

Behnam ATAZADEH, Mohsen KALANTARI, Abbas RAJABIFARD







### **Legal and Physical views**

- Spatial extent of ownership interests can be defined in three approaches:
  - Pure legal modelling: Cognitive legal spaces (LADM)
  - Pure physical modelling: Physically existent elements (CityGML)
  - Integrated modelling: Appropriate composition of legal spaces and physical elements (Legal extension of IFC or CityGML)

 BIM have the flexibility to represent spatial extent of 3D ownership interests by all the above approaches



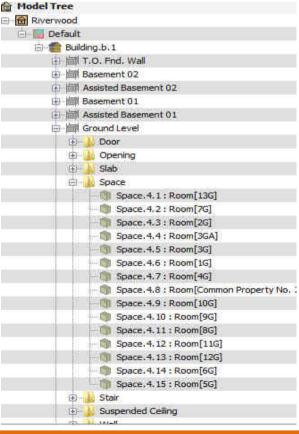
## **BIM (Building Information Modelling)**

- CSDILA
  THE CENTRETON SMATTAL
  DATA INFRASTRUCTURES
  & LAND ADMINISTRATION
- A rich data repository of information about physical and functional aspects of buildings.
- It can be enriched with legal objects (Atazadeh et al, 2016)

IFC standard provides a hierarchical spatial structure to store

building information:

- site
- building
- stories
- spaces and
- building elements







#### **LADM**



- Spatial Unit
  - Spatial representation of ownership interests
    - textual descriptions
    - sketch maps
    - Points
    - unstructured set of lines
    - areal and volumetric objects
- Basic Administrative Unit
  - arrange and group a set of spatial units
  - apartment unit, and its car park
     and storage area
- Versioned Object ofeature Type x Party::LA\_Party +party 0..1 Versioned Object mP arty «featureType» Administrative: LA\_RRR Each spatial unit has a dimension. There Topology relationship Versioned Object can be a 2D spatial unit, or a 3D spatial ISO19125\_Type as «feature Type» defined in ISO 19125 unit with a spatial unit with dimension unitRr Administrative::LA BAUnit "liminal" in between, See Annex B. O.. \* +baunit suHierarchy Versioned Object relationSu suBaunit «featureType» 0..\* +su 0..\* Spatial Unit: {If structure = text then LA RequiredRelationshipSpatialUnit geometry/topology is optional} 0..\* relationship: ISO19125\_Type «feature Type» Spatial Unit::LA\_SpatialUnit «invariant» extAddressID: ExtAddress [0..\*] Lif dimension=2D then volume not specified Versioned Object area: LA\_AreaValue [0..7] if dimension=3D then area not specified} suGroupHierarchy dimension: LA DimensionType [0..1] «feature Type» label: CharacterString [0..1] Spatial Unit::LA Level referencePoint: GM Point ID. 11 sulD: Did + IID: Old Versioned Object 0..\* 0..1 + name: CharacterString [0..1] surfaceRelation: LA\_SurfaceRelationType [0..1] registerType: LA\_RegisterType [0..1] volume: LA VolumeValue [0..\*] «feature Type» structure: LA\_StructureType [0..1] Spatial Unit::LA\_SpatialUnitGroup areaClosed(): Boolean type: LA LevelContentType [0..1] hierachyLevel: Integer +part volumeClosed(): Boolean label: CharacterString [0..1] computeArea(): Area name: CharacterString [0..1] computeVolume(): Volume «invariant» referencePoint: GM\_Point [0..1] suSuGroup createArea(): GM\_MultiSurface (If dimension = 3D than structure in createVolume(): GM\_MultiSolid LA Level can be toplogical, polygon, unstructured or point? constraints countroart)+countrelement)>01 «feature Type» «feature Type» Spatial Unit::LA\_Legal Space UtilityNetwork Spatial Unit::LA\_Legal Space Building Unit extPhysicalNetworkID: ExtPhysicalUtilityNetwork ID...11 + extPhysicalBuildingUnitID: ExtPhysicalBuildingUnit [0..1] status: LA\_UtilityNetworkStatusType [0..1] type: LA\_BuildingUnitType [0..1] type: LA\_UtilityNetworkType [0.1]

- Boundary Faces
  - Boundaries of 3D spatial units



## **CityGML**

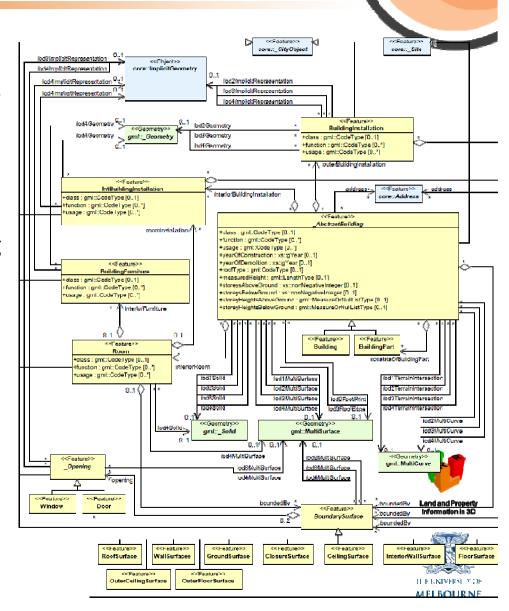
- "\_Room" class
  - for modelling ownership interests

#### Physical boundaries

Subclasses of
 "\_BoundarySurface" for modelling
 wall, ceiling, floor and roof
 boundaries.

#### Virtual Boundaries

- "ClosureSuface" subclass for boundaries without physical manifestation
- those ones defined in balcony and terraced areas.



DATA INFRASTRUCTURES & LAND ADMINISTRATION

### **Integrated Spatial Data Models**

- Some jurisdictions, such as those of Australia, define arrangements of ownership interests within multi-level buildings using both physical structures and legal spaces.
- Various integrated models proposed:
  - LADM-based ADE extensions of CityGML (Rönsdorff et al. 2014)
    - China (Li et al. 2016), Poland (Gózdz et al. 2014)
  - Other ADE extensions of CityGML
    - Preliminary ADE of CityGML for cadastral purposes(Dsilva 2009)
    - CityGML ADE for immovable property taxation (Çağdaş 2013)
  - Linking IndoorGML and LADM (Zlatanova et al. 2016)
  - Integration of CityGML and ePlan
    - 3DCDM (Aien 2013), LADM OWL (Soon et al. 2014)
  - Cadastral Extension of IFC (Atazadeh et al, 2016)







## Methodology



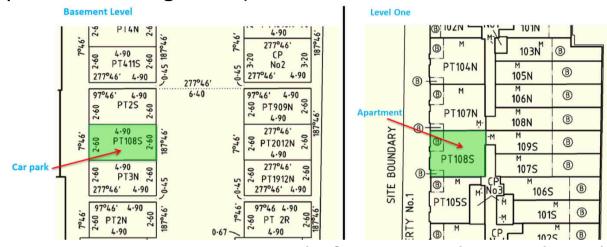
- Identify 3D ownership interests in Victoria, Australia.
- Select a relatively complex multi-level building and develop three types of BIM-based models
  - Legal model
  - Physical model
  - Integrated model
- Compare models by using some metrics.
  - number of objects
  - geometry batches
  - visualization speed
  - query speed
  - communication of structural boundaries





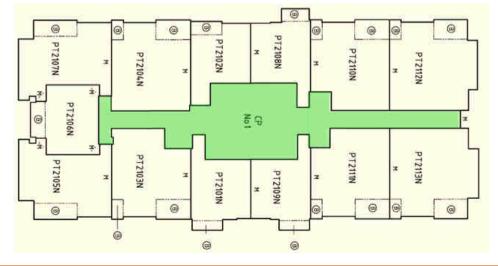
## 3D Ownership Interests In Victoria

 Strata Lots: Composed of a main lot (apartment unit) and accessory lots (carpark and storage area)



Common Properties: Composed of various indoor and outdoor spaces as

well as physically structures.



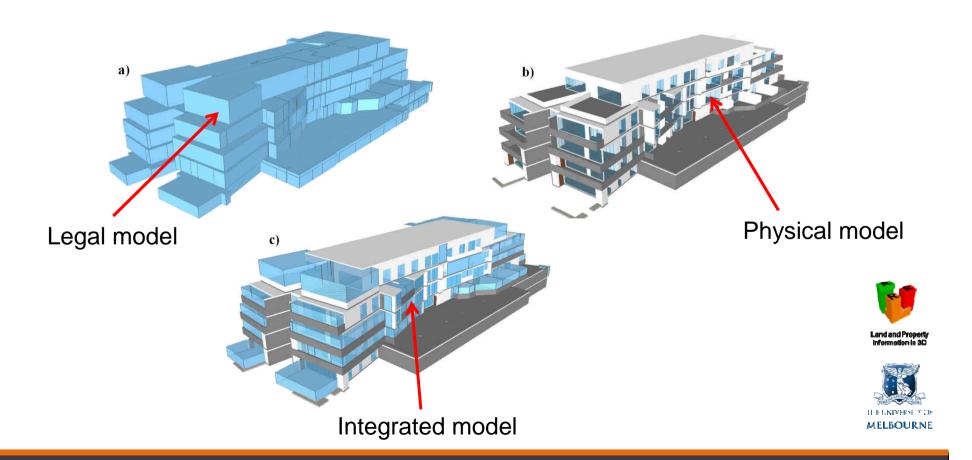


DATA INFRASTRUCTURES & LAND ADMINISTRATION



# Implementation of BIM Models

- CAD plans used for creating physical model
- Subdivision plans used for creating legal model
- Both plans used for creating integrated model





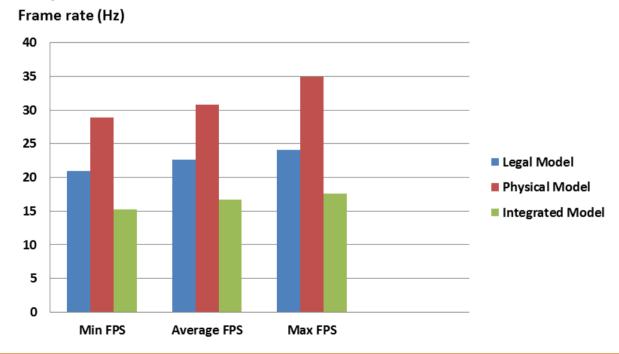
### **Results**



Number objects and geometry batches

BIM Model	Number of objects	Number of geometry batches	
Legal model	146	146	
Physical model	962	1131	
Integrated model	1108	1277	

Visualization speed



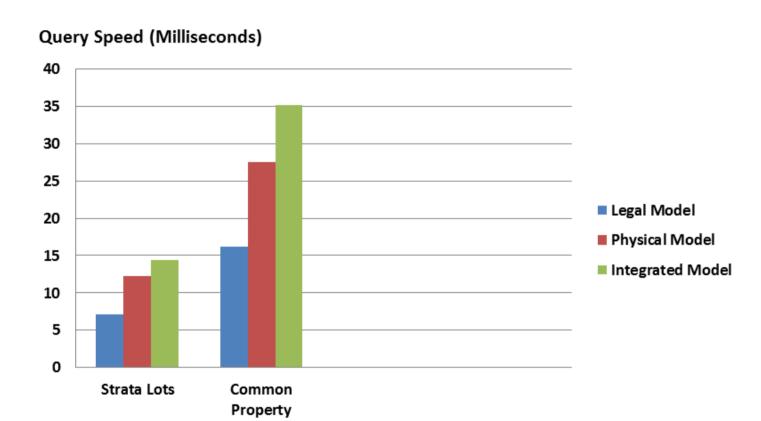




# **Results (Continued...)**



Query speed





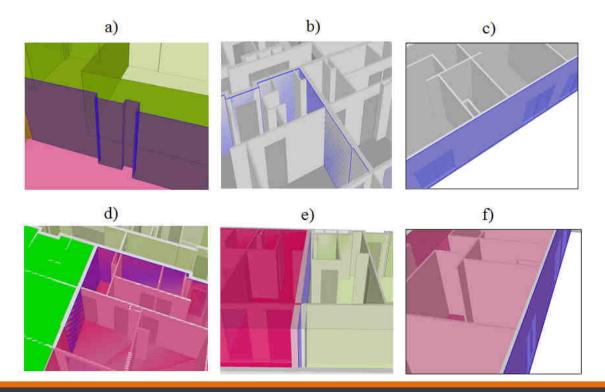


# **Results (Continued...)**



Communication of structural boundaries

BIM model	Interior Boundaries	Median Boundaries	<b>Exterior Boundaries</b>
Legal model	Incommunicable	Incommunicable	Incommunicable
Physical model	Communicable	Incommunicable	Communicable
Integrated model	Communicable	Communicable	Communicable







#### **Conclusions and Future work**



#### Findings

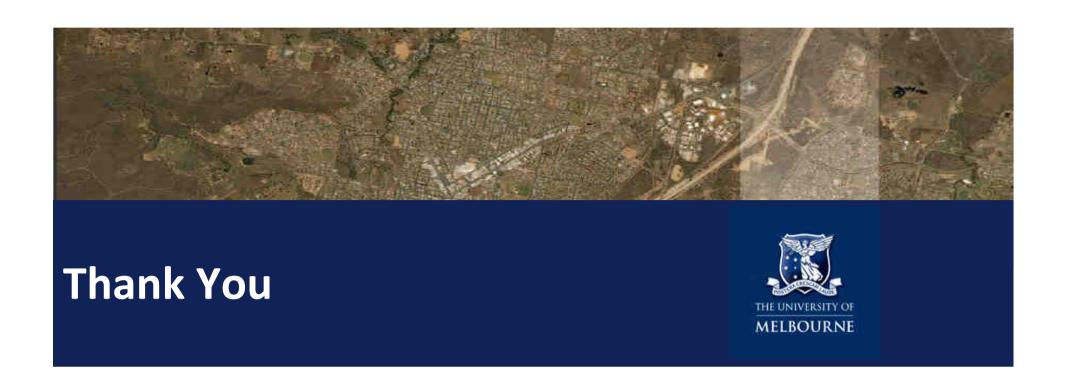
- Pure legal or physical models can perform better in terms of visualizing and querying
- Integrated models would provide more intuitive and visual communication of 3D ownership interests

#### Recommendations for Future research

- Using the adopted approaches for modelling ownership interests associated with urban infrastructure (tunnels, bridges, roads, ...)
- Investigating the viability of BIM environment for managing lifecycle of cadastral information (nD modelling) in multi-level building







Questions?

