Digital twins and Ontology for Robot Assisted Decommissioning Operations

DORADO

Common data environment to support nuclear decommissioning projects using BIM-enabled technologies

Overview of project DORADO

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Project overview

Digital twins and Ontology for Robot Assisted Decommissioning Operations

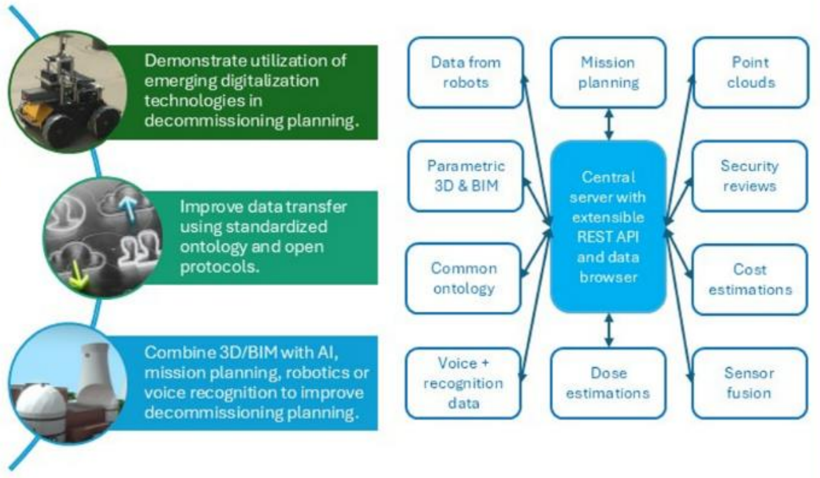
Key facts

36 months
12 partners
8 countries
5 work packages

Technologies

Robotics
Sensor fusion
Data management
Voice recognition
Ontology
BIM / 3D
Artificial intelligence
Dose estimation
Mission planning

Research goals



Work packages in brief

WP1
Prepare and manage project

WP2
Finetune research goals

WP3
Implement technologies

WP4
Demonstrate on real use cases

WP5
Train, exploit & standardize

Final expectations

1) Integrate emerging digital technologies into one coherent platform to support decommissioning planning.
2) Extend decommissioning ontology and data transfer protocols to cover new use cases.
3) Describe extensible API to provide standardized data exchange between tools used in decommissioning planning.

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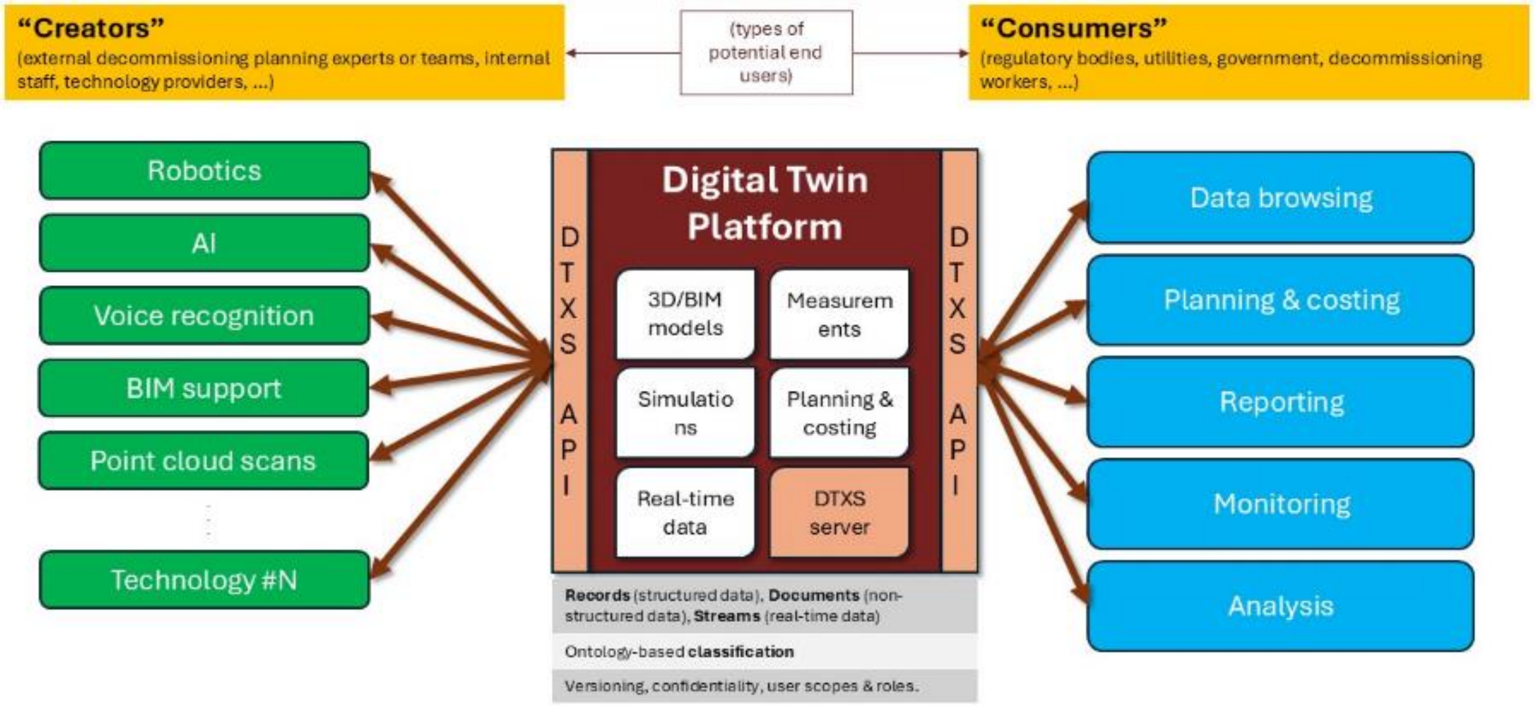
End-user's opinions (some highlights)

- Some of the responses highlighted **the need to adapt the technologies to the need of nuclear industry (e.g., standardize how nuclear related data are represented in BIM**);
- Digital twin updates shall be frequent, but a real-time update is not necessary unless an immediate notification is needed for a hazard spotted or an anomaly detected;
- This was reflected by the interest in using the digital twin features for scenario planning, and visualization of contamination spread and migration while still having a strong need for real-time updates of sensor readings;
- **Automatic pre-filling of reports and work permits** was one of the applications with high interest;
- **Inefficient data management was one of the main issues reported**, especially for big projects where excel sheets or similar data logging methods have issues with scalability.

Common data environment architecture



Main requirements:

1) Provide centralized data storage with the support of decommissioning ontology
2) Possibility to connect with any technology.
3) Open to any data formats and standards.
4) Provide a user interface to browse the stored data.
5) Compatible with BIM principles.
6) Deployable on the premises of the user.

Secured authenication and authorization of access is a key.
=> Achieved by well-known OAuth 2.0 protocol.

Technologies and file formats

The DORADO project combines numerous digitalization and 3D visualization technologies into one platform.

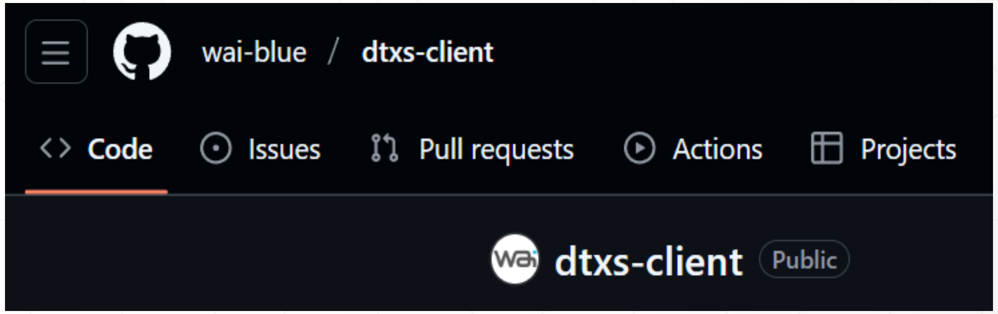
It also works with many different file formats to bring a comprehensive solution.

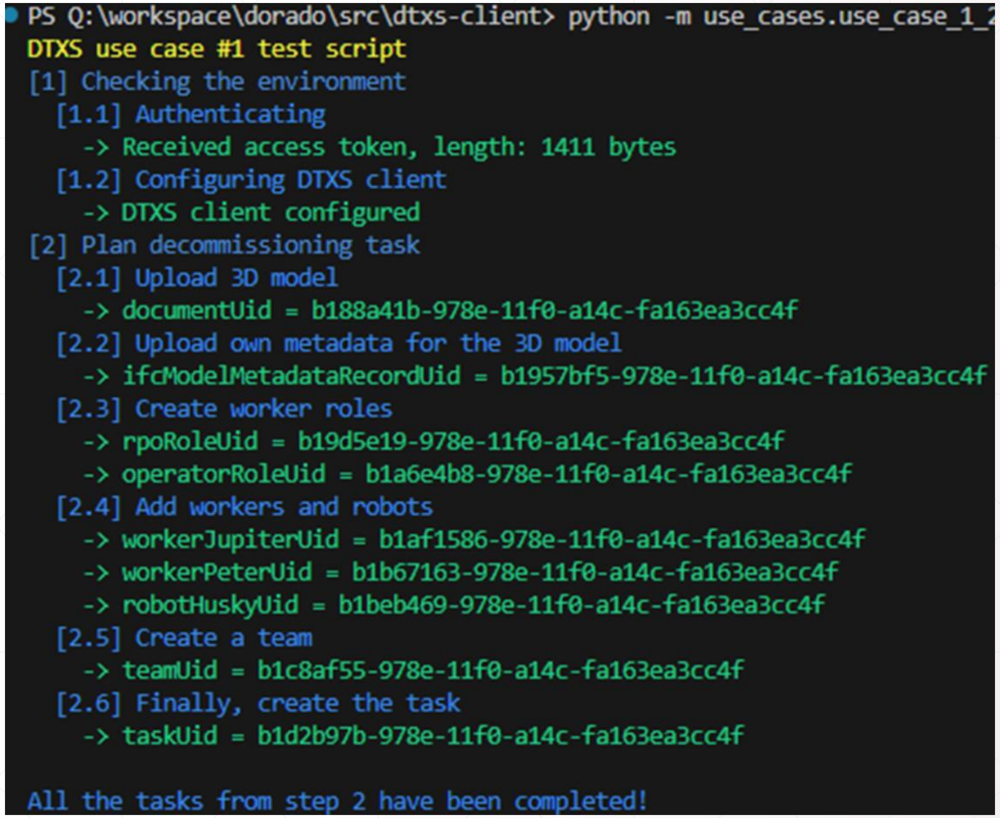
File formats

- .ifc - 3D models
- .e57 - point clouds
- .xyz - spatial doserate maps
- .czt, .spe - spectrometry data
- .json - custom metadata
- .rviz - robotic visualization config

Integration via REST API

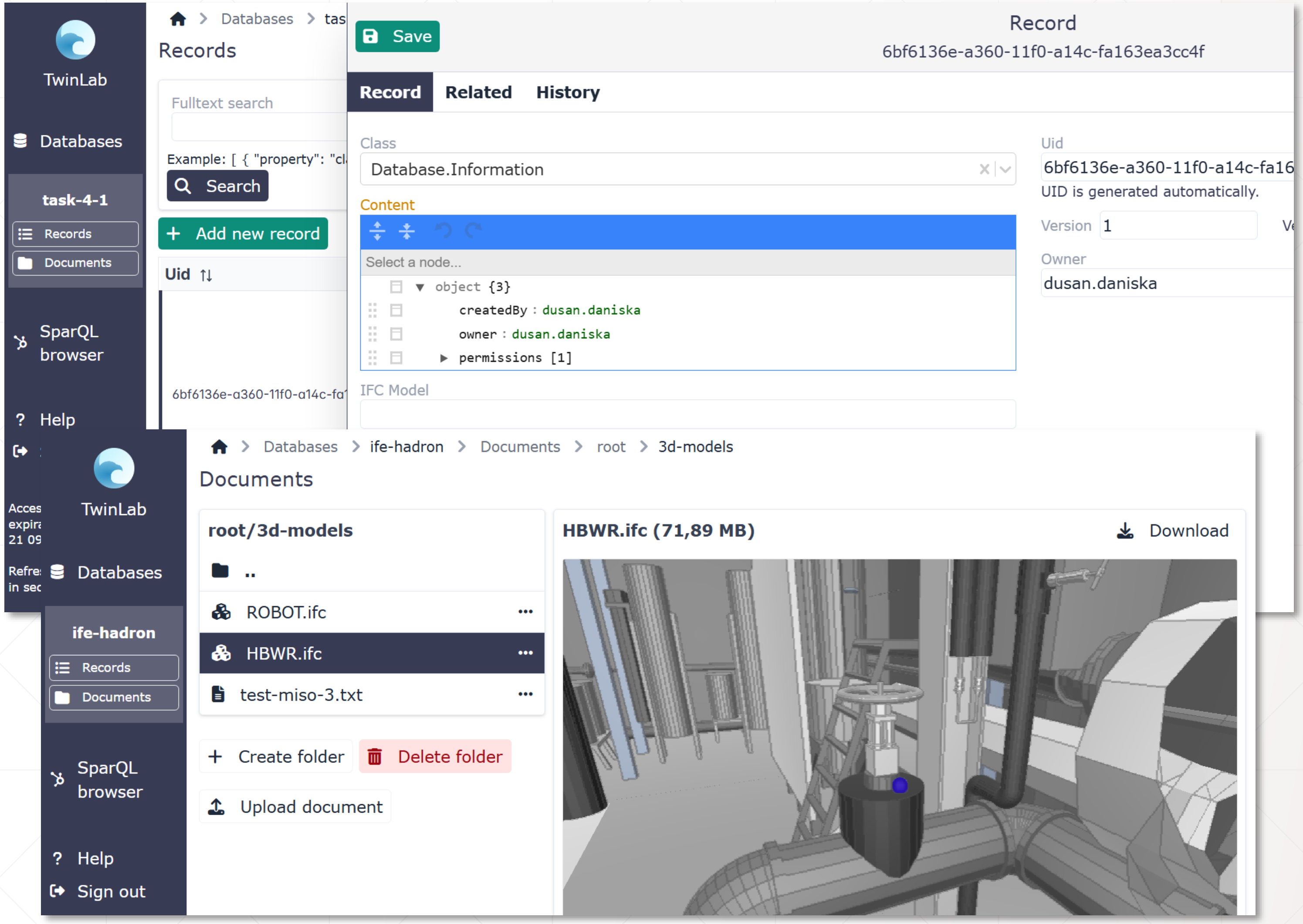
- IFC file format for 3D models chosen (is open and supported by large community)
- Server part of the common data environment contains extra functionality to work with IFC files
- Storage for 3D model metadata of any structure implemented.
- **RESTfull API** available to upload/download data.
  - Opensource Python client available on Github.
- Various types of information can be stored:
  - **Documents** – representing non-structured data like, e.g. Word or PDF documents.
  - **Records** – representing structured data like, e.g. radiological measurements.





Data visualisation (web-based)

- Specialized tool developed to visualize data
- Files & folders
- Records
- Integrated 3D visualisation
- Secured with Keycloak OAuth IAM



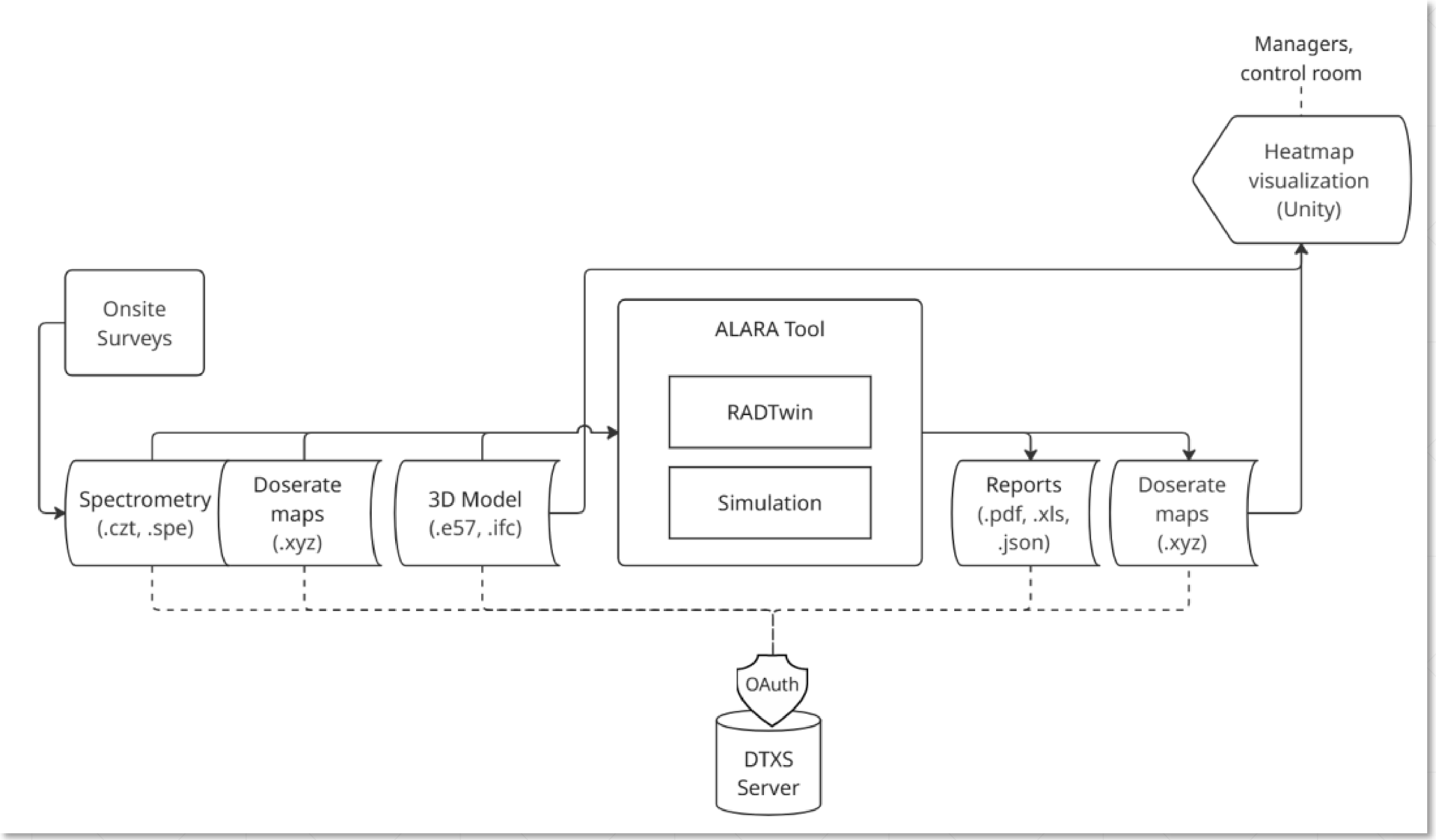
Work to be done:

- Add multi-layer feature to 3D visualisation - show static 3D model layered with metadata (measurements, risks, robots, …).
- Implement real-time visualisation engine.

Expected activities in demonstration use cases

- 4 demonstration cases expected based on following activities / workflows:
  - LIDAR+RGBD scan of the room and conversion to IFC
  - (Semi-)Automated detection of change in point clouds
  - Planning of tasks and missions to collect data from selected facilities
  - Collection of different kind of information from the field, e.g.:
    - Autonomous robot-operated radiological measurements in selected facility
    - In-field inspection using hands-free voice recognition technologies
  - Post-processing collected data into spatial radiological information
  - Modelling radiological environment using collected radiological measurements
  - Visualizing achieved information using different techniques (web-based 3D, augmented reality, virtual reality, …)
  - Planning of tasks for risk and safety assessment

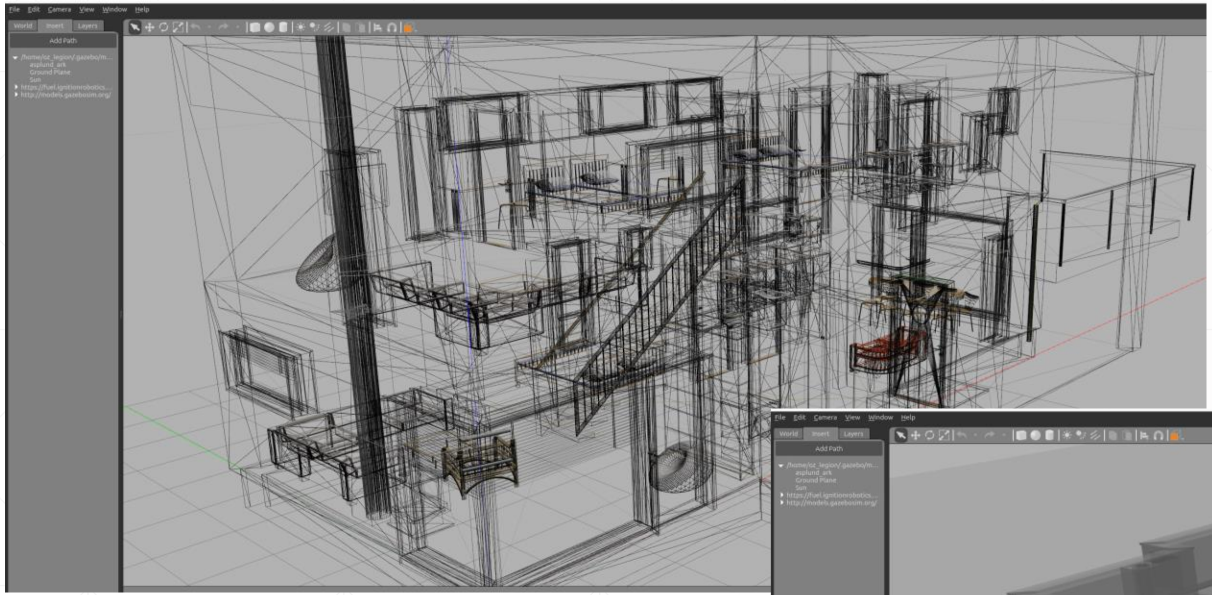
Workflow and dataflow (example)

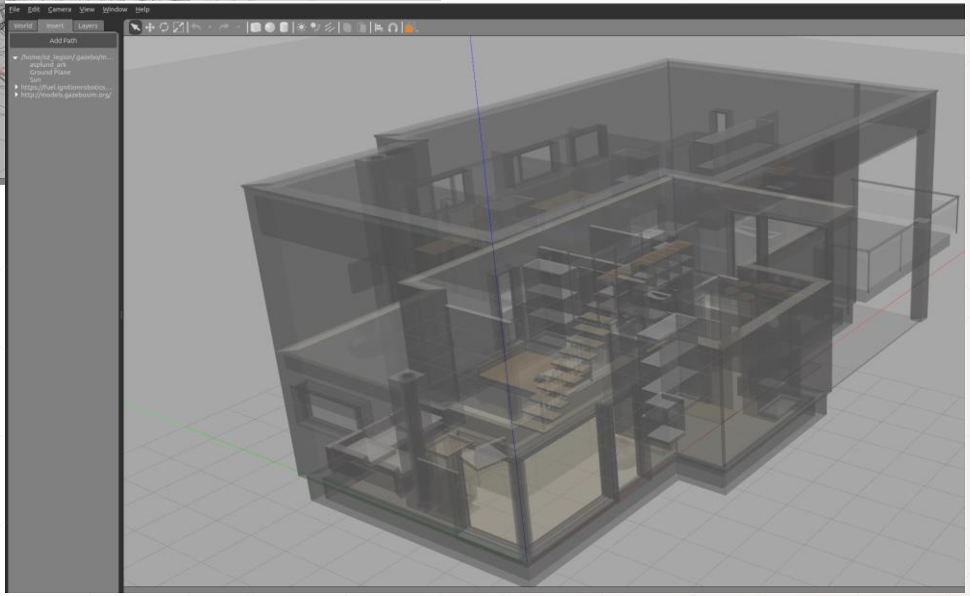


More examples in Deliverable D3.1 System Design and Data Plan https://www.dorado-project.eu/results-and-publications

From BIM to Robotics Physics simulator (Gazebo)

- Gazebo is an open-source robotics simulator for 2D and 3D environments, supporting realistic physics and sensors.
- Gazebo world formats primarily use XML-based SDF (Simulation Description Format); it also supports OBJ models for objects.
- BIM/IFC models are not directly supported in Gazebo; converting BIM/IFC to mesh formats like OBJ or COLLADA is recommended for import.





Conclusions

- DORADO continues the previous PLEAIDES project by integrating more technologies to the server and extending the ontology for new applications.
- Eight new technologies are handled. Emphasis on utilizing BIM and AI.
- Holistic approach and data compatibility is the key!
  - Don’t re-invent the wheel and leave room for future applications
  - The development work can benefit from experiences in other fields of industry (and vice versa)
- After the first year we have completed the techinical requirements and business value analysis
- Technical development work is on-going in 2025-2027.
- Looking forward for end-users’ comments for demonstration of use cases.
- Interested? Join our events and newsletter for more info.

Thank you for your attention.

Questions?

- Follow us at LinkedIn (join our community of 200+ followers:
  - https://www.linkedin.com/company/dorado-project
- Register for the newsletter and join the End-Users Group:
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