Evaluation of the International 3D Geospatial Data Models and IFC Standard for Implementing LADM-based 3D Digital Cadastre

Behnam Atazadeh, Hamed Olfat,
Abbas Rajabifard, Bahram Saeidian

csdila.unimelb.edu.au
linkedin.company.com/csdila
@UoMCSDILA

THE UNIVERSITY OF MELBOURNE

CSDILA
THE CENTRE FOR SPATIAL DATA INFRASTRUCTURES & LAND ADMINISTRATION
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LADM and 3D digital cadastre

- The Land Administration Domain Model (LADM) provides a conceptual description of fundamental entities required for implementing 3D digital cadastre.

- There is no specific technical encoding to implement the LADM standard for 3D digital cadastre.

- In reality, there are various types of legal spaces in each jurisdiction, which may have complex geometric shapes such as oblique and curved boundaries

- Depending on the jurisdictional requirements, the LADM standard can be implemented variably for the purpose of 3D digital cadastre.

Aim of this study

Aim: To evaluate 3D data encoding standards (i.e. CityGML, IndoorGML, InfraGML, and IFC) and their relations with the LADM standard to identify how the concepts defined in the LADM standard can be encoded within these stndards.

This will help us to identify series of recommendations for further enhancement of the current 3D geospatial data models as well as the IFC standard to support LADM-based 3D digital cadastre.

3D Geospatial Standards

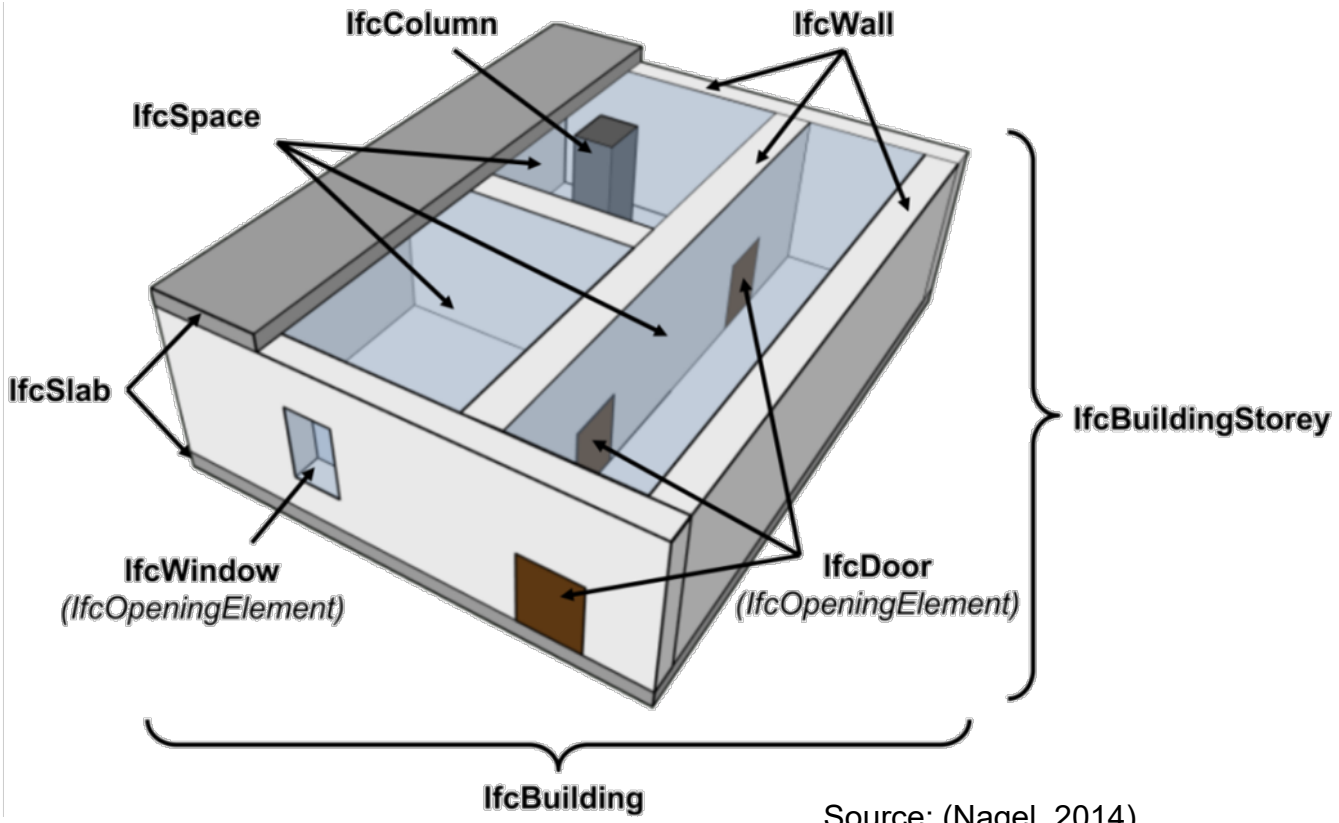
- **CityGML: An open 3D data standard for storing and exchanging digital 3D models of built and natural objects in cities.**

- **LandInfra/InfraGML: Developed for modelling civil engineering infrastructure objects, surveying data and land and property interests.**

- **IndoorGML: For modelling, representing and exchanging datasets associated with indoor spaces.**

Industry Foundation Classes (IFC)

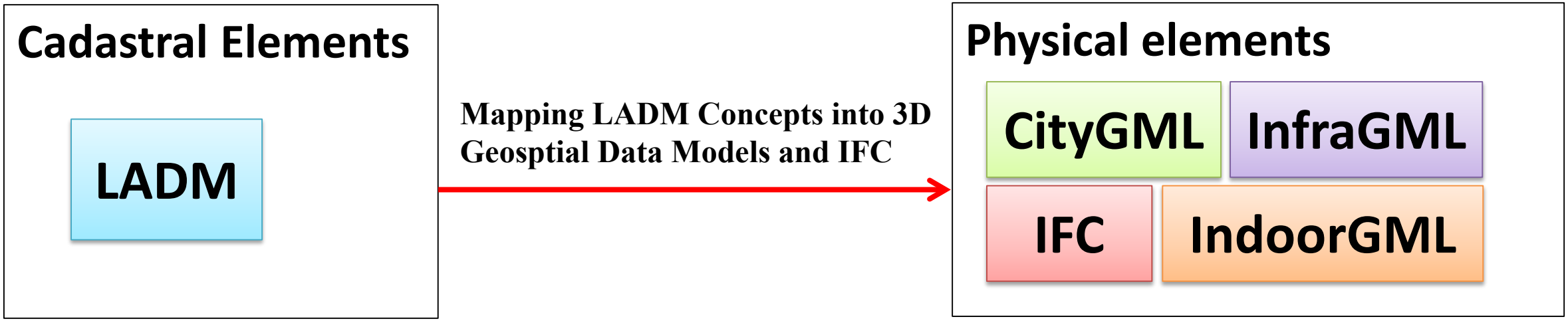
- Facilitates interoperability in the BIM domain
- Hundreds of entities to model lifecycle of built assets
- Spatial relationships between building elements and spaces



Source: (Nagel, 2014)

3D encoding standards and LADM

- 3D geospatial data models and IFC standard mainly define physical reality of built and natural environments.
- Most 3D geospatial data models and IFC standard (except InfraGML) in their current form do not include cadastral elements for managing ownership boundaries and rights, restrictions, and responsibilities.



Current Literature

- **Integrating CityGML and LADM using ADE mechanism**

  1. **Generic**
  2. **Jurisdiction Specific**

- **Linking IndoorGML and LADM**

- **LADM and IFC**

- **LADM and LandInfra/InfraGML: These standards are partly complementary to each other while some functionalities are overlapped between LADM and LandInfra/InfraGML**

Evaluation

- The evaluation is based on LADM packages, and the main concepts defined within each package.
- We identified the suitable entities within each technical encoding for mapping LADM concepts.
- We also considered the appropriate extension mechanisms allowed by each technical encoding.

Party Package

The core part of CityGML and IndoorGML standards do not provide explicit attributes or classes for encoding party package of the LADM standard.

On the other hand, InfraGML and IFC standards include some relevant classes and attributes for implementing the party package.

Both InfraGML and IFC standards provide the mechanism of property sets to incorporate any further user defined attribute basedon the LADM standard.

Party Package in LandInfra

- In the LandInfra/InfraGML standard, parties can be encoded using attributes of the "Professional" class as well as the "Signature" attribute in the "Statement" class.

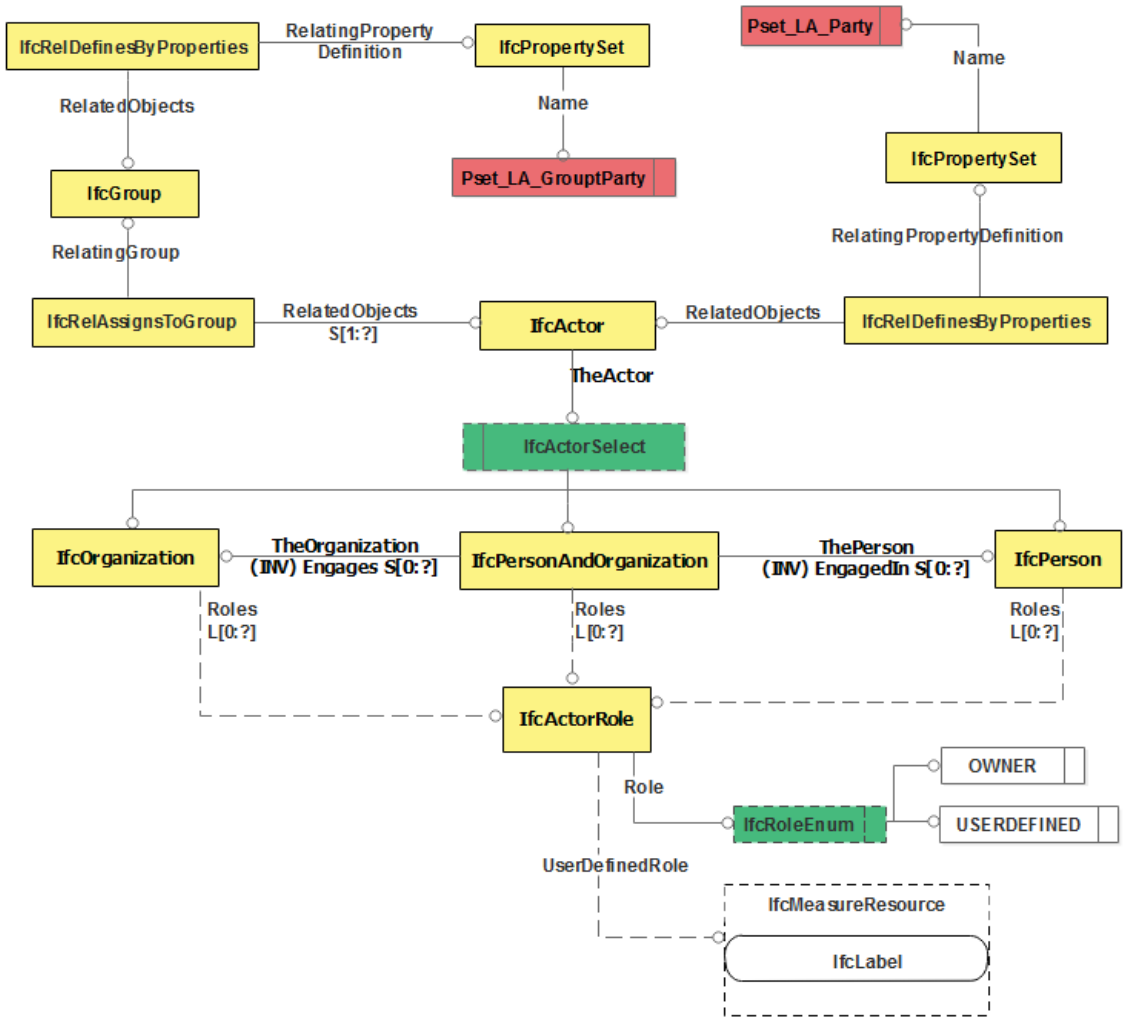
- Another attribute is the "beneficiaryPary" attribute defined the "Easement" class, which can be used to encoding parties such as utility companies.

- In addition, the "Ownership" class is also defined in the LandInfra/InfaGML standard to specify single or multiple owners of a property unit.

Party Package in IFC

IfcActor
IfcActorRole
IfcOrganization
IfcPerson
IfcPersonAndOrganization

Group parties in the LADM can be encoding by considering both "IfcActor" and "IfcGroup" entities as well as the the "IfcRelAssignsToGroup" relationship entity



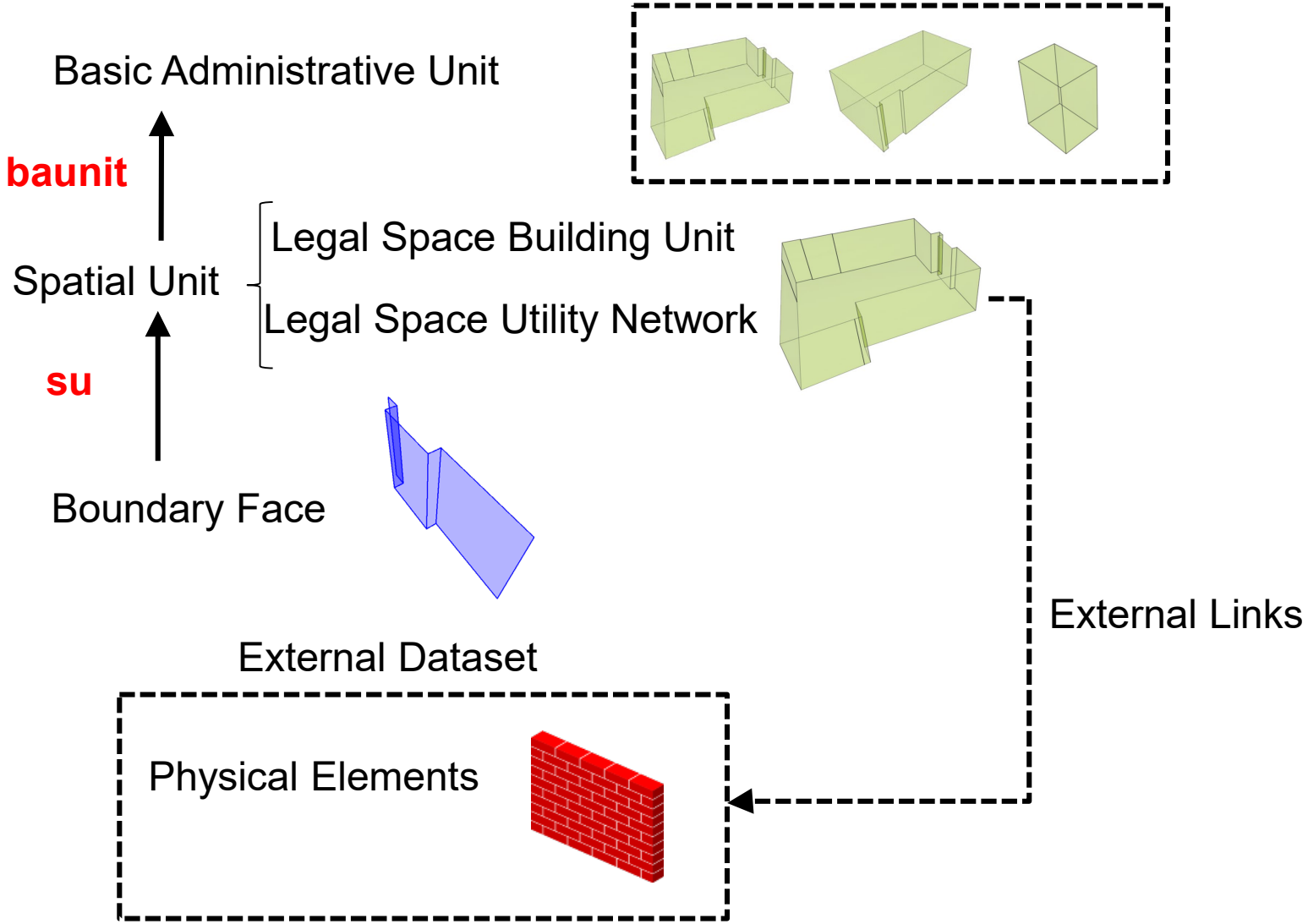
Administrative Package

- **CityGML, IndoorGML, and IFC: The administrate package is not explicitly defined in the core part of these standards. However, there are possible entities to encode basic administrative units**

- **InfraGML**

LADM	**LandInfra/InfraGML**
LA_AdministrativeSource	Statement
LA_Restriction	Easement
LA_BAUnit	PropertyUnit
LA_RRR	InterestInLand

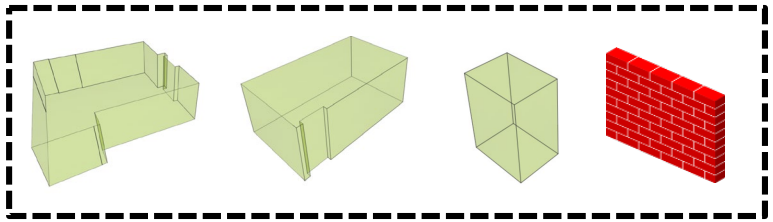
Spatial Unit Package



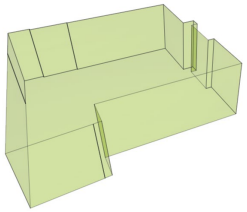
CityGML

Basic Administrative Unit→ City Object Group

Group Member



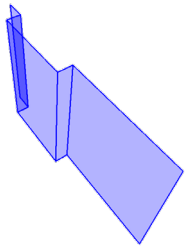
Spatial Unit → Room



Bounded By

Legal Boundary → Boundary Surface

- Wall Surface
- Interior Wall Surface
- Ceiling Surface
- Outer Ceiling Surface
- Floor Surface
- Outer Floor Surface
- Roof Surface
- Ground Surface
- Closure Surface

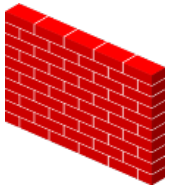


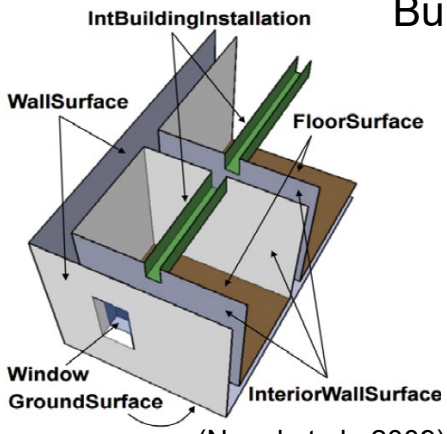
Physical element →

Building Part

Interior Building Installation

Building Installation

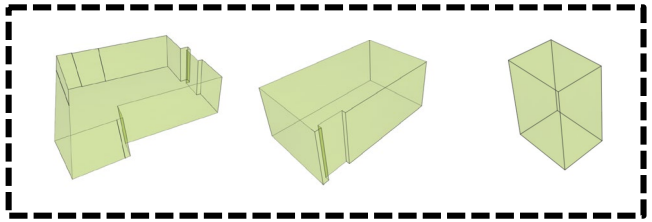




(Nagel et al., 2009)

InfraGML

Basic Administrative Unit → Condominium Unit

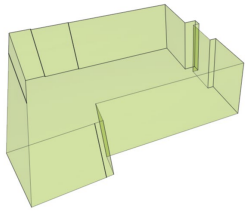


Main Part or Accessory Part

Spatial Unit → Building Part

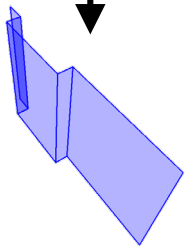
Shape and Location

Spatial Unit



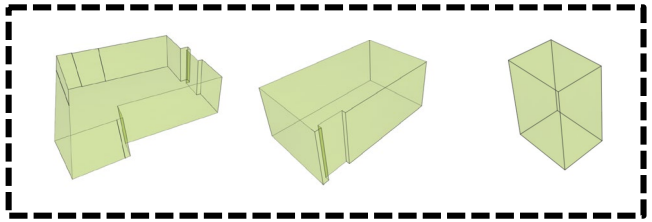
Bounding Element

Boundary Face → Bounding Element (Face)

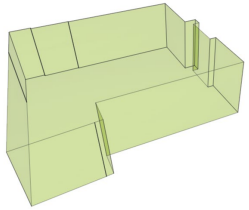


IndoorGML

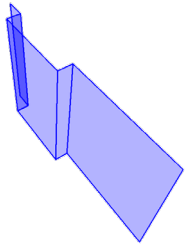
Basic Administrative Unit → Primal Space Features



Spatial Unit → Cell Space

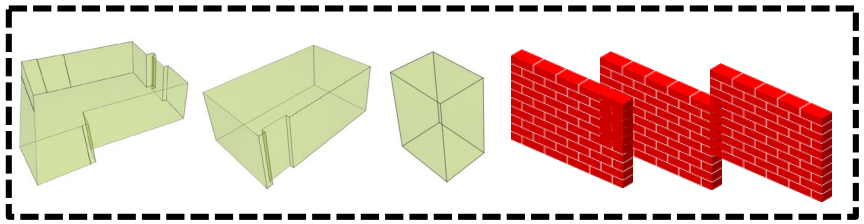


Boundary Face → CellSpaceBoundary



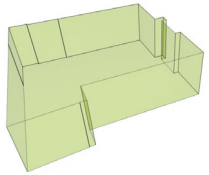
IFC Standard

Basic Administrative Unit → (Spatial) Zone



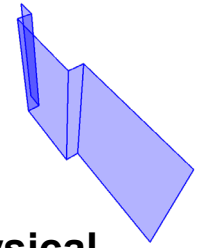
Referenced in Spatial Structure

Spatial Unit → IfcSpace
IfcExternalSpatialElement



Relating Space

Boundary Face → Space Boundary



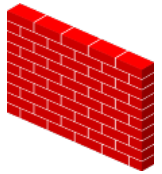
Internal

External

Physical

Virtual → Virtual element

Physical element



- Building elements (e.g. walls,)
- Distribution elements (e.g. flow segment)
- Geographic elements

Discussion and Key Messages

- Each implementation model or technical encoding should have a **distinct use case**
- **An IFC-based implementation** of the LADM standard might be effective for 3D digital lodgement of cadastral datafor **individual buildings and property subdivisions**
- Creating a **CityGML encoding** for LADM would be a key step towards realising **3D property maps** with fully integrated representations of subsurface and aboveground RRRs.
- **InfraGML** offers **surveying features** that are not fully covered by the LADM standard
- **IndoorGML linked to LADM data** can be useful for **lawful indoor navigation**

Discussion and Key Messages

If jurisdictional profiles are considered, there would be **theoretically many implementation encodings** of the LADM standard