Digital twins and Ontology for Robot Assisted Decommissioning Operations
DORADO

Euratom project DORADO

Digidecom2024 conference

Antti Räty & DORADO consortium.
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Contents

Background: Previous research in PLEIADES project

- PLatform based on Emerging and Interoperable Applications for enhanced Decommissioning processes (PLEIADES) was organized in 2020-2023.
- The aim was to build a Building Information Model (BIM) as a platform for software integration and interoperability.
- Applications included, e.g., 3D scans, VRDose, AquilaCosting and facility data database.
- Demonstrations with real facilities

Continuation from the PLEIADES project

- In PLEAIDES, a platform has been developed, but software integration just started. Recommended next steps:
  - Extend the coverage of the supported ontology and supported decommissioning planning activities
  - Integrate more technologies, such as AI, robotics and sensor networks.
  - Promote the concept for wider use.

Digital twins and Ontology for Robot Assisted Decommissioning Operations

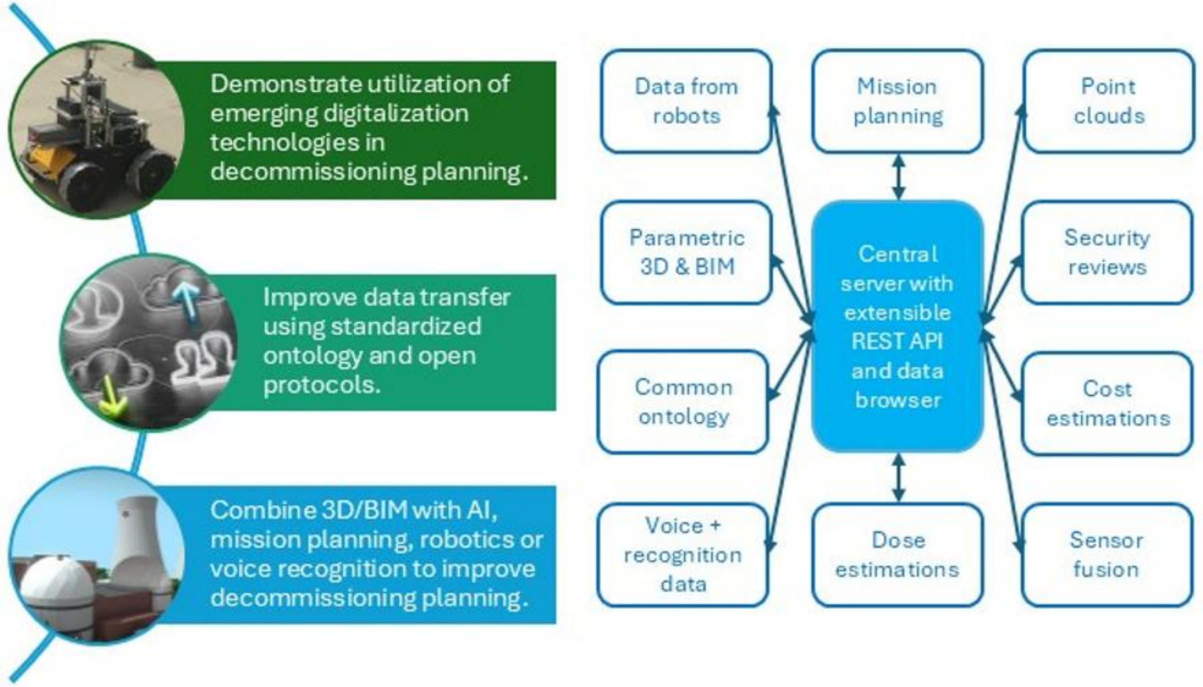
Key facts

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

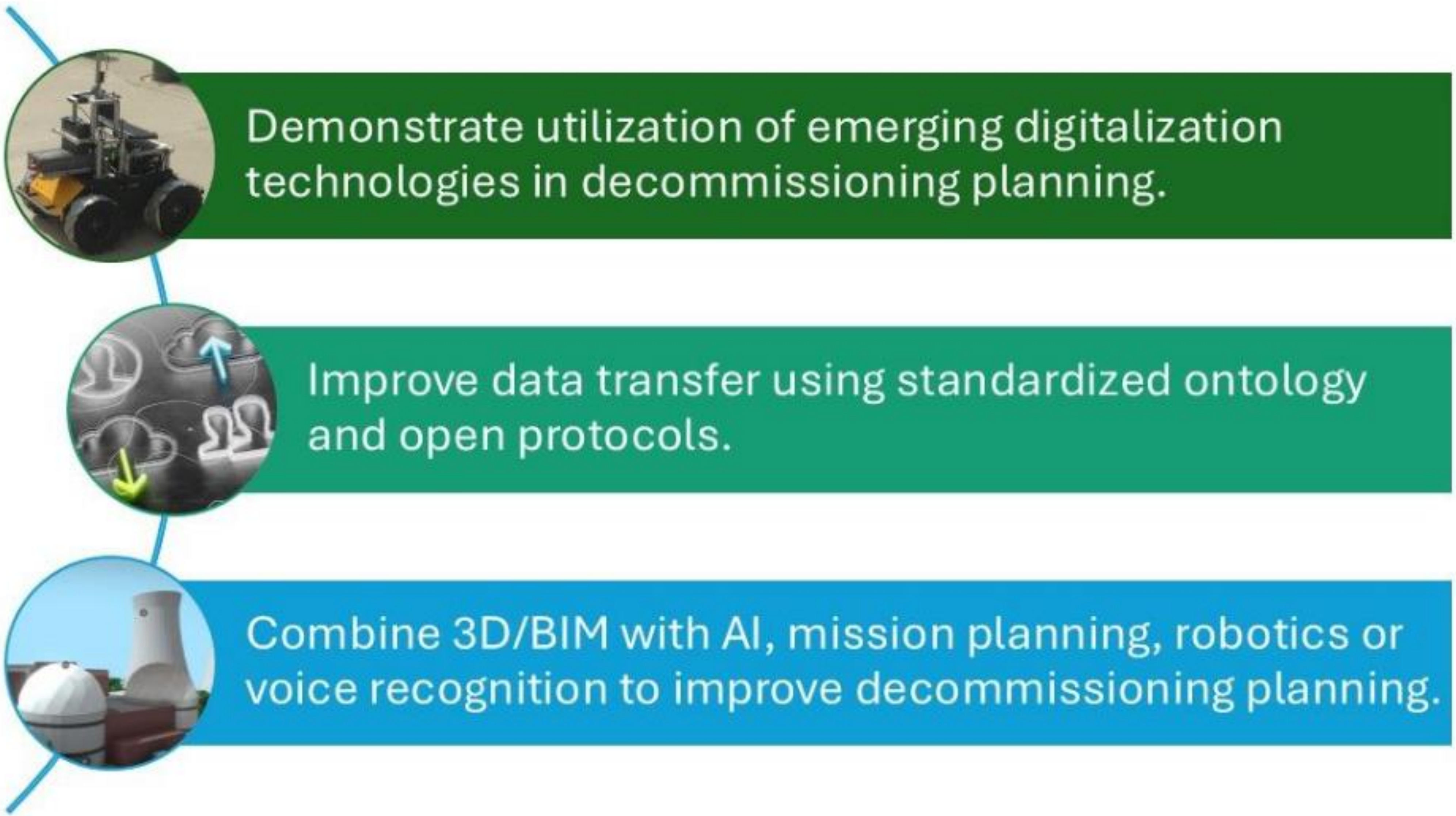
WP4
Demonstrate on real use cases

WP5
Train, exploit & standardize

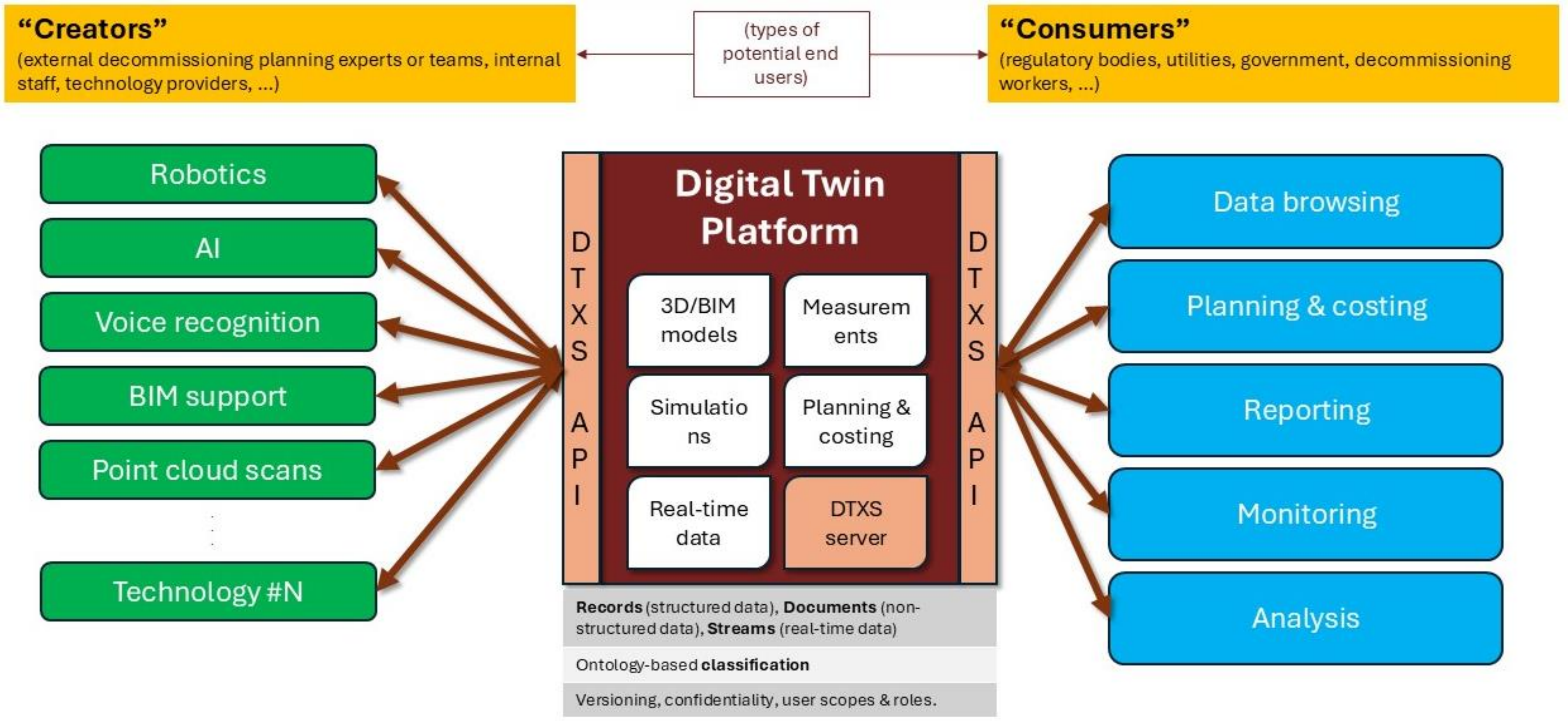
Final expectations

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.

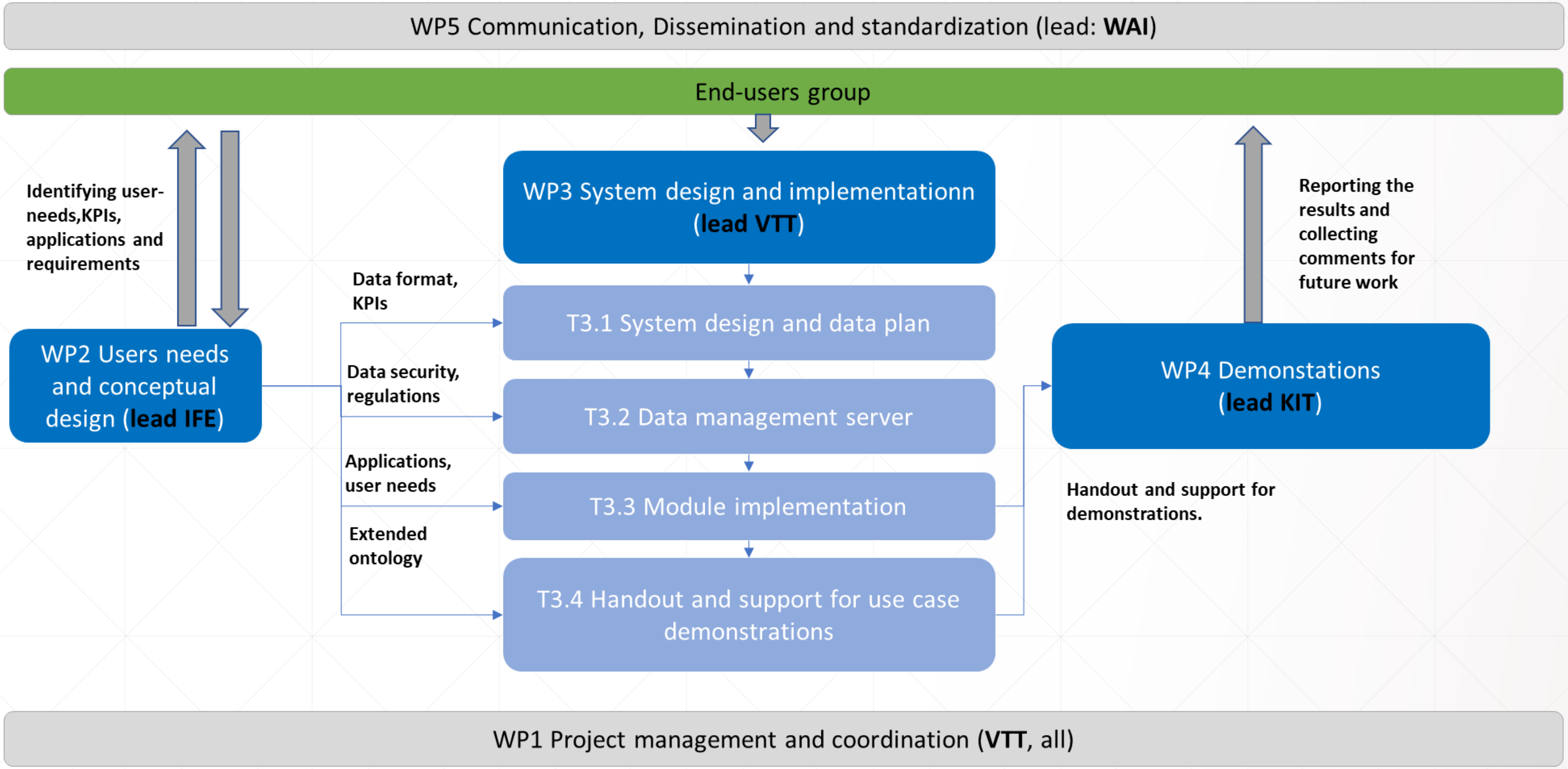
Objectives and overall aims



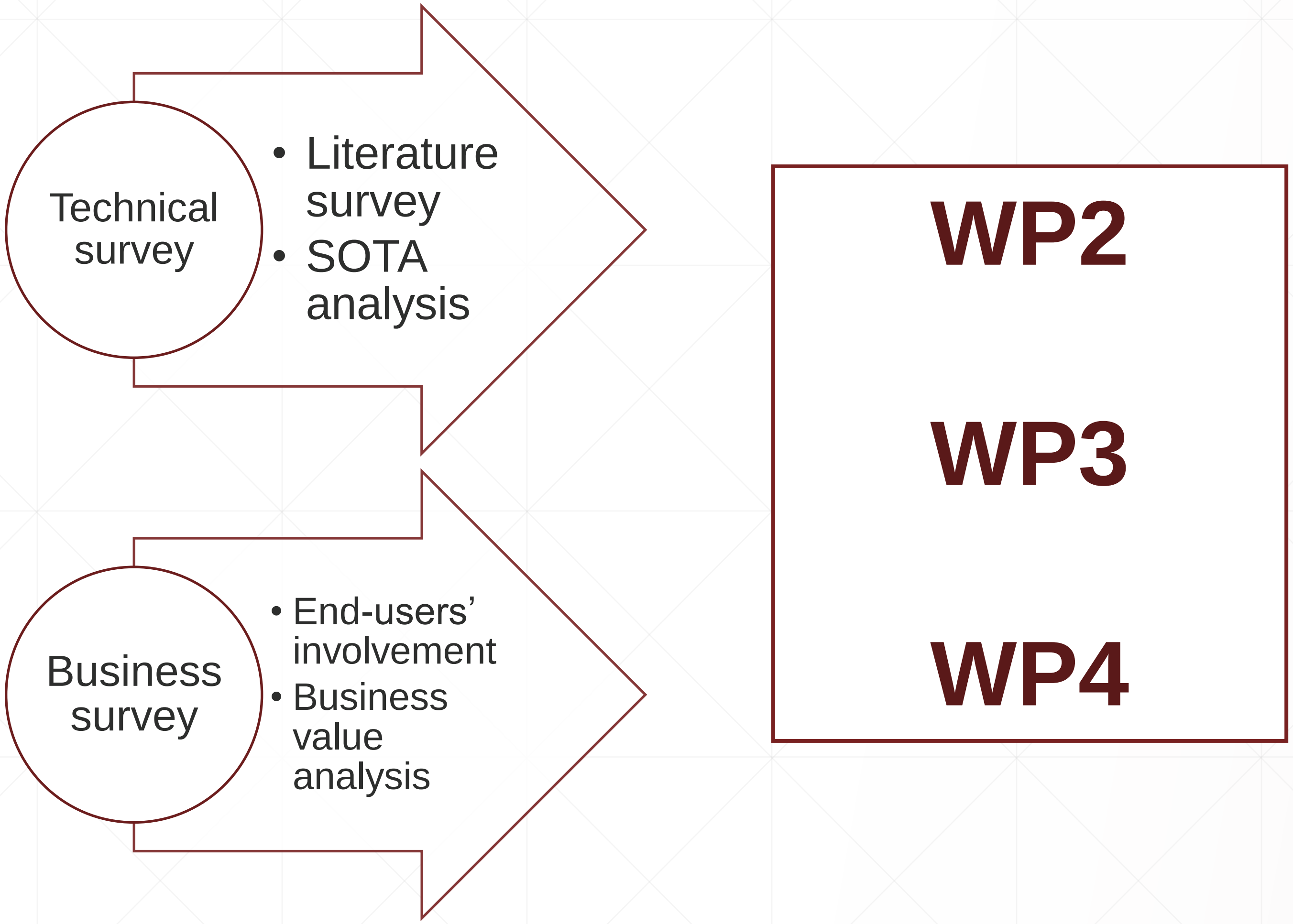
Digital platform



Project flow

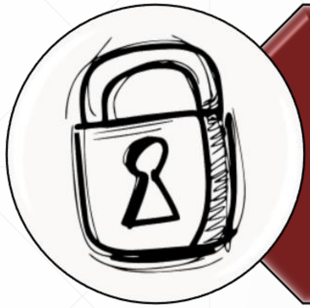


WP2 “fine tune the research goals”



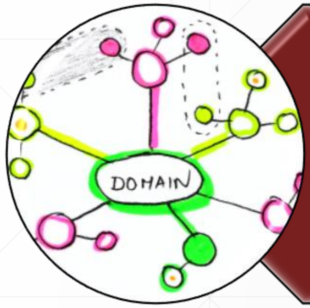
WP2 objectives

- **Establishing Design Requirements:** Determine the requirements for the DORADO platform's design to align with project expectations.
- **Developing Prototype Specifications:** Create specifications for the system prototype and testing/demonstrations in accordance with established requirements.
- **Defining Key Performance Indicators (KPIs):** Identify/Update KPIs to assess the DORADO platform's impact relative to user needs.
- **Understanding the impact mechanisms** of the *platform changes* and *KPIs* into **business value (KBIs)**. How the changes are linked to different business processes and how to evaluate the impact.



Data governance

- Safety and security
- Data management framework



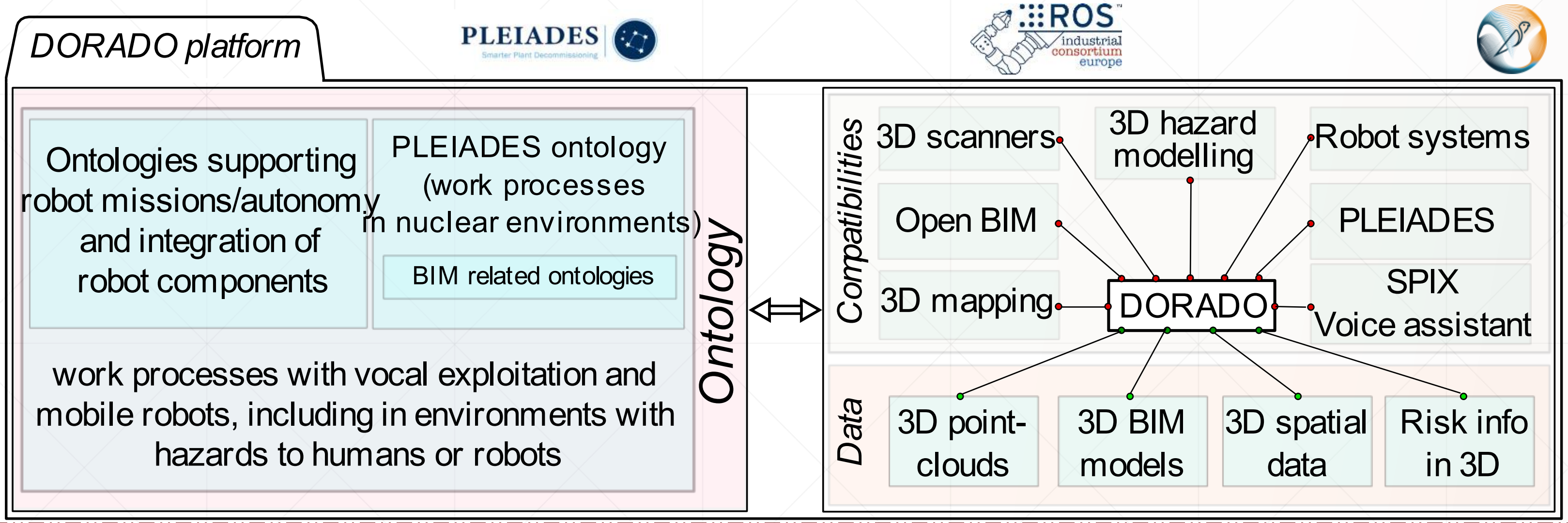
DORADO Ontology

- Ontology for the decommissioning
- Accommodate target technologies

WP3: Technological development

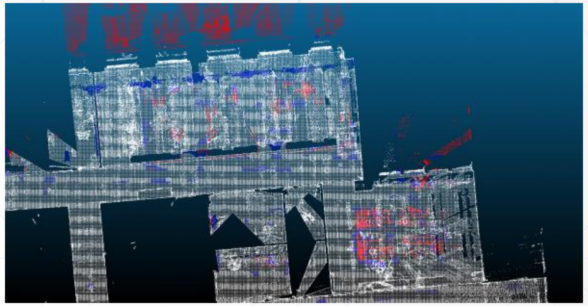
1. Sensor data fusion with temporal dimension
2. Environment data comparison against BIM
3. Point-cloud and 3D model change detection
4. Digital twins based ALARA dose estimation

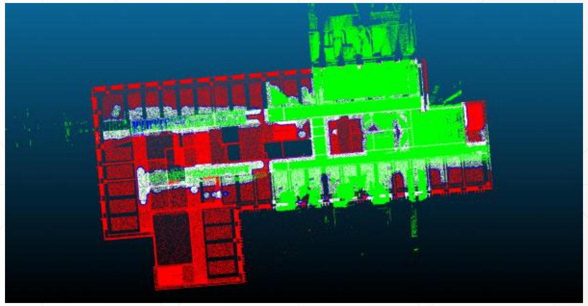
5. Server-based integration with IFC file format and extended data queries
6. Mission control, robot route optimization
7. Human to System smart voice assistant interface
8. Standardization using the common ontology

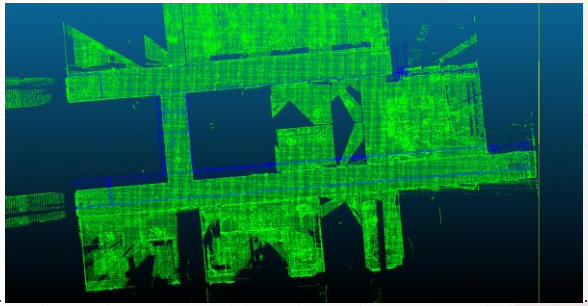


Sensor data fusion

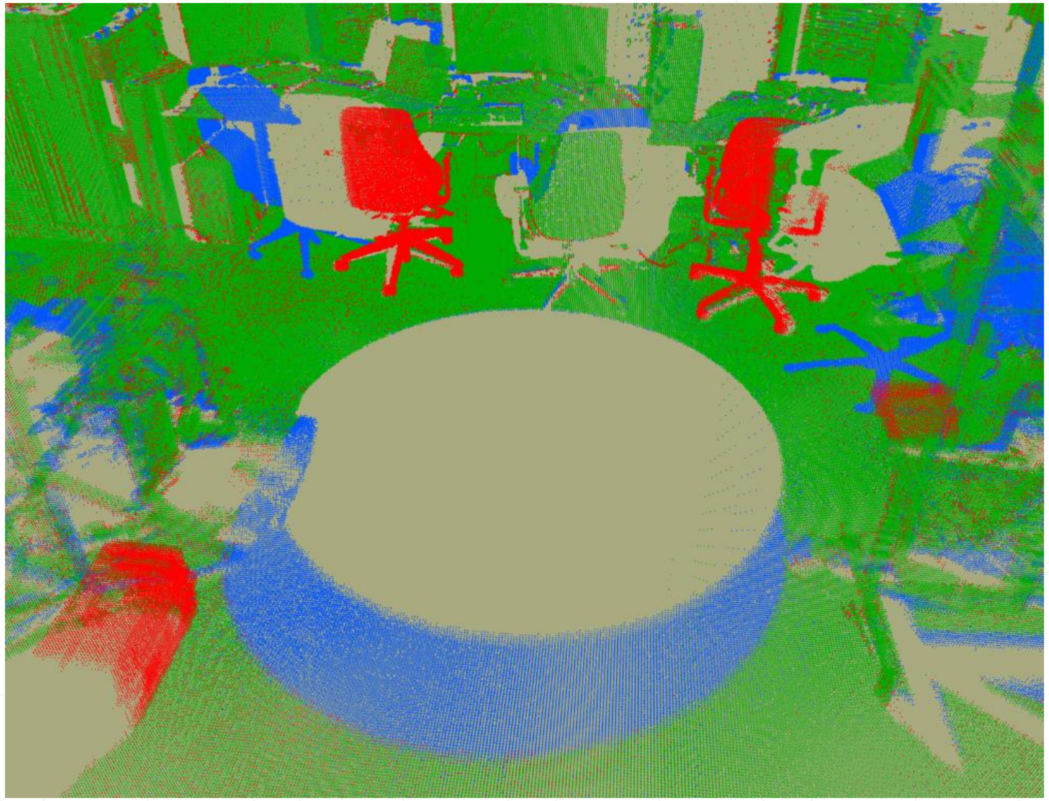
- State-of-the-art technology: Sensors (LiDAR, thermal cameras, gamma the cameras, dose rate meters, imaging radars, and hyperspectral cameras,…) provide information at a single point of time, or in a sequence of time steps but disconnected from other modalities. These sensors also mostly operate separately without a common frame of reference in temporal and spatial dimensions.
- Enable automatic sensor data fusion from a large set of sensor modalities that provide disjointed types of information.
- Enable building a more holistic view of the environment, by combining the output of different sensors into a unified frame of reference.
- Enables associating the data samples with a point in the temporal dimension, thus enabling analysis of changes over time.







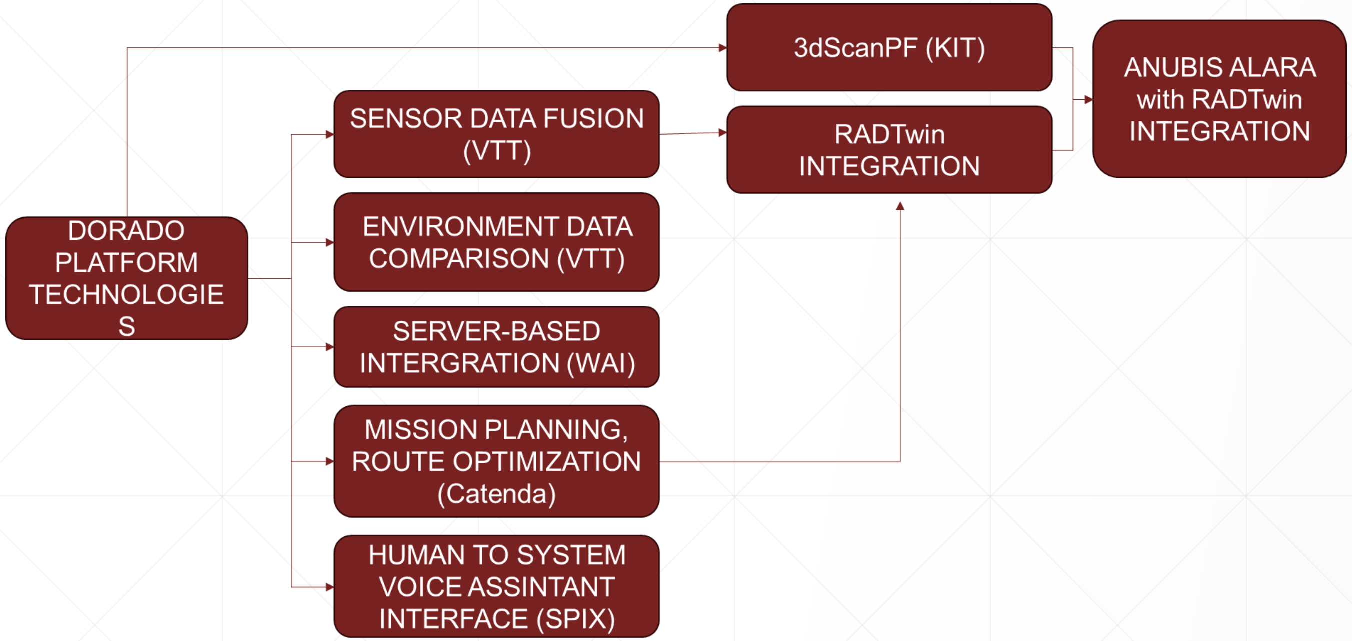
Pointcloud and 3D model change detection



- Volumetric change detection using occupancy map
- True volumetric changes (red) in the environment can be distinquished from false changes caused by the object "shadows" or by the change in the scanning location (blue)
- When the true changes have been recognized, it is easier to associate them with the BIM model components and understand the changes semantically

Digital twins based ALARA dose estimation

- RADTwin dose assessment tool that will dynamically adapt to changes in radioactive source terms during decommissioning
- Streamlines radiation protection by adjusting plans based on ongoing structural changes, minimizing the radiation characterization effort and exposure risk while supporting efficient dose management.
- SCK-CEN as the task lead.



Robot route optimization

- Ontology enables modelling the system with spatial relationships and interdependencies within the environment.
- Conduct context-aware mission planning and control
- Enable adaptively assign tasks and respond to changes in the decommissioning environment.
- Integrates real-time safety monitoring and risk assessment, leveraging sensory data, semantic mapping, and artificial intelligence to discern and mitigate potential hazards related to operating robots.

Human to System smart voice assistant interface

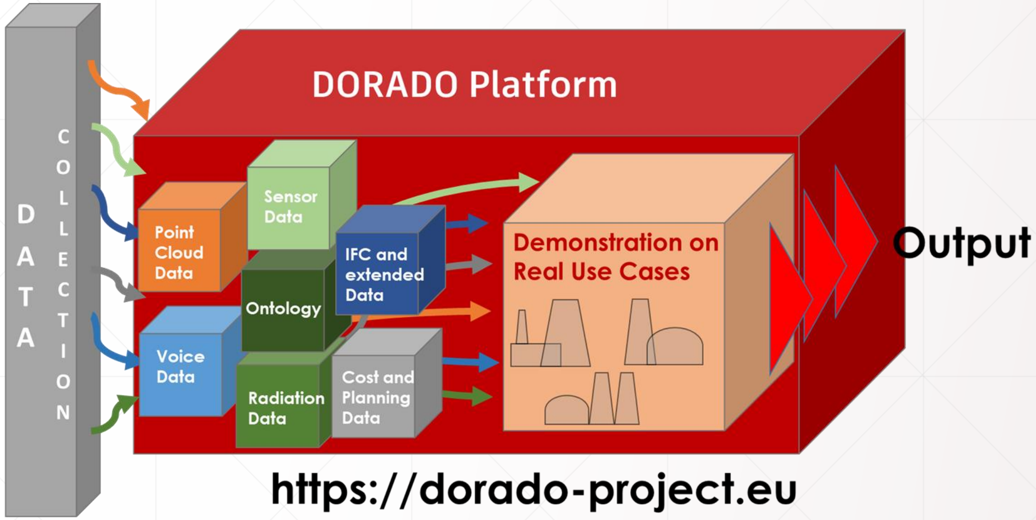
- Smart Voice Assistant can be used to capture the observations of field operators.
- Enables field workers to keep their PPEs on, keep their digital equipment safe (smartphone or tablet protected), and continue to use the digital content during their interventions.
- Enable the ability of front-line workers to access digital content by voice based on an agreed ontology integrated in the BIM model.
- Demonstrate the ability of the front-line worker to report hazardous or unsecure situations or report discrepancies between the BIM (digital description of a site) and its actual situation (ground truth).
- Task lead SPIX industry.

WP4 Demonstrations on real use cases

- **Main objective**: to demonstrate that the implementation of DORADO is possible in real use cases

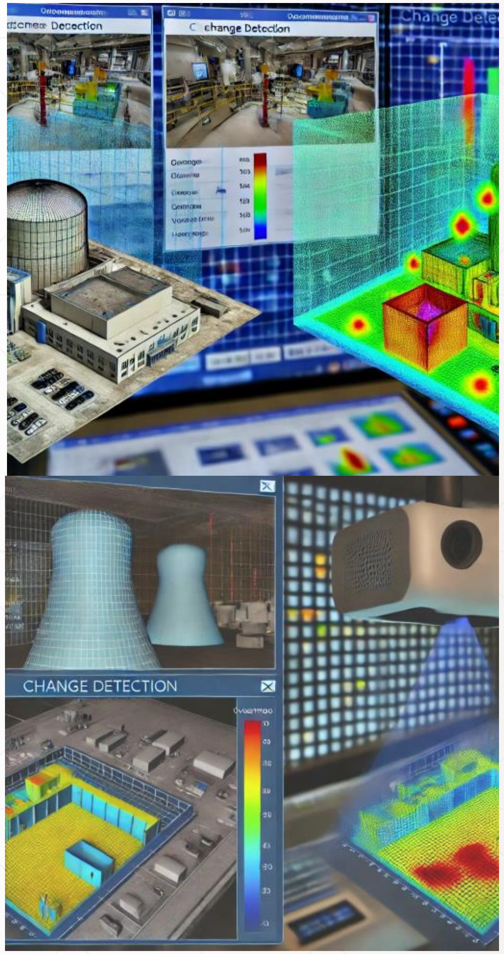
  - Data from different facilities will be used;
  - The different demonstrations are defined separately and independently;
  - However, they can partially benefit from the data from other demonstration cases.

1) Creation of a parametric 3D model
2) Detecting the changes in the 3D models over time
3) Detecting the changes in the 3D models over time (+ comparison of plans vs. reality)
4) Decommissioning safety and risk/hazards assessment



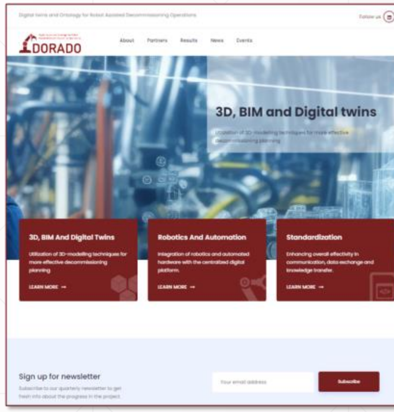
WP4 Demonstrations on real use cases (cont.)

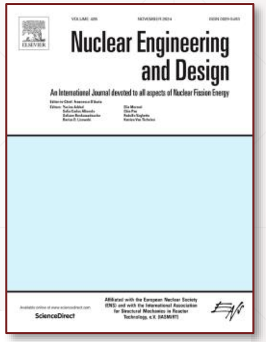
- Datasets from different facilities corresponding to real cases will be used (data is being defined, and anonymized if needed)
- Expected Technologies / Functionalities used:
  - Change detection, by identifying geometric and environmental deviations using data from on-site sensors;
  - Automation monitoring, by tracking the history of changes to analyze where full automation between the real and virtual environments has been achieved;
  - Voicie assistant integration to identify changes and log them in the system;
  - Digital twin technology to build a dynamic model of a room or facility, reflecting real-time changes.
- Results will be:
  - Checked through Milestone MS5 (Mid-term check from demonstrations) on M21 and Milestone MS6 (All demonstrations finished) on M30;
  - Validated through a deliverable for each Task on M30



WP5: Communication, dissemination and standardization

- Communication
  - Participation on workshops and conferences. (DigiDecom (NO), WM Arizona (US), DEM (FR), ICOND (DE), DECOM (UK),…)
  - Cooperation with other related R&D projects (XS-ABILITY, HARPERS, IAEA NET4D, …)
  - Organization of webinars and online workshops for the end-users group.
- Exploitation
  - Engage potential end-users in the development processs
  - Transfer know-how through various guides, technical specifications or similar documents.
  - Make results public to enable further development
- Standardization
  - Producing publicly available results and interaction with IAEA or NEA networks. (at least new updated ontology and new updated API).
  - Suggest creation of working group to further develop achieved results.





End-users group interaction

End-users are invited to participate in webinars presenting the technologies of DORADO project

- Technological experts and DORADO tools users
- Business management (how tools connect to business value chain and enable new services)

What will be the value for end-users to participate in webinars?

The end-user's value in participating in the webinars is built on the opportunity for the end-user to increase their understanding of each technology, strengthen their own understanding of the benefits of using each technology and hence, gain a better understanding of how the technologies can be utilized in their own business. In the webinar, the end-user will get answers to the following questions:

- **What is the technology and how is it used?**
- **What are the benefits of using the technology? Examples presented.**
- **How can the technology be applied? Examples presented.**
- **How does the technology support nuclear decomissioning and dismantling projects?**

https://www.dorado-project.eu/join-us

Summary

- 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!
- Developed technologies will be demonstarted with data from real environments.
- The development work can benefit from experiences in other fields of industry (and vice versa)
- We welcome new members to the end users group!

Université de Strasbourg

Thank you for your attention!

Questionnaire for stakeholders

Funded by the European Union