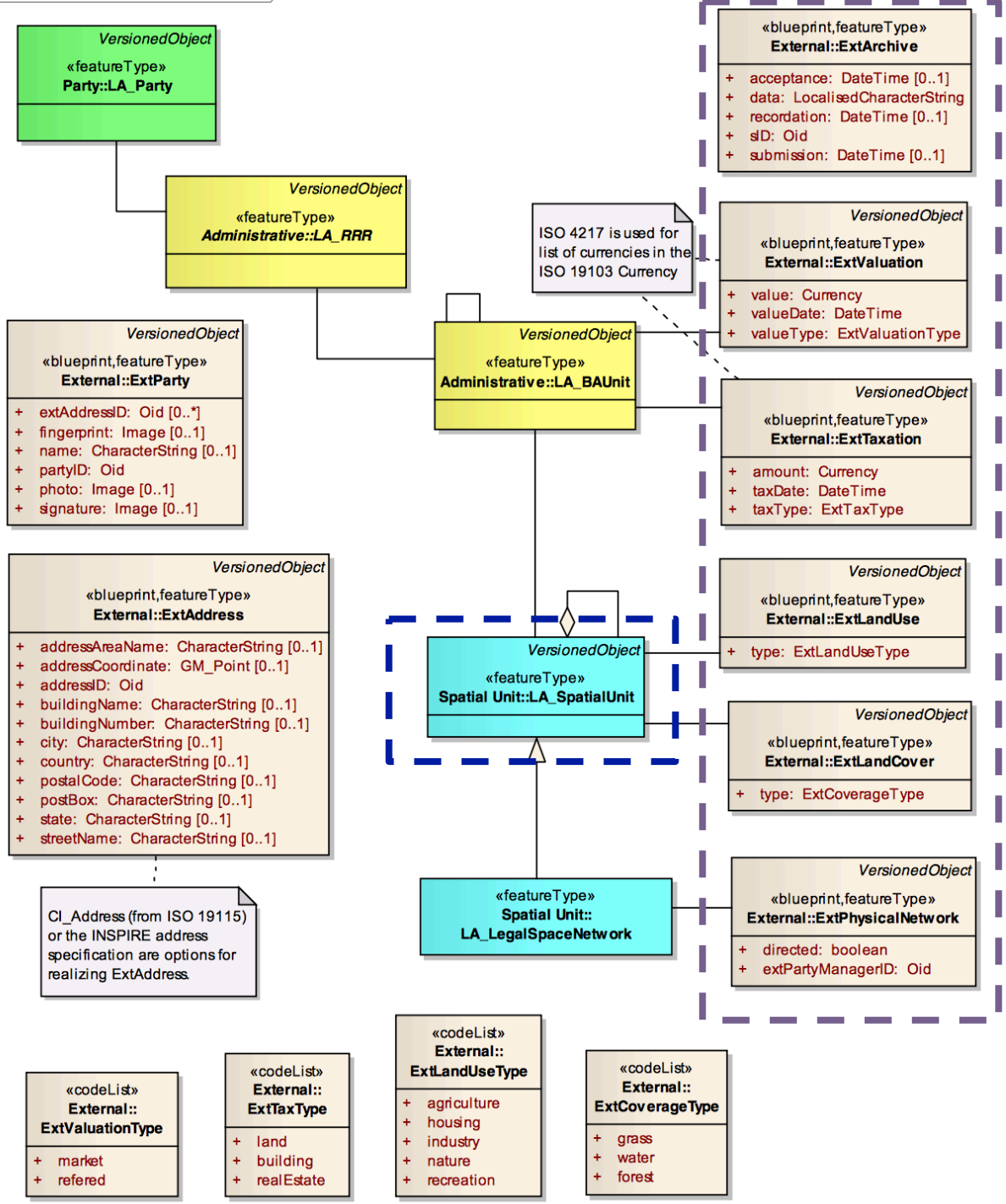
[Andrew S. Tanenbaum]



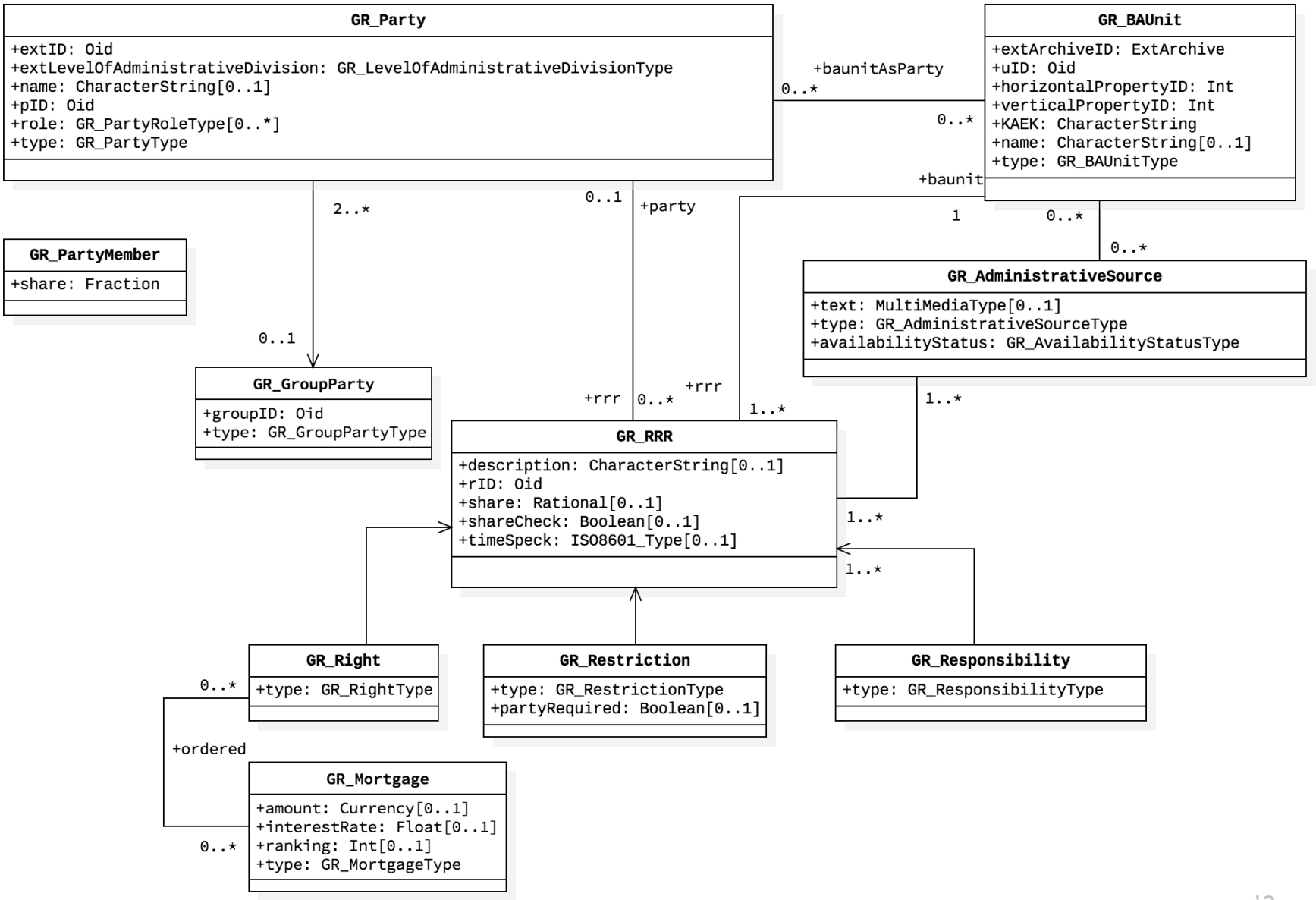
[Lemmen C., 2012]

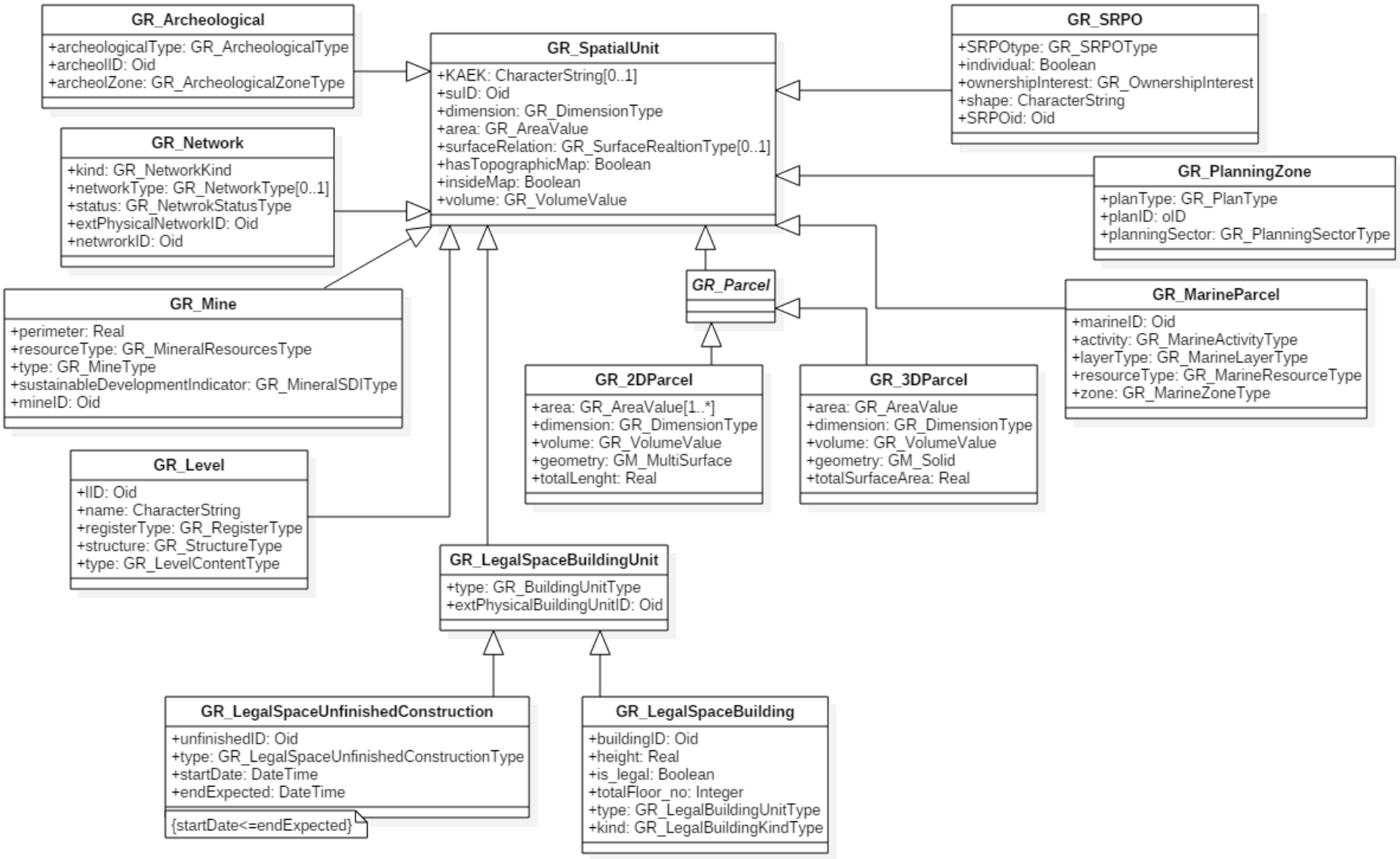
LADM - ISO 19152

- Model Driven Architecture
- Flexible and Extensible model
- Distinguishes and Links legal and physical objects with External Classes
- Supports Both 2D and 3D cadastral registration

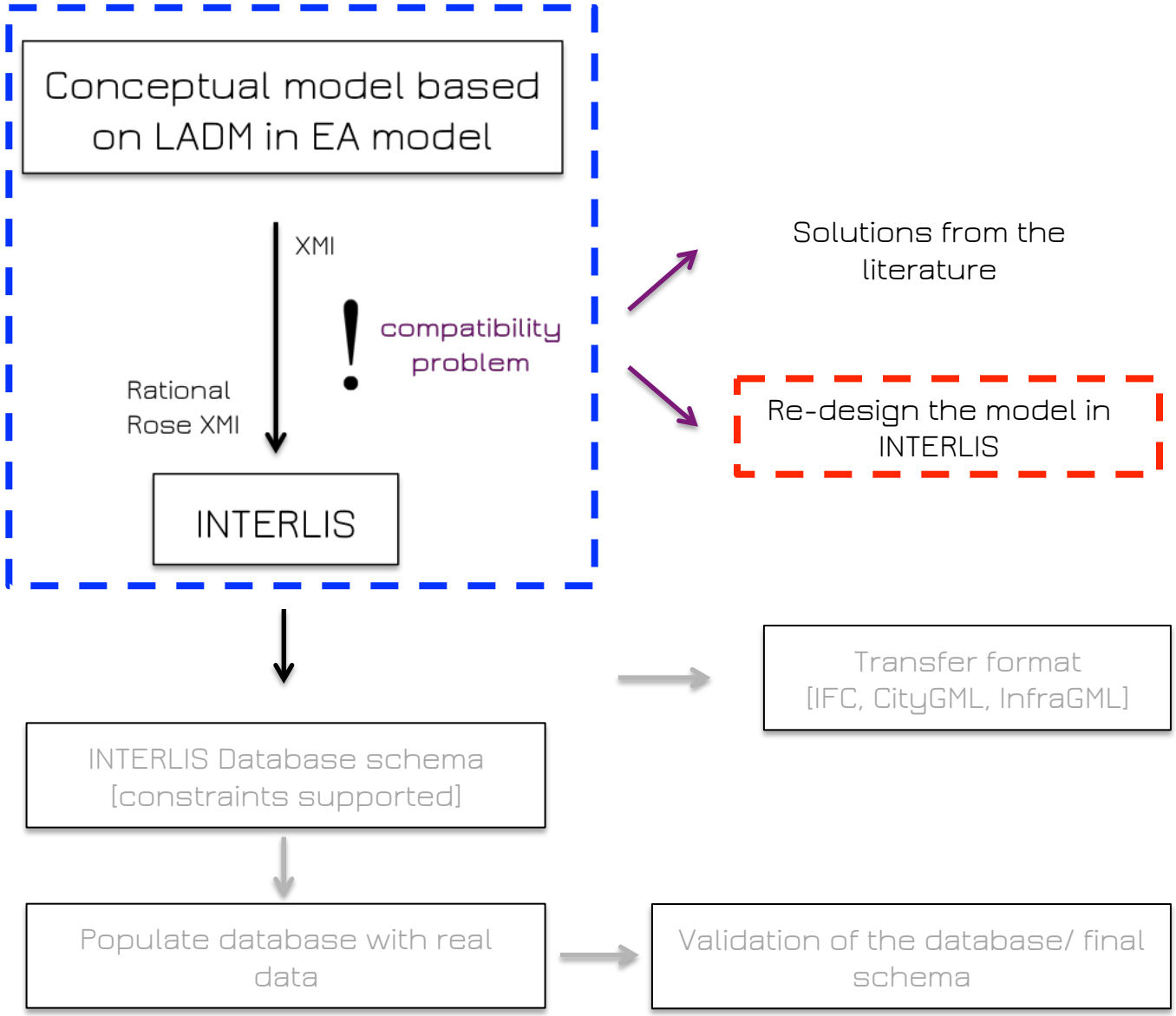


- Versioned object: State based modeling - - 4D
- External classes: linking legal – physical aspects
- “LA_Level” concept


GR_Party
+extID: Oid
+extLevelOfAdministrativeDivision: GR_LevelOfAdministrativeDivisionType
+name: CharacterString[0..1]
+pID: Oid
+role: GR_PartyRoleType[0..*]
+type: GR_PartyType
+baunitAsParty
0..*
0..*
GR_BAUnit
+extArchiveID: ExtArchive
+uID: Oid
+horizontalPropertyID: Int
+verticalPropertyID: Int
+KAEK: CharacterString
+name: CharacterString[0..1]
+type: GR_BAUnitType
+baunit
1
0..*
0..*
2..*
0..1
+party
GR_PartyMember
+share: Fraction
GR_AdministrativeSource
+text: MultiMediaType[0..1]
+type: GR_AdministrativeSourceType
+availabilityStatus: GR_AvailabilityStatusType
0..1
GR_GroupParty
+groupID: Oid
+type: GR_GroupPartyType
+rrr
0..*
+rrr
1..*
1..*
GR_RRR
+description: CharacterString[0..1]
+rID: Oid
+share: Rational[0..1]
+shareCheck: Boolean[0..1]
+timeSpeck: ISO8601_Type[0..1]
1..*
GR_Right
+type: GR_RightType
0..*
GR_Restriction
+type: GR_RestrictionType
+partyRequired: Boolean[0..1]
GR_Responsibility
+type: GR_ResponsibilityType
+ordered
GR_Mortgage
+amount: Currency[0..1]
+interestRate: Float[0..1]
+ranking: Int[0..1]
+type: GR_MortgageType
0..*


GR_Archeological
+archeologicalType: GR_ArcheologicalType
+archeoID: Oid
+archeolZone: GR_ArcheologicalZoneType
GR_SpatialUnit
+KAEK: CharacterString[0..1]
+suID: Oid
+dimension: GR_DimensionType
+area: GR_AreaValue
+surfaceRelation: GR_SurfaceRealtionType[0..1]
+hasTopographicMap: Boolean
+insideMap: Boolean
+volume: GR_VolumeValue
GR_SRPO
+SRPOtype: GR_SRPOType
+individual: Boolean
+ownershipInterest: GR_OwnershipInterest
+shape: CharacterString
+SRPOid: Oid
GR_Network
+kind: GR_NetworkKind
+networkType: GR_NetworkType[0..1]
+status: GR_NetwrokStatusType
+extPhysicalNetworkID: Oid
+netwrorkID: Oid
GR_PlanningZone
+planType: GR_PlanType
+planID: oID
+planningSector: GR_PlanningSectorType
GR_Parcel
GR_Mine
+perimeter: Real
+resourceType: GR_MineralResourcesType
+type: GR_MineType
+sustainableDevelopmentIndicator: GR_MineralSDIType
+mineID: Oid
GR_MarineParcel
+marineID: Oid
+activity: GR_MarineActivityType
+layerType: GR_MarineLayerType
+resourceType: GR_MarineResourceType
+zone: GR_MarineZoneType
GR_2DParcel
+area: GR_AreaValue[1..*]
+dimension: GR_DimensionType
+volume: GR_VolumeValue
+geometry: GM_MultiSurface
+totalLenght: Real
GR_3DParcel
+area: GR_AreaValue
+dimension: GR_DimensionType
+volume: GR_VolumeValue
+geometry: GM_Solid
+totalSurfaceArea: Real
GR_Level
+lID: Oid
+name: CharacterString
+registerType: GR_RegisterType
+structure: GR_StructureType
+type: GR_LevelContentType
GR_LegalSpaceBuildingUnit
+type: GR_BuildingUnitType
+extPhysicalBuildingUnitID: Oid
GR_LegalSpaceUnfinishedConstruction
+unfinishedID: Oid
+type: GR_LegalSpaceUnfinishedConstructionType
+startDate: DateTime
+endExpected: DateTime
{startDate<=endExpected}
GR_LegalSpaceBuilding
+buildingID: Oid
+height: Real
+is_legal: Boolean
+totalFloor_no: Integer
+type: GR_LegalBuildingUnitType
+kind: GR_LegalBuildingKindType

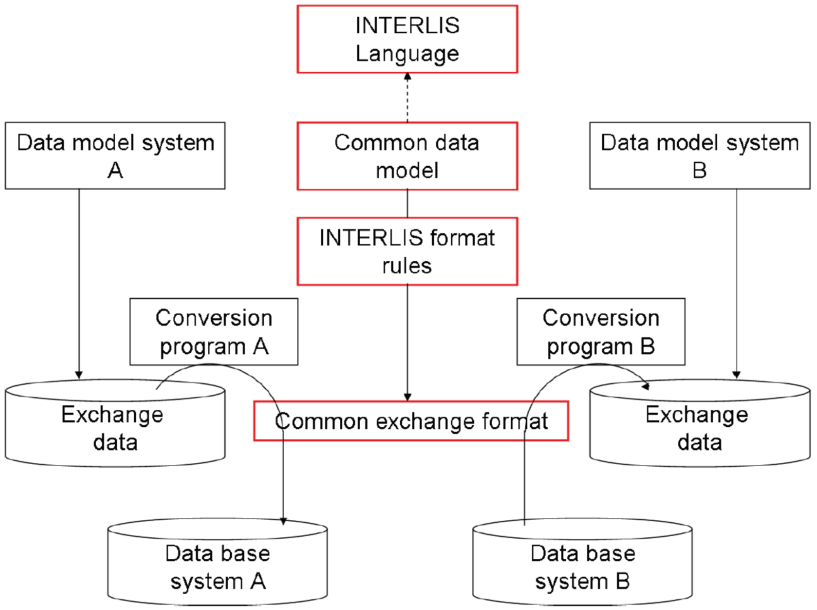
Transformation on conceptual schema level



A DATA EXCHANGE MECHANISM FOR LAS

INTERLIS

- NATIONAL (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



[COGIS, 2006]

IMPORT

ILI, RATIONAL XMI

EXPORT

SVG, JPEG, ILI, WMS, XML SCHEMA

SHOULD ALWAYS BE VALIDATED

HARD

- Should always be TRUE
- If NOT the transaction should be cancelled

SOFT

- 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

WHO CONTROLS THAT ?

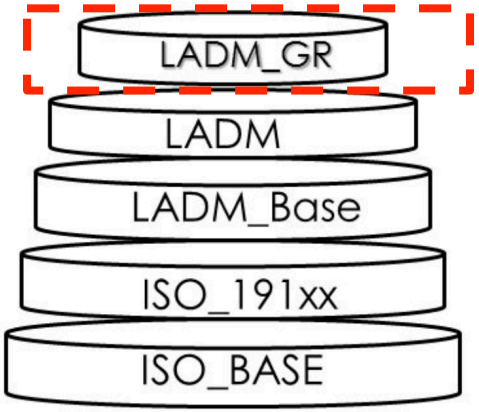
4 INTERLIS IMPLEMENTATION

INTERLIS TOOLS

MODEL DESCRIBED IN INTERLIS

CONSTRAINTS IMPELMENTATION

Already described ISO models from Swiss Land Management Group

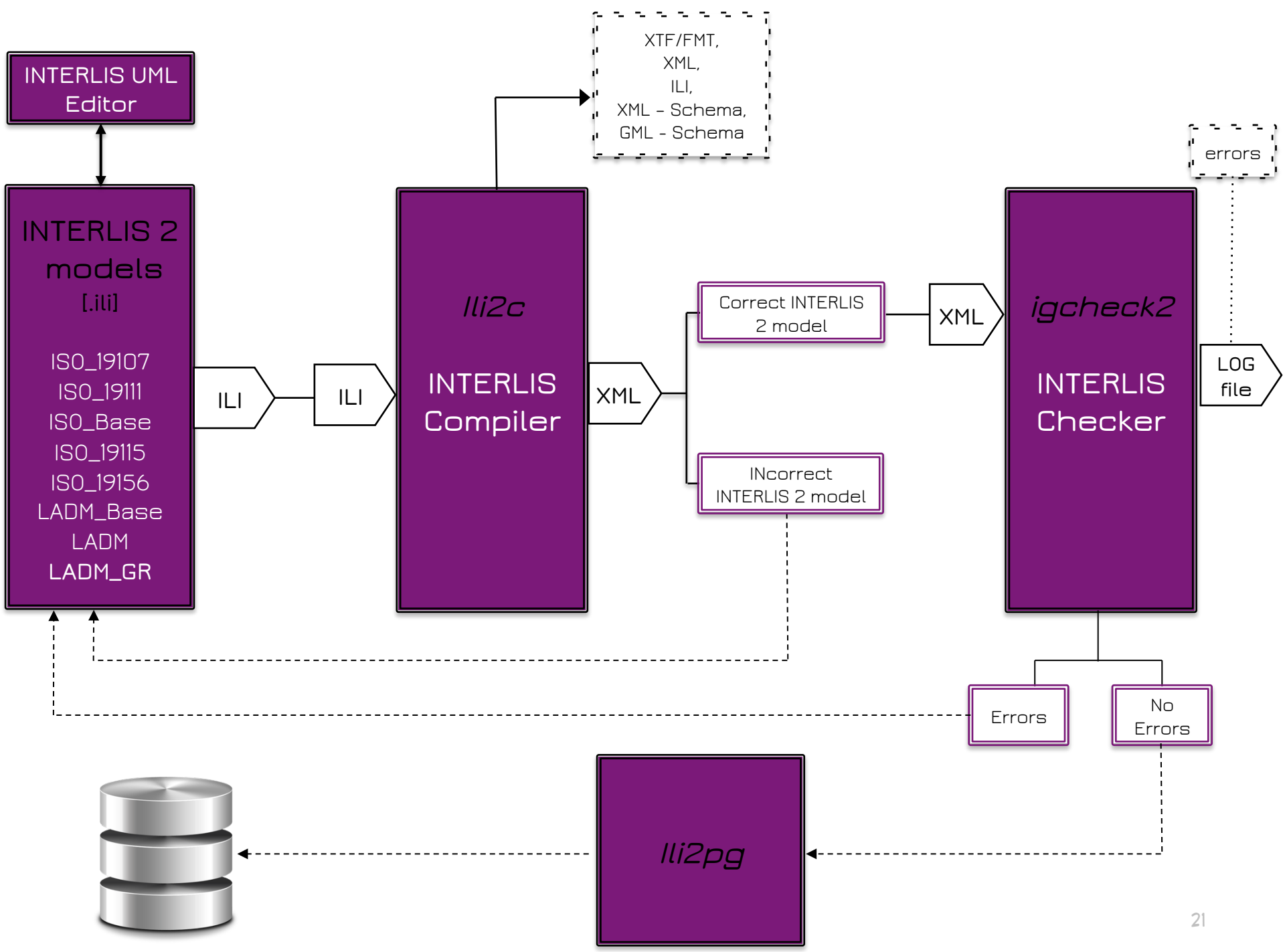


Neutral vendor format – Explicit formulation of constraints

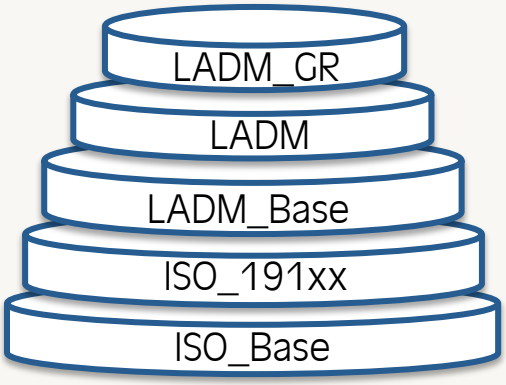
KEY challenges to describe

- Code lists – Enumeration types
- Constraints
- 3D data type

```
INTERLIS 2.3;

CONTRACTED MODEL LADM_GR (en)

AT "http://www.gdmc.nl/"
VERSION "2015-11-30" =

   IMPORTS UNQUALIFIED ISO_Base;
   IMPORTS UNQUALIFIED ISO19107;
   IMPORTS UNQUALIFIED ISO19111;
   IMPORTS UNQUALIFIED ISO19115;
   IMPORTS UNQUALIFIED ISO19156;
   IMPORTS UNQUALIFIED LADM_Base;
   IMPORTS UNQUALIFIED LADM;
```

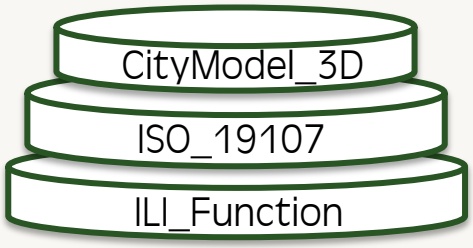

INTERLIS UML Editor
INTERLIS 2 models
[.ili]
ISO_19107
ISO_19111
ISO_Base
ISO_19115
ISO_19156
LADM_Base
LADM
LADM_GR
ILI
ILI
Ili2c
INTERLIS Compiler
XTF/FMT,
XML,
ILI,
XML - Schema,
GML - Schema
XML
Correct INTERLIS 2 model
INcorrect INTERLIS 2 model
XML
igcheck2
INTERLIS Checker
errors
LOG file
Errors
No Errors
Ili2pg

MODEL DESCRIBING LEGAL REALITY

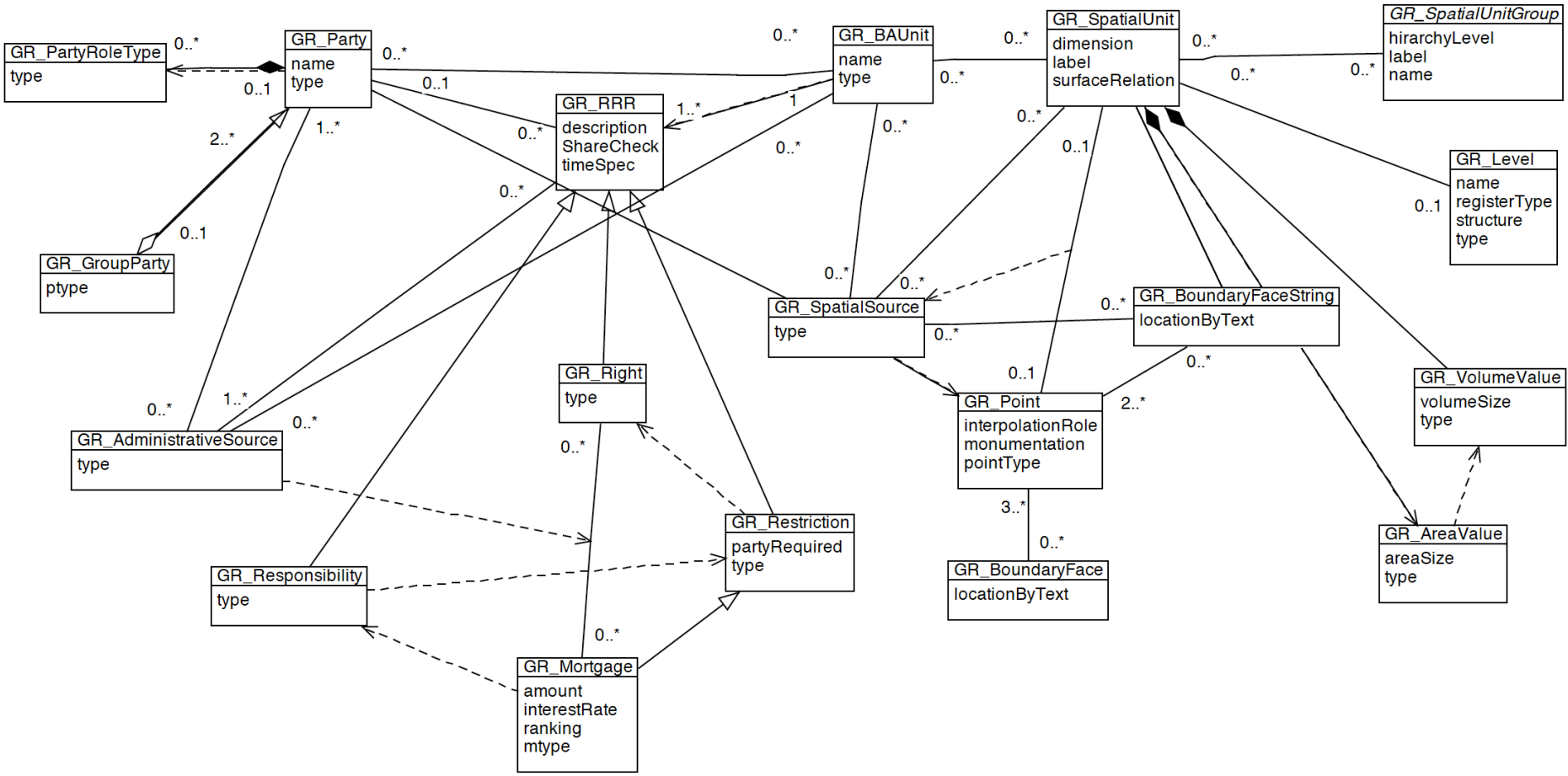



```
CONTRACTED MODEL LADM_GR (en)
TOPIC SpatialUnit (ABSTRACT) =
DOMAIN

STRUCTURE GR_VolumeValue (ABSTRACT) EXTENDS
LADM.Spatial_Unit.LA_VolumeValue =
    volumeSize (EXTENDED): MANDATORY Volume;
    grtype : MANDATORY GR_VolumeType;
END GR_VolumeValue;

CLASS GR_SpatialUnit (ABSTRACT) EXTENDS
LADM.Spatial_Unit.LA_SpatialUnit =
    grdimension : LADM.Spatial_Unit.LA_DimensionType;
    grarea : GR_AreaValue;
    grsurfaceRelation : GR_SurfaceRelationType;
    hasTopographicMap: Boolean;
    KAEK: MANDATORY CharacterString;
    label (EXTENDED): CharacterString;
    insideMap: Boolean;
    volume (EXTENDED):LIST {0..*} OF
LADM.Spatial_Unit.LA_VolumeValue;
END GR_SpatialUnit;
```

MODEL DESCRIBING PHYSICAL REALITY




```
!! 3D CityModel from Paper
!! "A methology for modelling of 3D spatial
constraints”

INTERLIS 2.3;

CONTRACTED MODEL CITYMODEL_3D (en)
 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;;
```


GR_PartyRoleType
type
GR_Party
name
type
GR_BAUnit
name
type
GR_SpatialUnit
dimension
label
surfaceRelation
GR_SpatialUnitGroup
hirarchyLevel
label
name
GR_RRR
description
ShareCheck
timeSpec
GR_Level
name
registerType
structure
type
GR_GroupParty
ptype
GR_SpatialSource
type
GR_BoundaryFaceString
locationByText
GR_Right
type
GR_Point
interpolationRole
monumentation
pointType
GR_VolumeValue
volumeSize
type
GR_AdministrativeSource
type
GR_Restriction
partyRequired
type
GR_Responsibility
type
GR_BoundaryFace
locationByText
GR_AreaValue
areaSize
type
GR_Mortgage
amount
interestRate
ranking
mtype

```
CLASS GR_Archeological EXTENDS GR_Level =
    archeologicalType : GR_ArcheologicalType;
    zones: GR_ArcheologicalZoneType;
    END GR_Archeological;
```

Code lists

```
STRUCTURE GR_ArcheologicalType =
    ArcheologicalTypeCode_ID: MANDATORY Oid;
    parentCode_ID: Oid referring to GR_SpatialUnit.GR_Arheolocal.GR_ArcheologicalType;
    description: CharacterString;
    !! Possible code list values:
(ancient_monument,modern_monument,historic_place,archeological_site_traditional_villag
e,fortress,movable_objects,theater,public_building,temple,architectiral_building,hydra
ulic_construction);
END GR_ArcheologicalType;
```

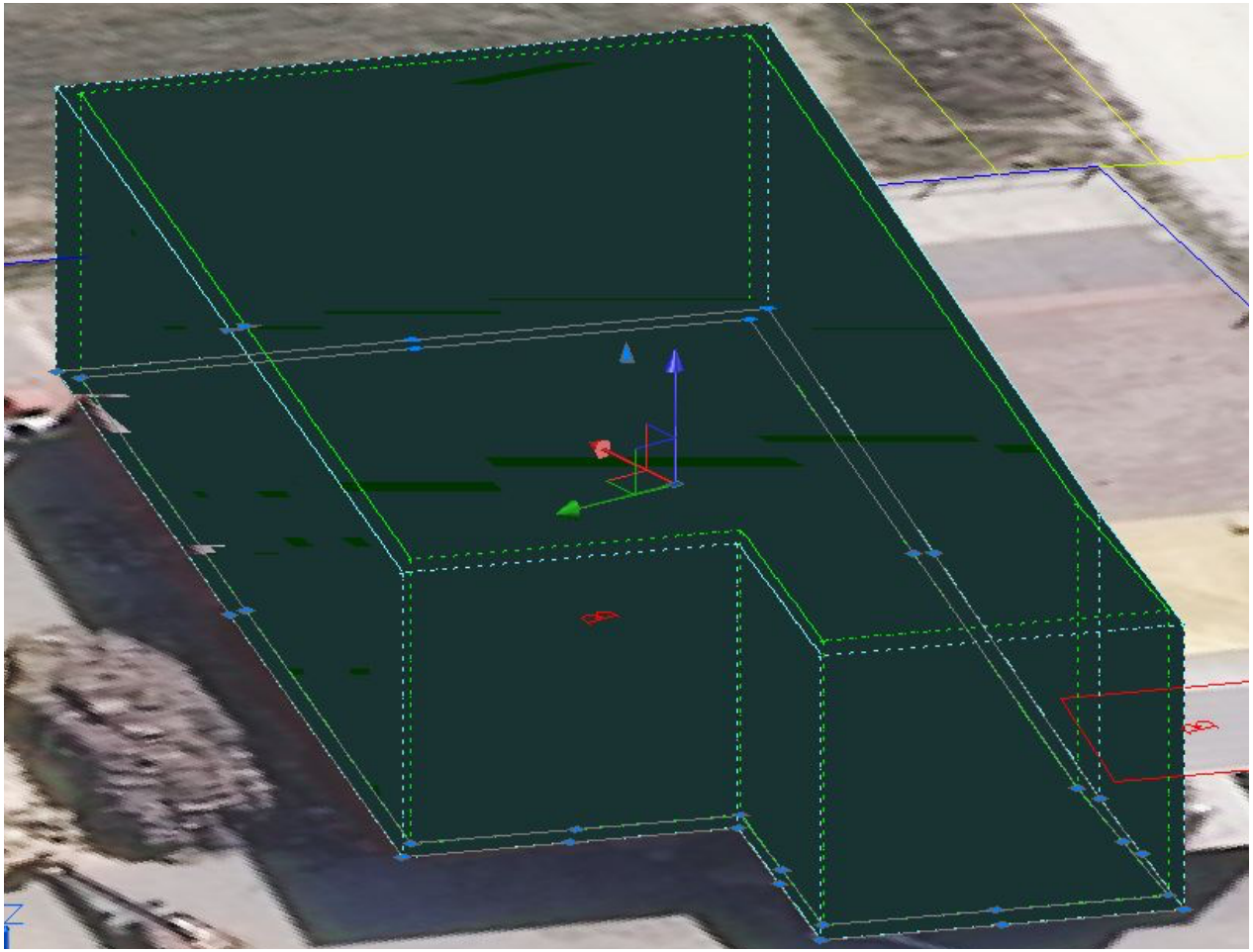
Enumeration types

```
GR_ArcheologicalZoneType = (
        protection_Zone_A,
        protection_Zone_B
                        );
```

Constraints should be:

- Defined at a **vendor neutral** way;
- Set for both **legal & physical models** (e.g. no time gaps between different property interests, number of shares=1, etc);
- Set also **for simple actions** preventing problems;
- Maintained and checked by …

Cross model constraints should be set in order to enforce the integration of legal and physical models



THE BUFFER OF THE PHYSICAL OBJECT SHOULD ALWAYS BE **INSIDE** THE BUFFER OF THE LEGAL OBJECT

INTERLIS

```
STRUCTURE GM_Point EXTENDS GM_Object =
geometry: MANDATORY Coord3D;
END GM_Point;
```

DATABASE

```
CREATE TABLE gm_point
(
t_id integer NOT NULL,
geometry geometry (PointZ),
Constraint GM_POINT_PKEY (T_tid)
);
```

```
CREATE TABLE gr_legalspaceunfinishedconstruction(
t_id integer NOT NULL,
type integer,
startdate character varying(20) NOT NULL,
endexpected character varying(20),
CONSTRAINT gr_legalspaceunfinishedconstruction_pkey PRIMARY KEY (t_id),
CONSTRAINT start_end_dates CHECK (endexpected::text >= startdate::text)
)
INHERITS (gr_legalspacebuildingunit);
```

5 CONCLUSIONS & FUTURE WORK

CONCLUDING REMARKS

RECOMMENDATIONS FOR FUTURE WORK

3D MLAS FOR GREECE

- A step towards the creation of a NSDI
- Levels : unified LAS proposal for Greece
- link with external registrations
- 3D cases in Greece can be solved
- The development of the prototype helps the assessment of the proposed model

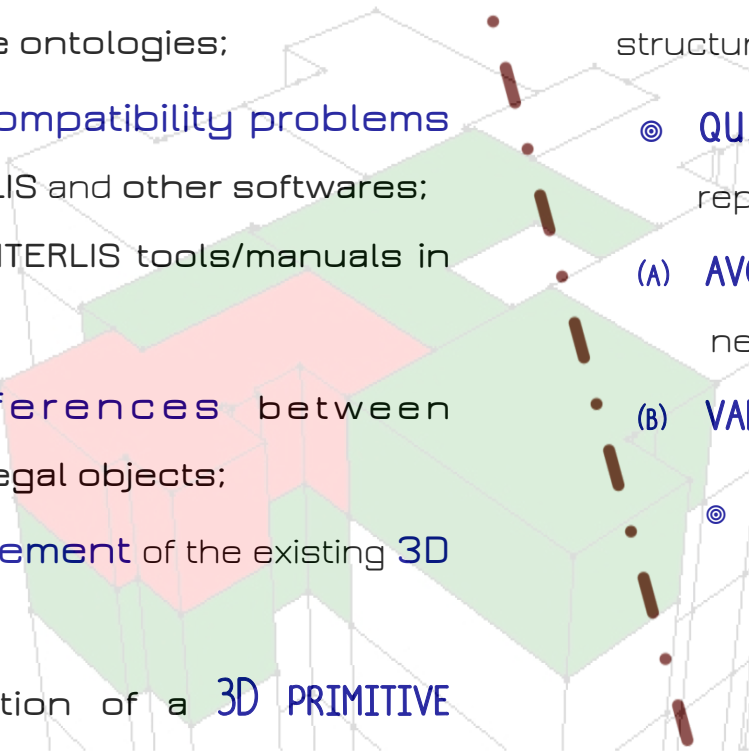
INTERLIS EXPERIENCE

- directly implementable LADM model which speed up the technical implementation
- Compatibility problems arise - faced
- Proposed hierarchical structure for code lists
- Formal specification of constraints

EVALUATION OF THE MODEL

- Conceptual model is validated with real sample data
- Some constraints and associations are not supported
- Linking legal & physical with external classes is succeeded
- 3D geometry is stored in multiple ways ~~ difficult to validate

- Include **air** as a **level**;
- creation of an **ontology** to define & maintain the values of the code lists;
- establishment of an **organization** at national/ international level for **maintaining** the ontologies;
- **solution** to **compatibility problems** between INTERLIS and other softwares;
- Provide more INTERLIS tools/manuals in **English**;
- **Create references** between physical and legal objects;
- further **improvement** of the existing **3D data types**;
- explicit definition of a **3D PRIMITIVE** (GM_Solid);
- use of actual geometry, topology or bbox?



- definition of **FUNCTIONS**, **CONSTRAINTS** and **RULES** to be applied at the data types and **CHECK** their **VALIDATION**;
- creation of the **MAPPINGS** between the **TOOLS** in order to recognize & check the proposed structures;
  - **QUALITY CHECKING** both 2D &3D representations:
    - (A) **AVOID GAPS AND OVERLAPPING** between neighboring objects
    - (B) **VALIDATE** that all the objects are **CLOSED**
  - Selection of **more coherent datasets** to cover a bigger area & investigate the **integration** of spatial and non-spatial data by performing **complicated queries**

Questions?

Thank you!

Σας ευχαριστω!