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# The use of Digital Twins for waste estimation in nuclear facilities D&D: the PLEIADES Project

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# PLEIADES

Smarter Plant Decommissioning



## The use of digital twins for waste estimation in nuclear facilities' dismantling and decommissioning: the PLEIADES project

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**Safe<sup>ND</sup> 2023 – Berlin**  
13-15 September 2023



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# Overview

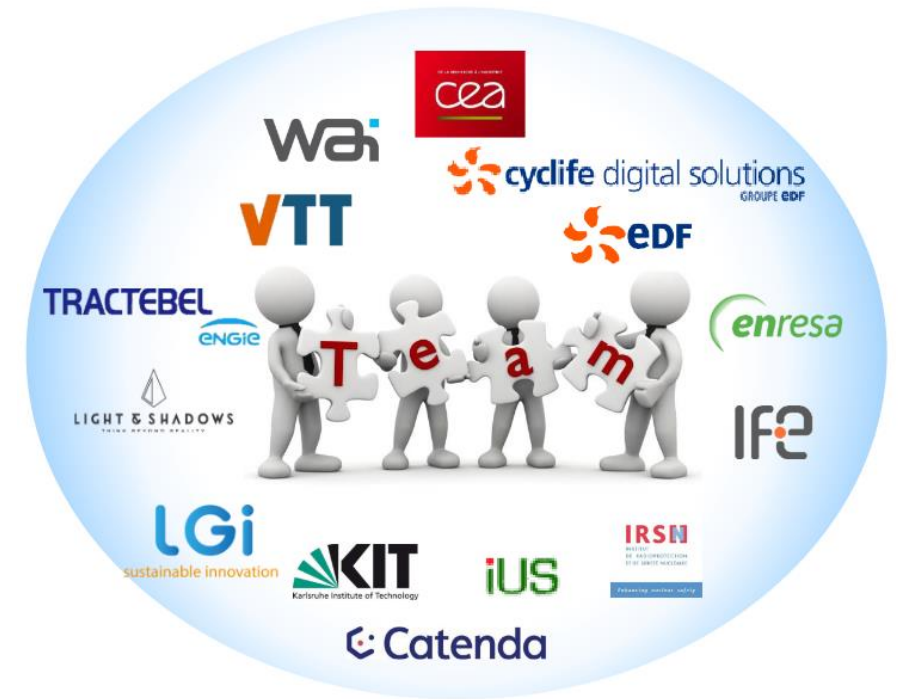
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# Introduction

- **Platform based on Emerging and Interoperable Applications for enhanced Decommissioning processes**
  - **Call: H2020 NFRP-2019-09** – « Fostering innovation in decommissioning of nuclear facilities »
  - **Duration:** 01.10.2020 – 30.11.2023
  - **Consortium:** 14 partners
    - 7 countries: FR (6), DE (2), NO (2), ES (1), FI (1), BE (1), SK (1)
    - 4 academic/research organisations, 1 TSO, 4 industrial companies, 5 SMEs



Source: [1]



# Digital Tools

- A number of cutting-edge digital tools is collected and implemented

Sources: [2] [11]

<b>CEA</b> <small>IDROP</small> VR dismantling simulation with collision & radiological modelling	<b>Cyclife DS</b> <small>DEMPLUS</small> Decision-support tool combined with 3D simulation	<b>IFE</b> <small>VRDOSE™</small> Detailed job planning tool with a radiological model library
<b>Catenda</b> <small>BIMSYNC</small> IFC <sup>1</sup> compatible BIM platform used in construction	<b>WAI</b> <small>AQUILA COSTING</small> ISDC <sup>2</sup> compatible client-server based costing tool	<b>IFE</b> <small>RADPIM</small> Radiological characterisation tool (part of VRdose family)
<b>iUS</b> <small>IMS</small> Semantic wiki based nuclear info system	<b>KIT</b> <small>3DSCANPF</small> Robotic platform for 3D scans and imaging	<b>LS</b> <small>INTERACT</small> XR <sup>4</sup> platform with physics engine
<b>EDF &amp; CEA</b> <small>DIM TOOL</small> Dismantling Info Modelling system for storing all facility data	<b>VTT</b> <small>ARWORKFLOW ALVAR BIM ACCESS</small> AR <sup>3</sup> training platform with advanced tracking capabilities	<b>Tractebel</b> <small>WASTREAM</small> Waste Routes and Activity Assessment tool

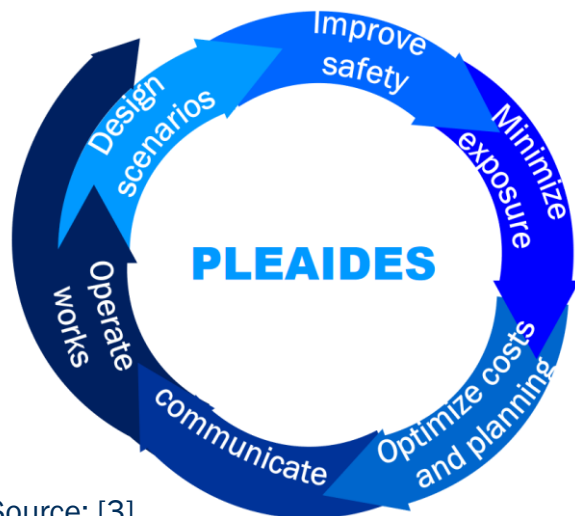
<sup>1</sup>IFC: Industry Foundation Classes; <sup>2</sup>ISDC: International Stricture for Decommissioning Costing; <sup>3</sup>AR: Augmented Reality; <sup>4</sup>XR: Mixed Reality





# Objectives

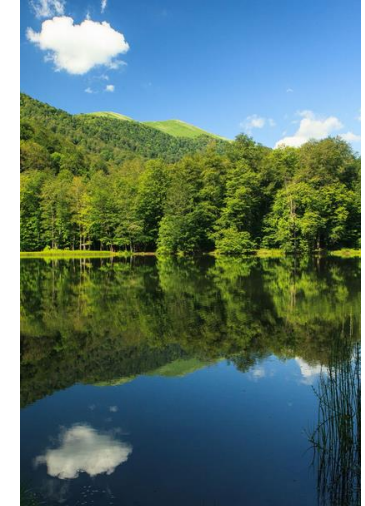
- Main objectives are:
  - Creating a new digital methodology to improve nuclear decommissioning;
  - Definition of an ontology and procedures for the digitization of nuclear facilities' dismantling and decommissioning;
  - Facilitate higher standardization required for international application.
- Ultimate goal is to protect workers, the environment and optimise costs.



Source: [3]



Source: [4]

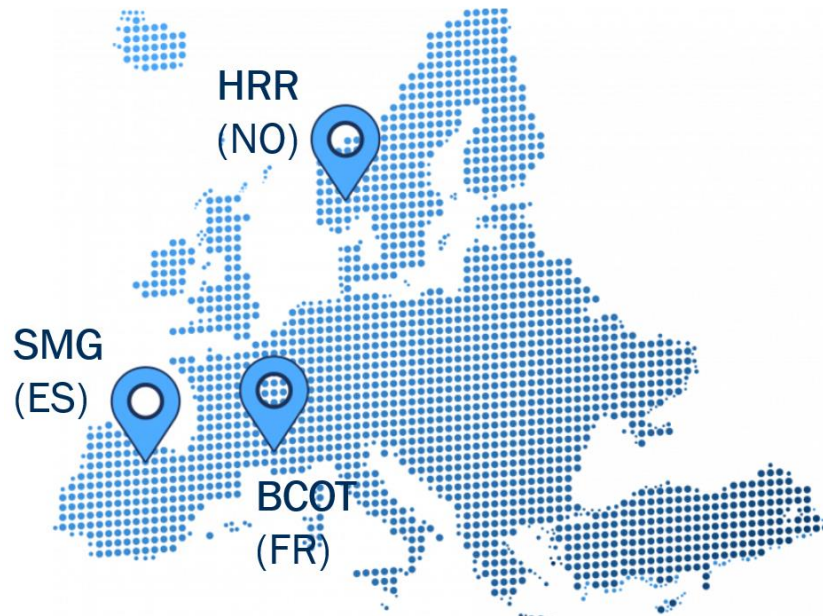


13-15 September 2023



# Demonstration on Real Use Cases

- Application on 3 real use cases in Europe
  - Halden nuclear Research Reactor (HRR), Norway;
  - Santa María de Garona (SMG), Spain;
  - Base Chaude Opérationnelle du Tricastin (BCOT), France.



Source: [5]

Santa María de Garona (SMG)



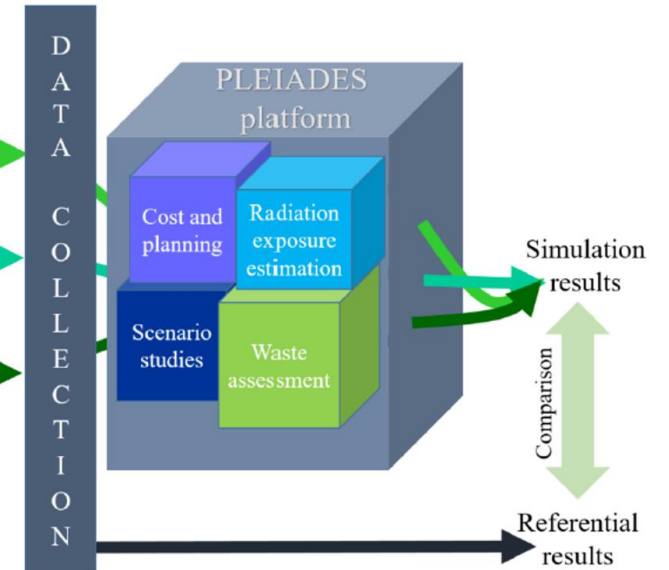
Halden Research Reactor (HRR)



Basse Chaude O. du Tricastin (BCOT)



Source: [6]



# Organization

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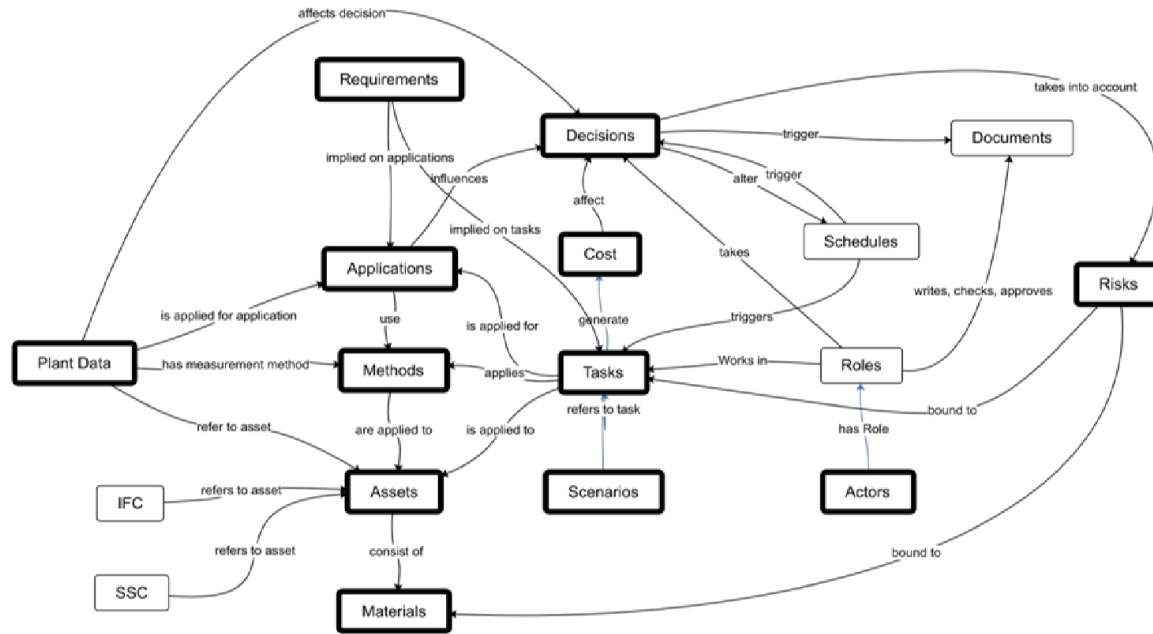
- 7 Work Packages (WP) in 38 months:
  - **WP1:** Requirement analysis, specification and test design;
  - **WP2:** PLEIADES platform development;
  - **WP3:** Implementation of PLEIADES platform on real use cases;
  - **WP4:** Modelling and results evaluation;
  - **WP5:** Standardisation efforts, exploitation and training;
  - **WP6:** Dissemination, communication & stakeholder engagement;
  - **WP7:** Project coordination and management.





# Results: Requirements & Specifications

- Definition of a core nuclear decommissioning ontology

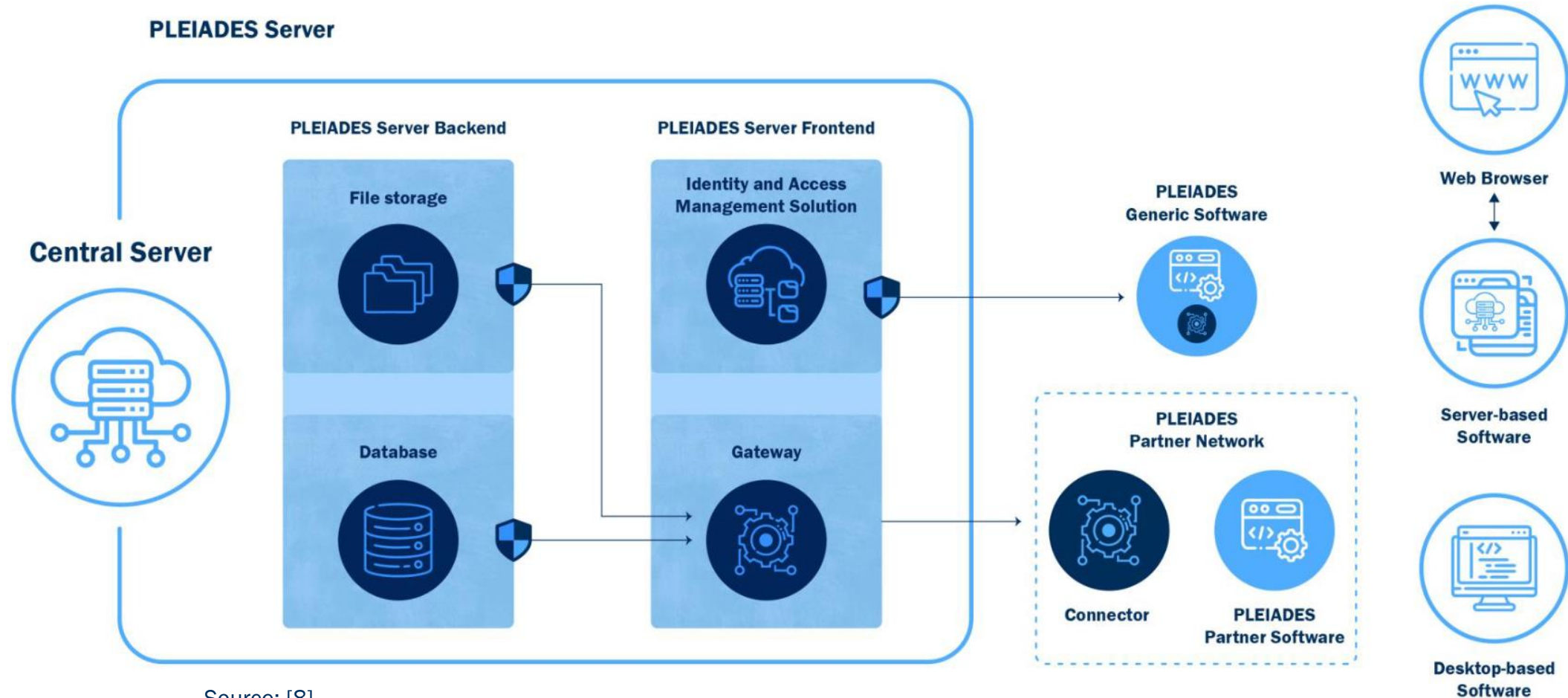


Source: [7]

- Definition of 6 user stories (US)
  - **US#1:** Manual vs. remote radiological characterization;
  - **US#2:** 3D supported vs. digitally enhanced dismantling;
  - **US#3:** Manual vs. automated decontamination of building surfaces;
  - **US#4:** Strategic risk management planning;
  - **US#5:** Regulatory/TSO review capabilities;
  - **US#6:** Strategic waste management planning.

# Results: PLEIADES Platform Development

- After being specified, developed and tested, the platform is operational



Source: [8]



# Results: Development of Digital Models

- Implementation on real use cases

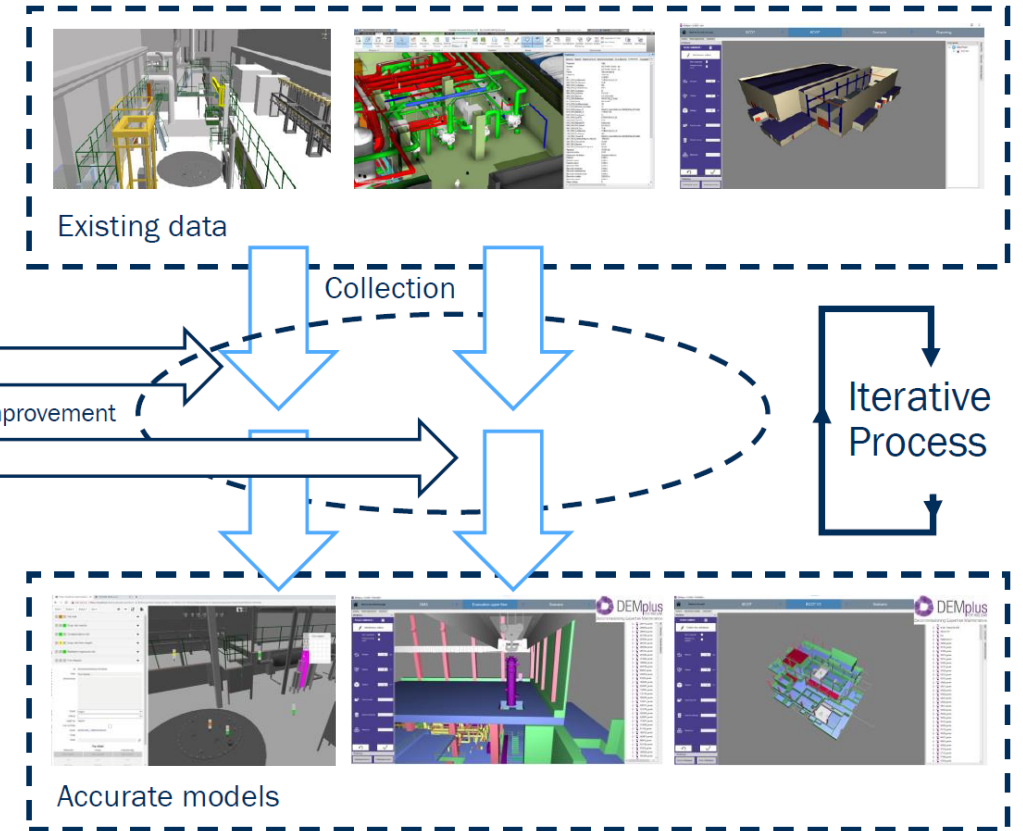
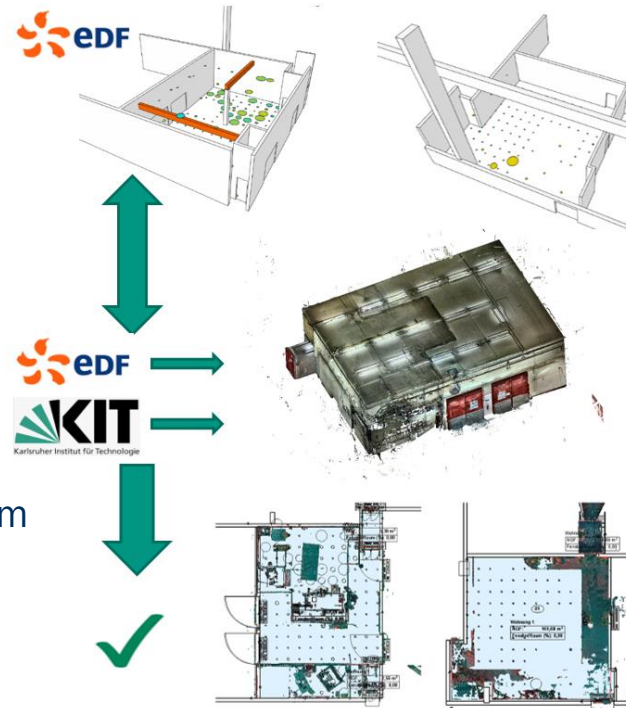
- Input

- Physical inventory, features;
    - Radiological inventory.

- Activities

- Analyze inputs;
    - Identify gaps and problems;
    - Propose and perform activities to complete the models.

- Output



# The Use of Digital Models

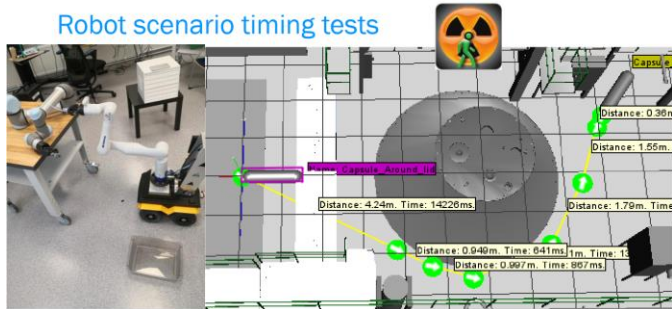
- Some examples of simulations

Halden Research Reactor (HRR)



**US#1:** Manual vs. remote radiological characterization

Robot scenario timing tests



Source: [11]

HVRC VRDose®

Scenario	Dismantling Distance
Manual scenario	0.3
Remote / robot scenario	0.336

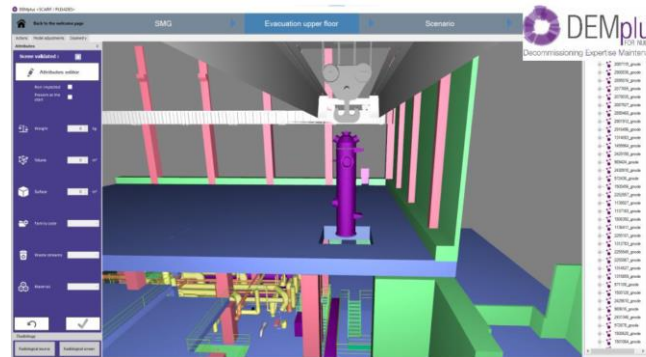
**US#4:** Strategic risk management planning

Santa María de Garona (SMG)



**US#2:** 3D supported vs. digitally enhanced dismantling

SMG 3D model visualization on DEMplus®



Source: [13]

**US#5:** Regulatory/TSO review capabilities

Basse Chaude O. du Tricastin (BCOT)

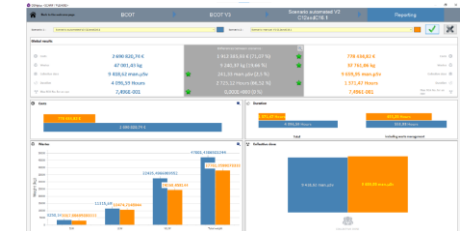


**US#3:** Manual vs. automated dec. of building surfaces

Test and results from DEMplus® scenario simulations



Source: [12]



**US#6:** Strategic waste management planning

- Decommissioning planning activities demonstrated:

Cost estimation, waste estimation, dismantling visualization, risk management, TSO/regulatory reviews





# Summary

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- Core **nuclear decommissioning ontology** was developed;
- **Open, robust and flexible platform** for digitalization of decommissioning planning implemented;
  - Open = the API interface is publicly available;
  - Robust = large amount of data can be processed (3D models, point clouds, structured data);
  - Flexible = any software, independent from the technology, can connect and benefit from the common data environment.
- Successfully demonstrated on **6 user stories** utilizing various technologies like 3D modelling, VR/XR, computational analysis used at different stages of decommissioning planning.





# Further Steps

- Continue in the development of the ontology and the API;
- Extend the coverage of the decommissioning planning activities that can be supported by the PLEIADES platform;
- Utilization of other digitalization technologies like artificial intelligence, robotics or integration with sensor networks.



Source: [14]

# Sources

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[1] [6] M.-B. Jacques (2021). PLEIADES, the Smarter Plant Decommissioning. DEM 2021 –International Conference on Decommissioning Challenges (France, Avignon)

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[3] [8] [9] M.-B. Jacques, J.-E. Hulsund, I. Szoke (2022). PLEIADES project overview. DigiDecom 2022- Halden.

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[11] [12] [13] I. Szoke, J.-L. Flouttard (2023). PPlatform based on Emerging and Interoperable Applications for enhanced Decommissioning processES. International Conference on Nuclear Decommissioning: Adressing the Past and Ensuring the Future. 15-19 May 2023, Vienna, Austria





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