A digital twin based on Land Administration

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Who are the 3D LA users and what do they want?

Users are interested in **apartment** building and its surrounding

- Buyers can see the exact location of the apartment building, including surrounding green spaces and the distance to neighboring structures. This easy information access will support buyers' purchasing decisions
- Notaries use 3D models to examine property parcel’s boundary and adjacent areas in detail, ensuring the accuracy of legal documents during real estate transactions
- Investors evaluate the potential for property appreciation by analyzing the nearby facilities, influencing their decision to purchase the property

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Digital Twin and 3D Land Administration

Digital twin improves the visualization and understanding of the complexities in 3D Land Administration via 3D models, updated information, decision support…

Missing functionally in earlier reported 3D LA work (next to fine functionality: 3D pan, zoom, rotate, selecting objects, slicing, select floor, underground, query by name,…):

1. Switch on/off physical objects to provide reference for legal spaces in a building (and surrounding buildings in a lower detail, depending on distance)

2. Next to spatial information also core administrative information of selected entities (in form of a LADM instance level diagram/ graph)

3. Support real time changes: directly show updates of administrative information, show daylight situation at different dates and times

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Content

1. **Related Work**
2. Prototype Development
3. Functionality Overview
4. Usability Testing
5. Conclusion and Future Work

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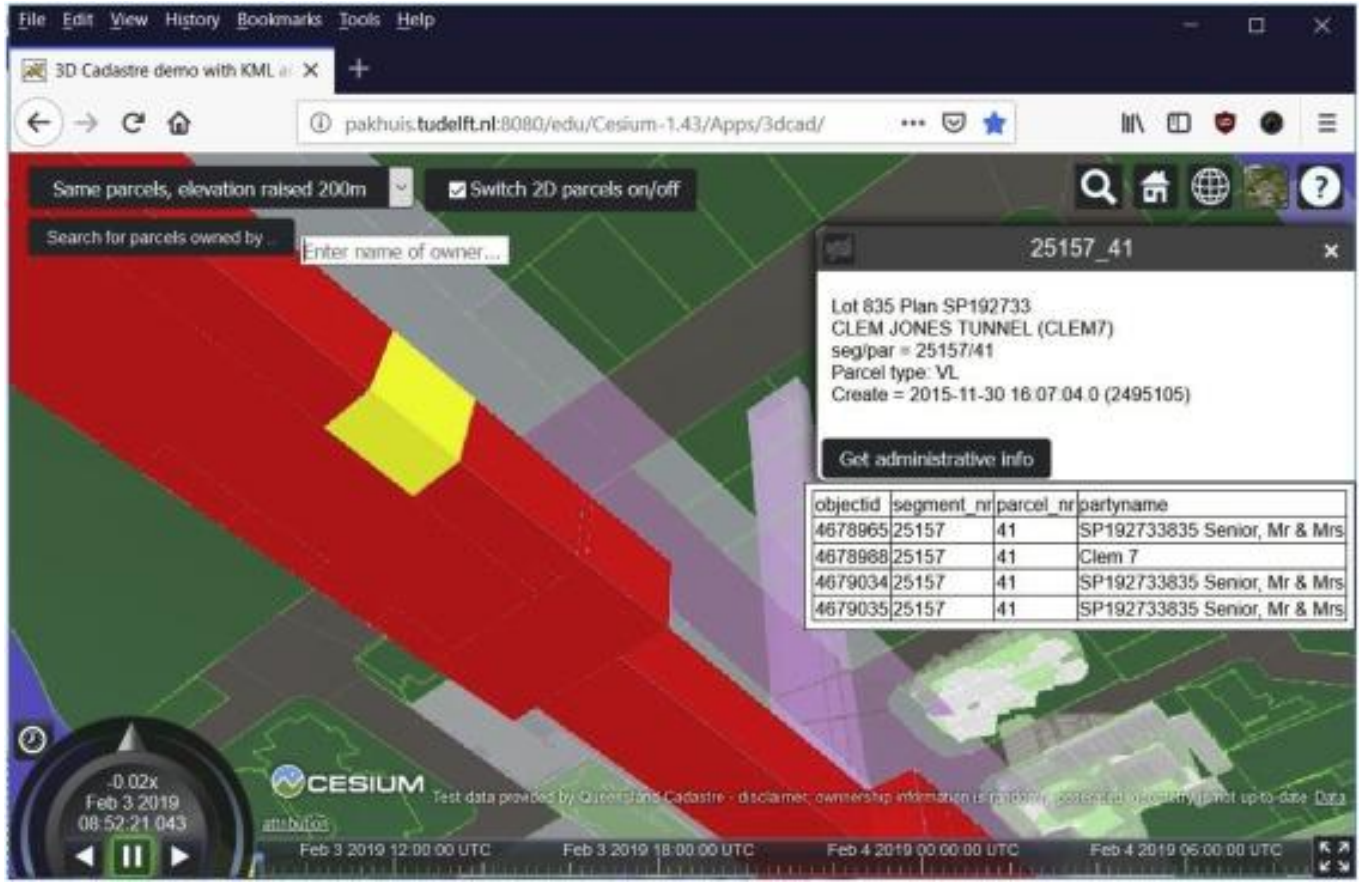
Related work

3D Land Administration Prototype Brisbane, Queensland

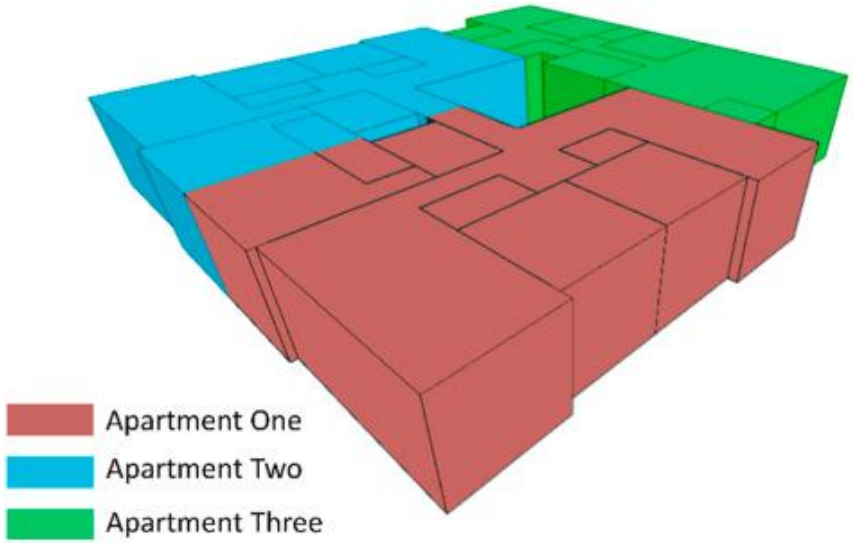


- 3D building data is mainly extracted and constructed from survey plans (in **PDF or TIFF** files) and stored in LADM database
- Legal/ administrative information is presented in **table** form in 3D web user interface

Cemellini, et al. (2020)

Related work

Modelling building ownership boundaries within BIM environment



Name	Value
Pset_AirSideSystemInformation	
Pset_ProductRequirements	
Pset_SpaceCommon	
Room Schedule	
Level	First floor
Number	
OwnershipType	private
PropertyNo.	one
PropertyType	Apartment
ServiceAreaOwnershipType	
ServiceAreaType	
Volume	318.572409
ZoneName	Apartment One

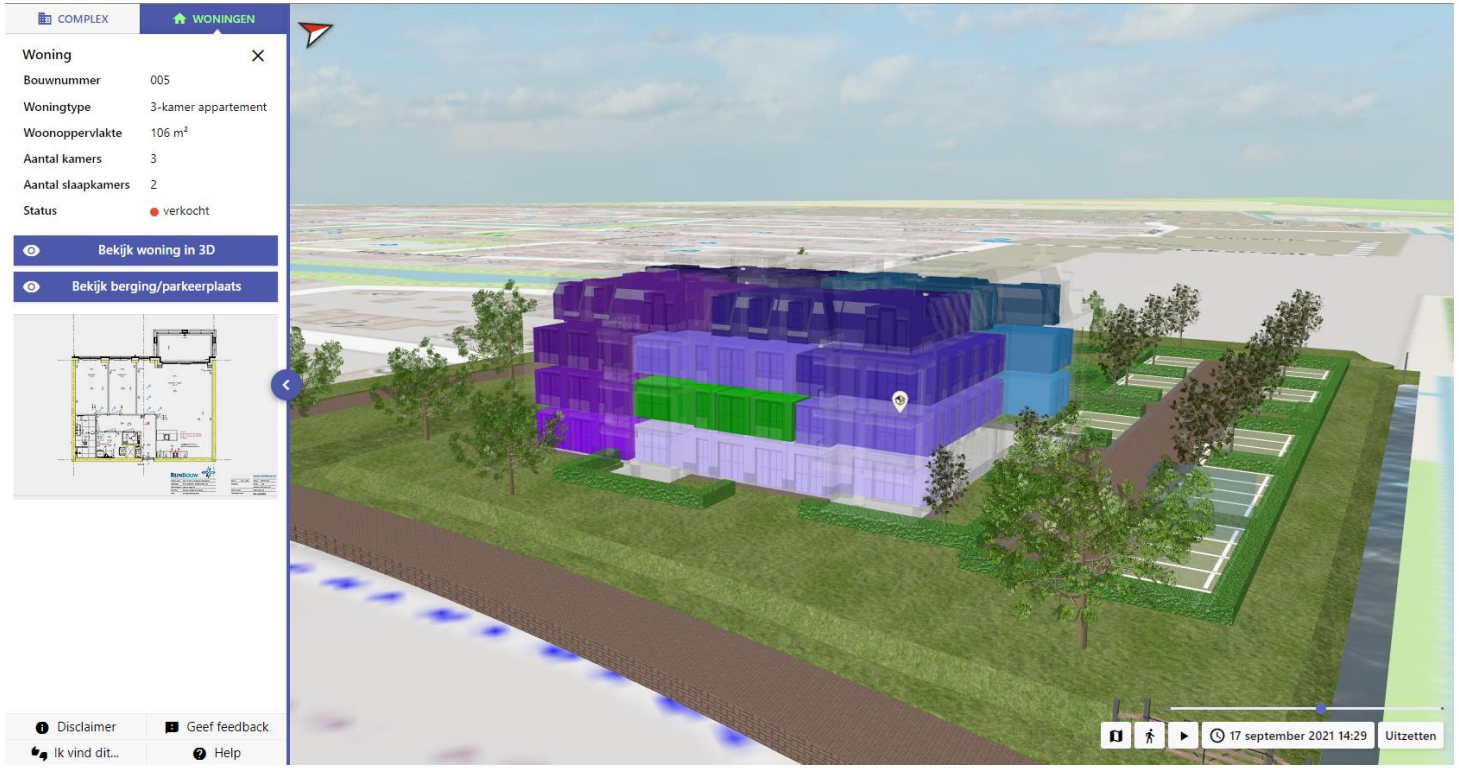
Legal information of Apartment One

- 3D building data is **IFC files**
- Enrich IFC for each building unit with closed space and identifier (user defined properties)
- Converted geometry from IFC into PostgreSQL/LADM database

Alattas, et al. (2021)

Related work

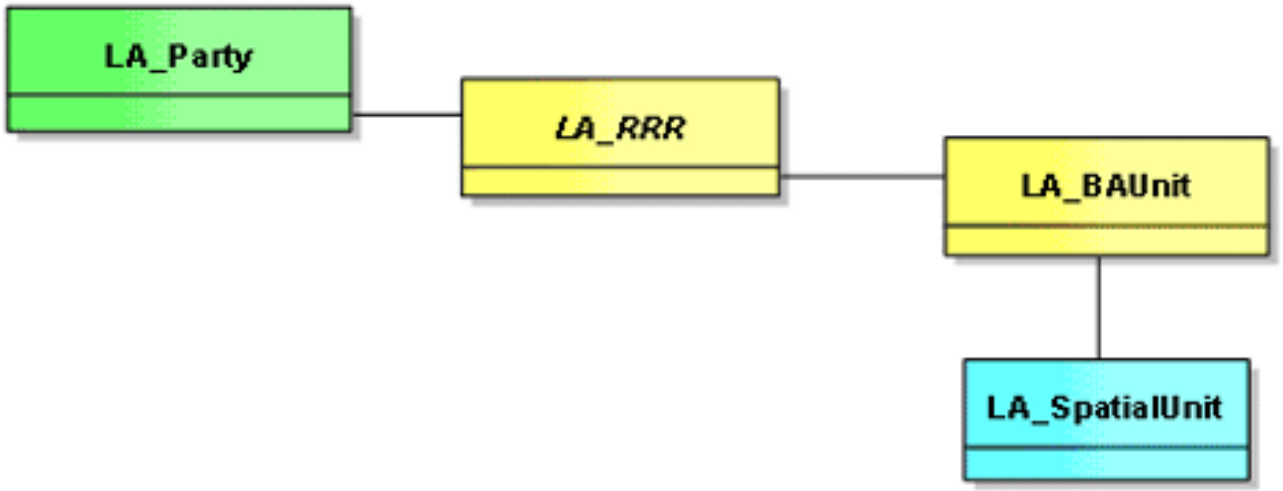
BIM Legal Prototype by Dutch Notaries



https://bpd2.ogdb.nl/bpd/project/9531/landgoed-hoevesteijn

- Provide 2 modes, physical space and legal space
- LADM is not considered
- Surrounding information is not considered

Methodology: LADM



Lemmen, C. (2012).

The Land Administration Domain Model (LADM, ISO 19152) is a conceptual model focused on the legal and geographical aspects of land administration

It provides packages that describe the framework of land administration

The three main packages of LADM are the Party Package (green), the Legal/Administrative Package (yellow), and the Spatial Unit Package (blue)

Methodology: Digital Twin

A digital twin is a virtual 3D representation of real-world asset(s) that includes both static and dynamic data

- Dynamically update real-time basic property information and legal information
- Sunlight simulation
- Enhances decision-making processes

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Methodology: Virtual Globes

With the development of 3D web-based applications, virtual globes have emerged as a new medium for visualizing and interacting with geographic data

Several WebGL-based virtual globes have been developed to facilitate cross-platform and cross-browser applications, including Cesium

Cesium is an open-source JavaScript library that enables the creation of 3D virtual globes and 2D maps in web browsers

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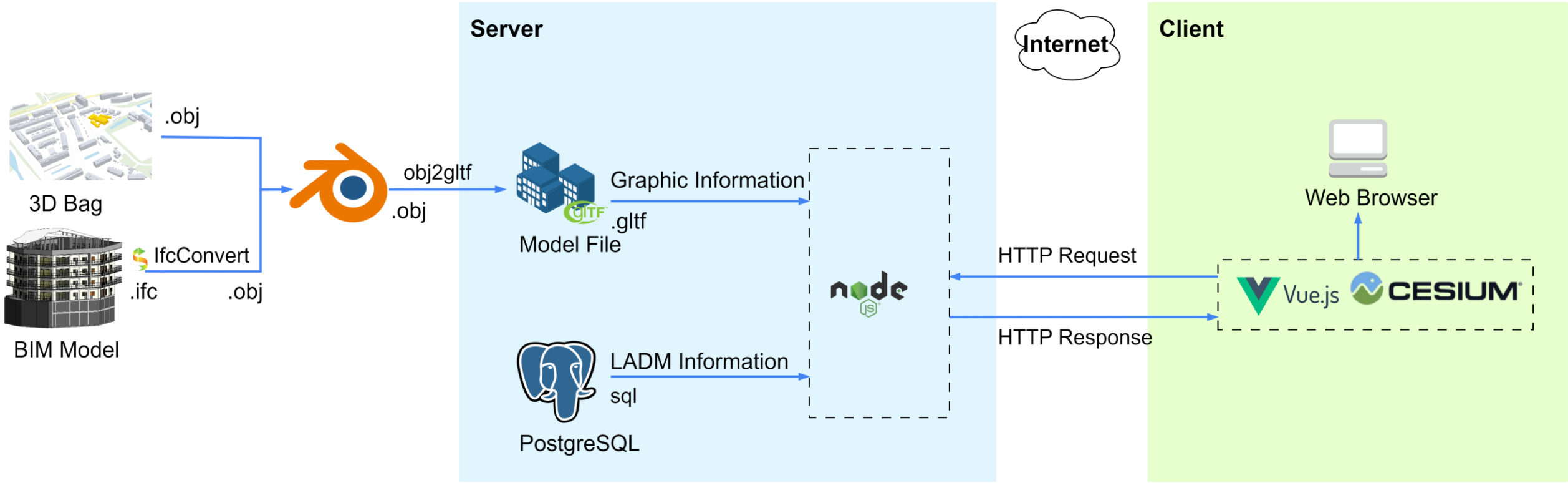
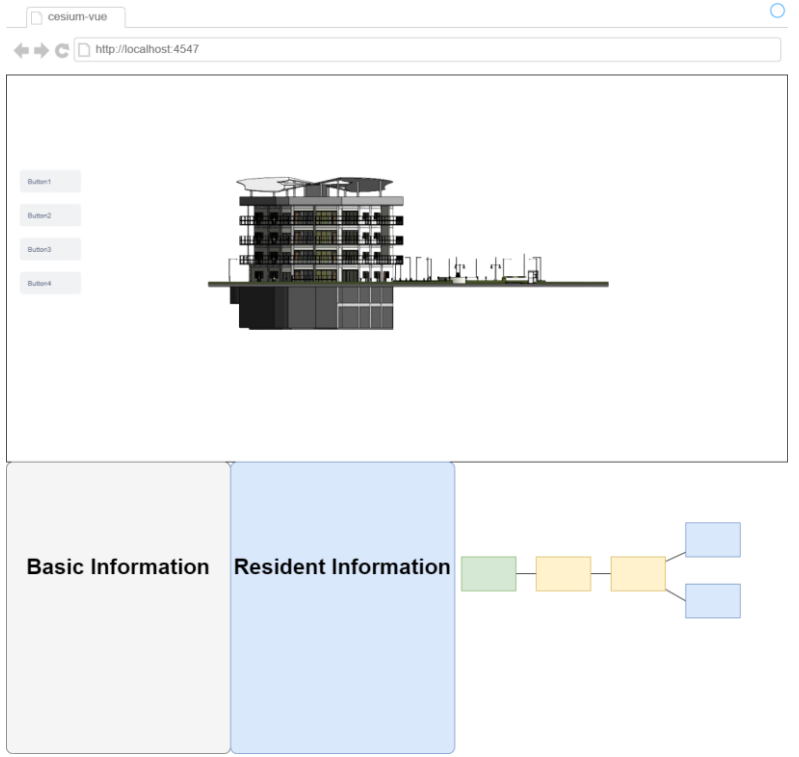
System Architecture



Prototype Design



Step 1 : LADM Database and Data Preparation

Step 2 : User Interface Development

The user interface was developed using Vue.js and Cesium to provide an interactive and intuitive experience for users

Step 3 : Webserver Development

The backend of the system was developed using Node.js, handling data requests and serving as the intermediary between the frontend and PostgreSQL database and file

Step 4 : Testing

- ✓ Component Verification: Test each system component for correctness and functionality.
- ✓ Meetings to gather feedback and make necessary adjustments to improve usability and functionality.
- ✓ Usability testing: Test if users can complete tasks and evaluate their satisfaction

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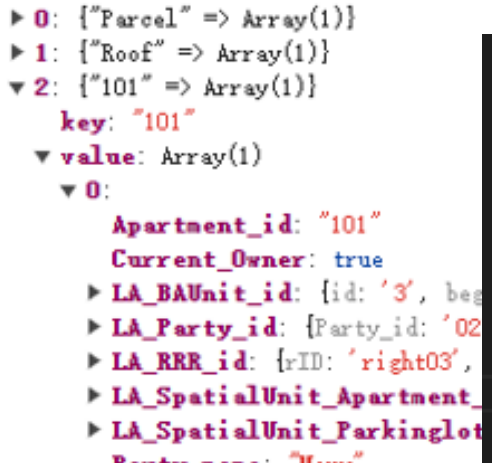
Information Flow

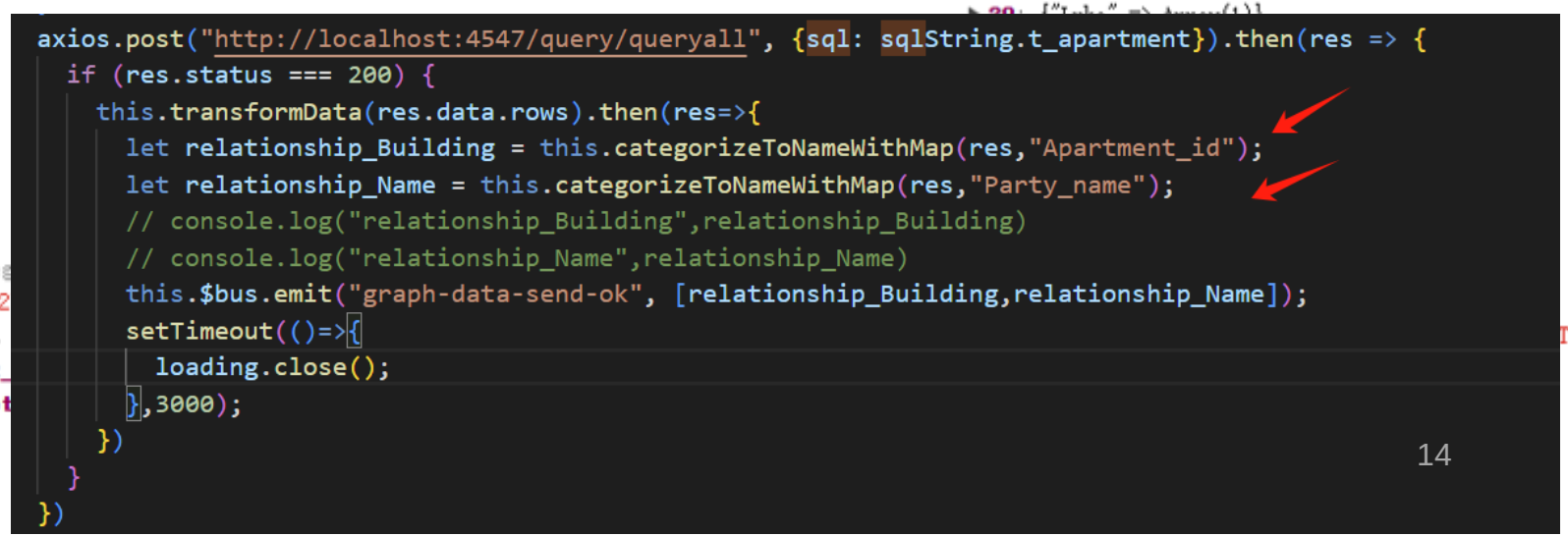
Integrate the LADM information from the database with the 3D models

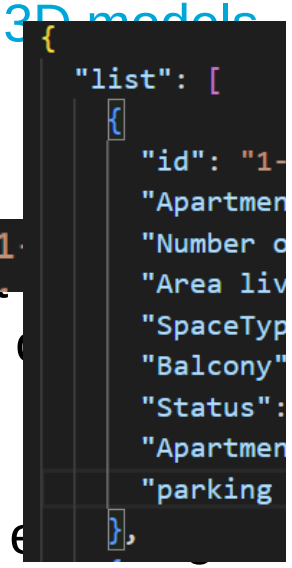
1. Load Models and Set IDs:
assign a unique ID to each 3D model and bind a click event. When a user clicks on a model, the ID of the selected model can be

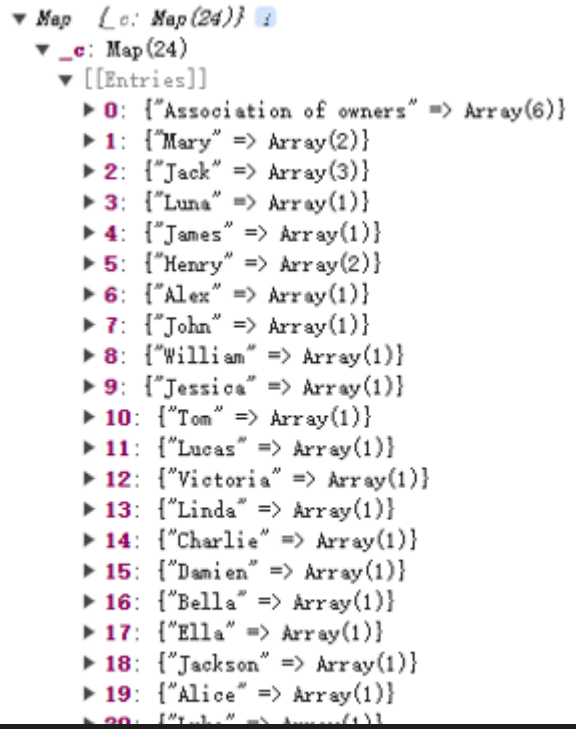
2. Basic information in .json file
Store the basic information of the properties in a JSON file, each piece of information has a unique ID corresponding to the model ID

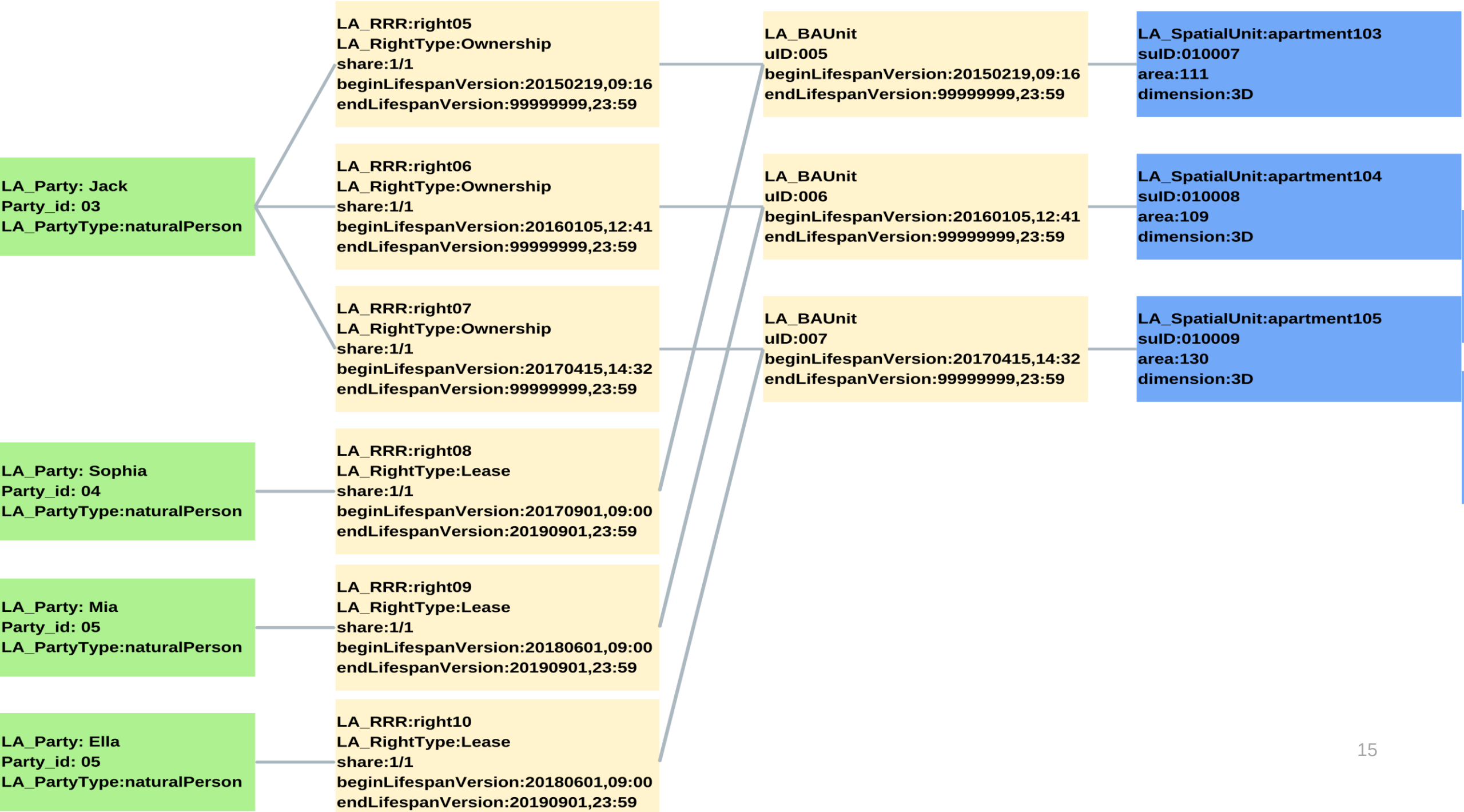
3. LADM Info
When loading
access optio



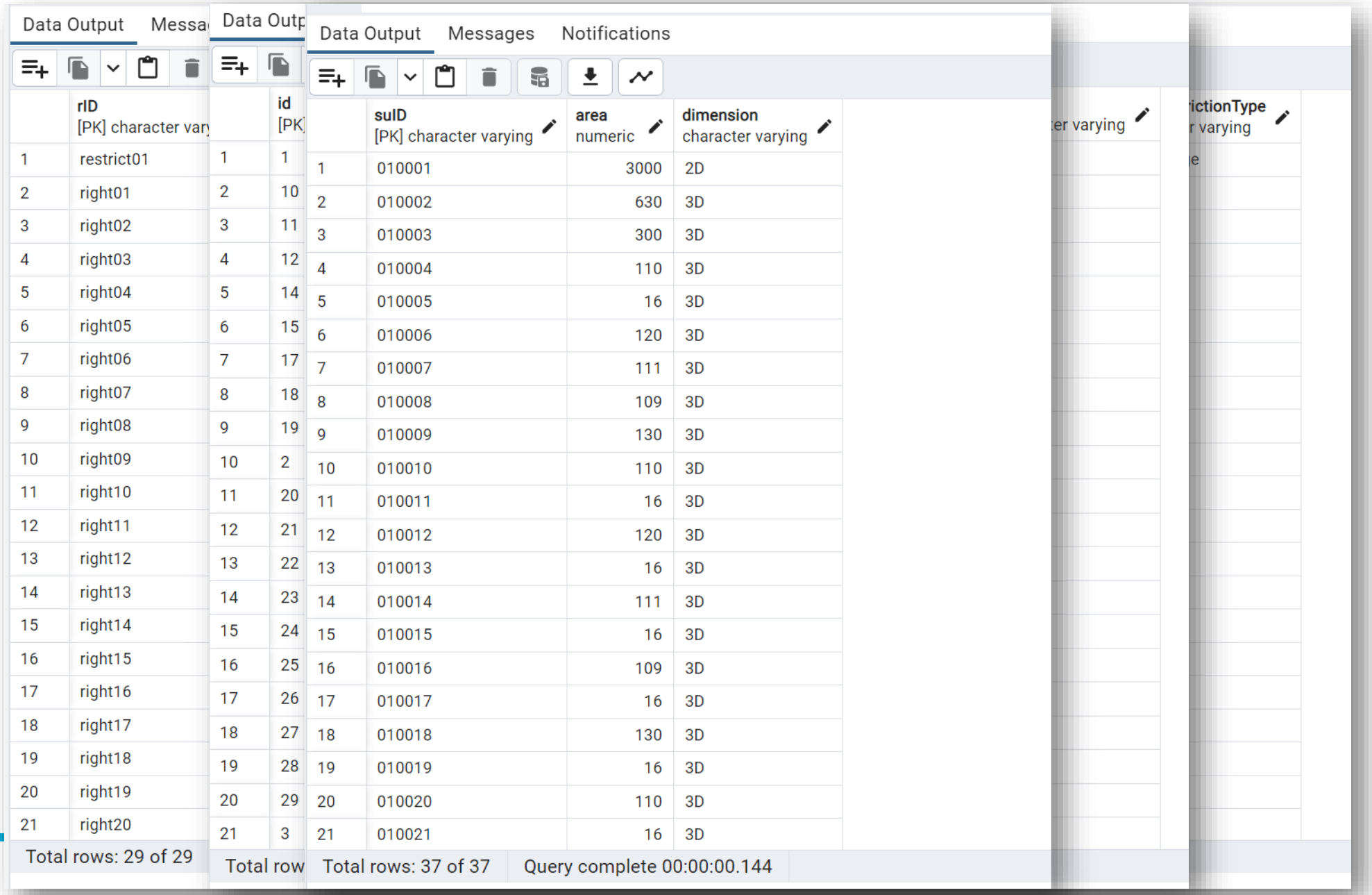







LA_Party: Jack
Party_id: 03
LA_PartyType:naturalPerson
LA_RRR:right05
LA_RightType:Ownership
share:1/1
beginLifespanVersion:20150219,09:16
endLifespanVersion:99999999,23:59
LA_RRR:right06
LA_RightType:Ownership
share:1/1
beginLifespanVersion:20160105,12:41
endLifespanVersion:99999999,23:59
LA_RRR:right07
LA_RightType:Ownership
share:1/1
beginLifespanVersion:20170415,14:32
endLifespanVersion:99999999,23:59
LA_Party: Sophia
Party_id: 04
LA_PartyType:naturalPerson
LA_RRR:right08
LA_RightType:Lease
share:1/1
beginLifespanVersion:20170901,09:00
endLifespanVersion:20190901,23:59
LA_Party: Mia
Party_id: 05
LA_PartyType:naturalPerson
LA_RRR:right09
LA_RightType:Lease
share:1/1
beginLifespanVersion:20180601,09:00
endLifespanVersion:20190901,23:59
LA_Party: Ella
Party_id: 05
LA_PartyType:naturalPerson
LA_RRR:right10
LA_RightType:Lease
share:1/1
beginLifespanVersion:20180601,09:00
endLifespanVersion:20190901,23:59
LA_BAUnit
uID:005
beginLifespanVersion:20150219,09:16
endLifespanVersion:99999999,23:59
LA_BAUnit
uID:006
beginLifespanVersion:20160105,12:41
endLifespanVersion:99999999,23:59
LA_BAUnit
uID:007
beginLifespanVersion:20170415,14:32
endLifespanVersion:99999999,23:59
LA_SpatialUnit:apartment103
suID:010007
area:111
dimension:3D
LA_SpatialUnit:apartment104
suID:010008
area:109
dimension:3D
LA_SpatialUnit:apartment105
suID:010009
area:130
dimension:3D

Database



Data Output | Messa

	rID [PK] character vary
1	restrict01
2	right01
3	right02
4	right03
5	right04
6	right05
7	right06
8	right07
9	right08
10	right09
11	right10
12	right11
13	right12
14	right13
15	right14
16	right15
17	right16
18	right17
19	right18
20	right19
21	right20

Total rows: 29 of 29

Data Outp

	id [PK
1	1
2	10
3	11
4	12
5	14
6	15
7	17
8	18
9	19
10	2
11	20
12	21
13	22
14	23
15	24
16	25
17	26
18	27
19	28
20	29
21	3

Total row

Data Output | Messages | Notifications

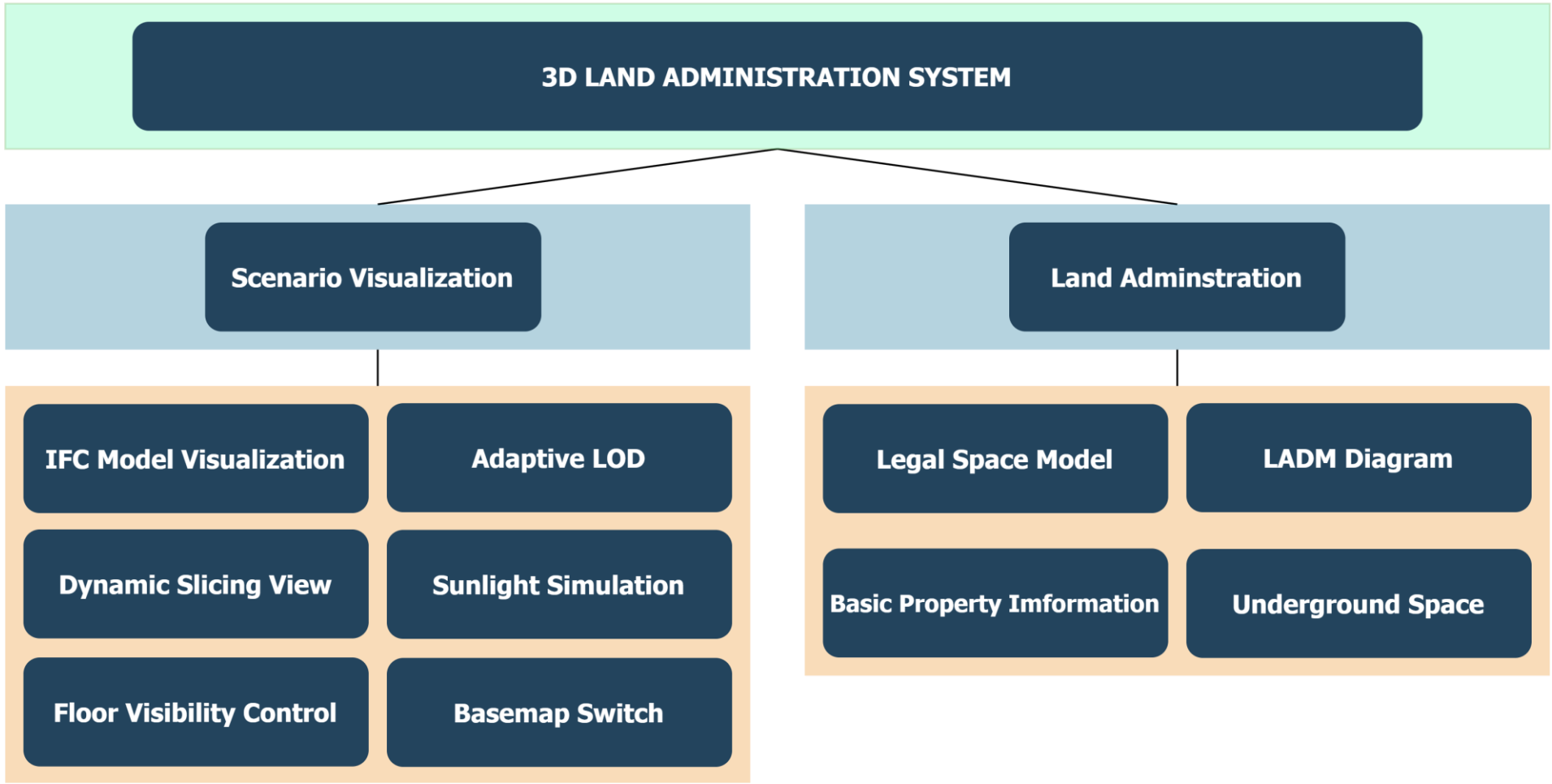
	suID [PK] character varying	area numeric	dimension character varying
1	010001	3000	2D
2	010002	630	3D
3	010003	300	3D
4	010004	110	3D
5	010005	16	3D
6	010006	120	3D
7	010007	111	3D
8	010008	109	3D
9	010009	130	3D
10	010010	110	3D
11	010011	16	3D
12	010012	120	3D
13	010013	16	3D
14	010014	111	3D
15	010015	16	3D
16	010016	109	3D
17	010017	16	3D
18	010018	130	3D
19	010019	16	3D
20	010020	110	3D
21	010021	16	3D

Total rows: 37 of 37 | Query complete 00:00:00.144

er varying

rictionType
r varying

System Functions



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Content

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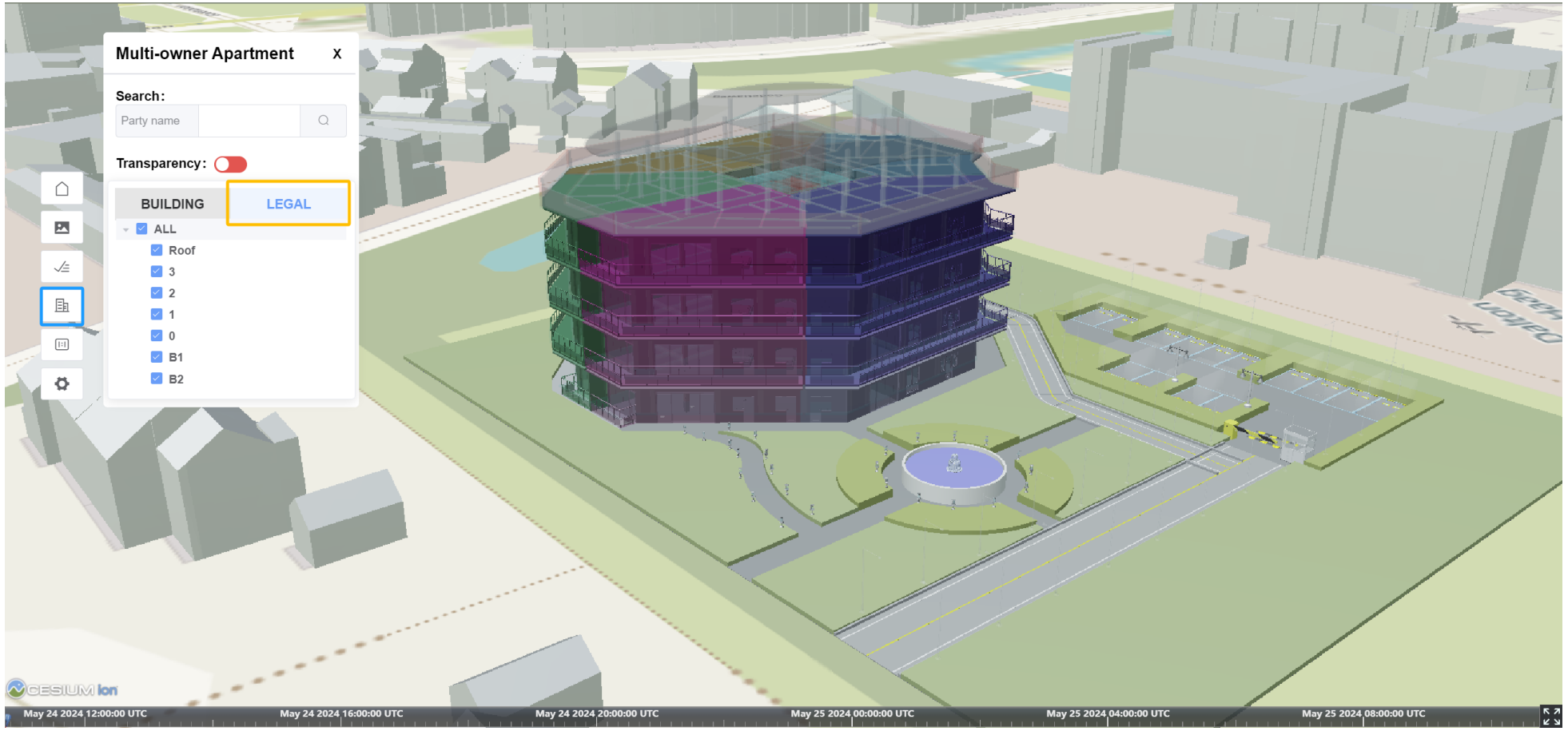
Load BIM Models

3D Physical Model

Clarify the physical structure of the building

Show legal spaces



3D Legal Model

Clarify property boundaries and apartment rights

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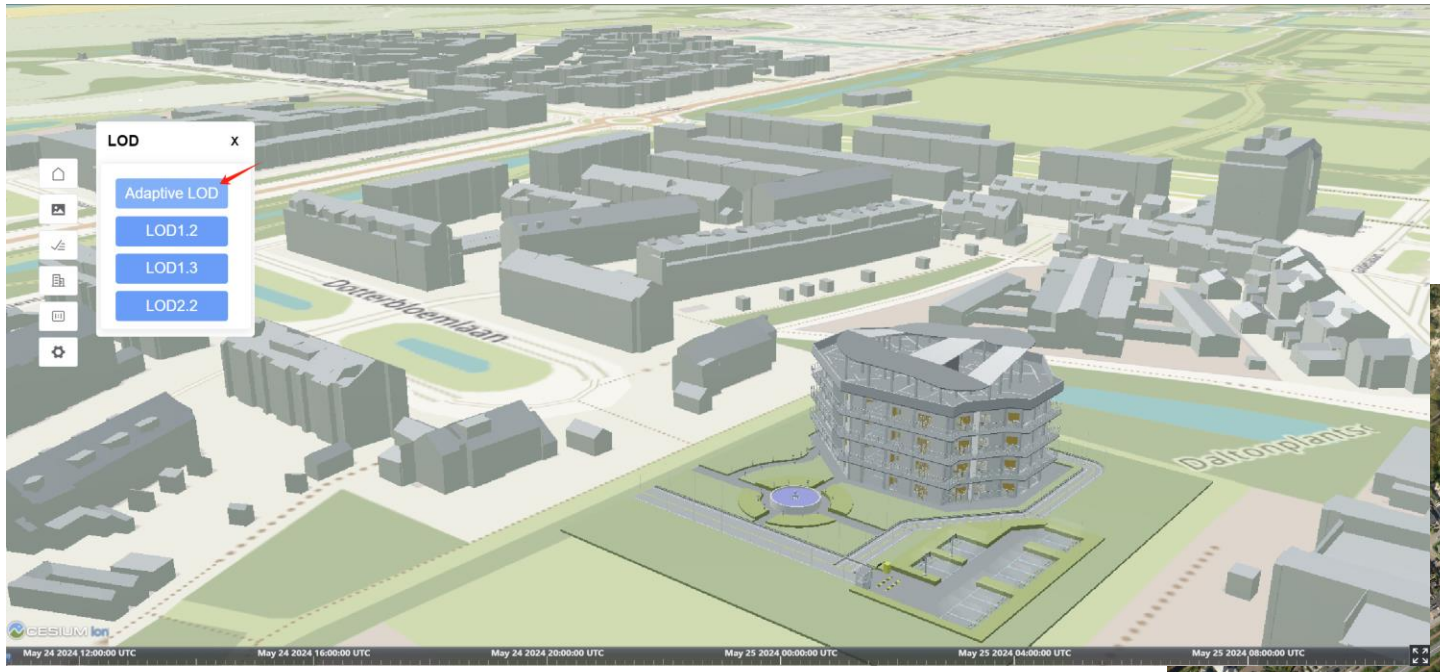
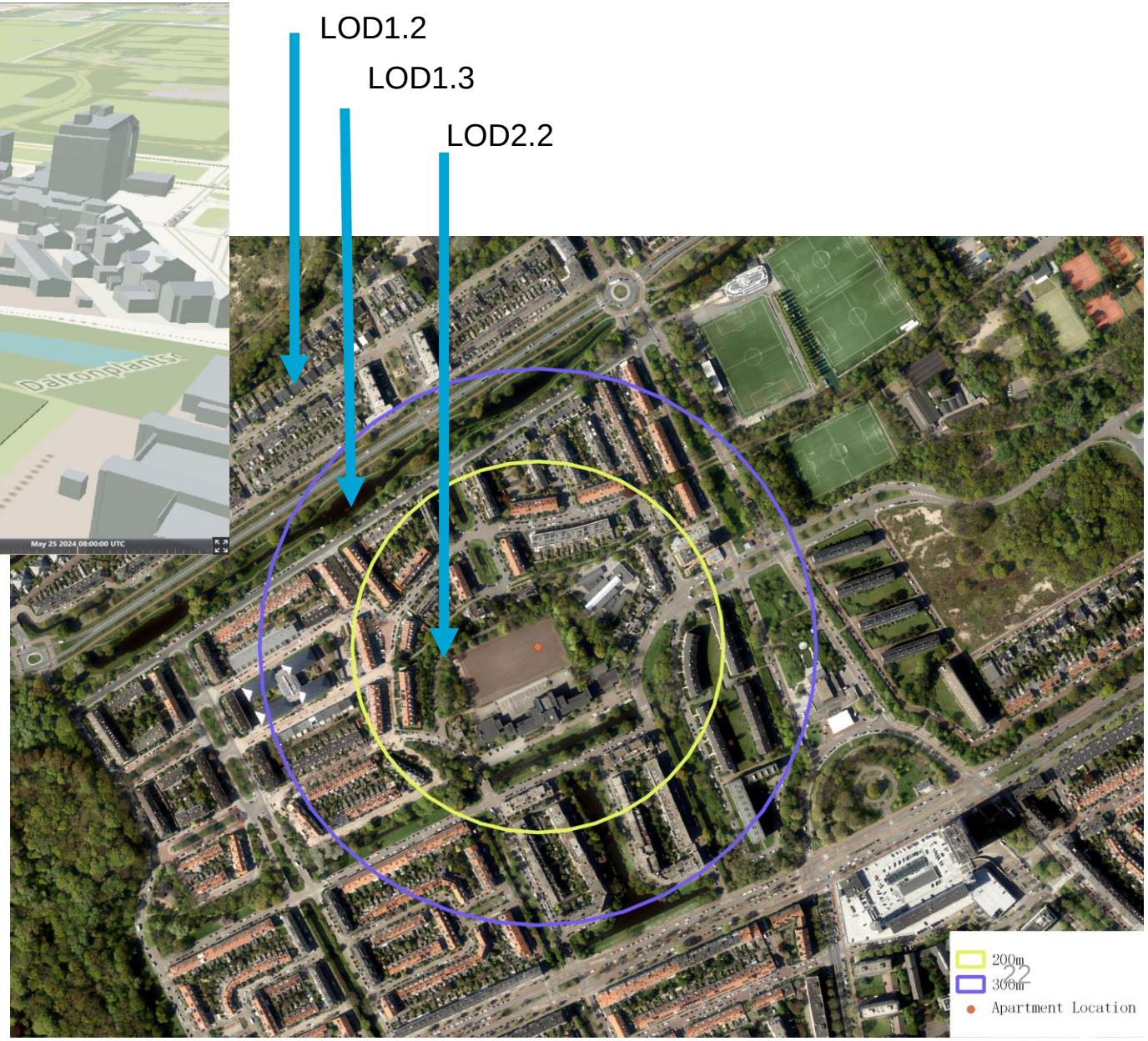
3D Surrounding Building Model Switch

This function allows users to control and switch between different Levels of Detail (LOD). Users can toggle the visibility of various LOD models to view the building at different detail levels based on their preferences

3D Adaptive Building Model Switch





- Within 200 meters: Displays the highest level of detail
- Between 200m and 300m: Displays a moderate level of detail
- Beyond 300m: Uses a simplified model

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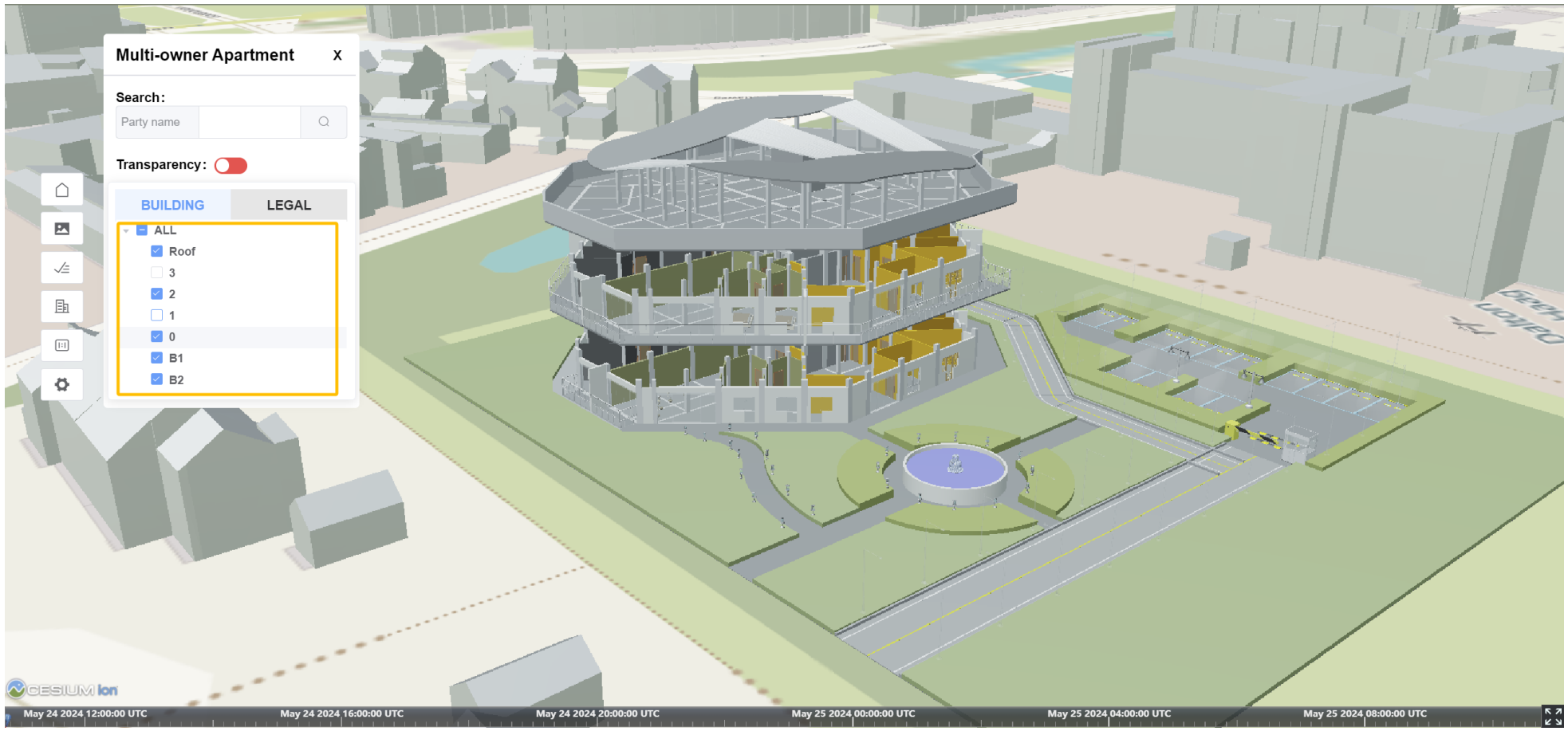
Floor Visibility Control



This function allows users to control the visibility of different floors in a multi-storey building model. Users can toggle between viewing the entire building, specific floors based on their preferences

Sunlight Simulation

Follow system time

This function allows users to dynamically view the effects of sunlight at different times of the day, thereby enhancing decision-making

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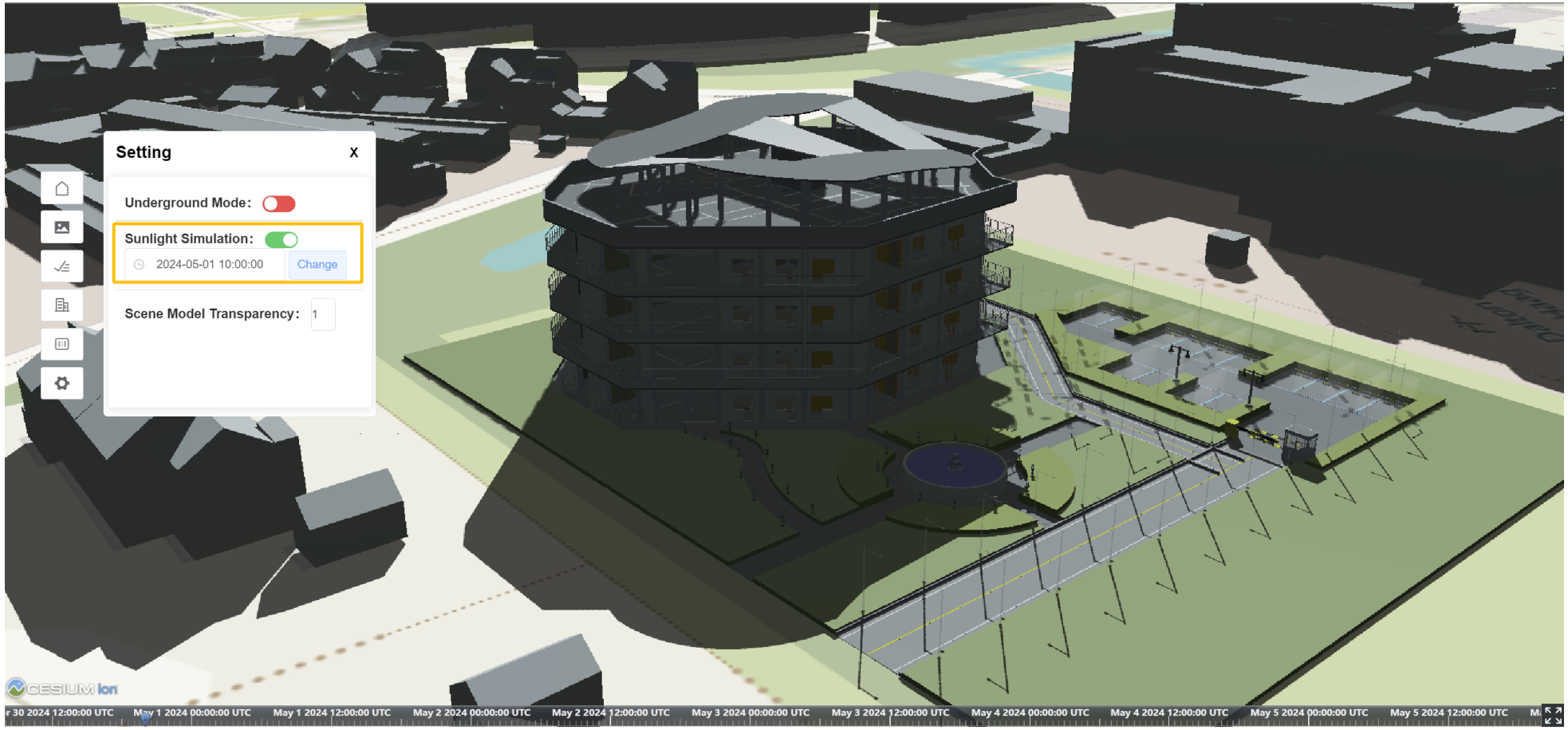
Sunlight Simulation

User can select time



- It helps architects evaluate overall sunlight exposure and potential shading from surrounding structures to optimize building designs
- It helps potential apartment buyers make purchasing decisions based on property lighting conditions

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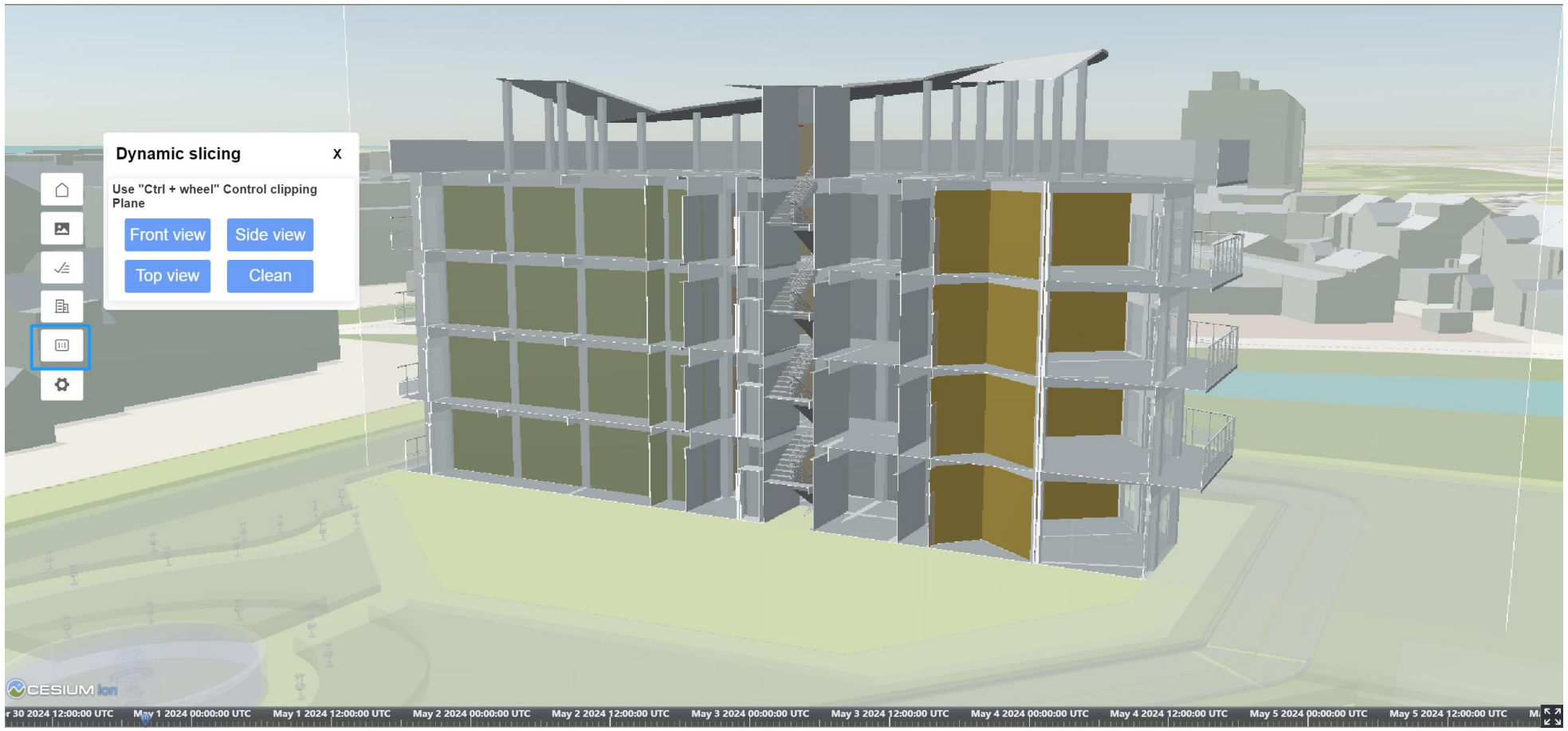
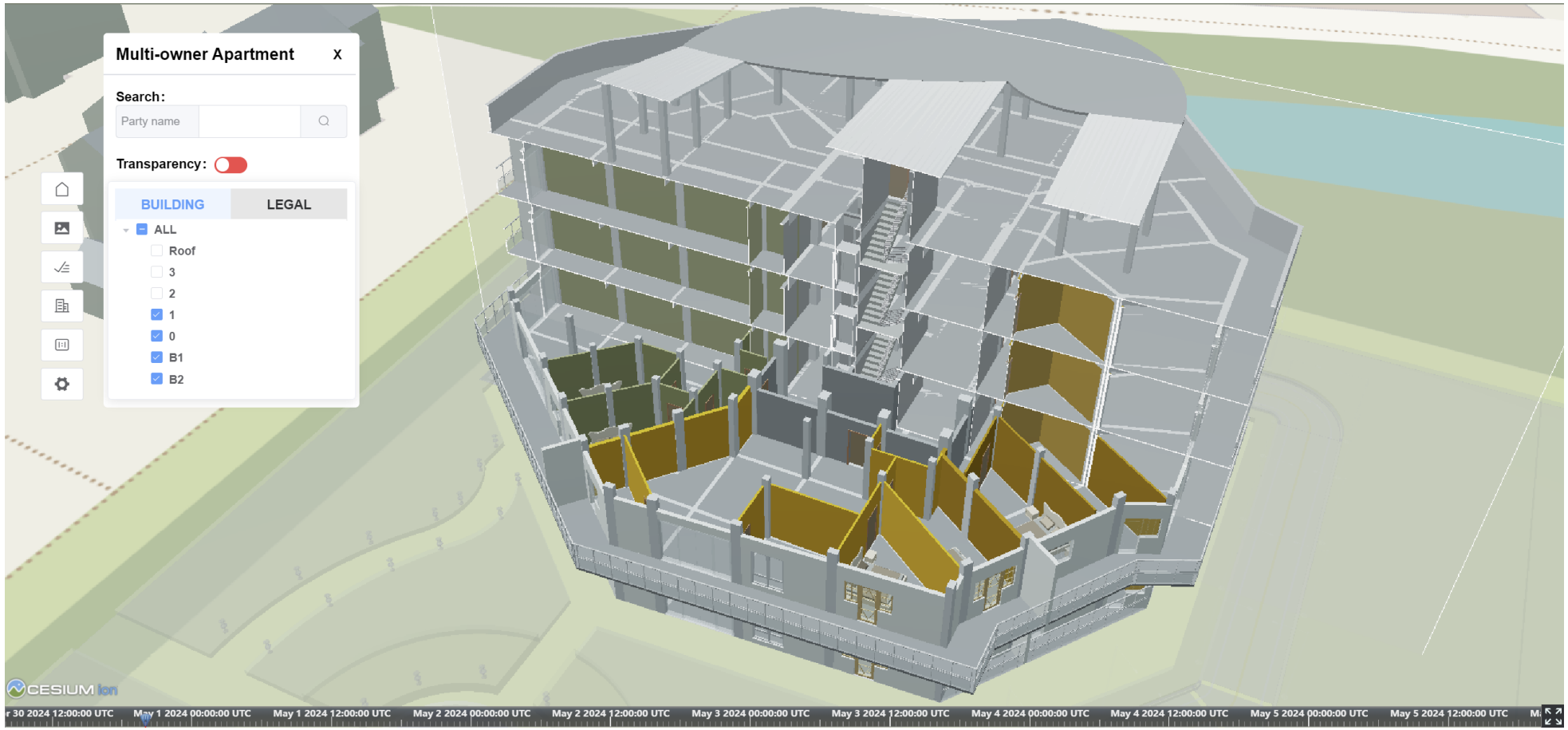
Dynamic Slicing View



This function enhances 3D cadastral visualization, allowing users to interactively slice through multi-story buildings and view cross-sections from a vertical perspective

Dynamic Slicing View



Overlay effect showing selected floor

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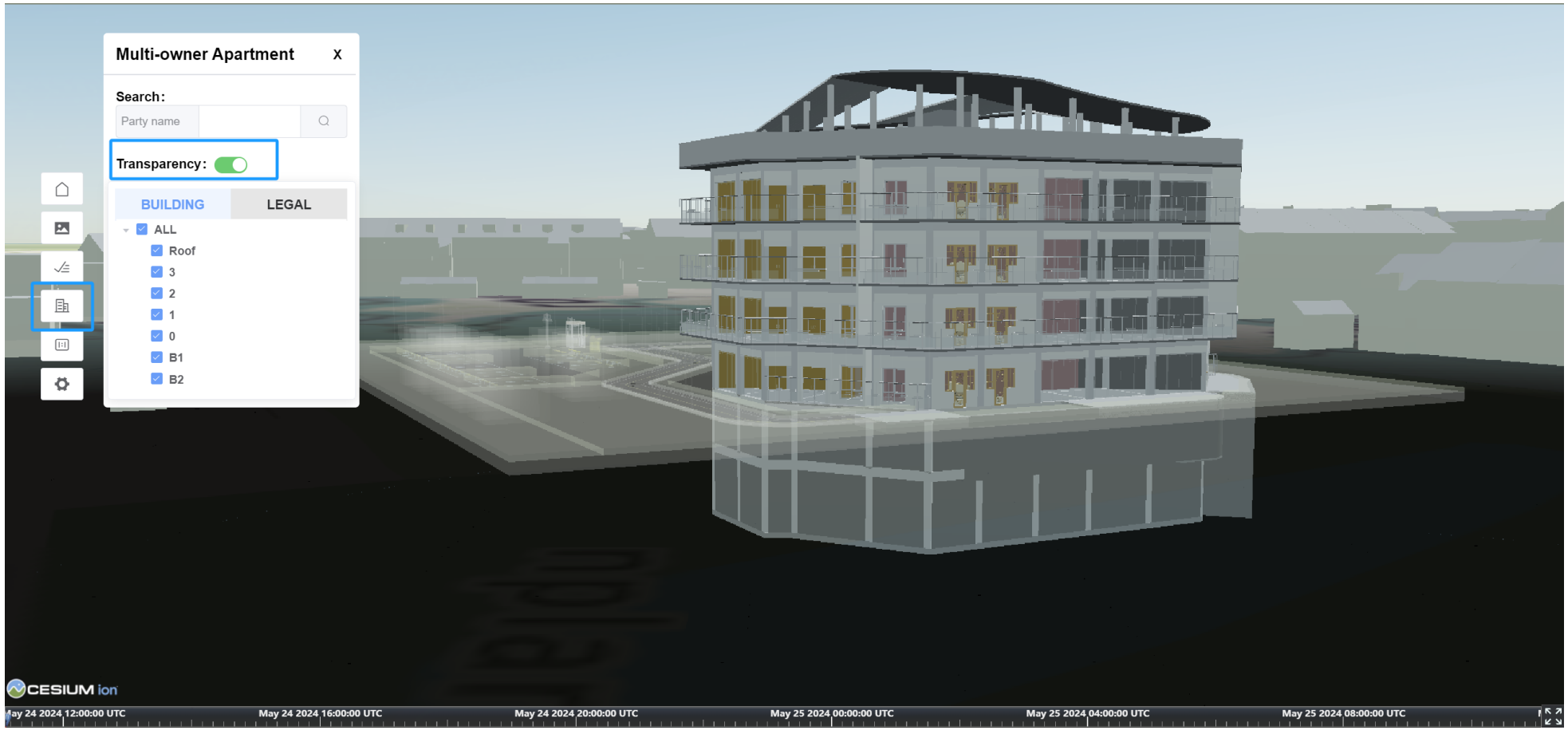
Visualizing underground space

Turn on the ‘transparency’ button



- This feature overcomes the limitation of 2D cadastral maps that hide underground information
- It provides users with a more intuitive and clearer view of underground space, allowing them to view underground garages, utilities, etc.

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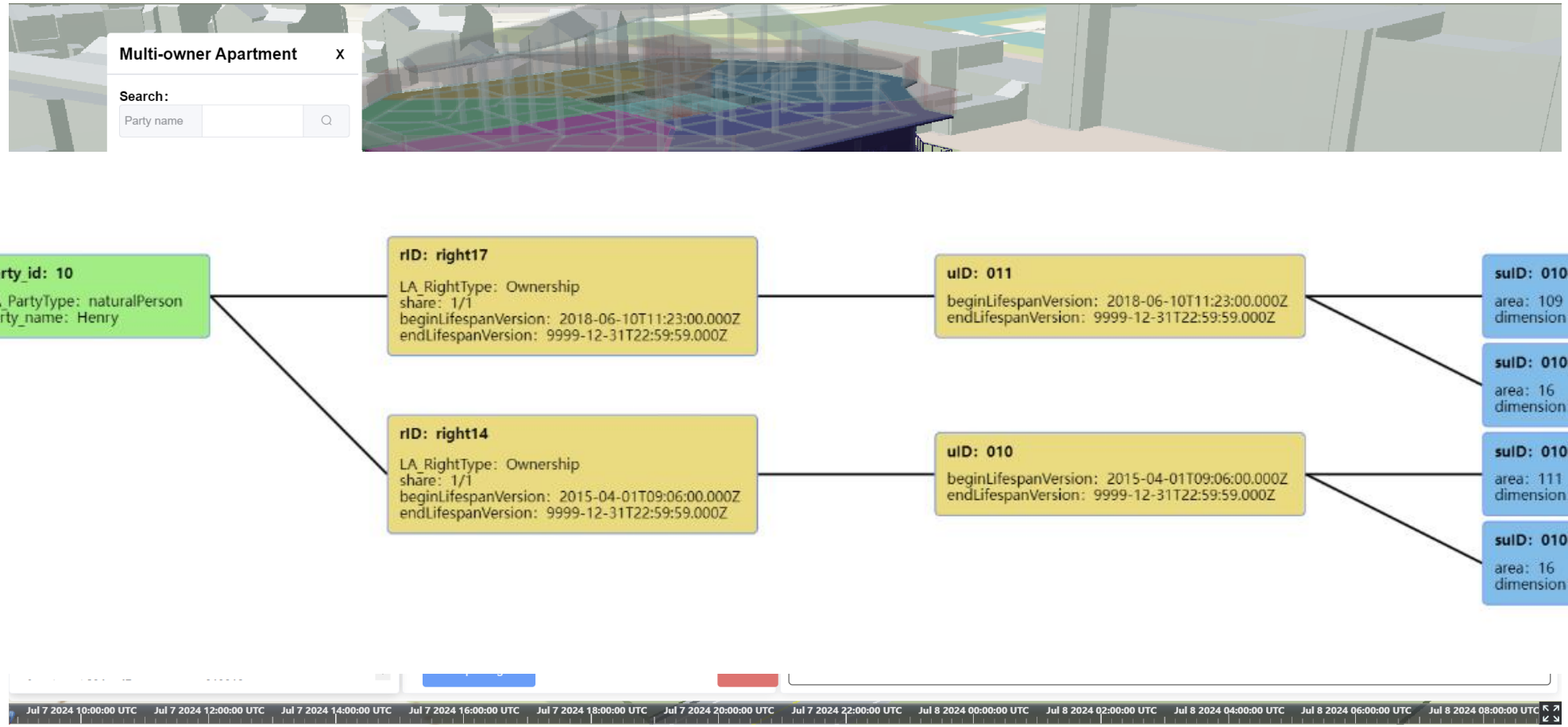
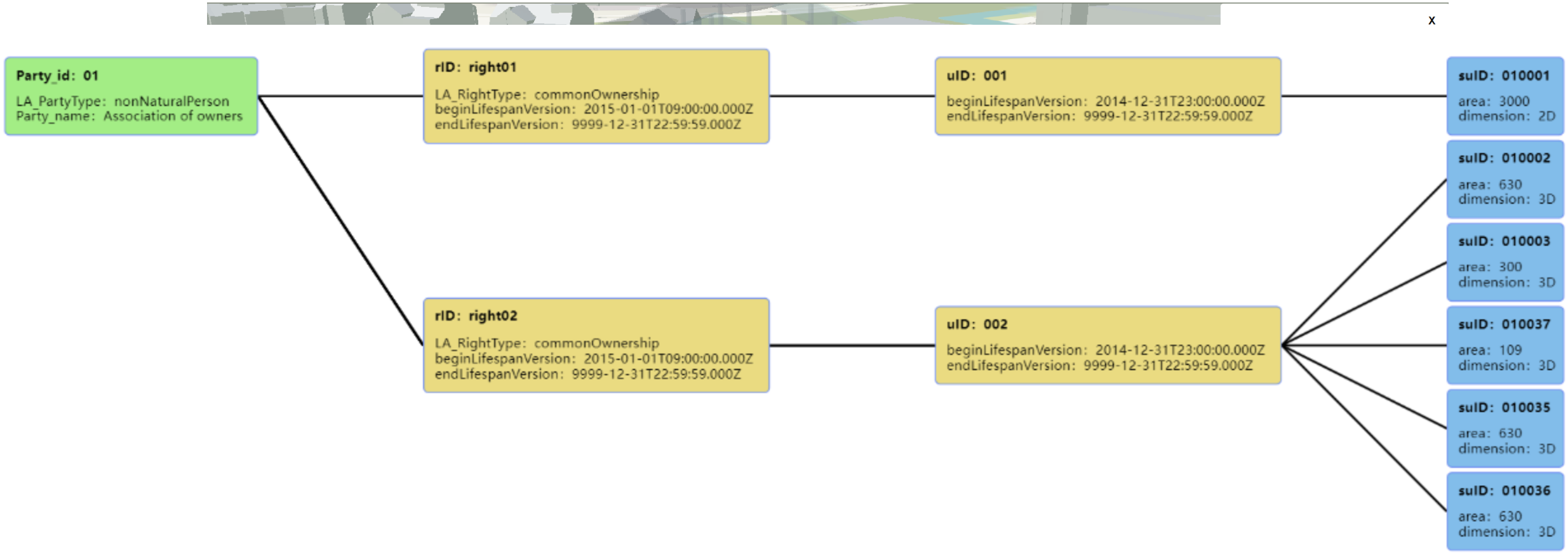
LADM Data Display: Spatial Query by Click on Apartment



LADM Data Display: Textual Query by Party Name

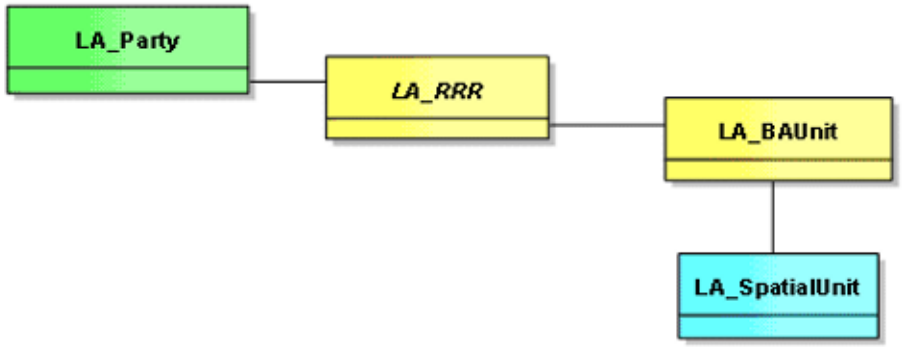


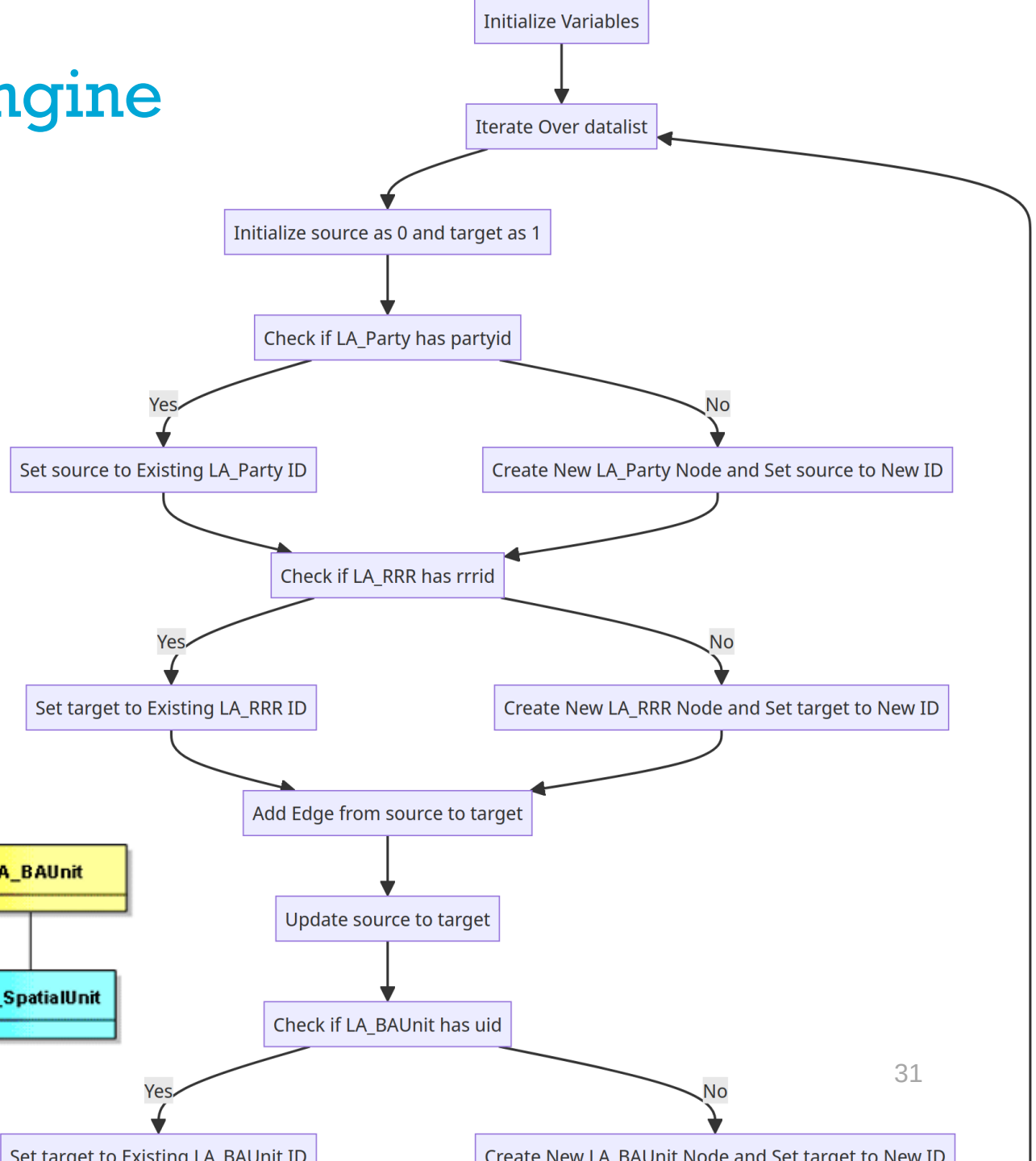
Search by ‘Association of owners’

AntV G6 Graph Visualization Engine

This method is designed to convert the data to the nodes and edges format required by AntV G6, in order to meet the specifications of the LADM graph

- Adds nodes sequentially in the order of LA_Party, LA_RRR, LA_BAUnit, and LA_SpatialUnit based on LADM
- Add edge: Specifies the source and target for each edge to ensure the correct relationships between nodes





http://g6-v3-2.antv.vision

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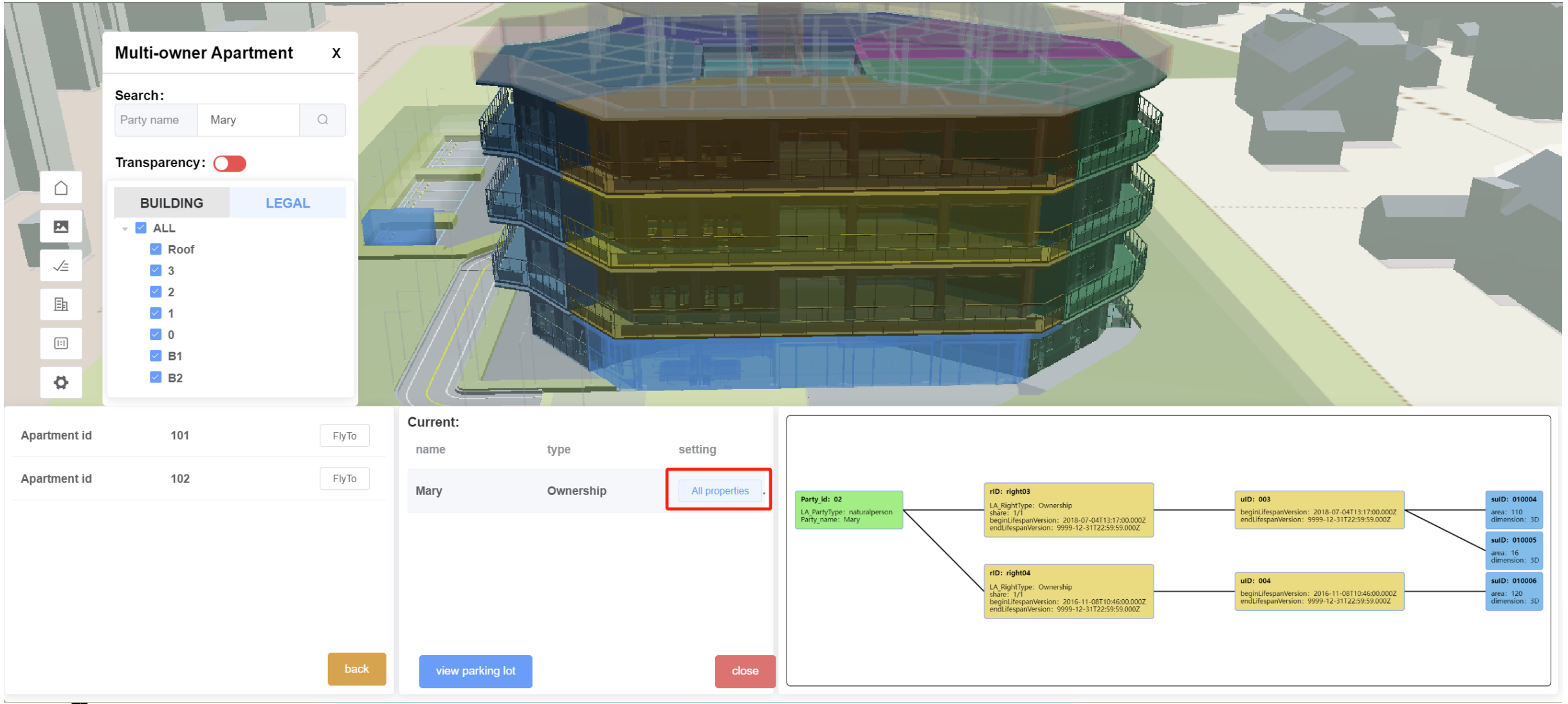
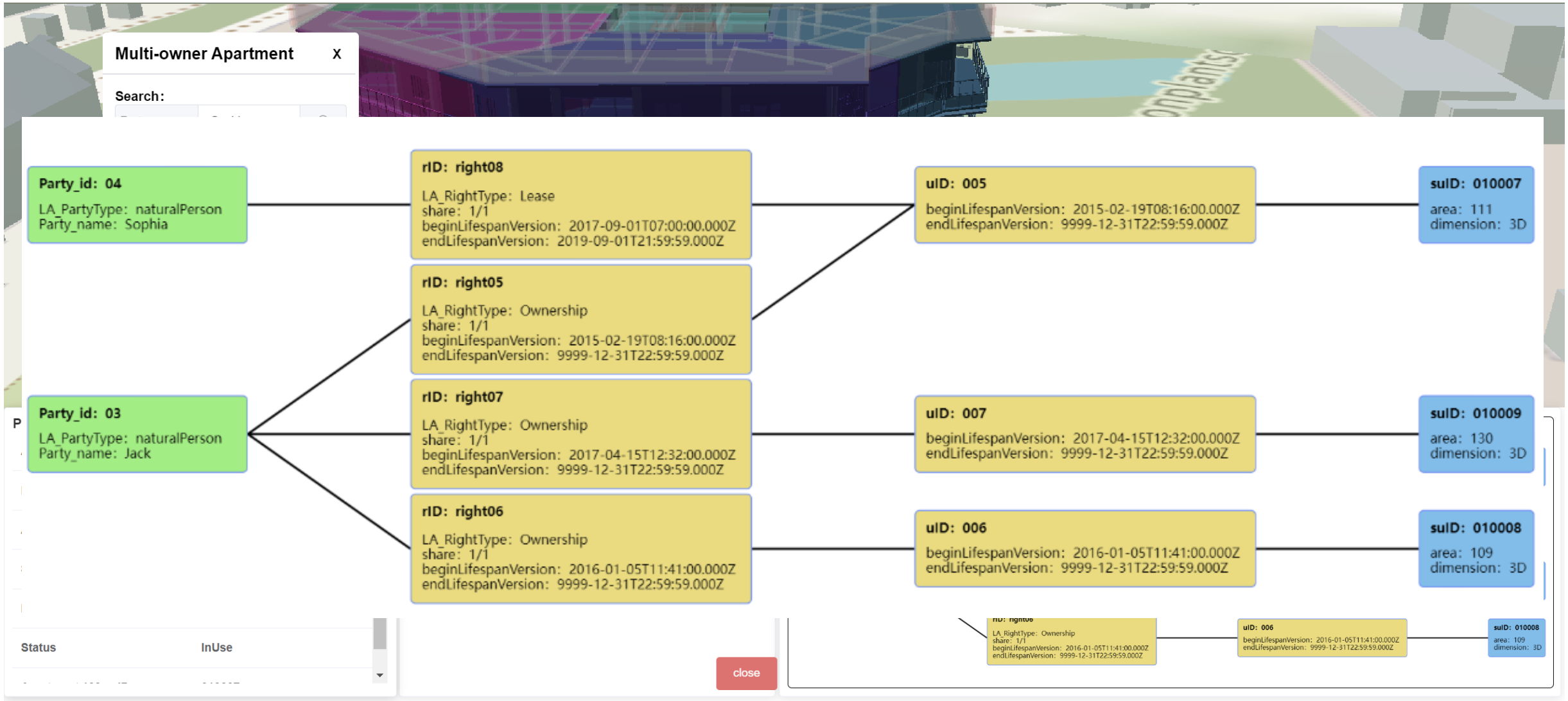
Search by Party Name (Result Apartment and Carpark)



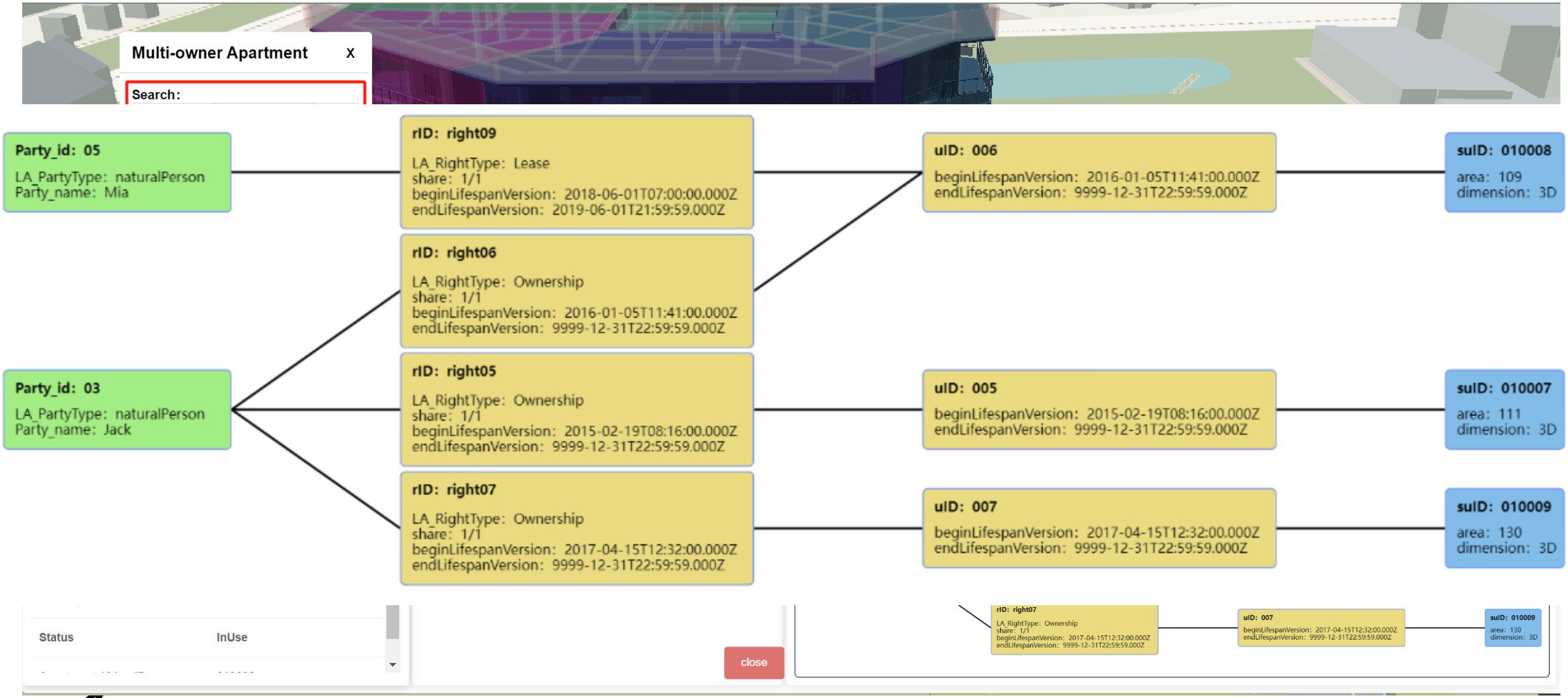
Search by Owner Name ‘Mary’

Search Result Multiple Owners



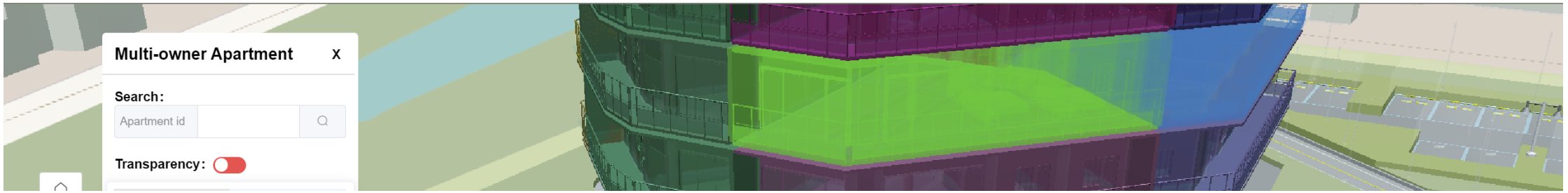
Search by Tenant Name 'Sophia'

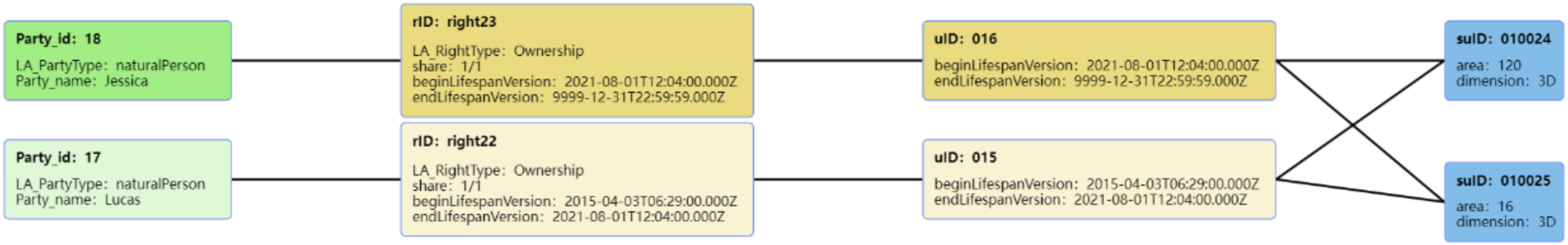
Search by Apartment Identification



Search by Apartment ID ‘303’

Search Showing Both Current And Previous Information





Display the previous owner's information

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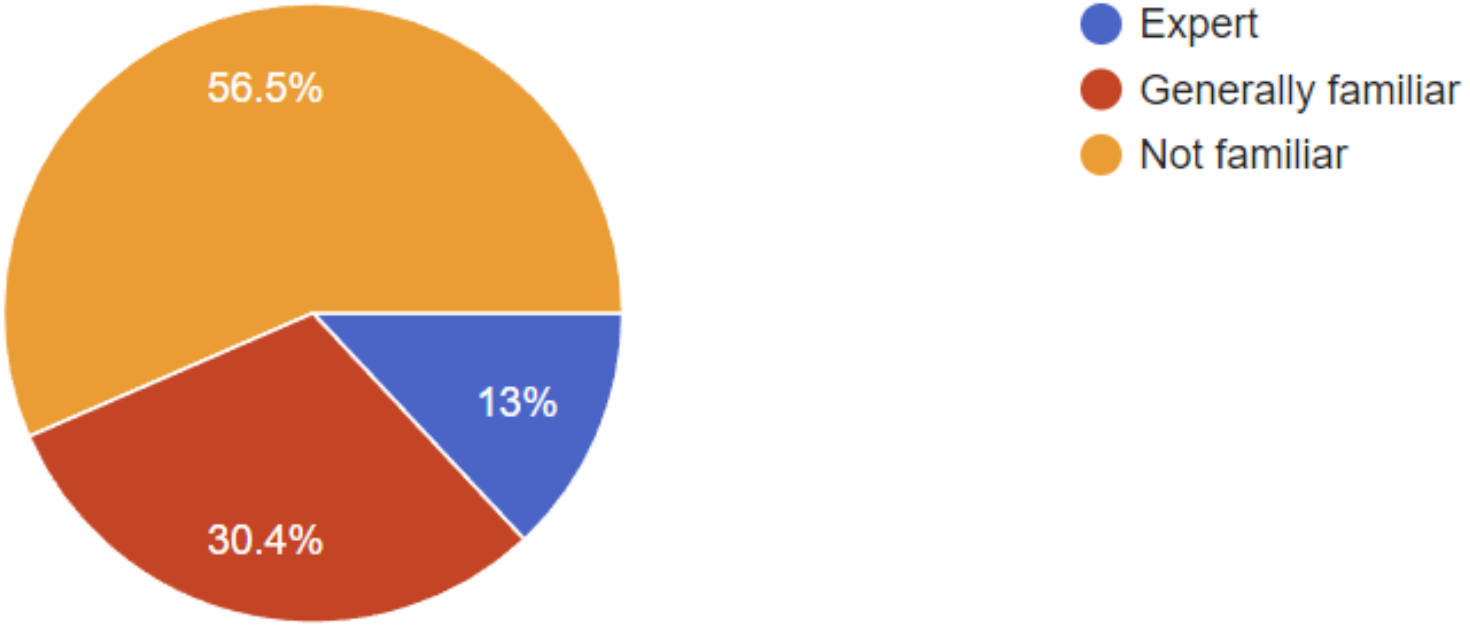
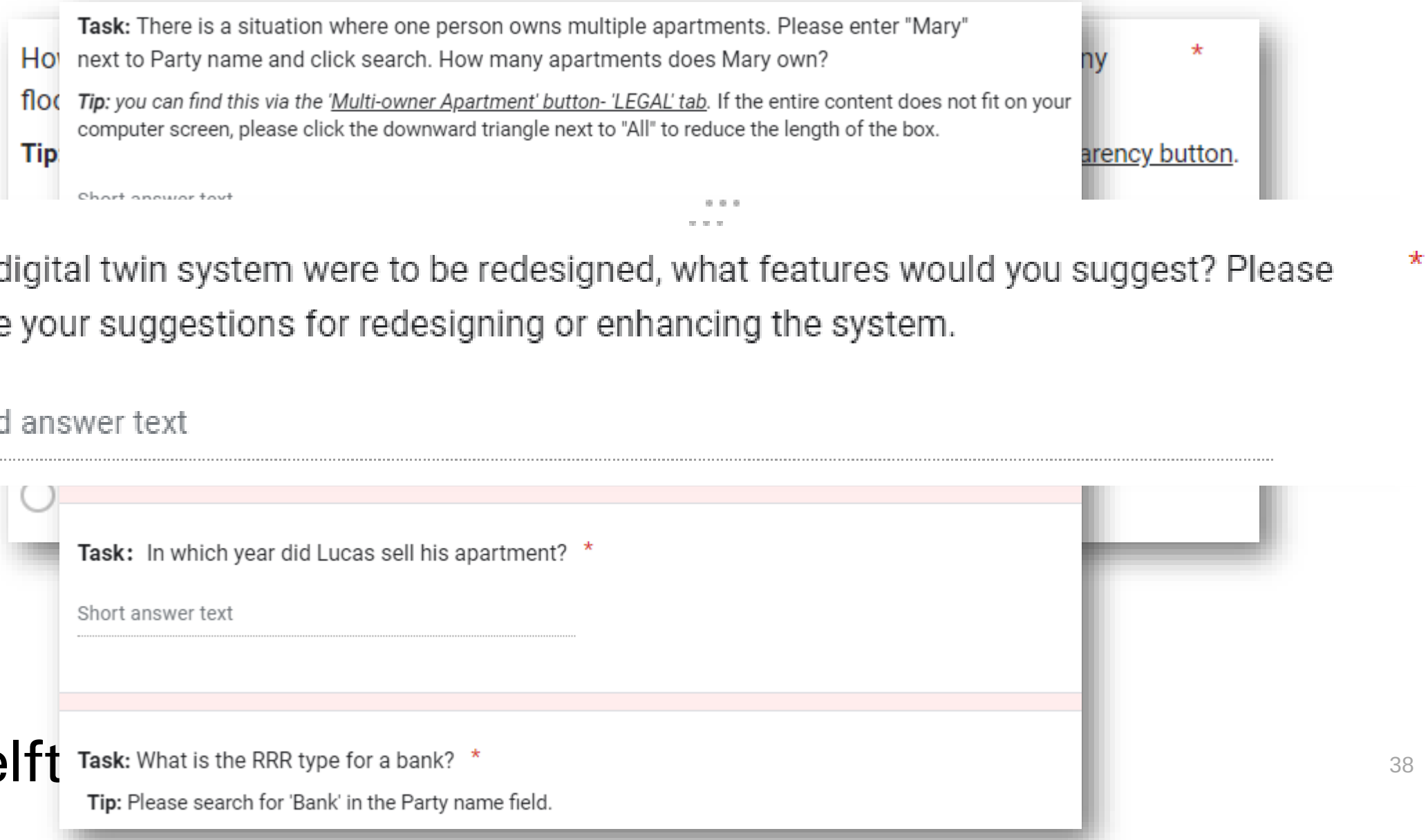
Usability testing

A total of 23 participants took part in the usability testing after invitation send to the FIG WG LADM and 3D LA members (June 2024)

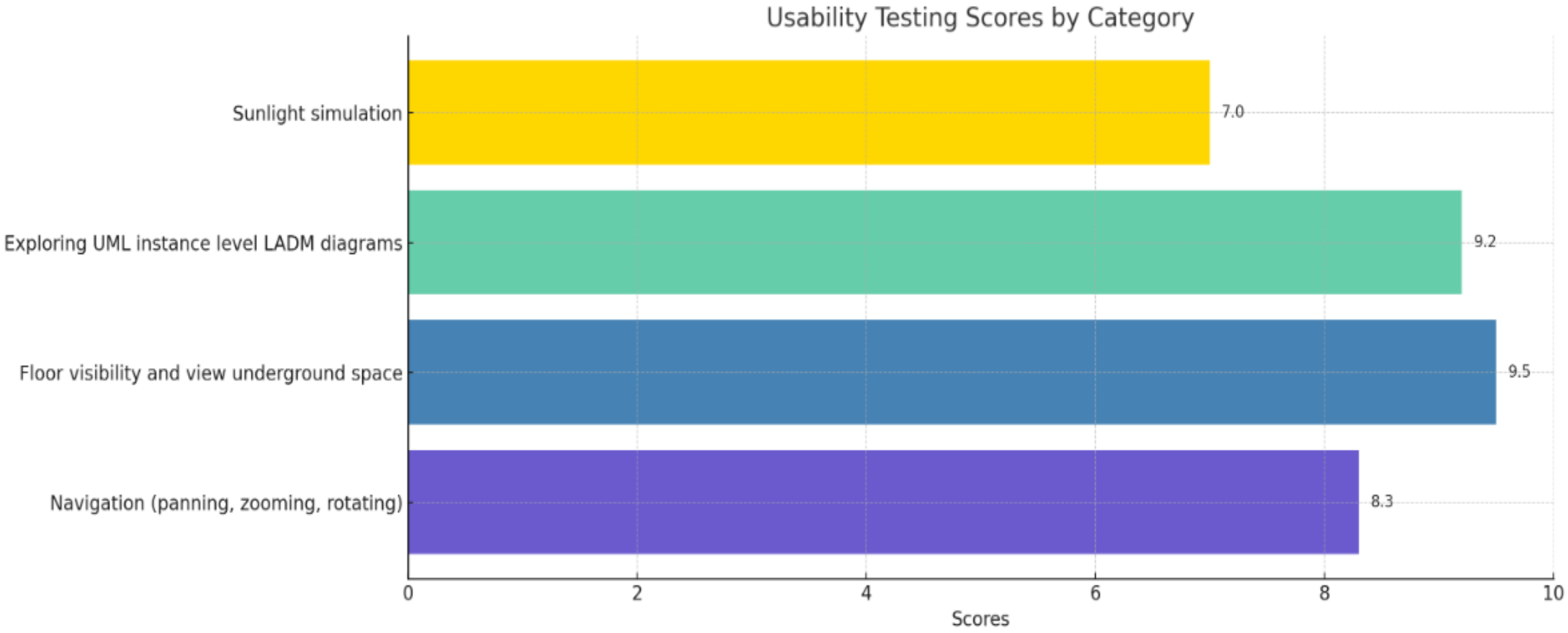
The results show varying levels of familiarity with the contents of LADM:



Instructions and Responses via Google Form



Usability Testing, Functionality Rated by Users



User Feedback and Suggestions

- Timeline:
  Prefer a time slider over a time selector for timeline

- Search Function:
  Enable the Enter key for search functionality in addition to the search icon;
  Add prompts about case sensitivity in searches; A general search bar

- Additional 3D objects with legal spaces:
  Incorporate more types of 3D RRRs, such as: Tunnels, Airspace, Mining rights

- First-person view:
  Add a first-person view to navigate inside buildings

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Conclusion

This study developed a multifunctional 3D Land Administration System

The most significant feature of this system is that it provides UML instance level LADM diagram in a clearer way, and can explore the building and the surroundings with adaptive LoD according to distance

The research utilizes BIM models in IFC format as spatial data input, the LADM data is store in a DBMS and employs Cesium create 3D geospatial application and web-based visualization, allowing for a broader user experience

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https://www.gdmc.nl/LADM3Dview/

Future Work

1. Address the challenges of complex real-world legal data, beyond the hypothetical data used in this study

2. Explore the inclusion of graphic data directly within the database

3. Explore more 3D legal spaces such as air rights, underground utilities, and mining concessions

4. Extend the system to include valuation and spatial plan

References

3D sales viewer url: https://bpd2.ogdb.nl/bpd/project/9531/landgoed-hoevesteijn

Alattas, A., Kalogianni, E., Alzahrani, T., Zlatanova, S., & van Oosterom, P. (2021). Mapping private, common, and exclusive common spaces in buildings from BIM/IFC to LADM. A case study from Saudi Arabia. Land Use Policy, 104, 105355.

Cemellini, B., van Oosterom, P., Thompson, R., & de Vries, M. (2020). Design, development and usability testing of an LADM compliant 3D Cadastral prototype system. Land use policy, 98, 104418.

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