

An aerial photograph of an archaeological site, possibly a Roman or Greek city, with a 3D LADM-based system overlay. The overlay consists of various colored polygons (pink, purple, blue, green, yellow) representing different areas or structures within the site. The site is surrounded by a wall and has a central area with a large circular structure.

MSc thesis defense in Geomatics

LADM-based 3D system for Archaeological Site Information Registration

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Company Supervisor:

Ir. Robert Voûte

Co-reader:

Prof. Mila Koeva

LADM-based 3D system for Archaeological Site Information Registration

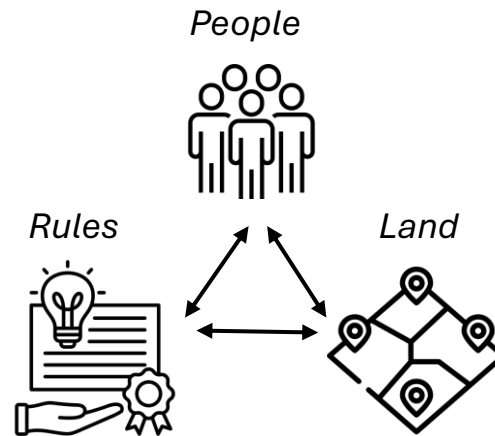


..it's an International Standard (ISO 19152) that concerns information on 'people to land relationships'

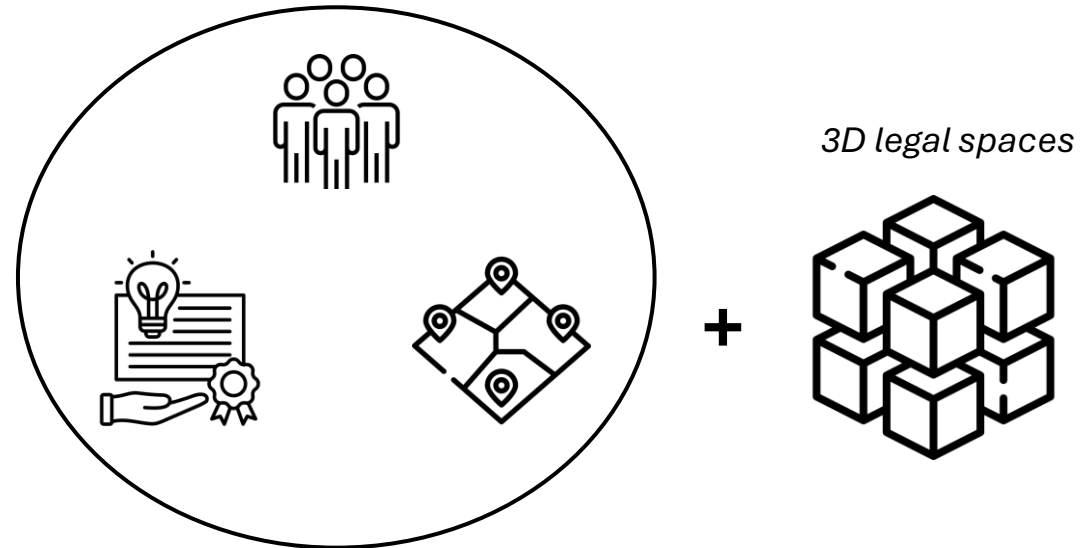
LADM-based 3D system for Archaeological Site Information Registration



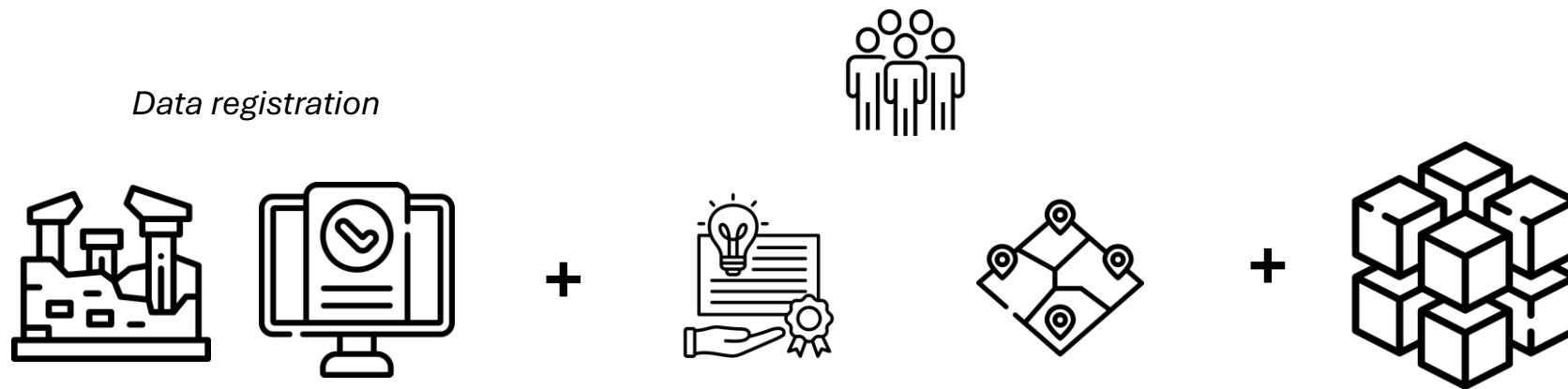
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LADM-based **3D system** for Archaeological Site Information Registration



LADM-based 3D system for Archaeological Site Information Registration



Agenda

01

Motivation

02

Research
Questions &
Research
Methodology

03

Literature
Review

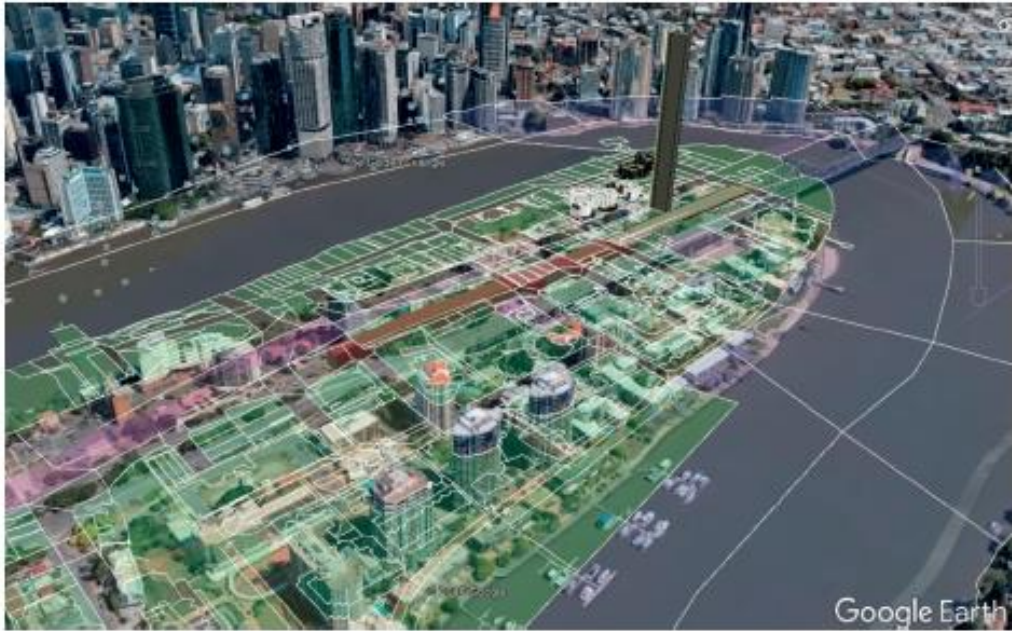
04

Model
Development
& Evaluation

05

Conclusions &
Discussion

1. Motivation



The prototype of a web-based 3D Cadastre dissemination built on top of Google Earth in Brisbane, Queensland (source: Peter van Oosterom FIG PUBLICATION NO. 72) system

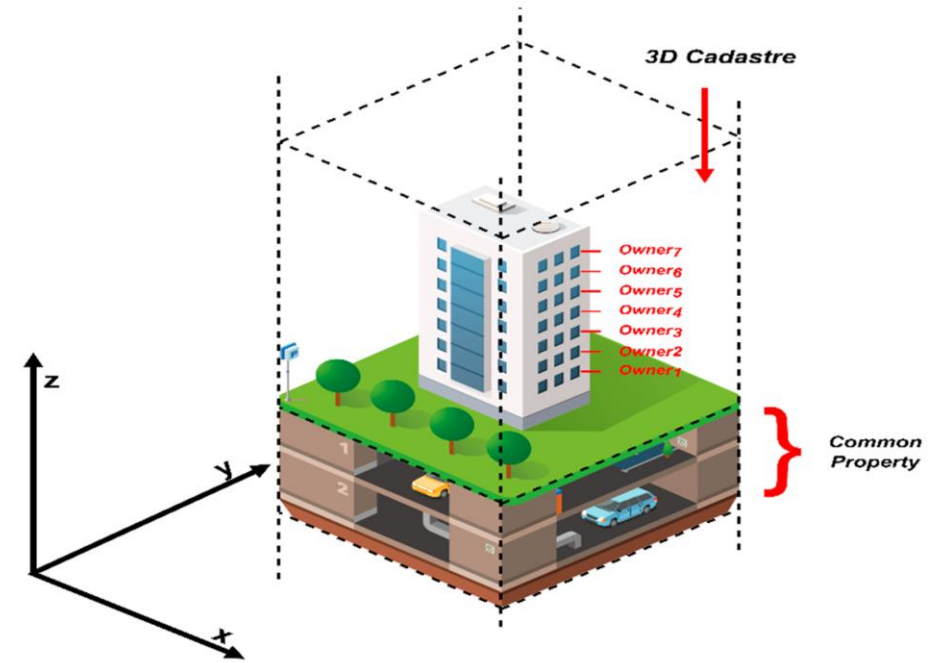


Illustration of the 3D property use (Sürmeneliet. al 2022)

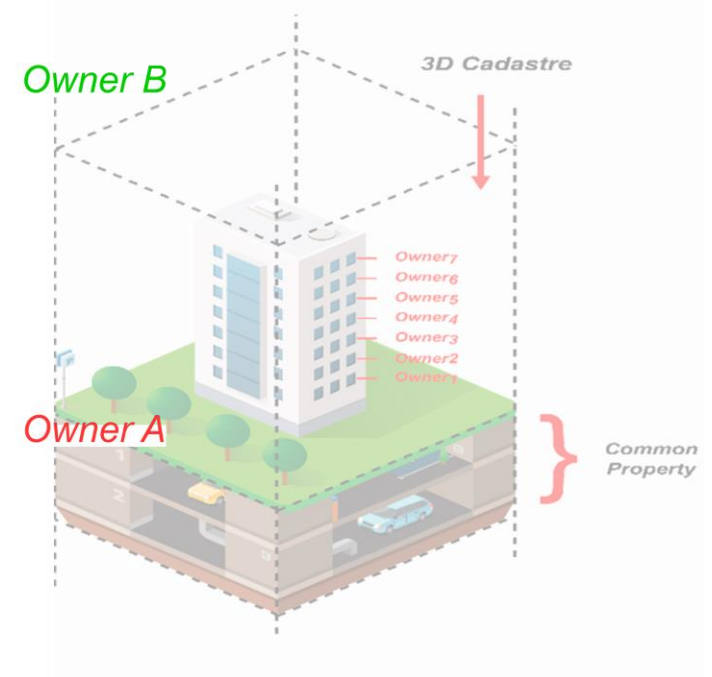
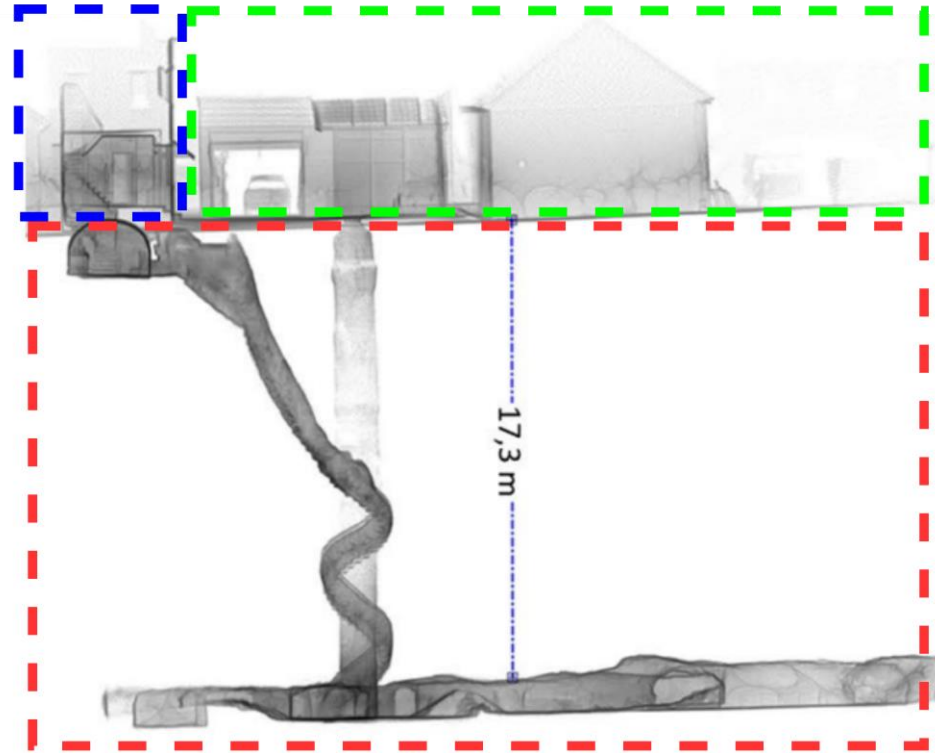


Why 3D?

1. Motivation



The prototype of a web-based 3D Cadastre dissemination system built on top of Google Earth
Oosterom FIG PUBLICATION NO. 72)

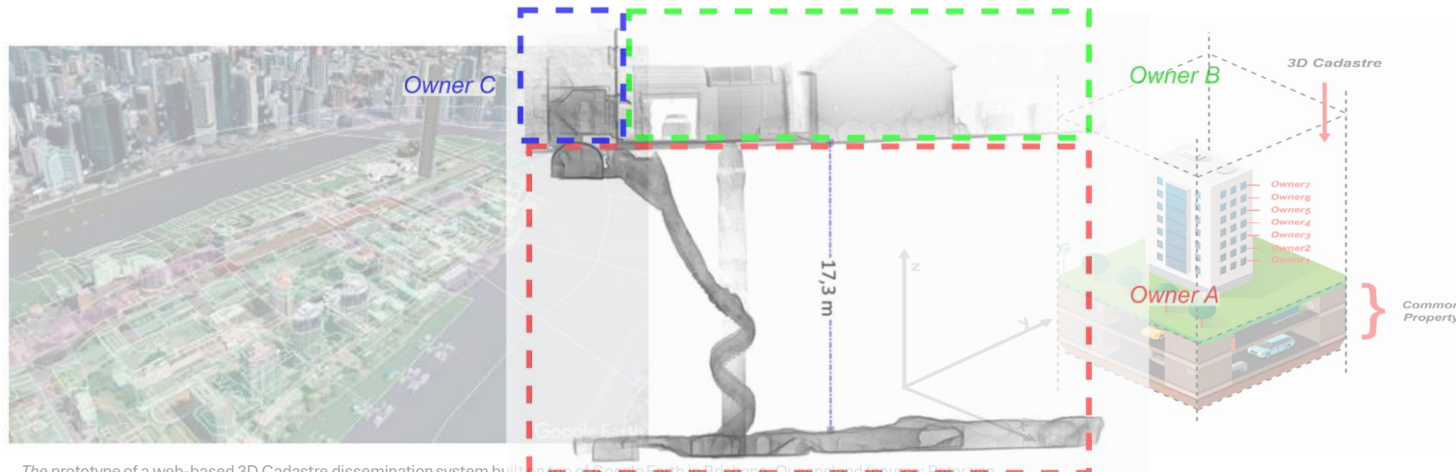


of the 3D property use (Sürmeneliet. al 2022)



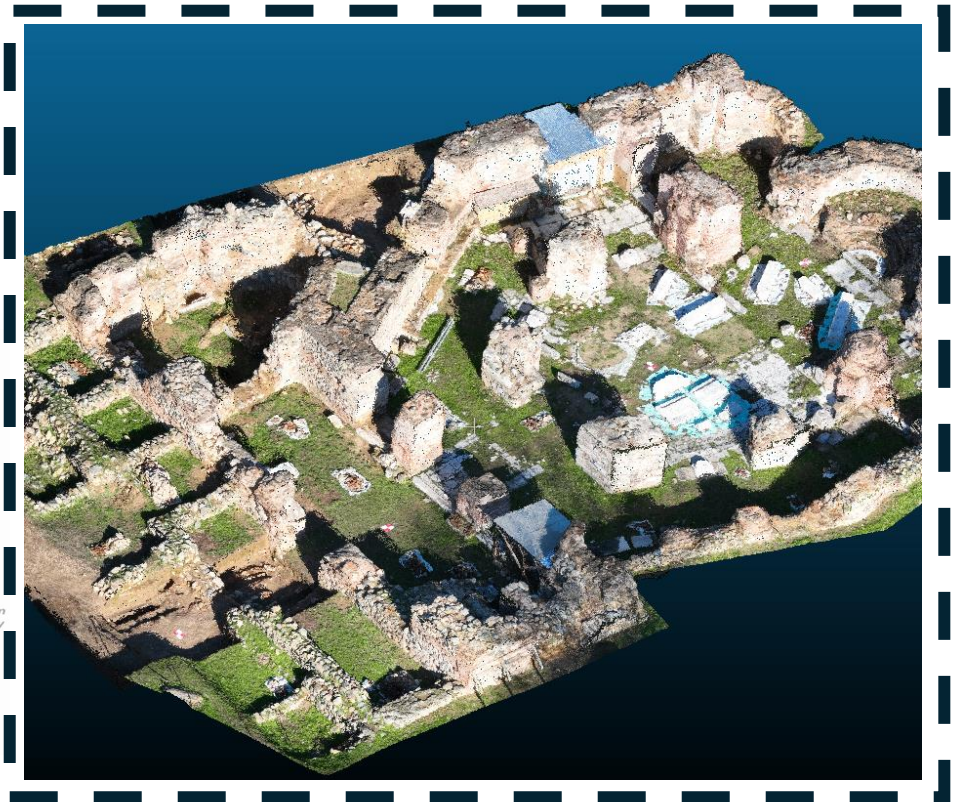
Why 3D?: Rapid urbanization and the emergence of complex multi-owner structures have put great pressure on traditional property management methods.

1. Motivation



The prototype of a web-based 3D Cadastre dissemination system built on...
Oosterom FIG PUBLICATION NO. 72)

Illustration of the 3D property use (Sürmeneliet. at 2022)



Lightweight Parnham, South West Aerial Surveys, 2022



Point cloud models have traditionally been associated with the documentation of archaeological sites, where capturing complex geometries is essential.

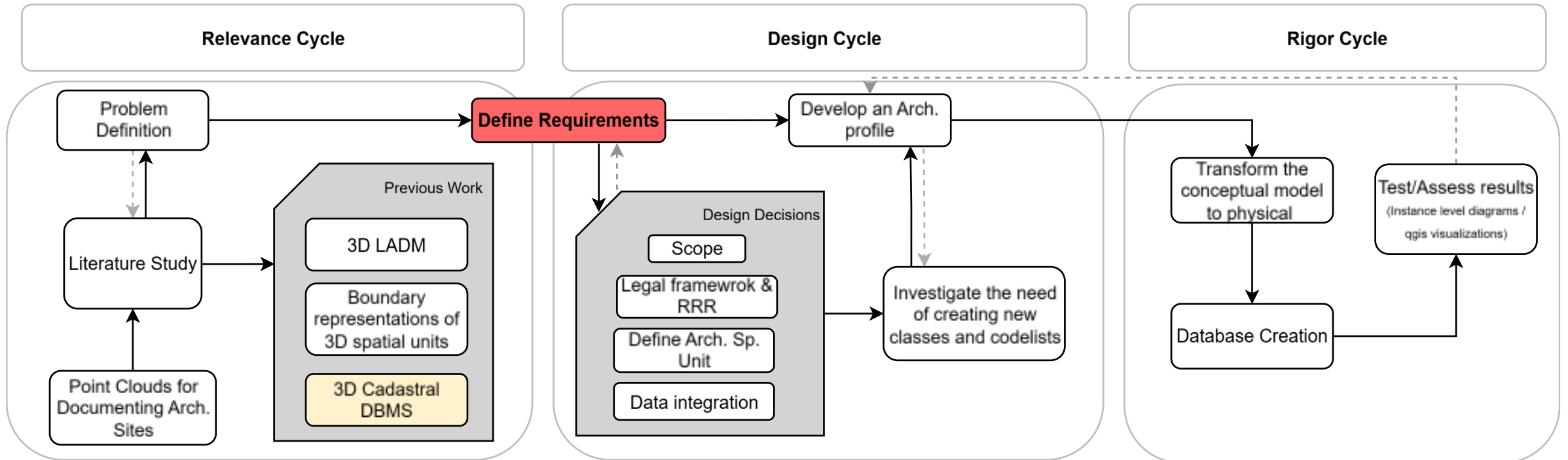
Research Questions

- **How can point cloud data be processed so that they can serve as boundary representations within LADM-based applications for archaeological purposes?**

Sub-questions:

- What is the LADM archaeological **profile** that should be developed?
- How can boundary **patches** be selected from point cloud data for use in archaeological applications?
- How to **link legal** and semantic information with **point clouds** for archaeological purposes in the context of LADM?
- How can point cloud-based boundary representations be structured to enable effective **querying, visualization, and validation** within LADM-based archaeological applications?

2. Research Methodology

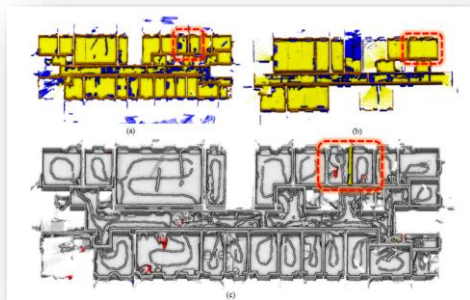


3. Literature Review

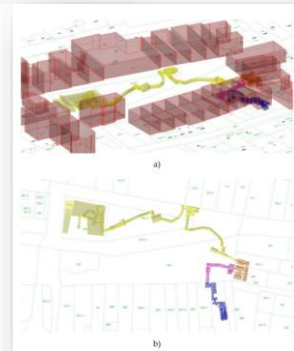
Related Work



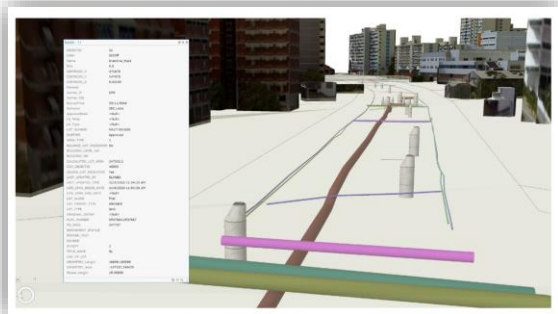
1. (Ramlakhan et al., 2023)



2. (Koeva et al., 2019)



3. (Bieda et al., 2020)



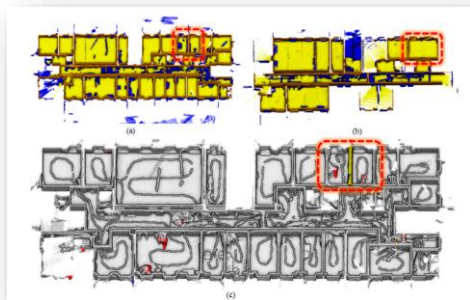
4. (Yan et al., 2019)

3. Literature Review

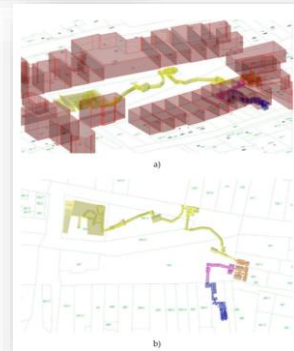
Related Work



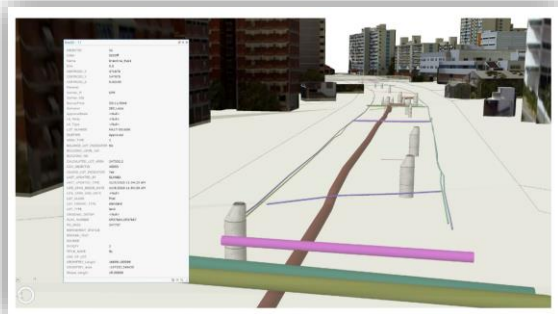
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3. (Bieda et al., 2020)



4. (Yan et al., 2019)

Archaeological Infrastructures

Country/System	Managing Authority	Scope&Content	Linkage to Cadastre	Standardization	3D Aspects
The Netherlands / National Monument Register	Dutch Cultural Heritage Agency	Registering all the designated monuments (old and new) and archaeological sites	Yes, through PLR	No	No
Belgium (Flanders) / Flanders Heritage Geoportal	Flanders Heritage Agency	Registering and digitizing protected monuments, archaeological sites, landscapes, UNESCO areas	Available only as overlay layers in the geoportal; no direct linkage to cadastral parcels	No	No
Greece / Hellenic Archaeological Cadastre	Directorate for the Curation of the National Archive of Monuments	Collecting, preserving, digitizing records of mobile and immovable monuments	No, only manual checks for public property identification	No (only conceptualization)	No (only conceptualization)

3. Literature Review



+

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Requirements:



Integrated legal-spatial model



Standardization (LADM-archaeological profiles)



Handling Cross-Boundary Cases



Legal Framework & RRRs

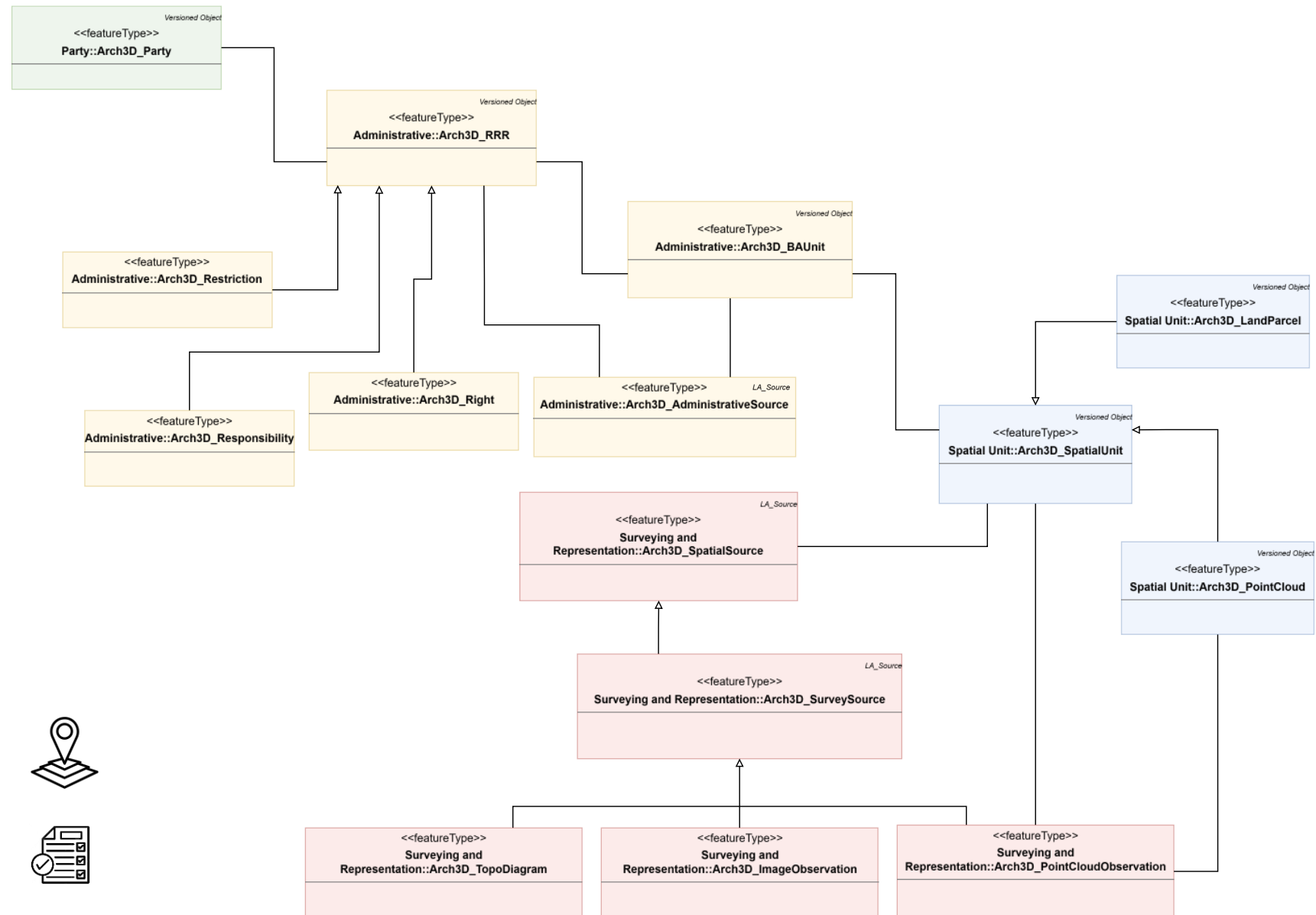


Versioning

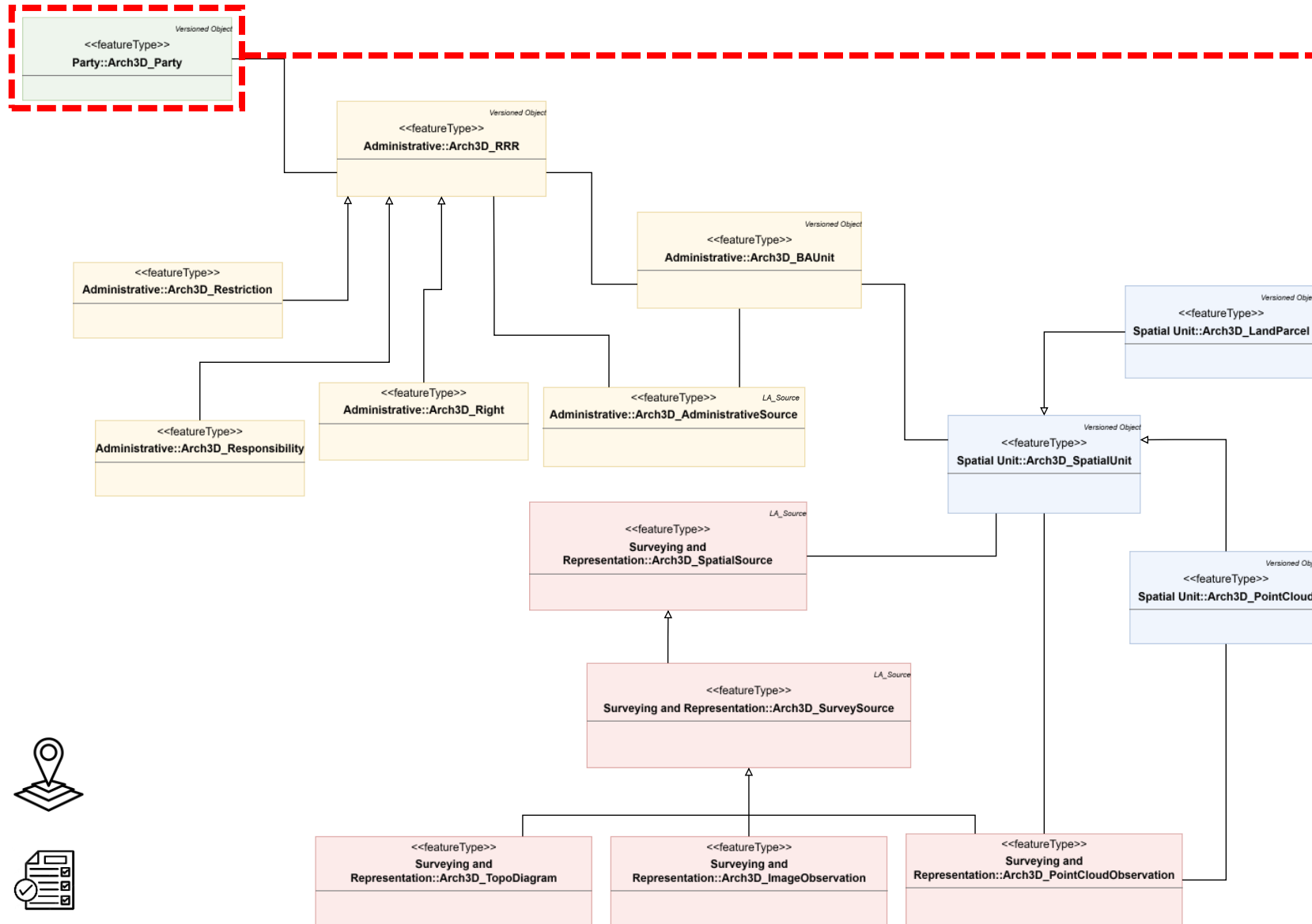


3D Archaeological Unit Definition

4. Profile Development



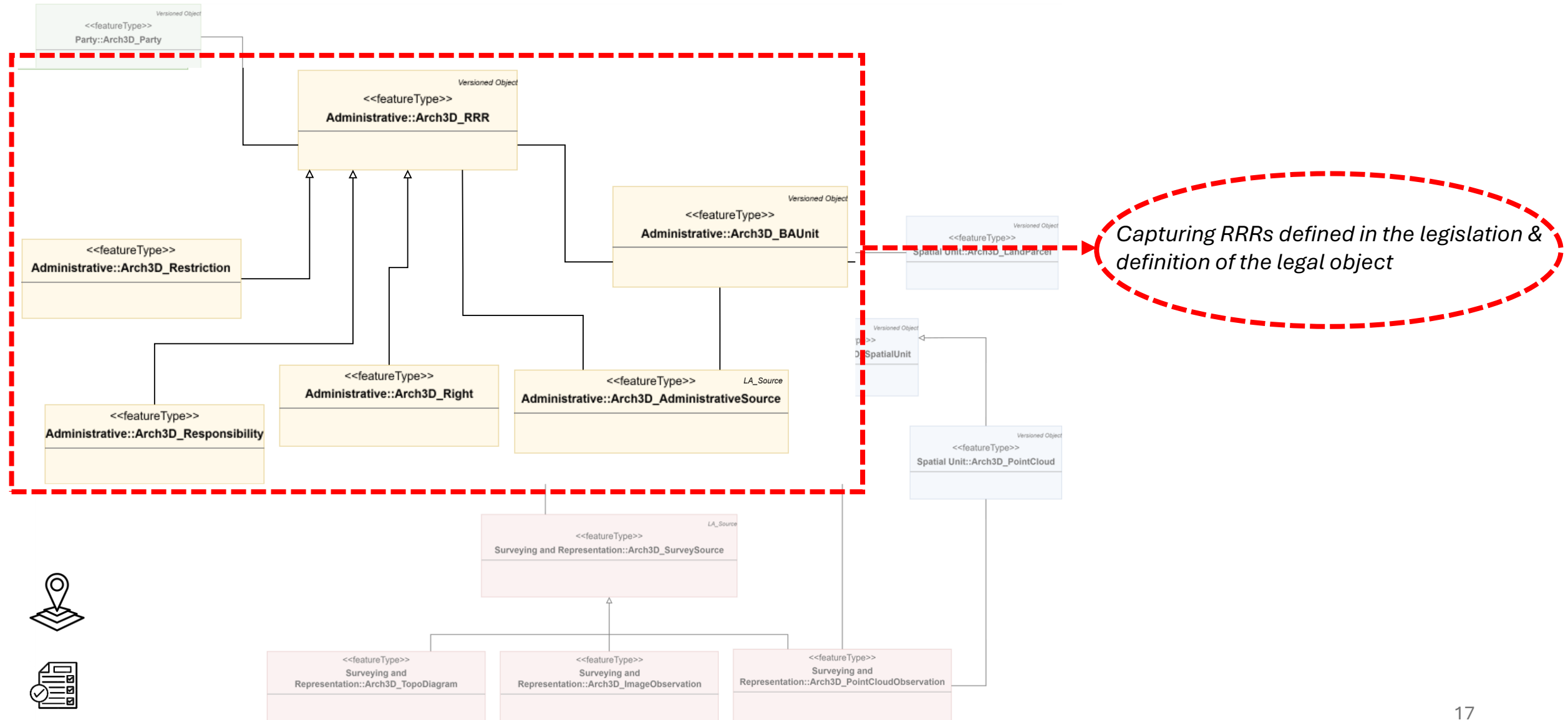
4. Profile Development



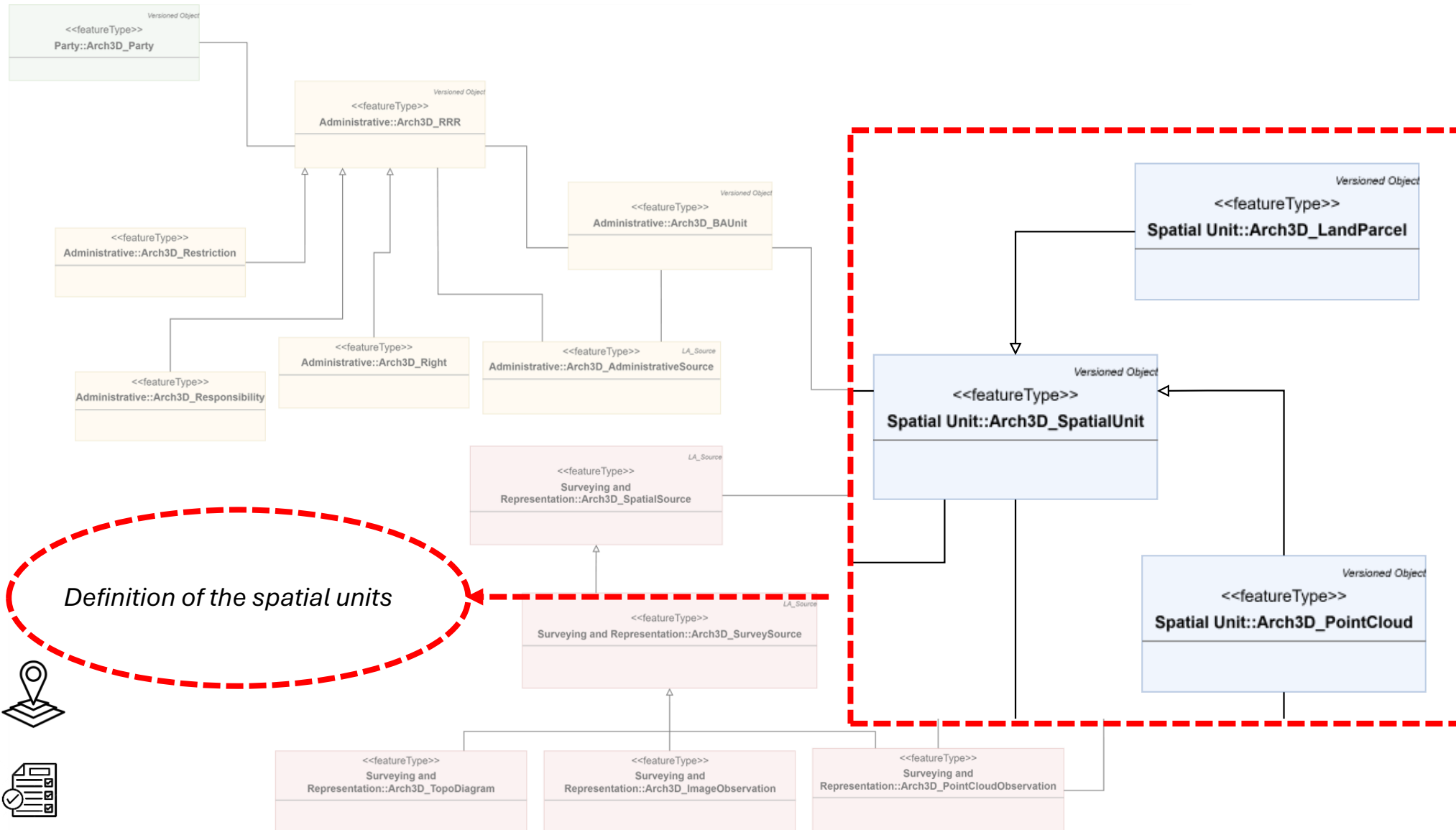
Represents all the actors involved (public agencies, private owners)



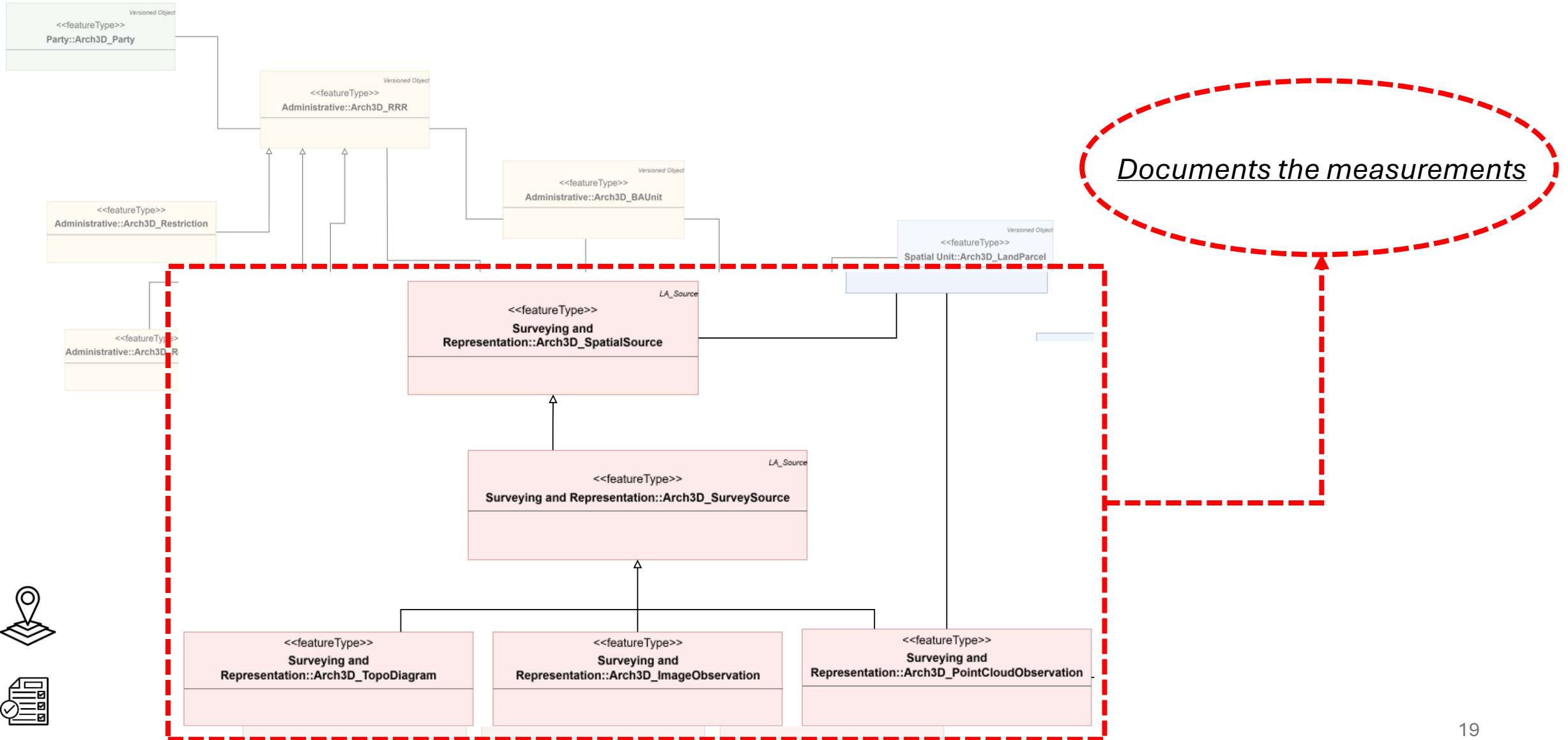
4. Profile Development



4. Profile Development



4. Profile Development

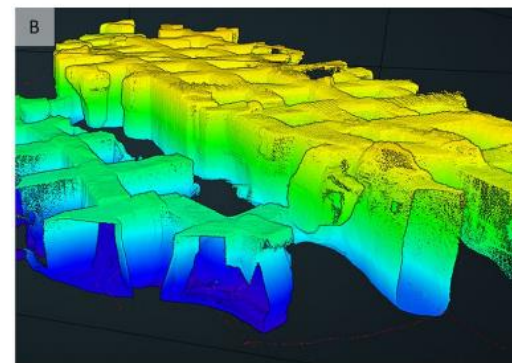
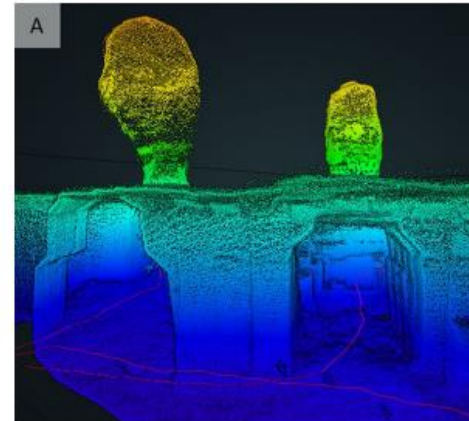


Case Studies

1. Ancient City, Greece



2. Limestone Quarries, Belgium & NL



4. Database Development

Arch3D_party table



```
CREATE TABLE versionedobject (  
  beginlifespanversion TIMESTAMP WITH TIME ZONE,  
  endlifespanversion TIMESTAMP WITH TIME ZONE,  
  beginrealworldlifespanversion TIMESTAMP WITH TIME ZONE,  
  endrealworldlifespanversion TIMESTAMP WITH TIME ZONE  
);
```

```
CREATE TABLE arch3d_party (  
  pid UUID PRIMARY KEY DEFAULT gen_random_uuid(),  
  firstname VARCHAR(100),  
  lastname VARCHAR(100),  
  role VARCHAR(50)  
) INHERITS (versionedobject);
```

	beginlifespanversion timestamp with time zone	endlifespanversion timestamp with time zone	beginrealworldlifespanversion timestamp with time zone	endrealworldlifespanversion timestamp with time zone	pid uuid	firstname character varying	lastname character varying	role integer	prtdescription character varying (255)
1	2025-06-02 13:24:05.345435+02	[null]	1975-06-02 13:24:05.345435+01	[null]	8480865e-6cb...	John	West	2	citizen
2	2025-06-02 13:26:49.786278+02	[null]	1985-06-02 13:26:49.786278+02	[null]	64d00db9-fda...	Mark	East	2	citizen
3	2025-06-02 13:32:43.63244+02	[null]	2000-06-02 13:32:43.63244+02	[null]	e0259571-a76...	Walter	South	2	citizen
4	2025-06-02 13:37:50.966216+02	[null]	1990-06-02 13:37:50.966216+02	[null]	a2bf5b17-267...	Tony	Mei	2	citizen
5	2025-06-02 14:00:39.249386+02	[null]	1976-06-02 14:00:39.249386+01	[null]	7a7a70d7-555...	Ephorate of ...	Ephorate ...	3	Ministry

- Look-up table: arch3d_partyroletype table

	prtid [PK] integer	prtdescription character varying (255)
1	1	bank
2	2	citizen
3	3	Ministry
4	4	Municipality

4. Database Development

Arch3D_right table

```
CREATE TABLE arch3d_right (
  rightid UUID PRIMARY KEY DEFAULT gen_random_uuid(),
  baunit UUID REFERENCES arch3d_baunit(baunitid),
  partyid UUID REFERENCES arch3d_party(partyid),
  righttype UUID REFERENCES arch3d_righttype(righttypeid)
)INHERITS ( versionedobject );
```

	beginlifespanversion timestamp with time zone	endlifespanversion timestamp with time zone	beginrealworldlifespanversion timestamp with time zone	endrealworldlifespanversion timestamp with time zone	rightid [PK] uuid	righttype integer	baunit uuid	partyid uuid
1	2025-06-02 14:50:13.445168+02	[null]	2002-06-02 14:50:13.445168+02	[null]	54184790-7f07-4...	2	287f3f67-96...	7a7a70d7-555b-4a13-b746-41ff4eb09154
2	2025-06-04 12:40:55.817952+02	[null]	2005-06-04 12:40:55.817952+02	[null]	e3c71d92-210f-41...	2	c46f59f6-e4...	a2bf5b17-2679-4620-8225-1781b4ed7e...
3	2025-06-05 17:47:08.86338+02	[null]	2005-06-05 17:47:08.86338+02	[null]	d80b3db6-5414-4...	2	f950cbed-96...	e0259571-a761-4300-ac3f-70ee853b60...
4	2025-06-05 17:49:03.004627+02	[null]	2005-06-05 17:49:03.004627+02	[null]	5fca3eea-bd68-4b...	2	dae53bec-9d...	64d00db9-fda7-4908-b4fa-b90cc630913c
5	2025-06-05 17:50:18.71922+02	[null]	2005-06-05 17:50:18.71922+02	[null]	3a54fea0-2f32-4e...	2	f30fd29a-80...	8480865e-6cb2-4b91-8cf9-2123ef484eb1
6	2025-09-19 19:01:33.635289+02	[null]	2002-09-19 19:01:33.635289+02	[null]	a110e406-0961-4...	2	18ee182c-63...	7a7a70d7-555b-4a13-b746-41ff4eb09154

**similar for restrictions, and responsibilities*

- Look-up tables:
arch3d_righttype,
arch3d_responsibilitytype,
arch3d_restrictiontype

	righttypeid [PK] integer	rightdescription character varying (255)
1	1	limited ownership
2	2	full ownership
3	3	Usufruct
4	4	Surface Right
5	5	Implantation Right
6	6	MiningRight
7	7	Air Righth
8	8	Water Righth
9	9	Lease
10	10	Financing Lease
11	11	Time-sharing lease
12	12	Utility Network lease
13	13	Jurisdiction

	responsibilitytypeid [PK] integer	responsibilitydescription character varying (255)
1	1	archaeological site declaration
2	2	monument indication fee
3	3	compensation fee
4	4	monument inspection
5	5	excavation process
6	6	monument conservation
7	7	Architectural building conservation
8	8	Facilitation in the access of the monument
9	9	Lease Charges Tax

	restrictiontypeid [PK] integer	restrictiondescription character varying (255)
1	1	building constraint
2	2	urban plan constraint
3	3	monument irrelevant use
4	4	agriculture
5	5	farming
6	6	hunting
7	7	economic activity in protection zone



4. Database Development

Arch3D_right table

```
CREATE TABLE arch3d_right (  
  rightid UUID PRIMARY KEY DEFAULT gen_random_uuid(),  
  baunit UUID REFERENCES arch3d_baunit(baunitid),  
  partyid UUID REFERENCES arch3d_party(partyid),  
  righttype UUID REFERENCES arch3d_righttype(righttypeid)  
) INHERITS ( versionedobject );
```

	beginlifespanversion timestamp with time zone	endlifespanversion timestamp with time	beginrealworldlifespanversion timestamp with time zone	endrealworldlifespanversion timestamp with time zone	rightid [PK] uuid	righttype integer	baunit uuid	partyid uuid
1	2025-06-02 14:50:13.445168+02	[null]	2002-06-02 14:50:13.445168+02	[null]	54184790-7f07-4...	2	287f3f67-96...	7a7a70d7-555b-4a13-b746-41ff4eb09154
2	2025-06-04 12:40:55.817952+02	[null]	2005-06-04 12:40:55.817952+02	[null]	e3c71d92-210f-41...	2	c46f59f6-e4...	a2bf5b17-2679-4620-8225-1781b4ed7e...
3	2025-06-05 17:47:08.86338+02	[null]	2005-06-05 17:47:08.86338+02	[null]	d80b3db6-5414-4...	2	f950cbed-96...	e0259571-a761-4300-ac3f-70ee853b60...
4	2025-06-05 17:49:03.004627+02	[null]	2005-06-05 17:49:03.004627+02	[null]	5fca3eea-bd68-4b...	2	dae53bec-9d...	64d00db9-fda7-4908-b4fa-b90cc630913c
5	2025-06-05 17:50:18.71922+02	[null]	2005-06-05 17:50:18.71922+02	[null]	3a54fea0-2f32-4e...	2	f30fd29a-80...	8480865e-6cb2-4b91-8cf9-2123ef484eb1
6	2025-09-19 19:01:33.635289+02	[null]	2002-09-19 19:01:33.635289+02	[null]	a110e406-0961-4...	2	18ee182c-63...	7a7a70d7-555b-4a13-b746-41ff4eb09154

- Indexes on the foreign keys

```
CREATE INDEX idx_right_baunit ON arch3d_right(baunit);  
CREATE INDEX idx_restriction_baunit ON arch3d_restriction(baunit);  
CREATE INDEX idx_responsibility_baunit ON arch3d_responsibility(baunit);
```



**similar for restrictions, and responsibilities*

4. Database Development

Arch3D_baunit table



```
CREATE TABLE arch3d_baunit (  
  baunitid UUID PRIMARY KEY DEFAULT gen_random_uuid(),  
  cadastralnumber VARCHAR(17)  
  CHECK (char_length(cadastralnumber) BETWEEN 12 AND 17)  
) INHERITS (versionedobject);
```

	beginlifespanversion timestamp with time zone	endlifespanversion timestamp with time zone	beginrealworldlifespanversion timestamp with time zone	endrealworldlifespanversion timestamp with time zone	baunitid [PK] uuid	cadastralnumber character varying (17)
1	2025-05-30 15:29:35.843208+02	[null]	2002-05-30 15:29:35.843208+...	[null]	287f3f67-9653...	420361722070
2	2025-05-30 15:33:28.064279+02	[null]	2002-05-30 15:33:28.064279+...	[null]	c46f59f6-e4c8...	420361722033
3	2025-05-30 15:33:56.549961+02	[null]	2002-05-30 15:33:56.549961+...	[null]	f950cbcd-96f6...	420361722068
4	2025-05-30 15:34:22.110177+02	[null]	2002-05-30 15:34:22.110177+...	[null]	dae53bec-9de...	420361722143
5	2025-05-30 15:35:14.642453+02	[null]	2002-05-30 15:35:14.642453+...	[null]	f30fd29a-8081...	420361722071
6	2025-09-19 18:43:35.038802+02	[null]	2002-09-19 18:43:35.038802+...	[null]	18ee182c-63c...	420361722033/1

- Constraint was added to maintain consistency during data insertion
- Association table between arch3d_baunit and arch3d_spatialunit due to many-to-many relationships

```
CREATE TABLE baunittospatialunit (  
  baunit UUID REFERENCES arch3d_baunit(baunitid),  
  spid UUID REFERENCES arch3d_spatialunit(spatialunitid),  
  PRIMARY KEY (baunit, spid)  
);
```

4. Database Development



Arch3D_spatialunit table

```
CREATE TABLE arch3d_spatialunit (  
  spatialunitid UUID PRIMARY KEY DEFAULT gen_random_uuid(),  
  gid INTEGER,  
  kaek VARCHAR(20),  
  area NUMERIC,  
  geom geometry,  
  sputype INTEGER,  
  spudimension INTEGER,  
  patch INTEGER  
) INHERITS (versionedobject);
```

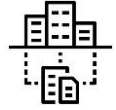
	gid integer	kaek character varying (14)	area numeric	geom geometry	spatialunitid [PK] uuid	sputype integer	spudimension integer	patch integer
1	16	420361722033	26967.2799999	010600002034080000010000000103000000010000002700000066666...	720a43e8-22fd-41c6-8a26-6803b9e27af4	3	2	[null]
2	22	420361722070	2000.05999999	0106000020340800000100000001030000000100000005000000713D0...	b6a64501-5326-4b40-b252-d19e15c85edf	3	2	[null]
3	21	420361722068	4000.19999999	0106000020340800000100000001030000000100000007000000295C8...	ffe09c3c-f6d4-4e8a-83f0-3d3c16b0a994	3	2	[null]
4	25	420361722143	4499.97999999	0106000020340800000100000001030000000100000007000000E17A1...	30e919ba-c4bf-4724-980c-5c62c4e423f4	3	2	[null]
5	26	420361722071	3703.88000000	01060000203408000001000000010300000001000000100000000C3F52...	ec767426-7006-4bda-b4ae-057d5212ee...	3	2	[null]
6	102	420361722070/1	[null]	[null]	e571c84a-0820-438c-9661-345f8725bfb9	1	3	2
7	103	420361722033/1	[null]	[null]	d474dd84-2ae8-4b51-97d2-808892f36746	1	3	1

- Not one-to-one mapping with the conceptual model
- 2D units have a polygon geometry and an area value, 3D ones have a patch number
- Look-up tables for spatial unit type (immovable property, public, or private) and for dimension type

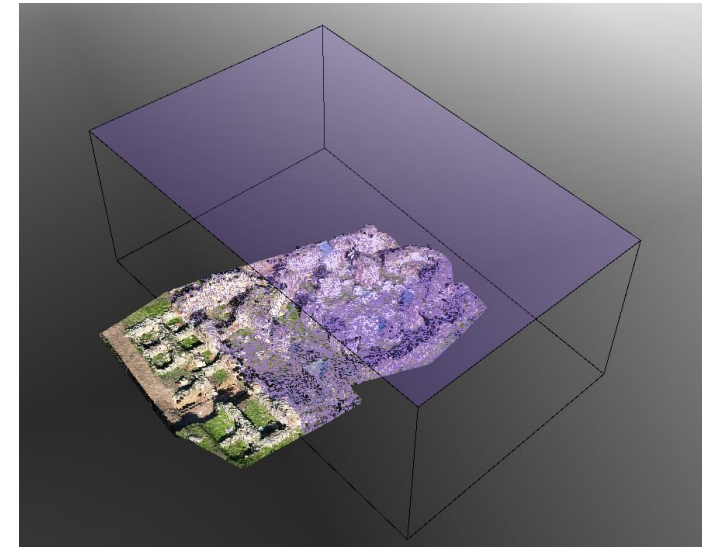
4. Database Development

Arch3D_pointcloudobservation table

```
CREATE TABLE arch3d_pointcloudobservation (  
  pid SERIAL PRIMARY KEY,  
  x NUMERIC,  
  y NUMERIC,  
  z NUMERIC,  
  point_source_id INTEGER REFERENCES arch3d_spatialunit(patch),  
  geom geometry(PointZ, 2100)  
);
```

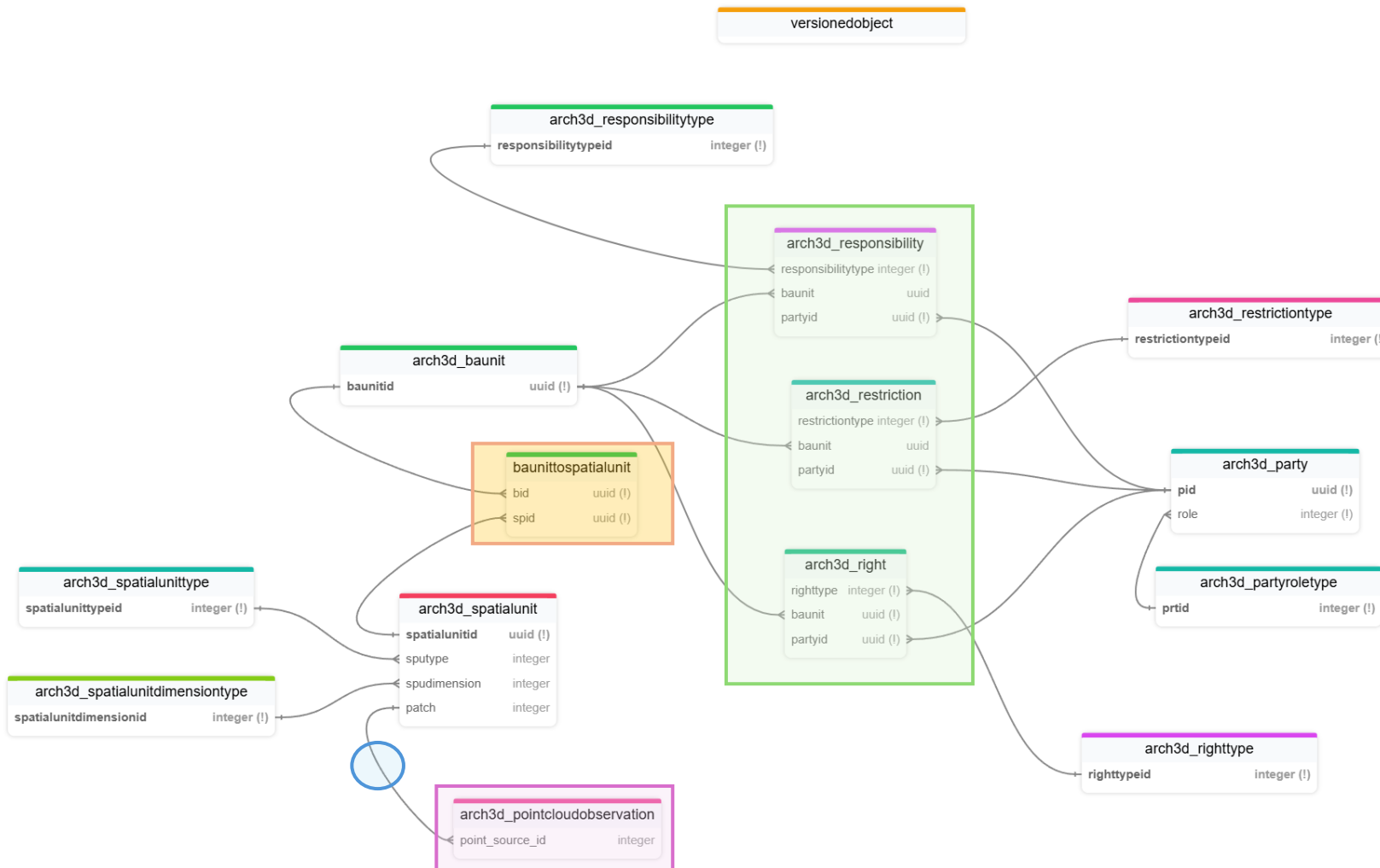


	pid [PK] integer	x numeric	y numeric	z numeric	point_source_id integer	geom geometry
1	1	611090.553220	4553600.327150	46.868330	1	01010000A034080000DFA63F1B25A622418E06F014E05E51415E11FC6F256F4740
2	2	611090.364260	4553602.135130	46.311330	1	01010000A034080000664980BA24A622414DF8A588E05E5141C02154A9D9274740
3	3	611089.059080	4553604.026120	46.797330	1	01010000A034080000D8BB3F1E22A6224138F3AB01E15E5141520FD1E80E664740
4	4	611089.044920	4553604.049130	46.826330	1	01010000A03408000016C1FF1622A6224128F22403E15E514112DA722EC5694740
5	5	611089.933110	4553603.960140	46.589330	1	01010000A034080000B98C0DD23A622410BEF72FDE05E51419D465A2A6F4B4740



- ST MakePoint after point cloud insertion
- spatial index (GiST) on the geom column

4. Database Development



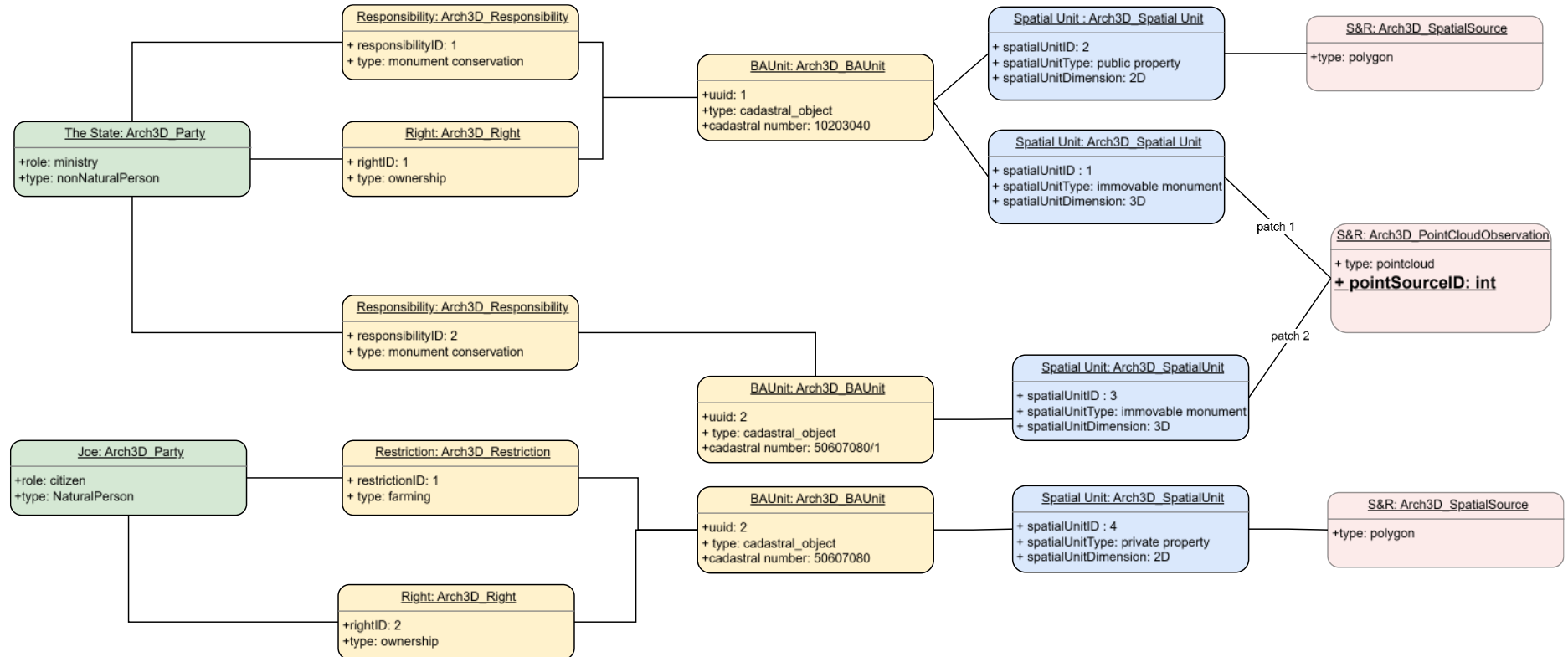
- **RRR as Specialized Tables**
(Abstract RRR modeled as separate Right, Restriction, and Responsibility tables)
- **BAUnit–SpatialUnit Association**
(Many-to-many relationship implemented via an association table)
- **Point Cloud as Single Dataset**
(All points stored in one table, indexed by spatial unit)
- **Patch–PointCloud Link**
(patch in SpatialUnit references point_source_id in PointCloudObservation)

4. Evaluation (instance level diagrams)

- A party owns the **red parcel** and the Arch. finds in the parcel **but also** the **Arch. Finds** outside the parcel which lie in the adjacent property owned by a second party



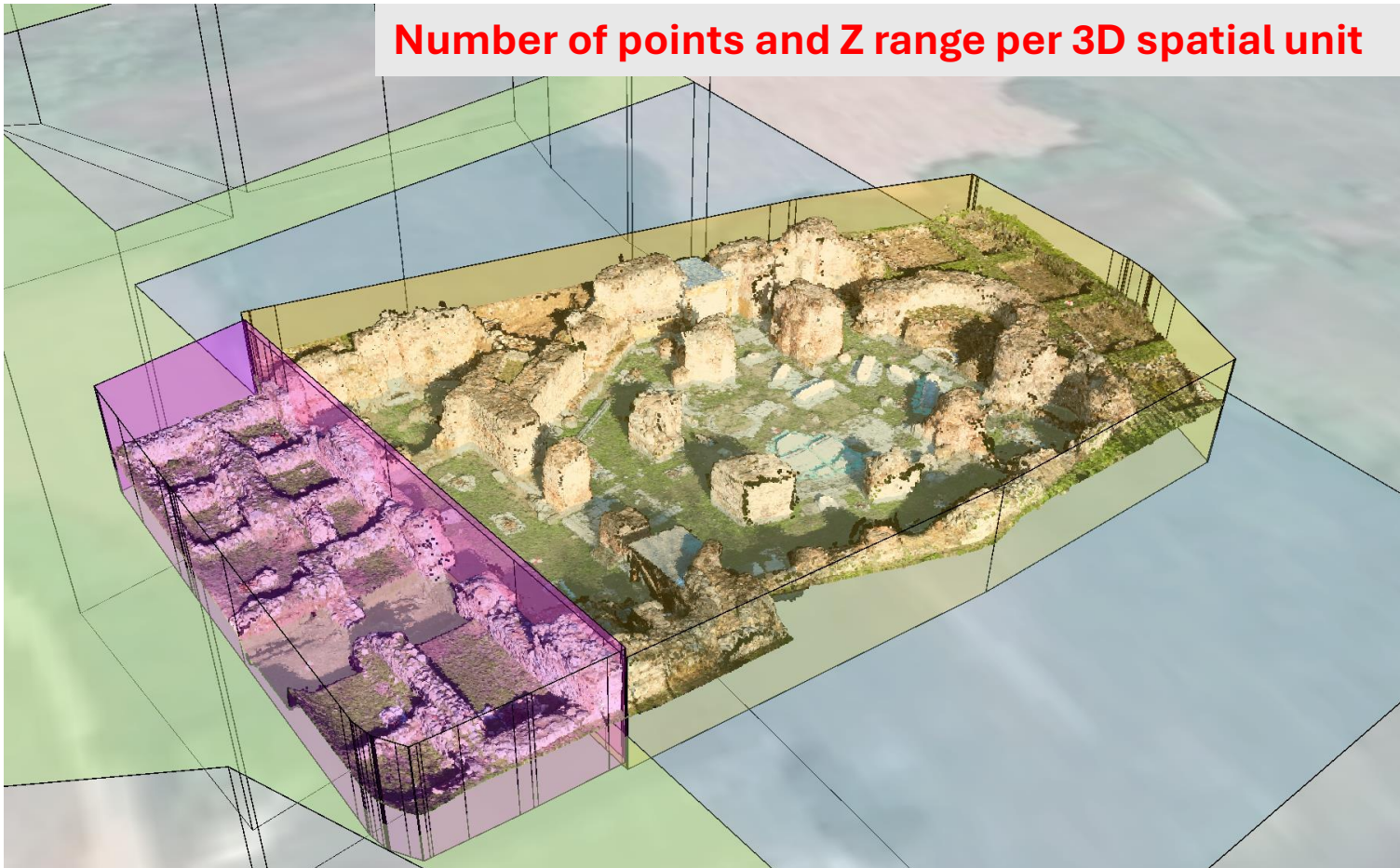
Case study 2



4. Evaluation (instance level diagrams)



4. Evaluation (querying the database)



```

SELECT
  s.gid,
  -- s.kaek,
  s.area,
  s.spatialunitid,
  -- s.sputype,
  -- s.spudimension,
  s.patch,
  b.baunitid,
  b.cadastralnumber,
  t.typedescription AS spatialunit_type,
  d.dimensiondescription AS spatialunit_dimension,
  h.zmin,
  h.zmax,
  'hull_from_points'::text AS footprint_source,
  ST_Multi(h.hull_2d)::geometry(MultiPolygon,2100) AS geom
FROM arch3d_spatialunit AS s
JOIN baunitsspatialunit AS bs ON bs.spid = s.spatialunitid
JOIN arch3d_baunit AS b ON b.baunitid = bs.bid
JOIN arch3d_spatialunittype AS t ON t.spatialunittypeid = s.sputype
JOIN arch3d_spatialunitdimension AS d
  ON d.spatialunitdimensionid = s.spudimension
JOIN (
  SELECT
    s2.spatialunitid,
    ST_ConvexHull(ST_Force2D(ST_Collect(p.geom))) AS hull_2d,
    MIN(ST_Z(p.geom)) AS zmin,
    MAX(ST_Z(p.geom)) AS zmax
  FROM arch3d_spatialunit AS s2
  JOIN gr_temple_class AS p
    ON p.point_source_id = s2.patch
  JOIN arch3d_spatialunitdimension AS d2
    ON d2.spatialunitdimensionid = s2.spudimension
  WHERE d2.dimensiondescription = '3D'
  GROUP BY s2.spatialunitid
) AS h
  ON h.spatialunitid = s.spatialunitid;

```

	gid integer	spatialunitid uuid	footprint_area double precision	patch integer	baunitid uuid	cadastralnumber character varying (17)	sp_type character varying	sp_dimension character varying	rights character varying[]	restrictions character varying	responsibilities character varying[]	zmin double precis	zmax double precis	footprint_source text
1	103	d474dd84-2a...	208.81174787595637	1	18ee182c-...	420361722033/1	immovable ...	3D	{'full ownership'}	{NULL}	{NULL}	44.76833	49.231	hull_from_points
2	102	e571c84a-08...	840.7128430784535	2	287f3f67-9...	420361722070	immovable ...	3D	{'full ownership'}	{NULL}	{'monument conservation'}	44.36533	49.486	hull_from_points

4. Evaluation (querying the database)

Unified Retrieval of Rights, Restrictions, and Responsibilities

	partyfirstname character varying (255) 🔒	partylastname character varying (255) 🔒	rrr_type text 🔒	rrr_description character varying (255) 🔒	baunit_cadastral_number character varying (17) 🔒	baunitid uuid 🔒
1	Ephorate of Antiquities	Ephorate of Antiquities	Right	full ownership	420361722033/1	18ee182c-63c3-4b5a-8d29-5b5777c2f2...
2	John	West	Right	full ownership	420361722071	f30fd29a-8081-45ed-91d9-ceedaad1a57...
3	Mark	East	Right	full ownership	420361722143	dae53bec-9de5-46c5-abee-bd6aee84fa...
4	Walter	South	Right	full ownership	420361722068	f950cbcd-96f6-4c0b-80b2-a88a96d509...
5	Tony	Mei	Right	full ownership	420361722033	c46f59f6-e4c8-41cc-b2d2-f6933b2741...
6	Ephorate of Antiquities	Ephorate of Antiquities	Right	full ownership	420361722070	287f3f67-9653-4837-be05-892077f11fb4
7	Tony	Mei	Restriction	urban plan constraint	420361722033	c46f59f6-e4c8-41cc-b2d2-f6933b2741...
8	Ephorate of Antiquities	Ephorate of Antiquities	Responsibility	monument conservation	420361722070	287f3f67-9653-4837-be05-892077f11fb4

```
SELECT
  p.firstname AS PartyFirstName,
  p.lastname AS PartyLastName,
  'Right' AS rrr_type,
  rt.rightdescription AS rrr_description,
  b.cadastralnumber AS baunit_cadastral_number,
  b.baunitid
FROM arch3d_party p
JOIN arch3d_right r ON p.pid = r.partyid
JOIN arch3d_righttype rt ON rt.righttypeid = r.righttype
JOIN arch3d_baunit b ON r.baunit = b.baunitid

UNION ALL

SELECT
  p.firstname,
  p.lastname,
  'Restriction' AS rrr_type,
  rst.restrictiondescription AS rrr_description,
  b.cadastralnumber,
  b.baunitid
FROM arch3d_party p
JOIN arch3d_restriction rn ON p.pid = rn.partyid
JOIN arch3d_restrictiontype rst
  ON rst.restrictiontypeid = rn.restrictiontype
JOIN arch3d_baunit b ON b.baunitid = rn.baunit

UNION ALL

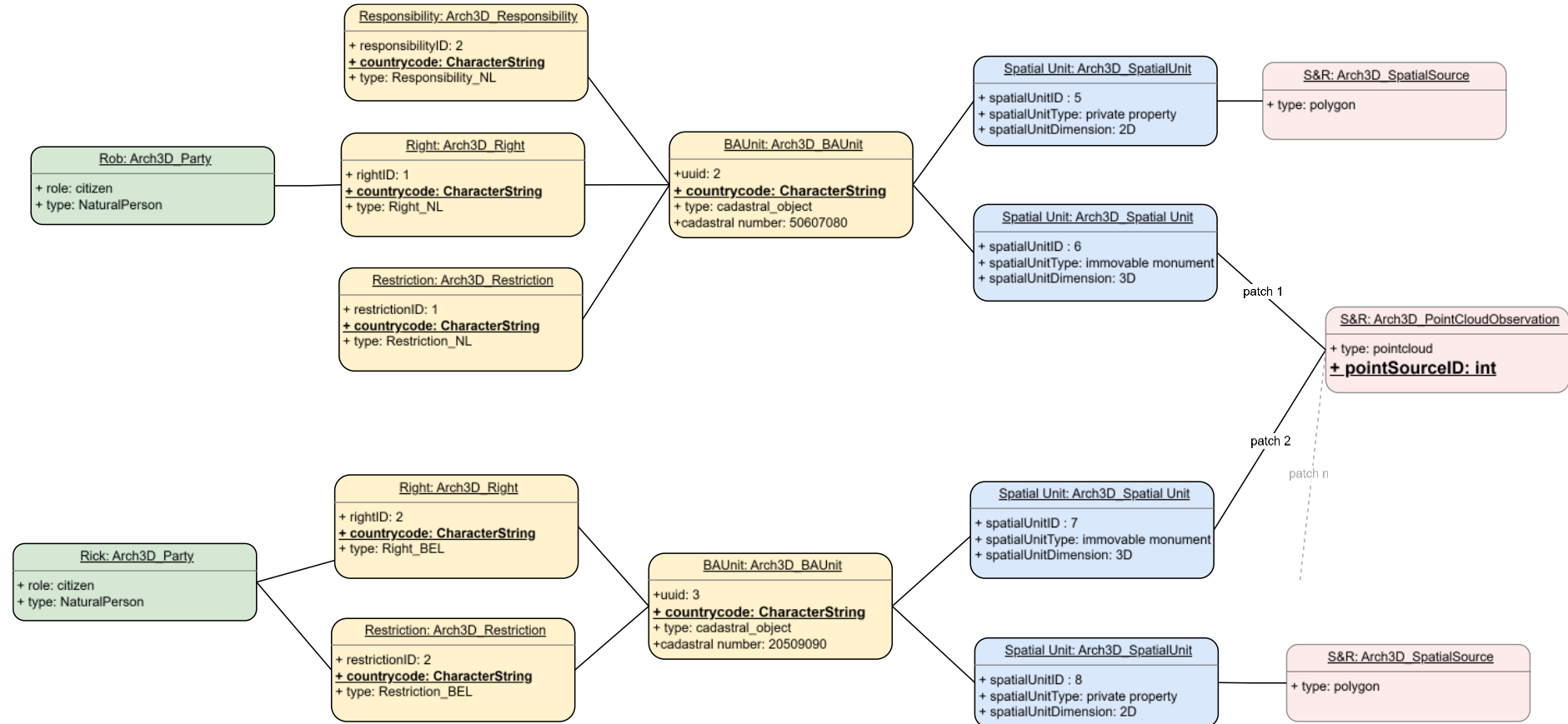
SELECT
  p.firstname,
  p.lastname,
  'Responsibility' AS rrr_type,
  rsp.responsibilitydescription AS rrr_description,
  b.cadastralnumber,
  b.baunitid
FROM arch3d_party p
JOIN arch3d_responsibility res ON p.pid = res.partyid
JOIN arch3d_responsibilitytype rsp
  ON rsp.responsibilitytypeid = res.responsibilitytype
JOIN arch3d_baunit b ON b.baunitid = res.baunit;
```

4. Evaluation (instance level diagrams)

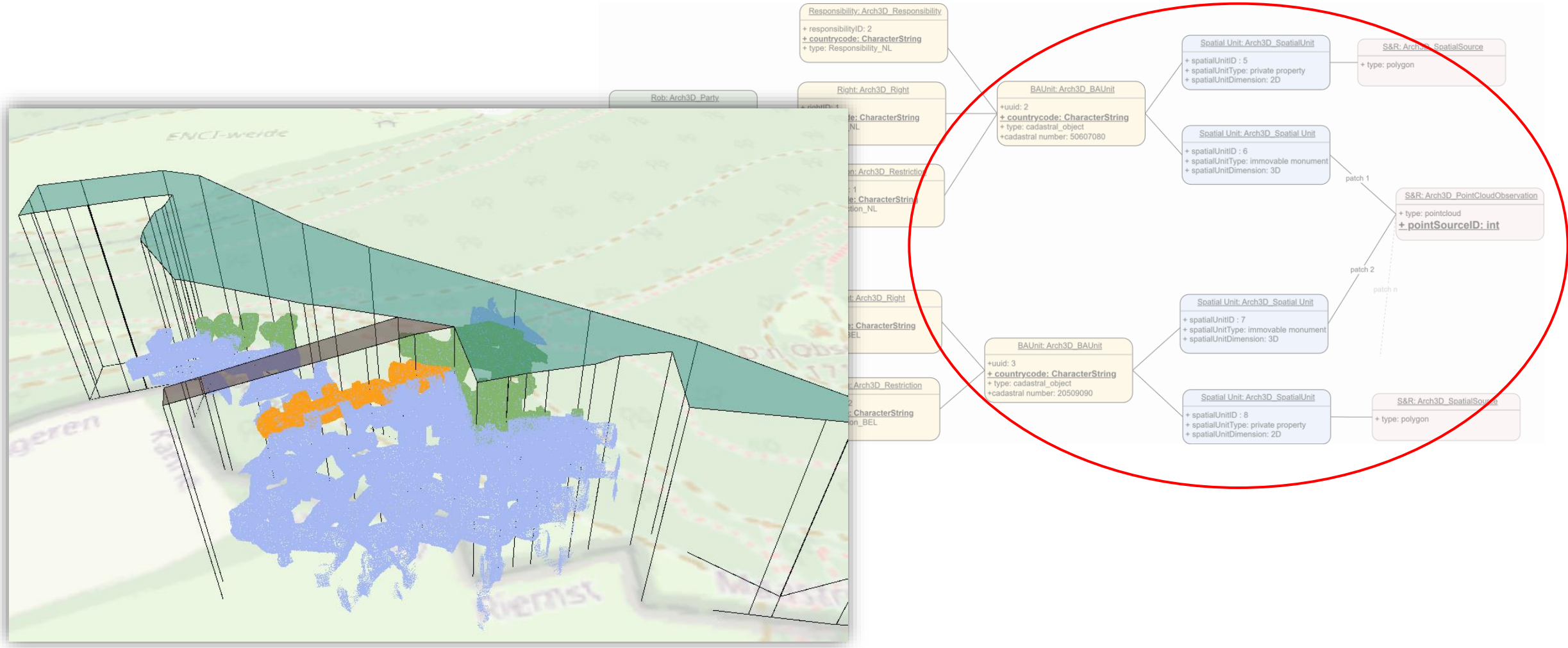
BAUnits in two different countries



Case study 3



4. Evaluation (instance level diagrams)



5. Conclusions

- What is the LADM archaeological profile that should be developed?

- Core classes: *Arch3D BAUnit*, *Arch3D Right*, *Arch3D Restriction*, *Arch3D Responsibility*, *Arch3D SpatialUnit (2D/3D)* + *Point Cloud classes*
- Supports both 2D cadastral parcels and 3D archaeological volume
 - How can boundary patches be selected from point cloud data for use in archaeological applications?
- Parcel-based classification of the point cloud
- Reference/Definition to/of the Spatial Unit
 - How to link legal and semantic information with point clouds for archaeological purposes in the context of LADM?
- Linkage of each point to RRRs through *Arch3D_pointcloudobservation* > *Arch3D_spatialunit* > *Arch3D_baunit* > *Arch3d_RRR*
 - Effective querying & visualization
- Effective querying and visualization is partially satisfied

5. Limitations & Future Work

Limitations

- Three case studies planned; **only two implemented**, one fully tested.
- **Cross-border case** used mainly for proof of concept.
- Validation **limited** to queries and diagrams.
- No stakeholder evaluation.
- **Versioning implemented but not tested** with examples.

Future Work

- Develop a **graphical user interface (GUI)**
- Extend the model to include **dynamic versioning** and **temporal analysis** of archaeological sites.
- Integrate **semantic enrichment** (e.g., heritage vocabularies, ontologies)
- Explore **automation**
- Conduct **cross-border interoperability studies** aligning legal semantics and data models.
- Test integration with **national heritage and cadastral infrastructures**.

Thank you for your attention!

