Modelling 3D underground legal spaces in 3D Land Administration Systems

11 October 2021

Rohit Ramlakhan, Eftychia Kalogianni, Peter van Oosterom

TU Delft

FIG

3D Cadastres

7th International FIG Workshop on 3D Cadastres
11-13 October 2021, New York, USA

Table of contents

1. Introduction / motivation

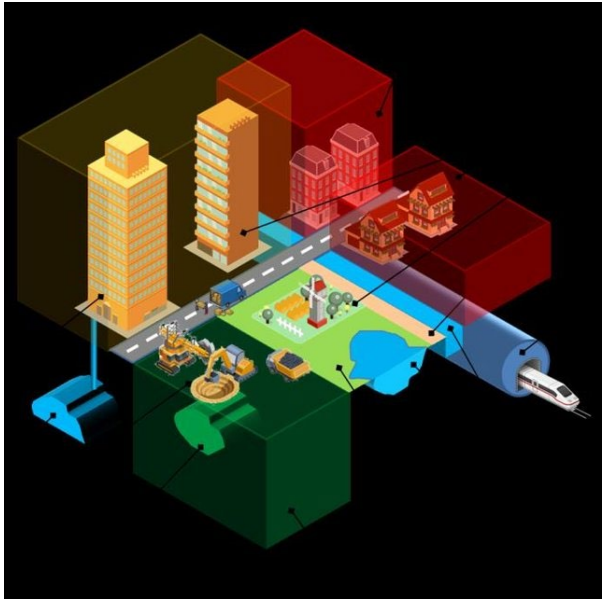
- Urbanisation has led to development of multi-level properties
- Implementation of multi-level properties requires 3D objects
- 2D LAS cannot represent the 3D legal reality well:
  - ownership of **underground objects (tunnels, utilities)** not easy to identify
  - relations between objects below and above the surface not explicitly provided

BIM model of Liverpool Street station, London

Image retrieved from: https://www.imeche.org/news/news-article/parallel-lines

1. Introduction / motivation

- 3D LAS clearly defines the relationships between the Rights, Restrictions, Responsibilities (RRRs) and the 3D objects
- The registration of the objects in 3D LAS facilitates a better understanding, more efficient registration and clear visualisation of the RRRs
- 3D LAS can support the decision-making in urban development



Schematic image of a 3D LAS

Image retrieved from: Indrajit, A., Van Loenen, B., Ploeger, H., Van Oosterom, P. (2018). Designing Open Spatial Information Infrastructure to Support 3D Urban Planning in Jakarta Smart City. 6th International FIG 3D Cadastre Workshop, 2-4 October 2018, Delft, The Netherlands

1. Introduction / motivation

- A need for data exchange and interoperability across the Architecture, Engineering, Constructor, Owner Operator (AECOO) community, industry and governments
- Increase in use of BIM/IFC models to enhance data exchange and interoperability
- Implementing the Land Administration Domain Model (LADM) in a 3D LAS results in easy determination of the RRRs of (underground) objects
- Challenges remain: 3D LAS vary around the world; different requirements for the collection, validation, registration, dissemination of 3D underground (cadastral) data

2. Related work

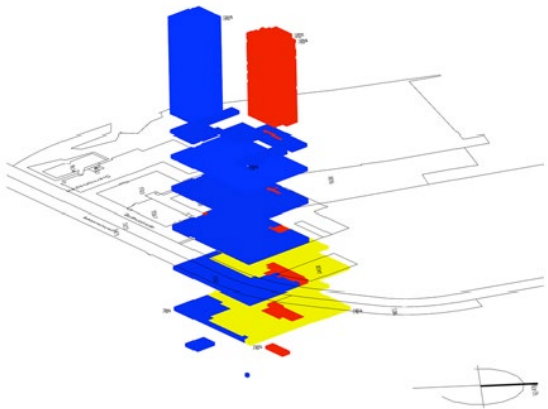
Modelling of underground legal spaces in the Netherlands

- Three types of cadastral objects: parcels, apartments, utility networks
- Other underground objects are not cadastral objects
- Property rights can be registered with the use of limited rights on 2D parcels
- Limited rights are: the right of superficies, the right of long lease and easements
- Dutch Cadastre adheres to the ‘specialty principle’

2. Related work

Modelling of underground legal spaces in the Netherlands

- Workflow by Stoter et al. (2017)
- Legal volumes are created from BIM models and validated.
- 3D-PDF created for the visualisation of the legal volumes and as a legal source document
- Legal volumes created also stored in the Dutch cadastre for the 3D geometry
- Not possible to extract coordinates from a 3D PDF, thus, the use of BIM/ IFC models is preferred



Maritim Hotel, Amsterdam

Stoter, J., Ploeger, H., Roes, R., Van der Riet, E., Biljecki, F., Ledoux, H., Kok, D., Kim, S. (2017). Registration of Multi-Level Property Rights in 3D in The Netherlands: Two Cases and Next Steps in Further Implementation. International Journal of Geo-Information, 8, 157.

2. Related work

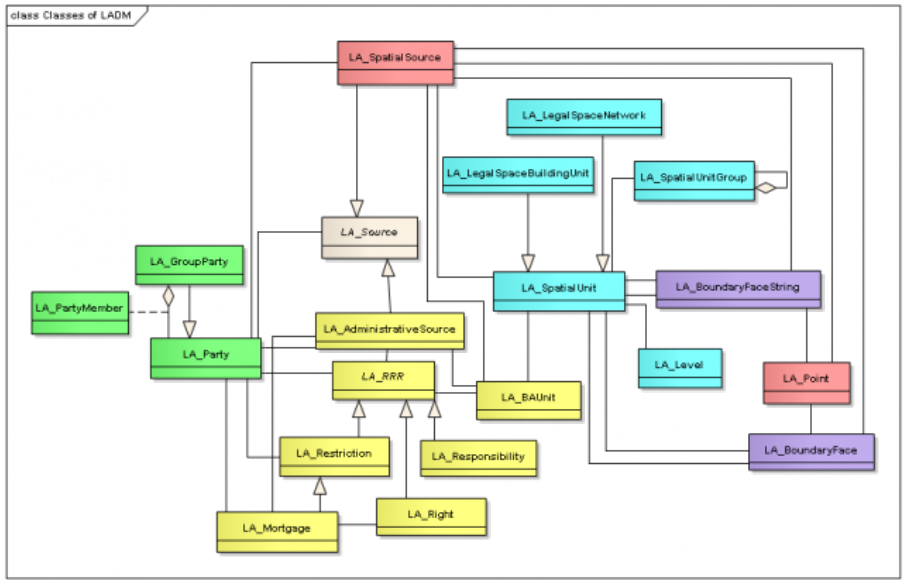
Standardised data models for underground infrastructure objects

LADM (ISO 19152:2012)

- Conceptual model that provides a formal language for describing both the spatial and non-spatial information in the land administration domain.

LADM revision ongoing:

- Increasing support for different types of legal spaces, for example, utilities
- Including technical models, for instance, BIM/IFC models



Land Administration Domain Model

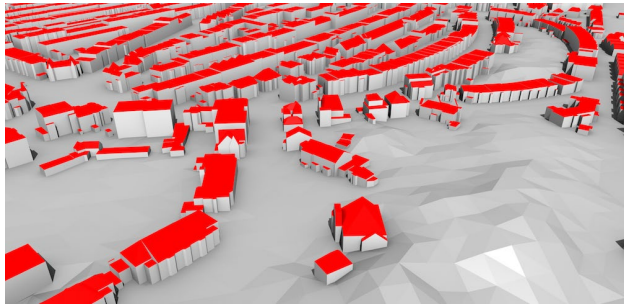
Image retrieved from: https://www.gim-international.com/content/article/land-administration-domain-model

2. Related work

Standardised data models for underground infrastructure objects

CityGML

- Open data model and XML encoded schema used for the storing and exchange of 3D city models
- Utility network ADE is used to store data on the geometry of the utilities and the relations between them
- Models of underground objects are less detailed than BIM/IFC, which can be necessary for registering legal information



CityGML model of The Hague (LOD 2)

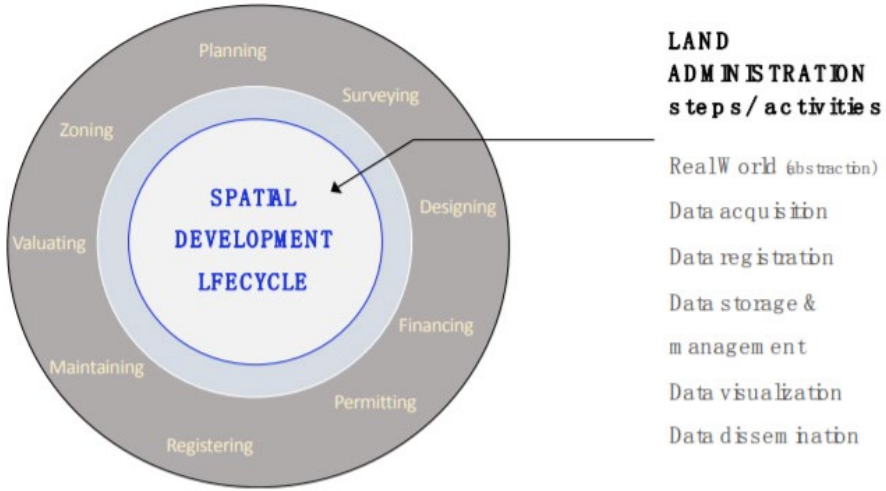
Image retrieved from: https://nervous-ptolemy-d29bcd.netlify.app/about/

2. Related work

Standardised data models for underground infrastructure objects

BIM/IFC (ISO 16739-1:2018)

- IFC is a standard for BIM data and contains requirements for data applied to buildings throughout their life cycle.
- IFC files made during the design phase could be reused for land administration
- Reusing and sharing IFC files could lead to a reduction in costs, higher efficiency and better decision making



Spatial Development lifeCycle (SDC)

Kalogianni, E., van Oosterom, P., Dimopoulou, E., Lemmen, C. (2020). 3D Land Administration: A Review and a Future Vision in the Context of the Spatial Development Lifecycle. International Journal of Geo-Information, 9 (107).

3. Research objective

Objective is to develop a standardised workflow in order:

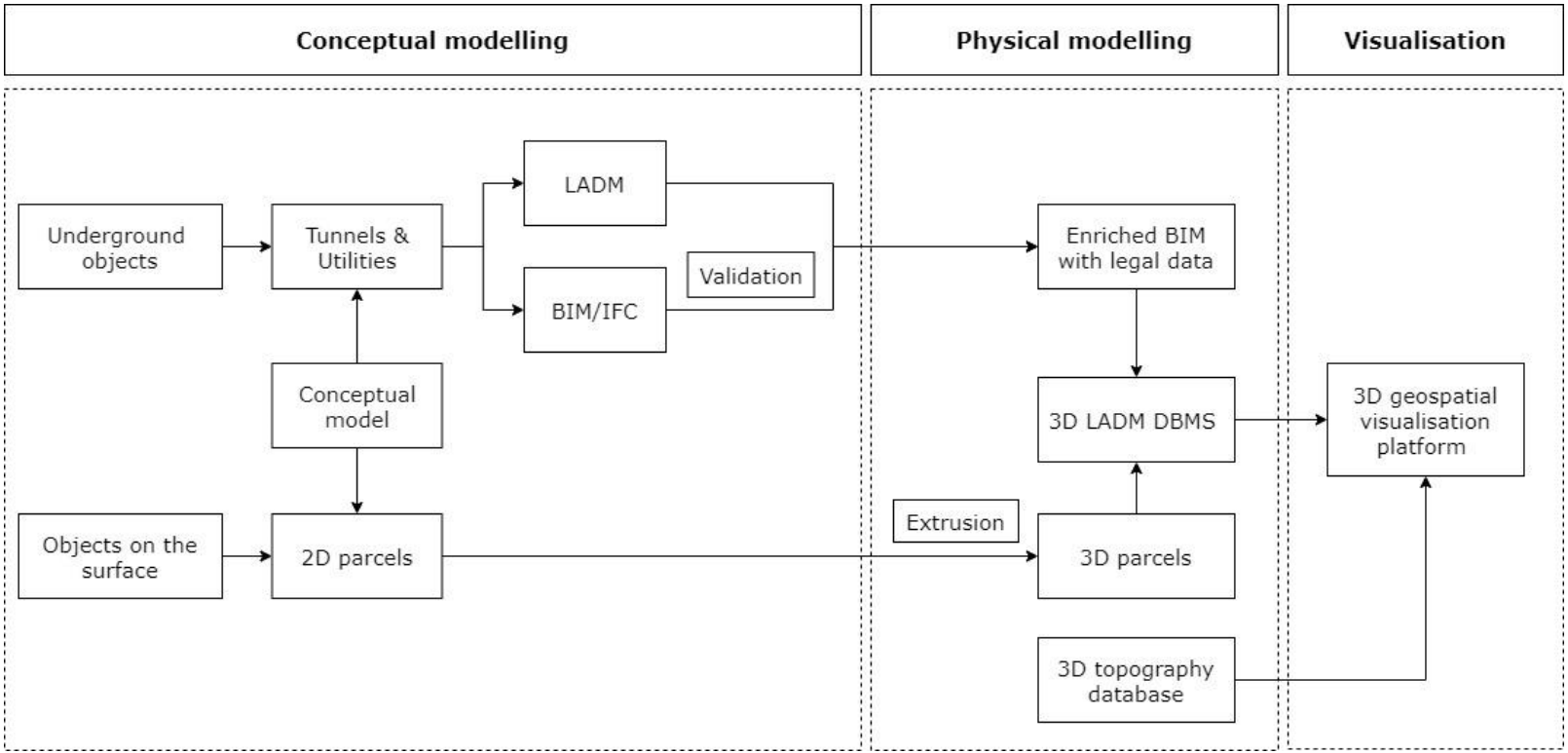
- to collect, process, store, visualise, disseminate and query 3D underground data in a 3D LAS according to ISO 19152:2012 (LADM standard)
- to model the relations between underground objects (tunnels, utilities) and their legal spaces
- to model the relations between underground legal spaces and 2D parcels on the surface
- to connect the workflows from AECOO (Architecture, Engineering, Construction, Owner Operator) to 3D LAS via a BIM/IFC model.

4. Research methodology

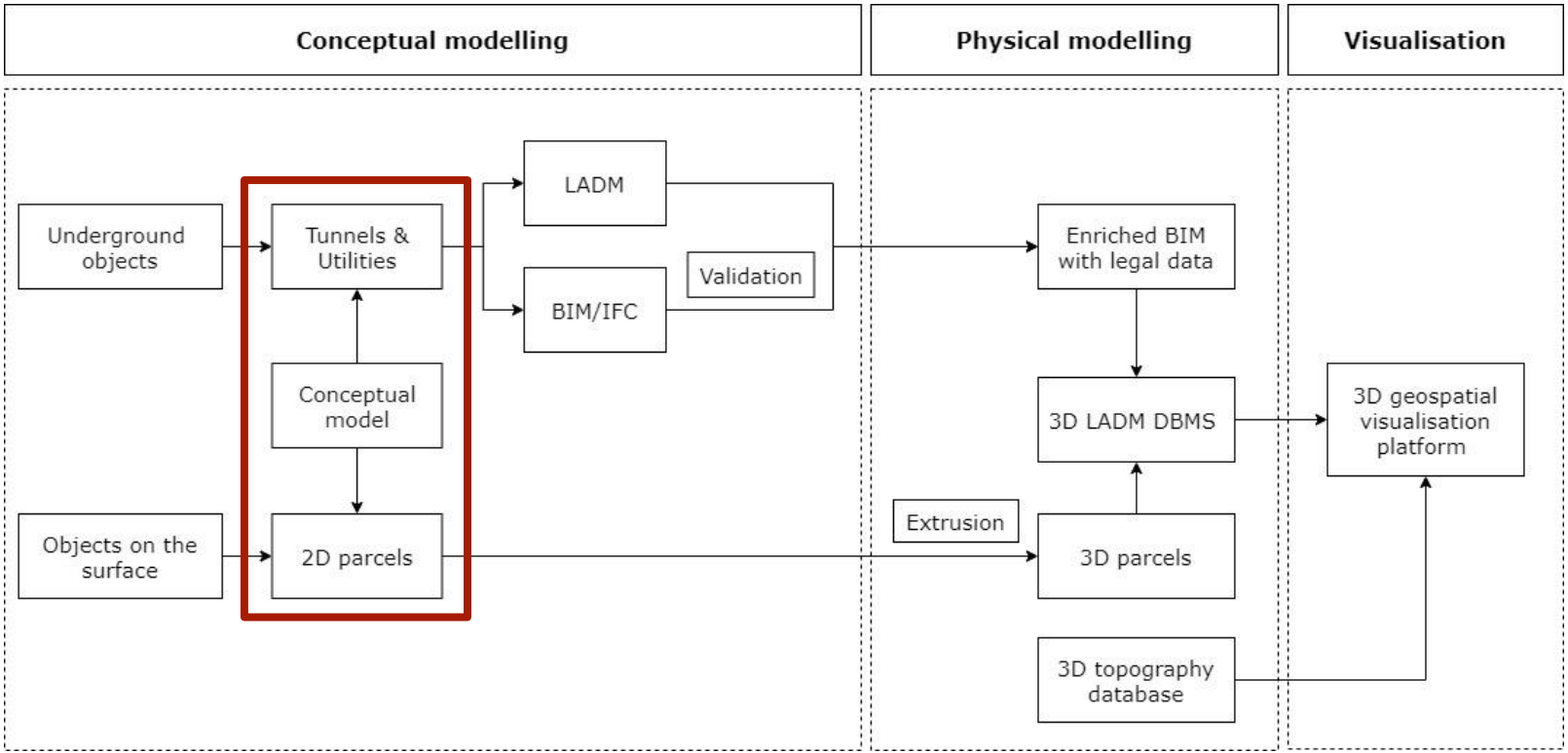
Literature review

- Objective: define the aspects that need to be part of the workflow
- Online search through journals and repositories
- Assessing articles on titles and abstracts
- Selecting articles after full review based on relevance
- Searching and evaluating the references of selected articles

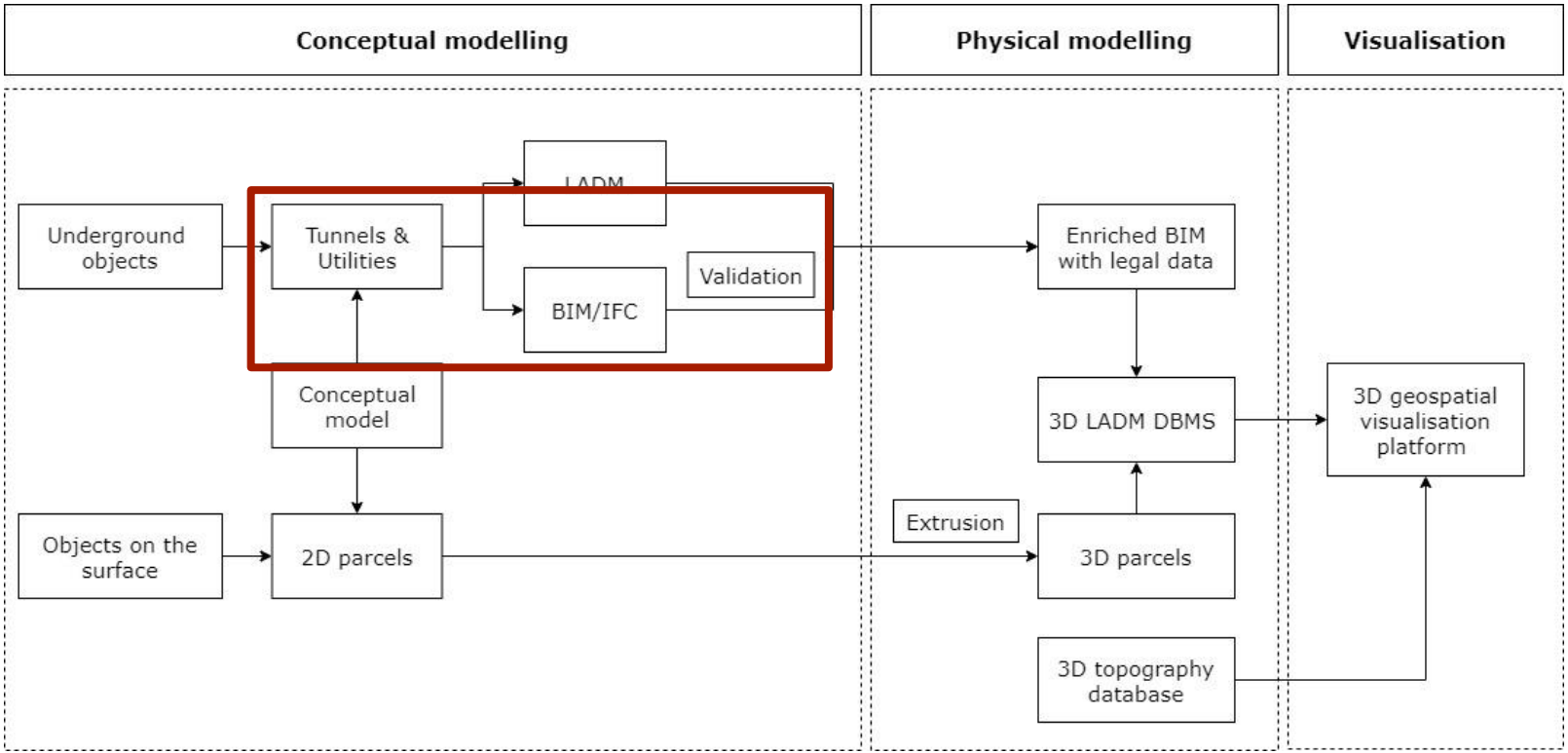
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

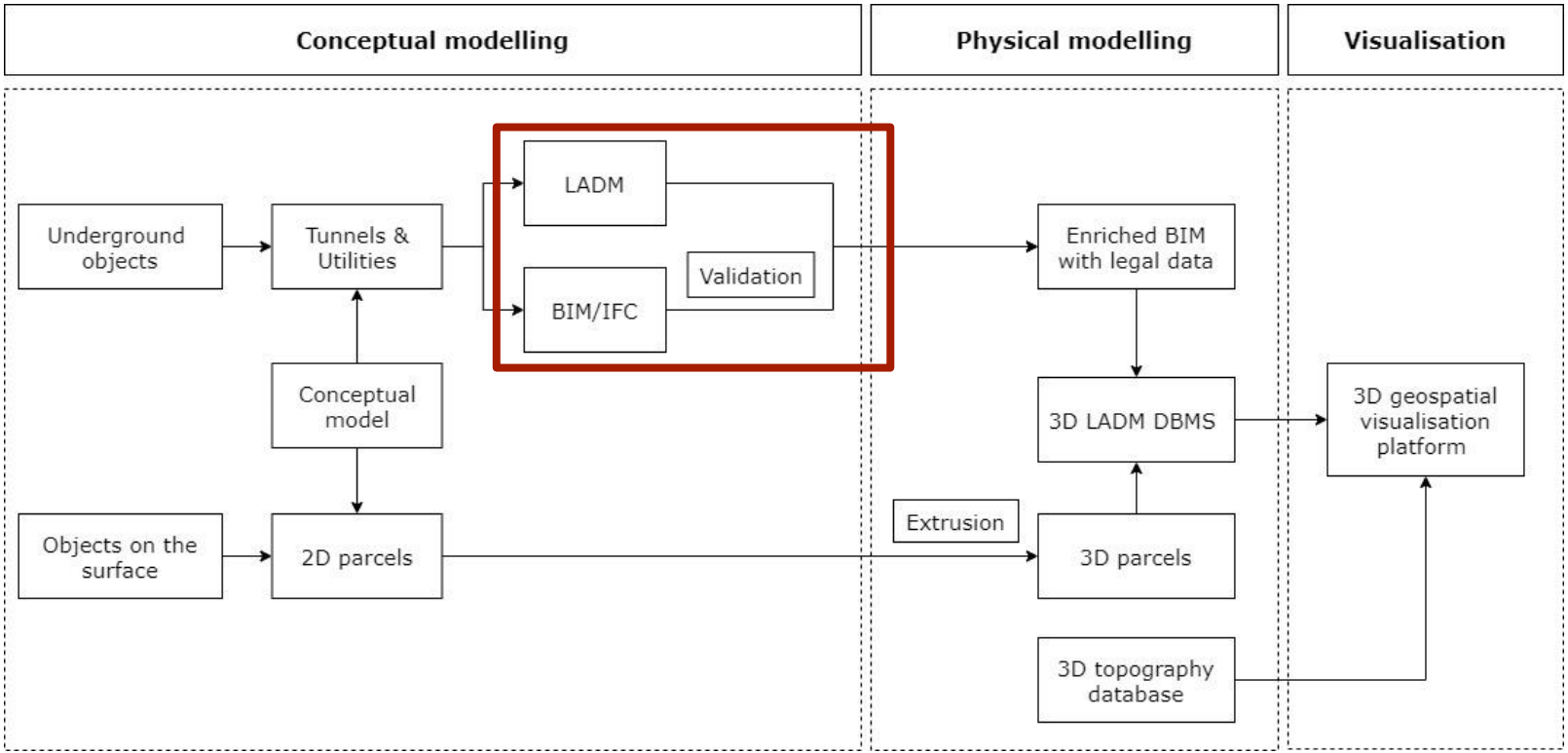
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

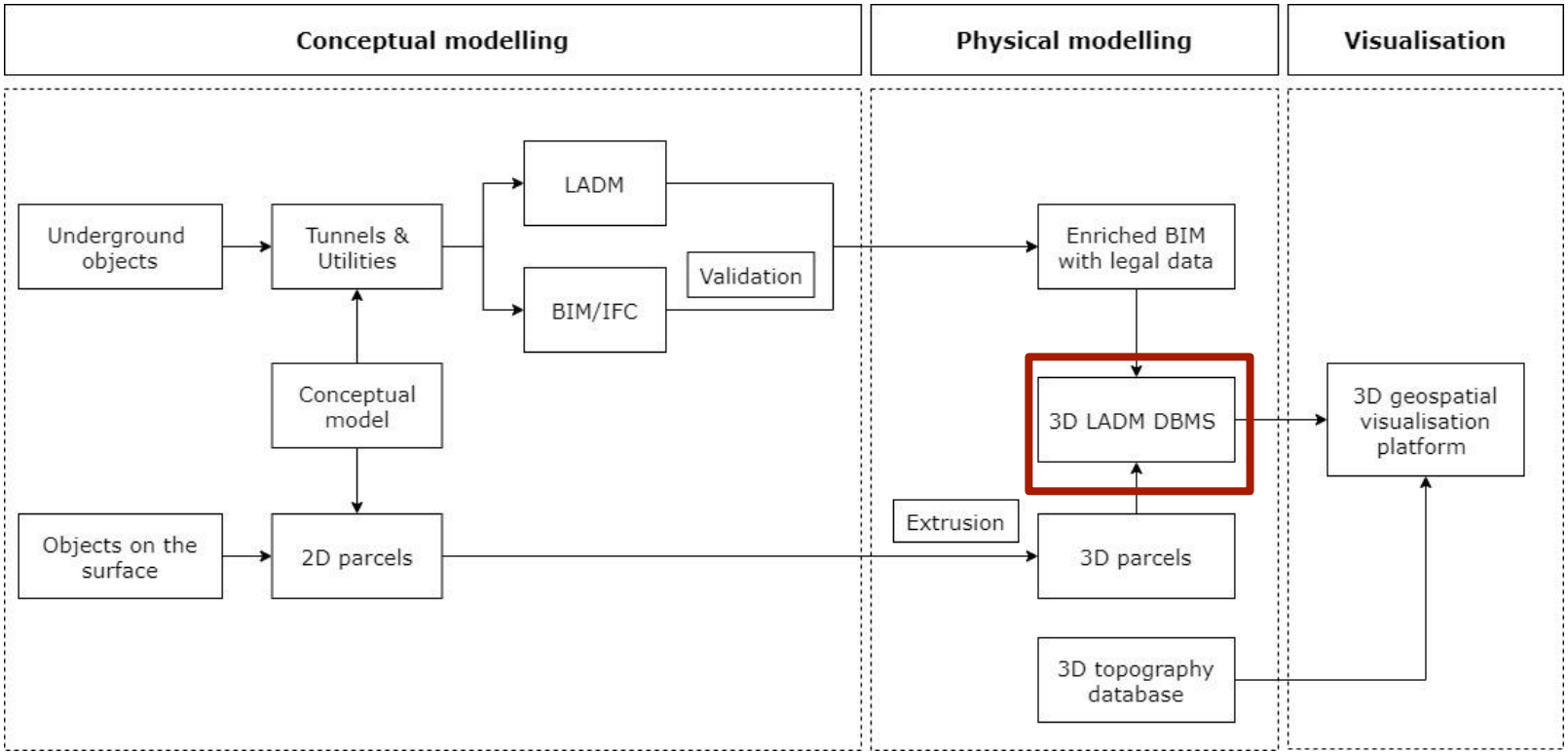
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

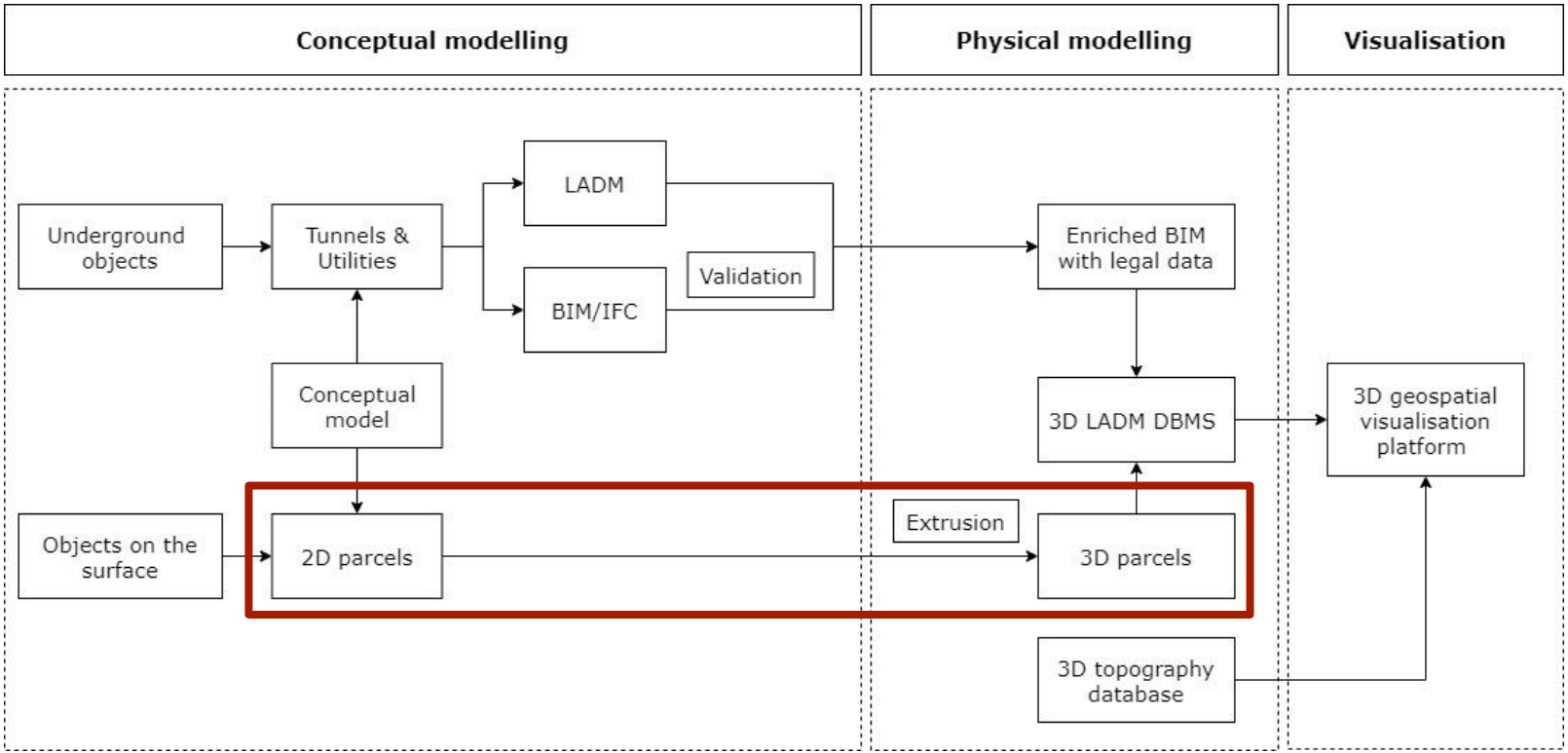
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Extrusion
Enriched BIM with legal data
3D LADM DBMS
3D parcels
3D topography database
3D geospatial visualisation platform

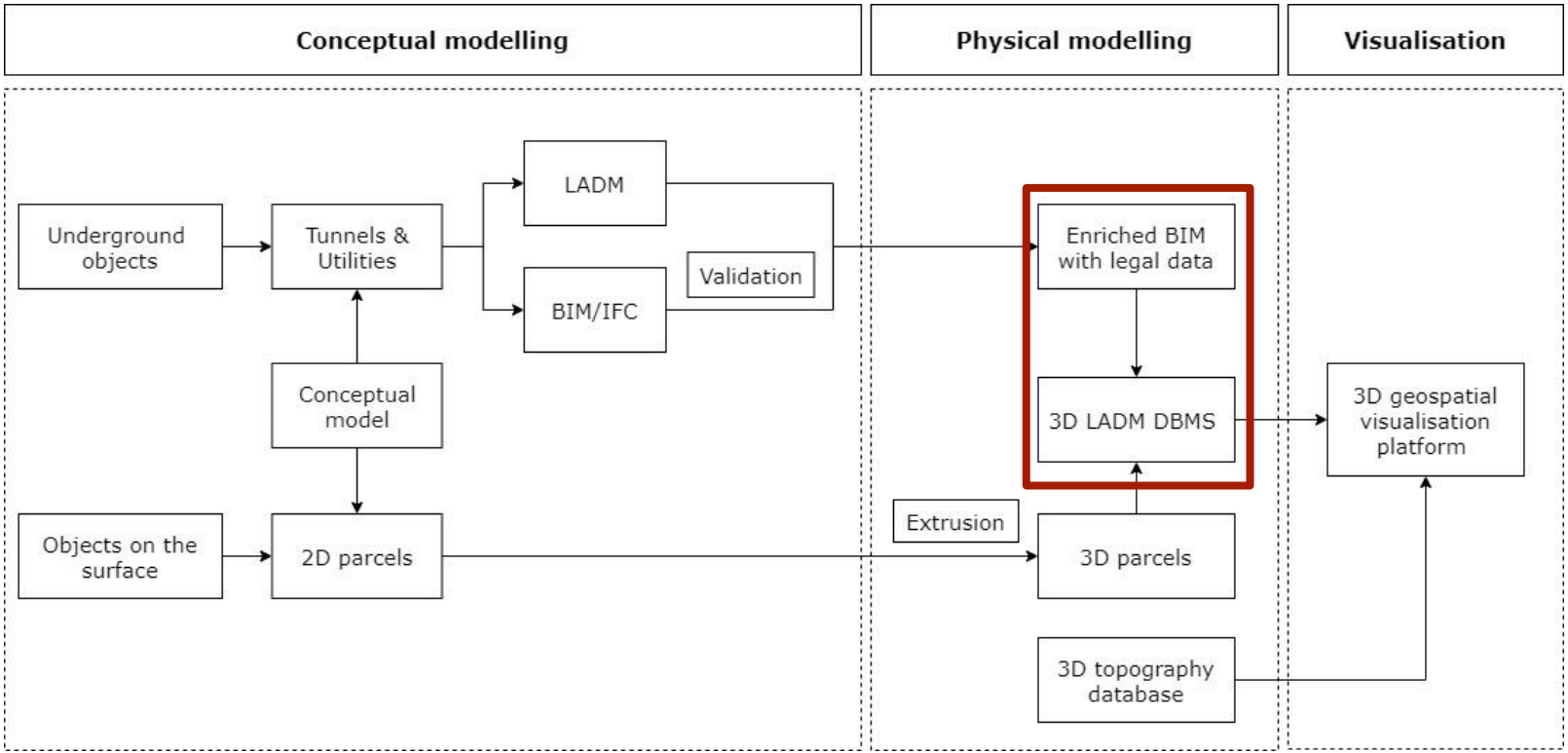
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

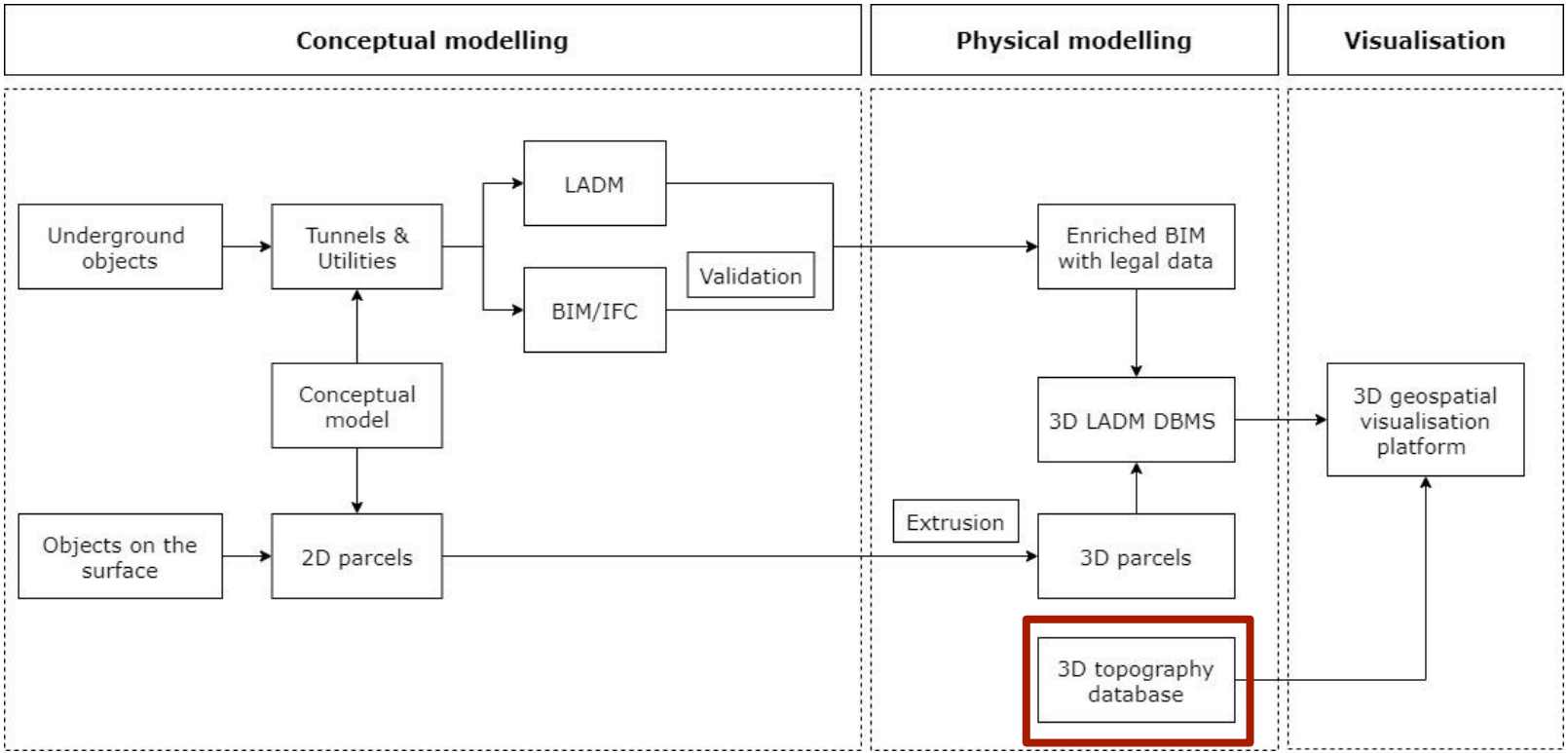
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Enriched BIM with legal data
Conceptual model
3D LADM DBMS
3D geospatial visualisation platform
Objects on the surface
2D parcels
Extrusion
3D parcels
3D topography database

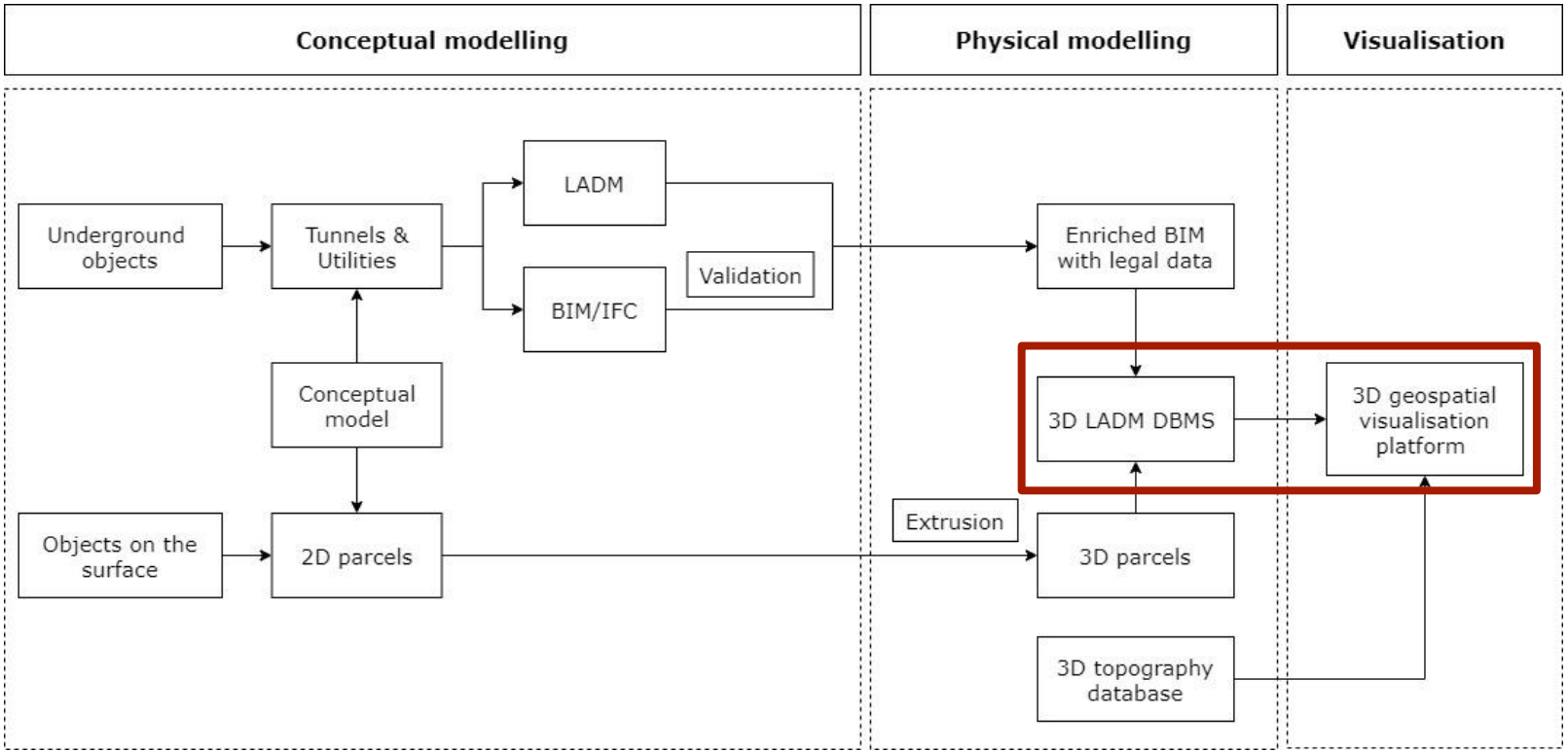
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

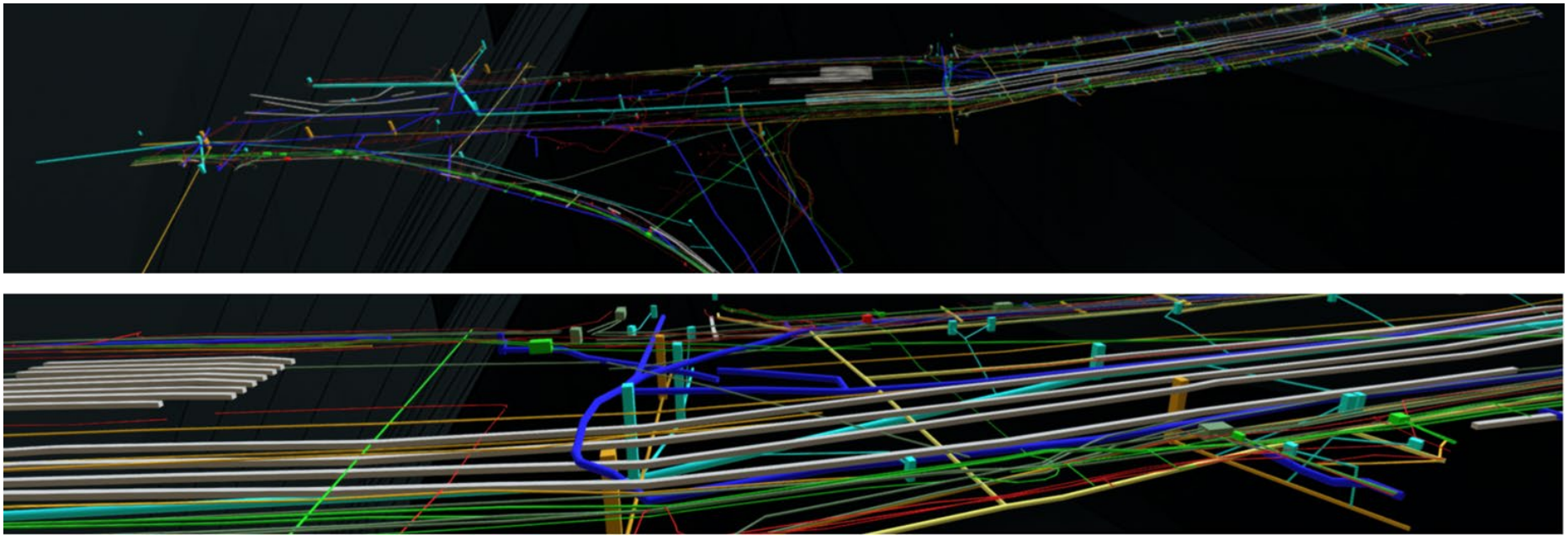
5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
Extrusion
3D parcels
3D topography database
3D geospatial visualisation platform

5. Results


Conceptual modelling
Physical modelling
Visualisation
Underground objects
Tunnels & Utilities
LADM
BIM/IFC
Validation
Conceptual model
Objects on the surface
2D parcels
Enriched BIM with legal data
3D LADM DBMS
3D geospatial visualisation platform
Extrusion
3D parcels
3D topography database

6. IFC model



IFC model of underground utility network

Images retrieved from: https://sketchfab.com/3d-models/underground-utility-ifc-model-adf25bea28774ef492946b489ef24740

7. Discussion and conclusions

Objective

A workflow is presented that provides the user with a framework on how to model the legal spaces of 3D underground objects in a 3D LAS.

Limitations

- Upcoming revisions of LADM and IFC were not taken into account in developing the workflow
- Only BIM/IFC models of buildings with limited underground objects were available for use, making validation of the workflow not possible

7. Discussion and conclusions

Future work

- Validating the workflow with use cases of BIM/IFC models of underground objects
- Investigating the option to include data formats other than BIM/IFC in the workflow
- Investigating and improving methods to convert other data formats to BIM/IFC
- Assessing the impact of the revisions of the LADM and IFC standards on the workflow
- Investigating how the workflow can be adapted in order to comply with the revisions of the LADM and IFC standards