Digital technologies in DORADO project

Robot planning, voice recognition & server-based integration

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December 17th, 2024
DORADO Webinar

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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 plannling

Research goals

Demonstrate utilization of emerging digitalization technologies in decommissioning planning.

Improve data transfer using standardized ontology and open protocols.

Combine 3D/BIM with AI, mission planning, robotics or voice recognition to improve decommissioning planning.

Data from robots

Mission planning

Point clouds

Parametric 3D & BIM

Central server with extensible REST API and data browser

Security reviews

Common ontology

Cost estimations

Voice + recognition data

Dose estimations

Sensor fusion

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.

The objective of DORADO

The problem to solve
- BIM and Digital Twins are used at all steps of large projects.
- Such data needs to be up-to-date and accessible by many actors.
- Common language and protocols are needed to insure the coherence of the data.

Sample technologies / situations
- Data for *robot planning*
- *Field operators*' data generation

The proposal from DORADO
- A platform to share/consume data accross a wide variety of actors
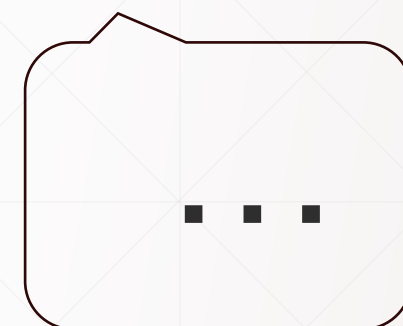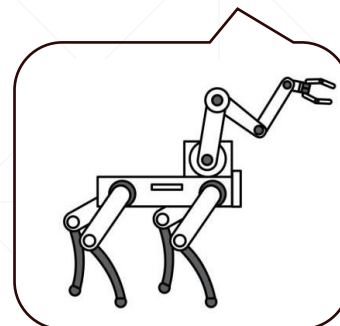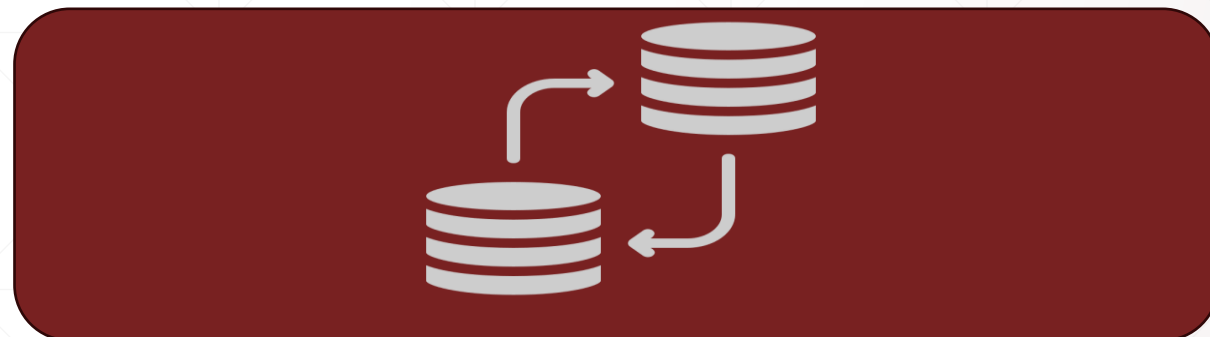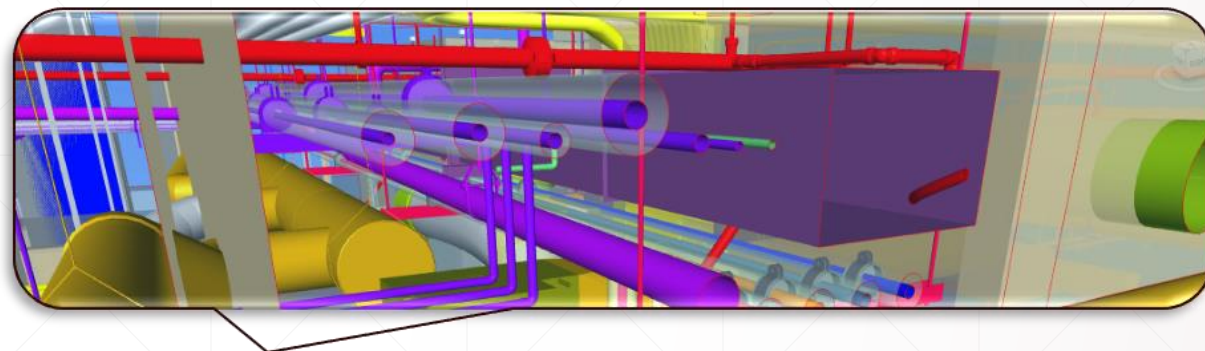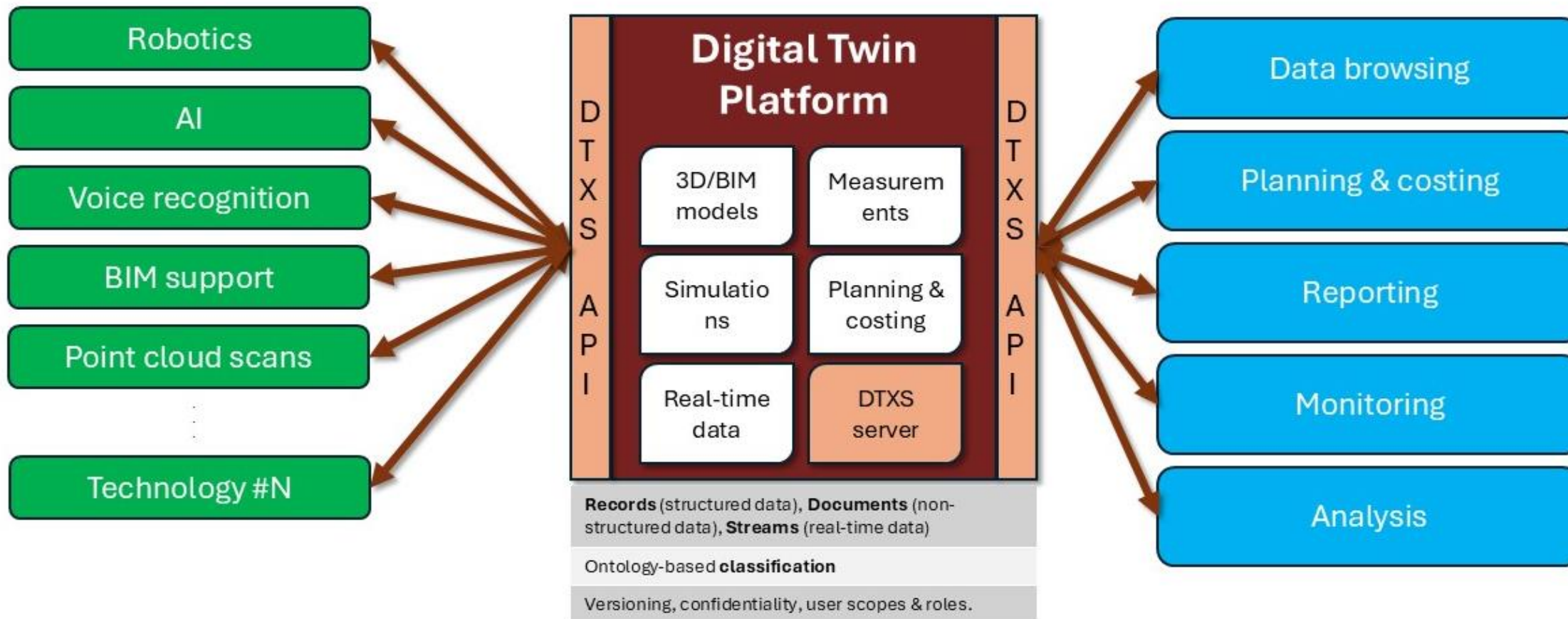
Digital platform

Agenda and purpose of the webinar

- Strengthen the understanding of each technology and utilization in nuclear decommissioning.

- Provide feedback and ideas for the technology developers.

- Next webinar in Feb 2025. Follow our LinkedIN and newsletters!

Introduction	
Introduction	5 min
End-user's perspective	5 min
Technology developers' pitches	
Mission planning and robot route optimization, by IFE	10 min
Human to System smart voice assistant interface, by SPIX	10 min
Server-based integration, by WAI	10 min
Discussion	
Questions and discussion	20 min

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Assisted Decommissioning Operations

Sogin at Glance

Sogin is the Italian State-owned company responsible for the **decommissioning of Italian nuclear plants** and for the **management of radioactive waste**
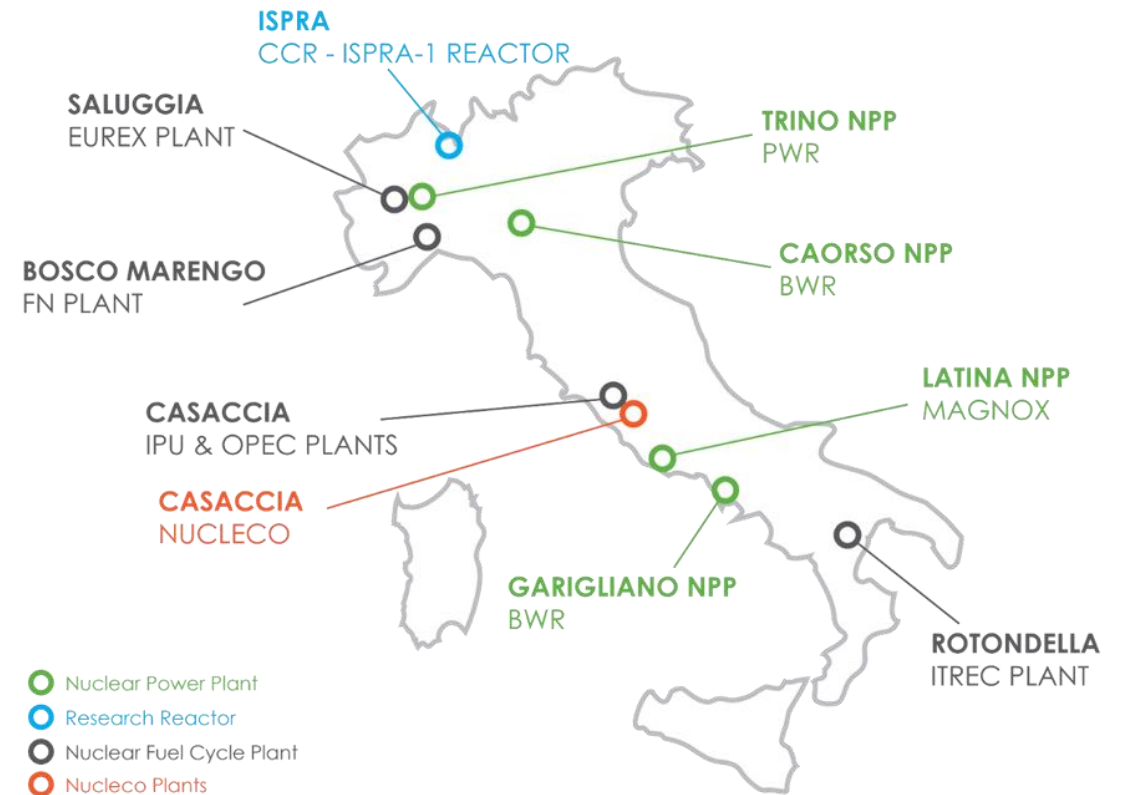
Italian **nuclear facilities in decommissioning** include:
- **4** NPPs with 3 different kinds of reactors (2 BWRs, 1 PWR and 1 GGR)
- **1** research reactor
- **5** nuclear fuel cycle plants

The company is also committed in the recovery and valorization of existing sites and infrastructures

Sogin is involved in the siting, designing, building and operating of the National Repository and the Technology Park for radioactive waste

The Company, born in 1999, became a Group in 2004 through the acquisition of the majority stake (60%) of **Nucleco**

ISPRA
CCR - ISPRA-1 REACTOR

SALUGGIA
EUREX PLANT

TRINO NPP
PWR

BOSCO MARENGO
FN PLANT

CAORSO NPP
BWR

CASACCIA
IPU & OPEC PLANTS

LATINA NPP
MAGNOX

CASACCIA
NUCLECO

GARIGLIANO NPP
BWR

ROTONDELLA
ITREC PLANT

- Nuclear Power Plant
- Research Reactor
- Nuclear Fuel Cycle Plant
- Nucleco Plants

Decommissioning and digital technologies

Nuclear decommissioning involves **complex and multi-disciplinary processes** in the final phase of the nuclear facilities lifecycle

It typically **lasts for decades** and must be implemented **safely**, in a **cost-effective** and **environmentally sensitive** manner and considering the **future uses** of the site.

Digital and innovative technologies can play a relevant role in **supporting** and **advancing** nuclear decommissioning **planning** and **implementation**, providing a **better** and **more quantifiable** understanding of what is involved and **optimizing** the integrated flow of information and data management

Sogin digital solutions for decommissioning and RWM

❑ Italian nuclear facilities were built before the digital age: available **data and records are old**, sometimes **incomplete**, and they don't accurately reflect the **reality of the facility as it is today**

❑ **Understanding the scope** of the work is of primary importance to make nuclear decommissioning safe and successful: D&D strategies depend on characteristics of the SSCs, level of contamination, type of processing required, and how much it's likely to cost
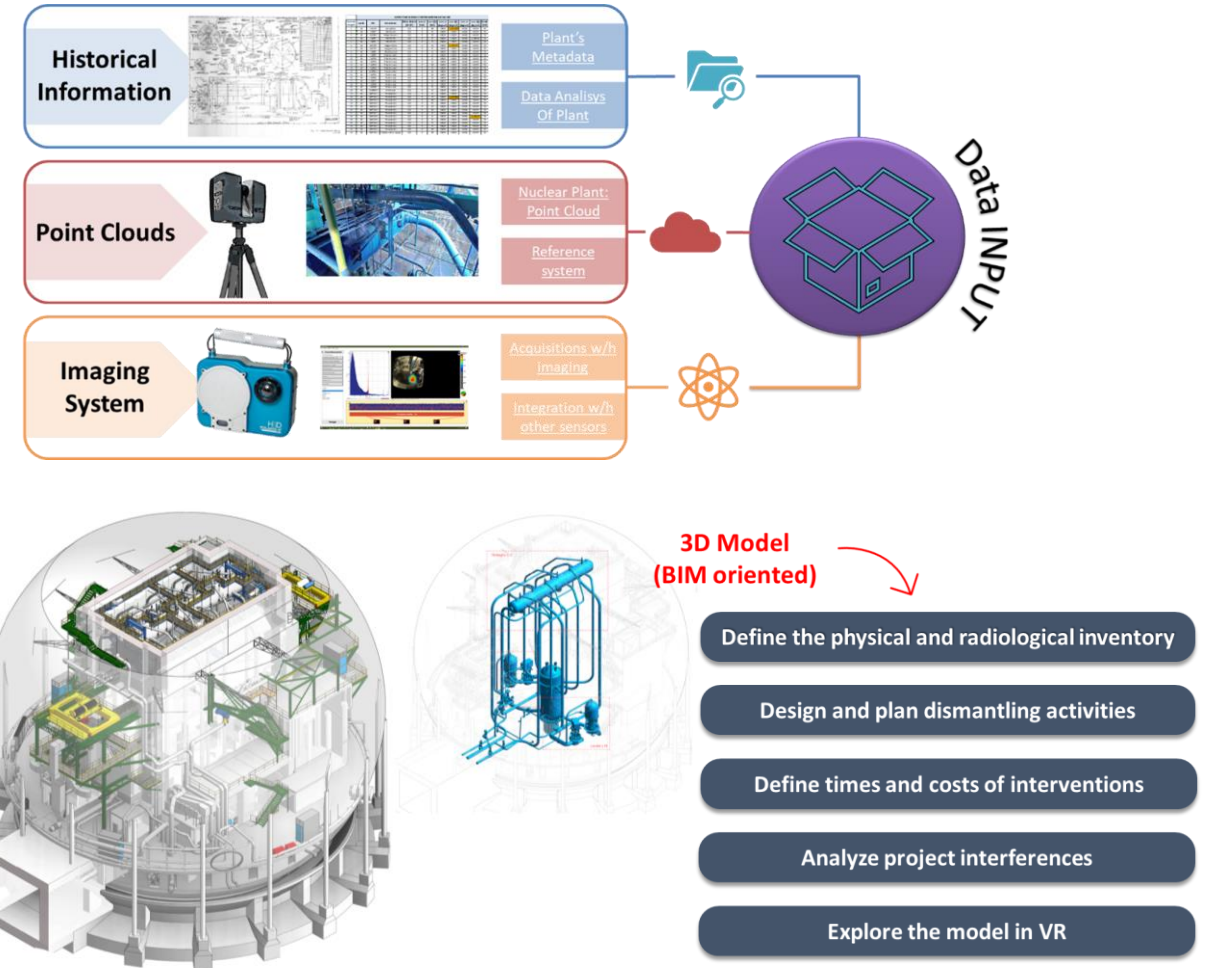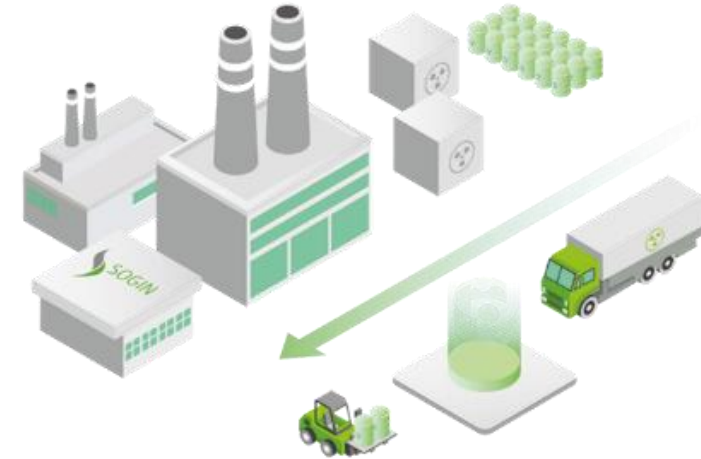
Sogin digital solutions for decommissioning and RWM

❑ Decommissioning produce **wastes** that need to be properly managed: need for a unique and traceable flow of information and data from the installation to be dismantled to the released material and final waste package

AIGOR (Radioactive Items Management System), aims to **optimize RWM** by a multi criteria analysis, to select the most appropriate waste process route for a defined waste stream, and to manage data and information in a flexible and reliable way

✓ Unique center at national level for collecting and archiving data
✓ Ensure traceability of data
✓ Ensure homogeneous application of terminology and processes

International collaborations

❑ IAEA Collaborative project – **NET4D**
  ✓ to provide information on new and emerging digital tools and technologies being used in data management, planning, and implementation of decommissioning

❑ H2020 **CLEANDEM** project
  ❑ to develop an Unmanned Ground Vehicle Platform (UGV) equipped with upgraded radiological sensing probes to support dismantling and decommissioning (D&D) operations and to provide a Digital Twin of the investigated area
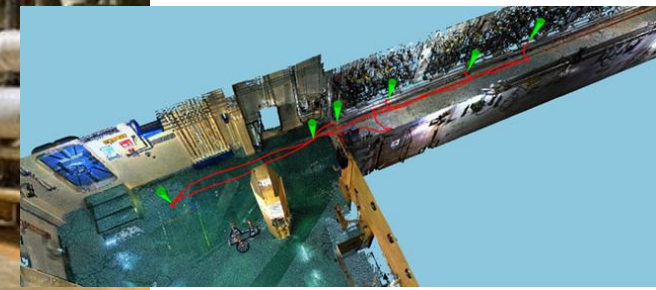
Challenges and benefits

❖ **Human and organizational** factors: need for a cultural and organizational transition to allow digital technologies to be integrated in D&D projects

❖ Modelling is **expensive and time consuming**: digital models may have different level of details depending on the different uses (cost-benefit analysis is needed)

❖ **Cybersecurity**: data-sharing technologies and increased connectivity

❖ **Flexibility is needed** to adapt technologies to different decommissioning challenges and tasks

❖ Improving **efficiency and effectiveness** of decommissioning activities starting from planning up to waste management

❖ Minimizing **radiation exposure** of the workforce and **optimizing RWM**

❖ Facilitating **stakeholder engagement** (i.e. with regulators and public), providing better visualization of decommissioning activities

❖ Ensuring collection, storage and **traceability of data**

❖ Facilitating **training and transfer of knowledge** and experience between current and future workforces

SOGIN | nucleare e ambiente

Robot planning

Brief overview

Omar Zahra, PhD., omar.zahra@ife.no
December, 2024
DORADO Webinar for End User Group members

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The objectives
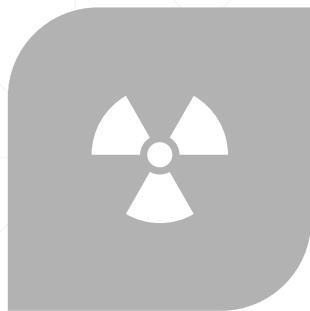
Enhance safety by minimizing exposure to radiation

Improve efficiency of decommissioning operations

Provide accurate, real-time data for decision-making

Reduce overall project costs

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Key role of robotics

Acts as mobile sensing platform

Collects crucial data for digital twin creation and maintenance

Enables remote monitoring of hazardous areas

Integration with the Digital Twin

- Robotic inspections feed data directly into digital twin

- Continuous updates ensure accurate representation of facility

- Enables simulation and predictive modeling for better and safer decommissioning

- Comprehensive data collection supports informed planning

- Updated instructions for the robot mission planning

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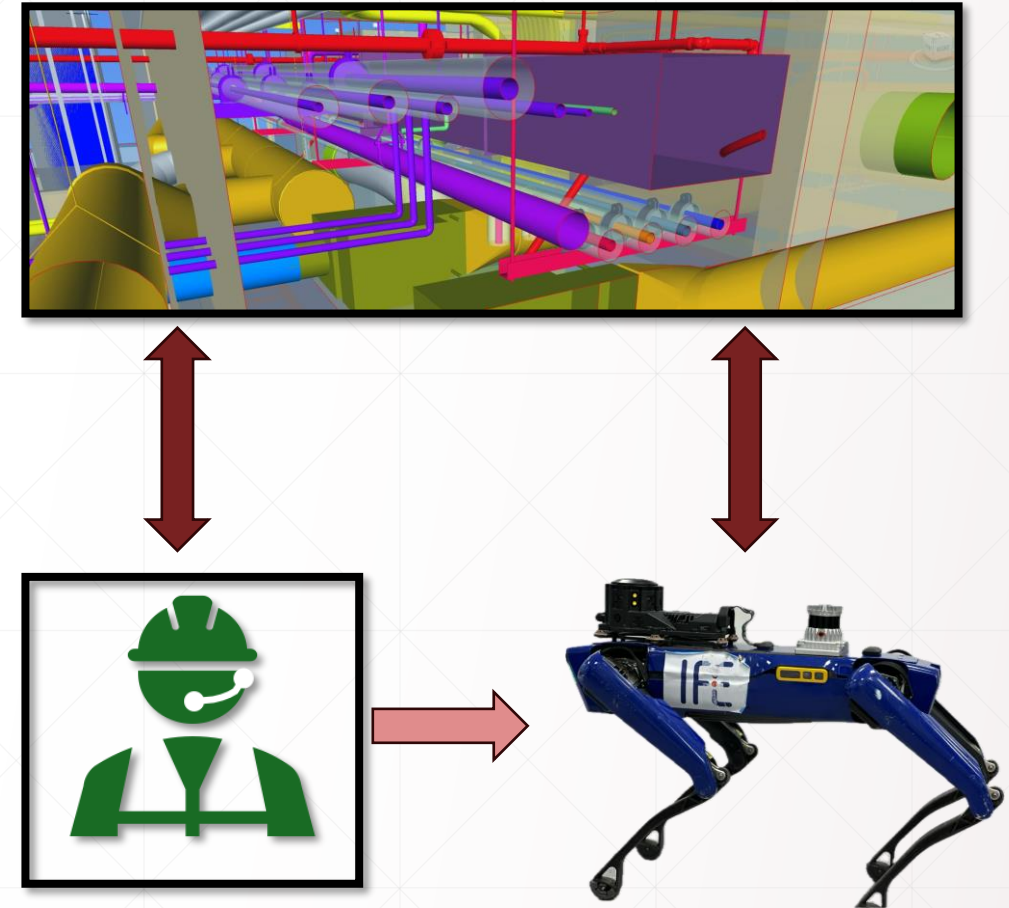
Robot Route Optimization

- Ontology enables modelling the system with various relationships (spatial, temporal, etc.) and interdependencies within the environment.
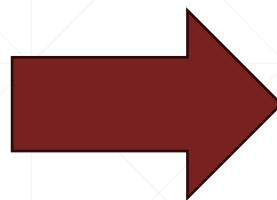
- Conduct context-aware mission planning and control.

- Enable adaptively assign tasks and respond to changes in the decommissioning environment.

- Integrates with AI and sensor fusion module for real-time safety monitoring and risk assessment (for workers and for the robot).

Beyond the State-of-the-Art

NOW

- Some instances of teleoperating robots for basic tasks in nuclear power plants.

- No connection with the sensory network in the facility.

- An emerging research direction is using LLM-based agents that until now suffer from hallucinations.

AFTER

- Introduce more mission control, scheduling and robot route optimization.

- The digital twin will allow connecting the robot to a wider sensory network.

- Ontology will be used for context-aware mission planning and control.

+ **DORADO**

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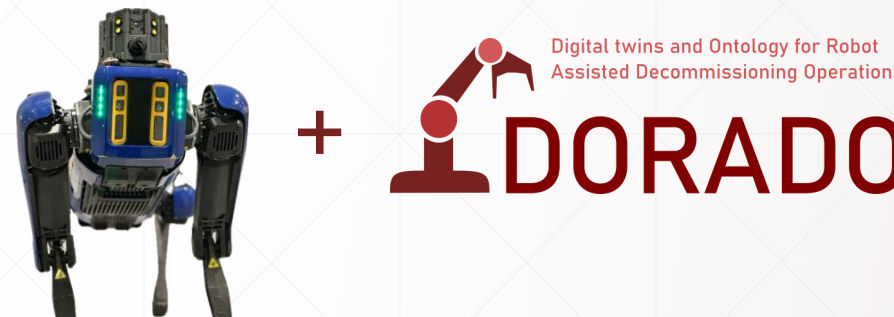
Field operators

Brief overview

André JOLY, PhD., andre.joly@spix-industry.com
December, 2024
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The Problem to Solve

How to include the feedback from the workers in the update of the Digital-Twin ?

Image: public web-site nrc.gov

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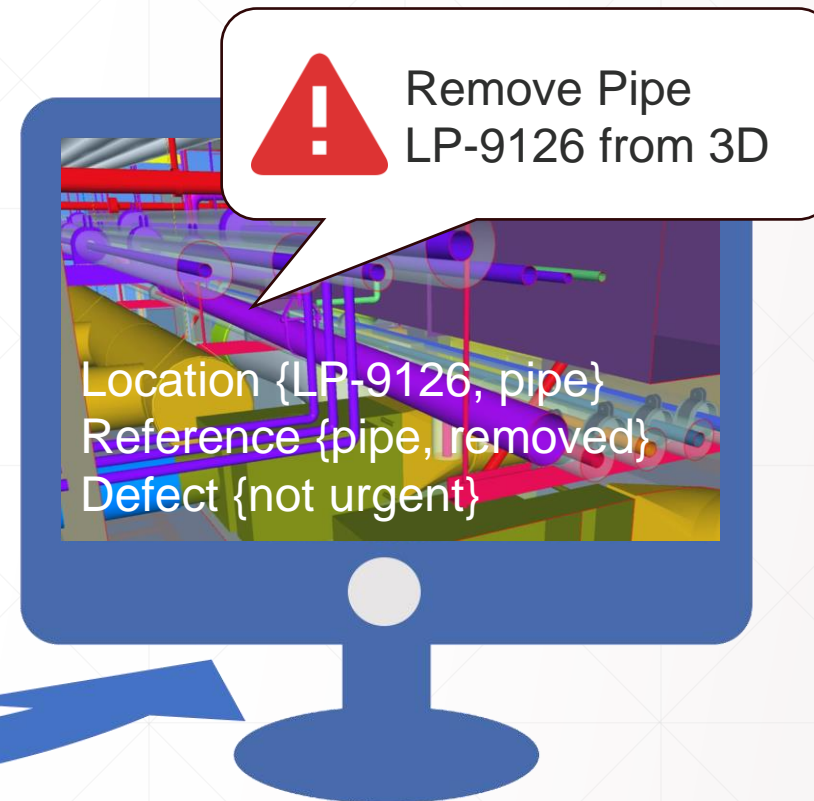
Typical Sample

Report Hazardous Situations by voice, on the field, to complete the BIM data.

Inspector: New problem pipe 815
   SPIX : Report pipe 815 created.
   SPIX: Do you want to complete details ?
Inspector: Yes

   SPIX: What is the position ?
Inspector: LP-9126
   SPIX: location LP-9126 stored

   SPIX: Set the root cause ?
Inspector: What are choices
   SPIX: removed, doubled, added
   SPIX: do you need more in the list ?
Inspector: no, it is removed

   SPIX: Is it urgent ?
Inspector: no
Inspector: save the report
   SPIX: report saved

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How to Interface with the Digital Twin

```
<type> <number>
<location>
<reference>
<default>
<severity>
if <comment>
```

100% offline operations

Smartphone safe in the pocket

Gloves & PPE on, focused on duty

Position: Pipe-815
Location {LP-9126, pipe}
Reference {pipe, removed}
Defect {not urgent}

DORADO Digital Twin
Shared ontology

DORADO Digital Twin
Shared ontology

Get

```
<type> <number>
<location>
<reference>
<default>
<severity>
if <comment>
```

Go

FORMULAIRE   TACHE EN COURS

1 Place   2 Breaks   3 Status

Step 2/2: Status

Status of the lighting

Good state

Quels sont les choix?   Passer

Back

R3

Send
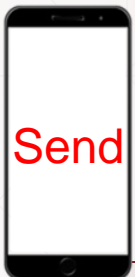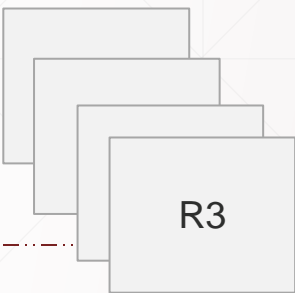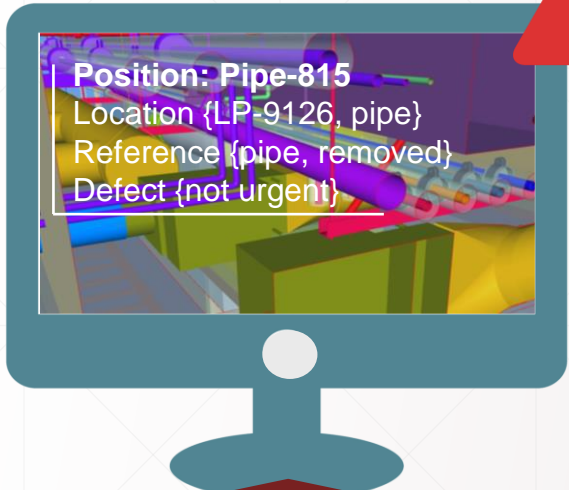
Beyond the State-of-the-Art of Voice Assistance

NOW

- Help field operators to interact with business data: get workorder, access documentation, generate field reports and Retex.

- Promote a safe use of digital equipment, keeping gloves and helmets, focusing on the environment.

- Work 100% offline in disconnected situations

SPIX Voice Assistant + DORADO

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- Enhance the safety of field operators with real-time information on the status of the construction/deconstruction.

- Increase the level of data of critical installations by considering the field operators' feedback and process it automatically.

- Takle the obsolescence of the BIM and Digital Twins by considering the updates from the field operators.

Server-Based Integration

Brief Overview

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December, 2024
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The Objective

> Provide a **single-source-of-truth platform (a.k.a. common data environment or central data management server)** to enable systematic exchange of data used in decommissioning planning by the broad spectrum of technologies and software tools.

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Beyond the State-of-the-Art

NOW

- Many useful digital technologies

- Many useful software tools

- All technologies generate data

AFTER

- Same technologies

- Same software tools

- Same data

Used in isolation, data exchange is painful, storage is inconsistent, machine reading unavailable.

Integrated together, consistent data storage & transfer, accessible by both humans (engineers) and machines (machine-readable).

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Requirements

Open
- Any technology can be integrated into the platform.

Flexible
- Any data and/or document can be flexibly managed.

Easy to use
- Well-described documentation enables newcomers to join.

Secure
- Enough security measures to prevent cyber attacks.

Reliable
- Managed data by the platform can be trusted and comprehensively checked.

@EndUsers

Do you have any other requirements?

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How to Use? (Automated Data Flow)

"Creators"
(external decommissioning planning experts or teams, internal staff, technology providers, …)

(types of potential end users)

"Consumers"
(regulatory bodies, utilities, government, decommissioning workers, …)

Technology #1

Technology #2

.
.
.

Technology #N

"The platform"

(a.k.a. central server, common data environment, single-source-of-truth)

Data browsing tools

Reporting tools

Analysis tools

https://platform.dorado-project.eu

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How to Use? (Sample Engineering Process)

Tech #1
- Download job description
- Produce data (measurements)
- Upload results

Tech #2
- Download job description
- Download results from Tech #1
- Produce new results and upload back

Tech #3
- Download job description
- Download results from Tech #2
- Produce new results and upload back

Reviewer
- Download results from any previous tech
- Do the review and upload results back
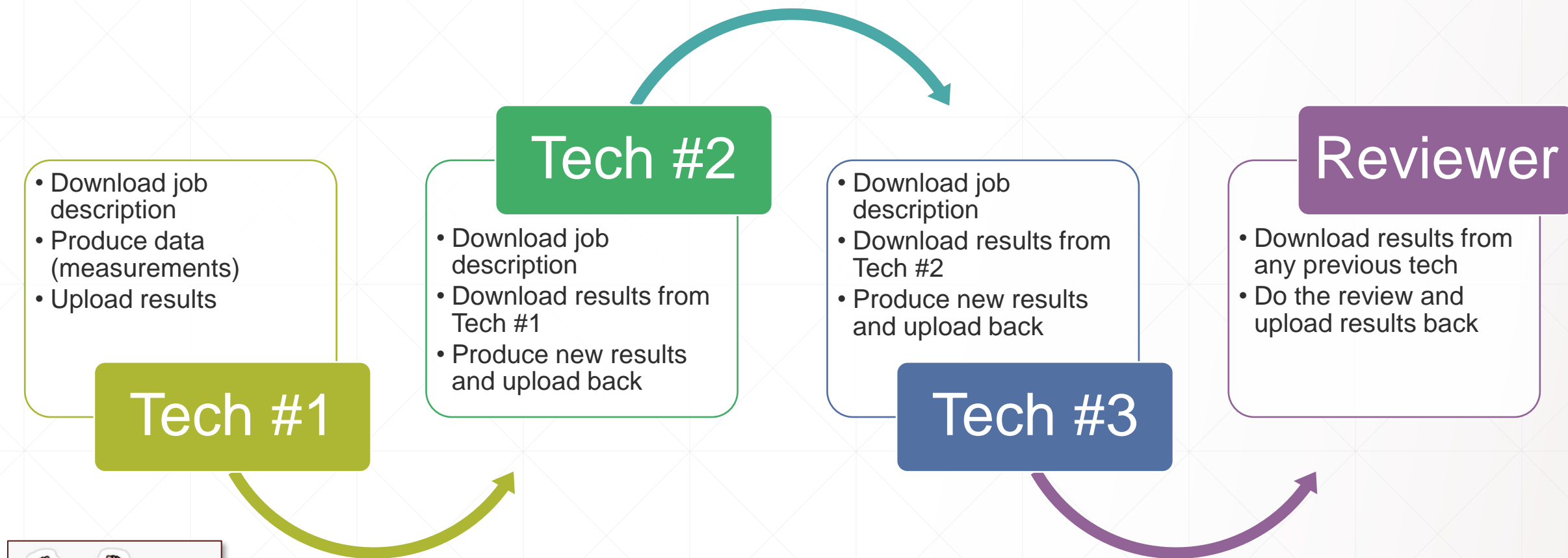
Hurray! All data is securely stored in the platform. History of records is well-managed. Each user (a "tech") gets appropriate permissions. Data security is maintained. Structure of data is based on commonly understood ontology.

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Example Use Case – Cost Estimation

1. Plan characterization campaign (VRdose software)
   - Inputs: IFC model of HRR, downloaded from the server
   - Engineering activity: Plan of the characterization campaign
   - Outputs: List of activities, uploaded to the server

2. Estimate costs (AquilaCosting software)
   - Inputs: List of activities, downloaded from the server
   - Engineering activity: Configure costing model, estimate costs
   - Outputs: Estimated costs, uploaded to the server

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- Join our end-user group: https://www.dorado-project.eu/join-us

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Further webinars will be organized in the future.

Discussion

Brief Overview

Dusan Daniska, PhD., dusan.daniska@wai.sk
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Questionnaire for Stakeholders

https://www.dorado-project.eu/questionnaire

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