A Common Ontology for Nuclear Decommissioning Projects

Conférence AGeCSO-KCO 2026
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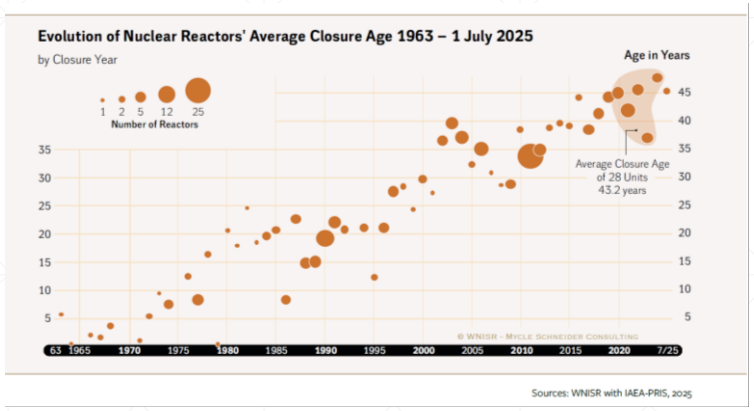
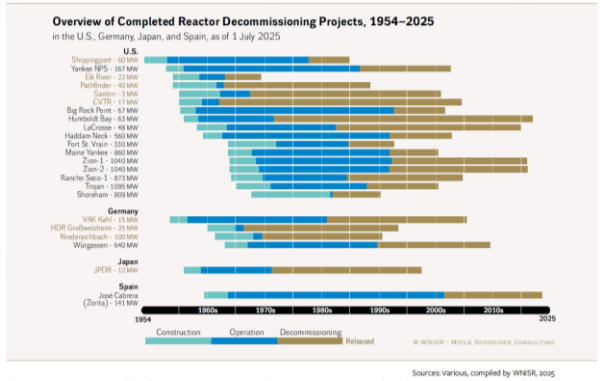
1. Introduction

The International Context of Nuclear Decommissioning

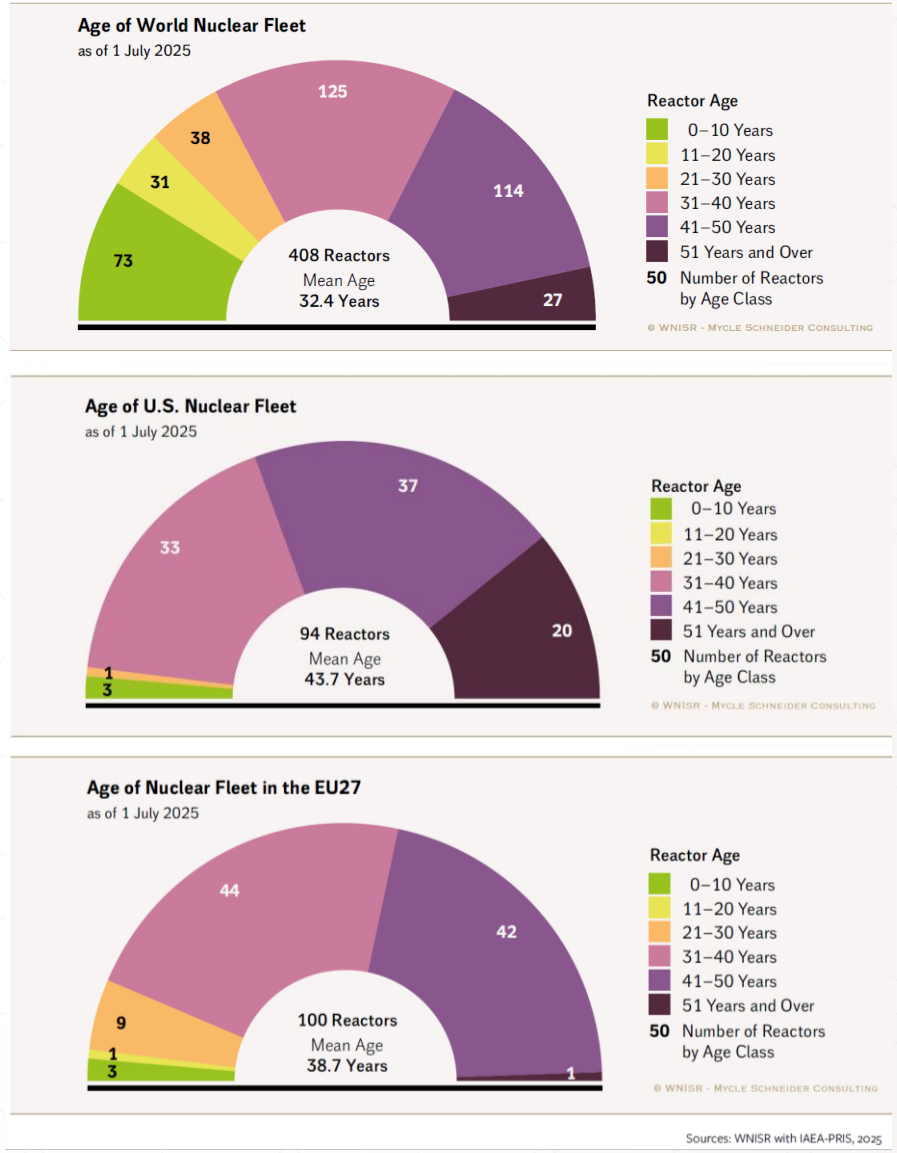
- The mean age of the nuclear reactors in the World is 32.4 years:
  - The European Union has the second oldest nuclear fleet (**38.7 years**) after the U.S.A. (43.7 years);
- The average closure of Nuclear Reactors (NRs) in the World between 2019 and 2023 was **42.8** years;
- The number of Nuclear Decommissioning Projects (NDPs) worldwide is expected to go from 50 today to **200 by 20240**;
  - Considering this, decommissioning activities is a growing market in Europe and worldwide.



[7] World Nuclear Industry Status Report 2025



[7] World Nuclear Industry Status Report 2025

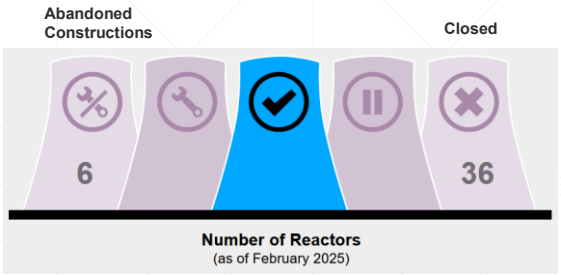


[7] World Nuclear Industry Status Report 2025

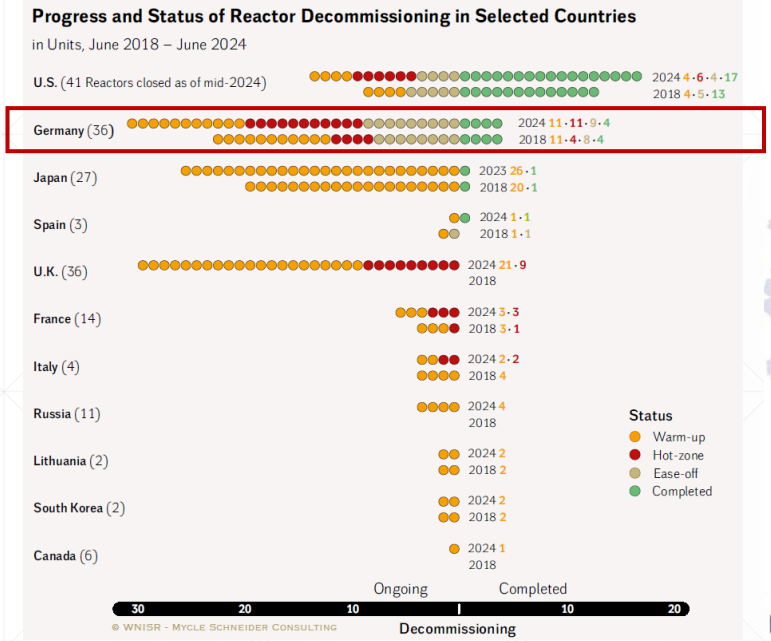
1. Introduction

The German Experience

- Germany decided to phase out nuclear power in 2011, after the Fukushima acccident;
- Decommissioning work is being conducted in 31 nuclear reactors:
  - 11 reactors in warm-up stage;
  - 11 reactors in hot-zone stage;
  - 9 reactors in ease-off stage.
- The last 3 operating German reactors were shut down in 2023;
- The German experience in NDPs is needed in the rest of European countries.

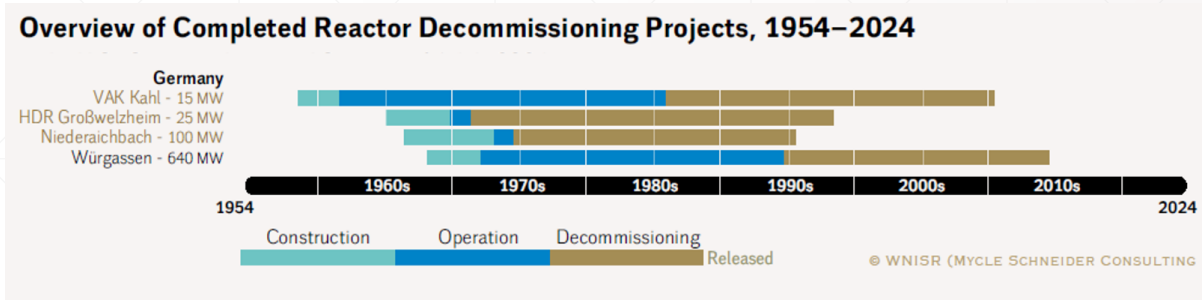


[8] Overview of Reactors in Germany
World Nuclear Industry Status Report 2025



Progress and Status of Reactor Decommissioning [9] (Fig.52)

Nuclear Power Plants in Germany [10]



Source:[11]

2. An International Approach of a Nuclear Decommissioning Ontology

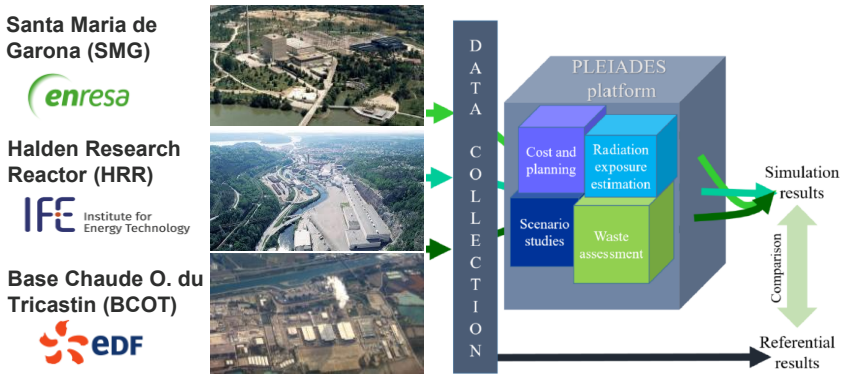
The Project PLEIADES

PLatform based on **E**merging and **I**nteroperable **A**pplications for enhanced **D**ecommissioning process**ES**

PLEIADES
Smarter Plant Decommissioning

[1] PLEIADES partners

[2]



[3] Implementation of PLEIADES on real use cases (Fig. 2)

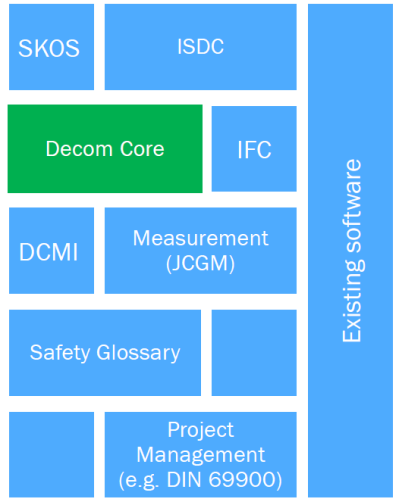
- **Call**: H2020 NFRP-2019-09 "Fostering innovation in decommissioning of nuclear facilities"
- **Duration:** 3 years (1/10/2020 - 30/09/2023)
- **Consortium:** 14 partners
  - Countries: FR (6), DE (2), NO (2), ES (1), FI(1), BE (1), SK (1)
  - 4 academic/research organisations, 1 TSO, 4 industrial companies, 5 SMEs
- **Objectives:**
  - Demonstrate a **modular software ecosystem** based on **interconnection of front-line support tools** through a **decommissioning specific ontology** building upon open **BIM (Building Information Modeling)**;
  - Propose an **ontology** for an international standard of decommissioning with **specific terminology/ vocabulary definition** for a **common understanding** and **common knowledge modeling**;
  - Validation of the platform in the **6 user stories** from **3 case studies** in **different European countries.**

2. An International Approach of a Nuclear Decommissioning Ontology

Creation of a Decom Core Ontology

- **Why generate a Decommissioning Core Ontology for PLEIADES?**
  - Necessity to create a common platform for existing Software;
  - Each Software has ist own history, terms and concepts, i.e. an implicit ontology;
  - Direct interfaces would be difficult to generate and maintain;
  - A common understanding between subject matter experts and data scientists is necessary.

- **The development approach**
  - No intention to reinvent the wheel; reuse what is available, established and suitable;
  - Simultaneous top-down and botton-up approach;
  - Decom Core covers specific parts.



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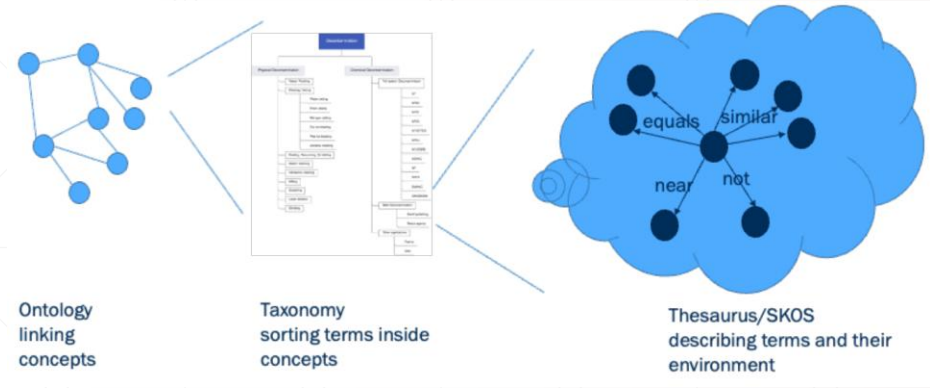
- Ontologies, Taxonomies, Thesauri:



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Ontology

Ontologies describe a model of a section of the real world

Categories or classes describe concepts, processes or things

Inheritance: make instances of classes

Properties connect classes and instances

Example:
KKE is a Siemens Konvoi Reactor
Siemens Konvoi Reactor is subclass of power reactor

Inference: KKE is a power reactor

Information Triple:
Subject – Predicate - Object

Taxonomy

Taxonomies describe the content of classes or categories

Classes or categories are collections of similar things

Taxonomies built a strictly hierarchical order, i.e. every item can have exactly one parent item

Example:
RPV is part of Primary Circuit
Primary Circuit is part of NPP
NPP is part of Site

Taxonomies can be graphically shown as tree graphs

Thesaurus/SKOS
(Simple Knowledge Organisation System)

Allows to organize metadata

Describes nearby terms, synonyms, antonyms

Used to describe the concepts

Example:

A BWR is not the same as a PWR

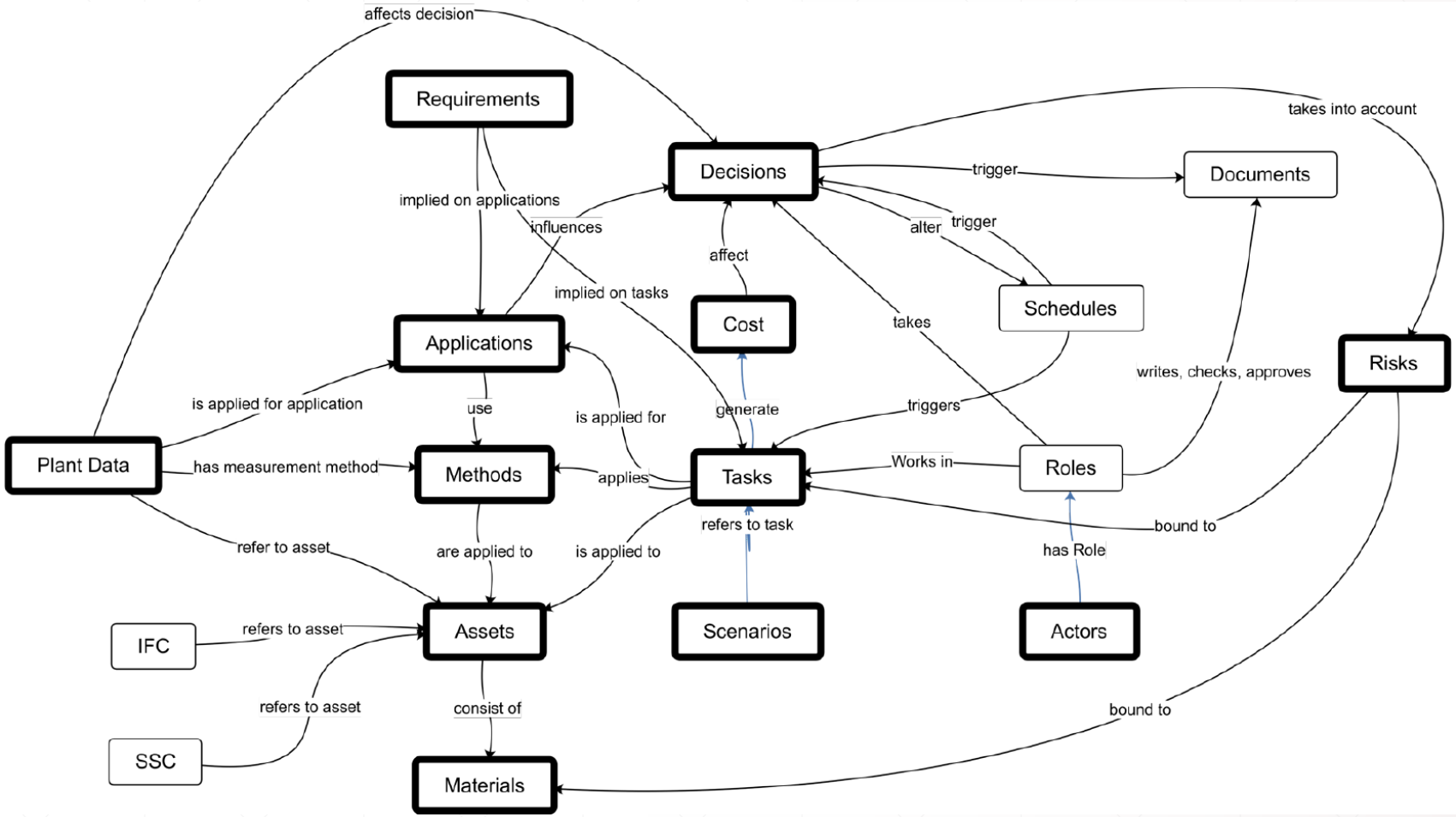
A PWR FA has some similarities with a BWR FA

[13]

2. An International Approach of a Nuclear Decommissioning Ontology

Creation of a Decom Core Ontology

- Common ontologies were reused. The Team used existing definitions wherever possilbe:
  - Either by the IAEA Safety Glossary 2018;
  - Other international or national standerds.
- Terms were properly defined:
  - Requirement; Decision; Application; Method; Asset; Material; Task; Scenario; Actor; Role; Document; Risk; Plant Data.



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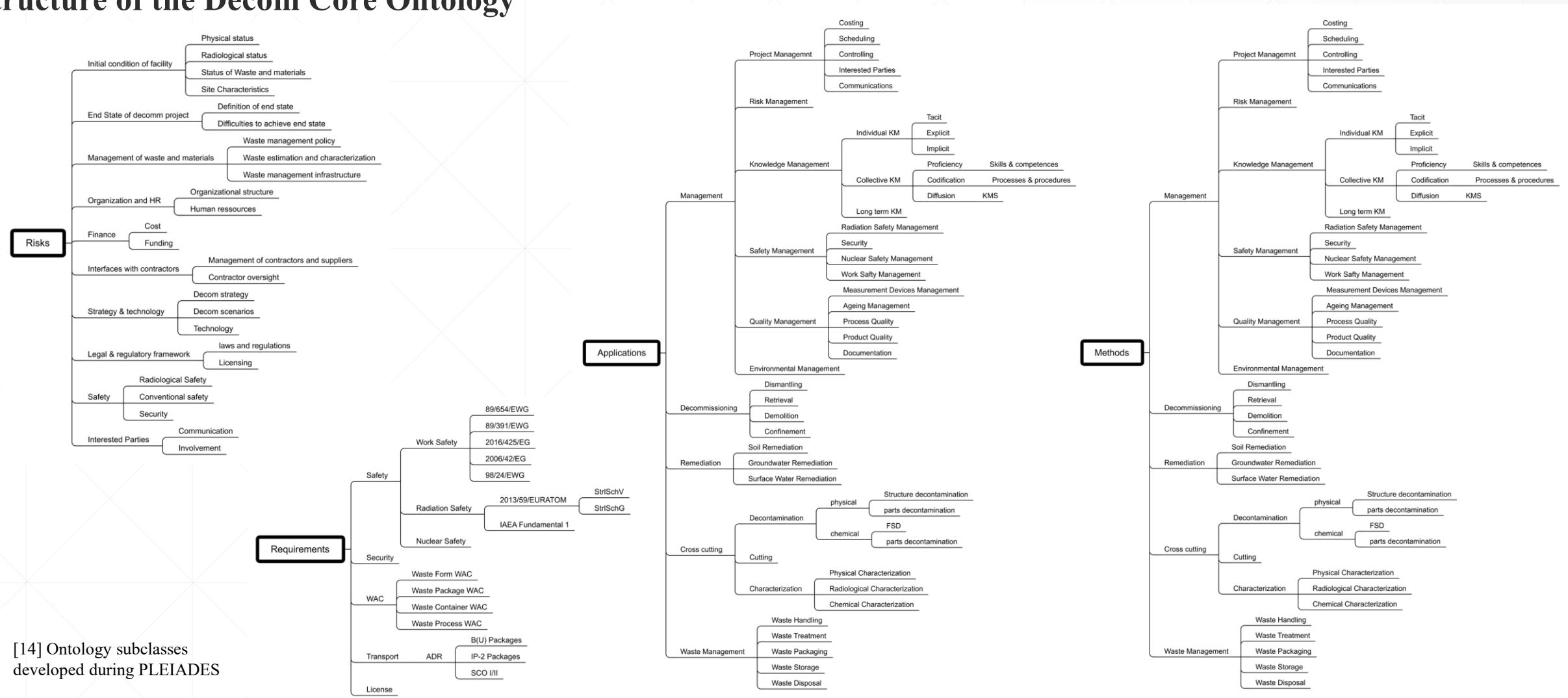
2. An International Approach of a Nuclear Decommissioning Ontology

Structure of the Decom Core Ontology



[14] Ontology subclasses developed during PLEIADES

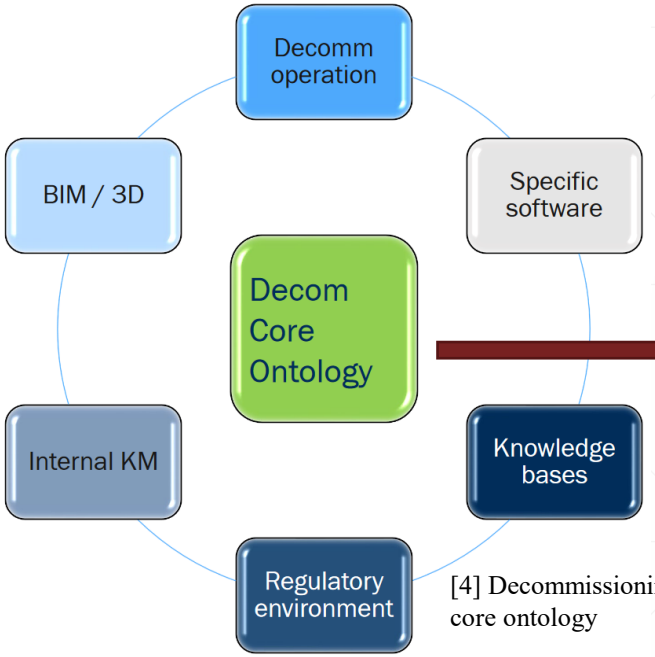
2. An International Approach of a Nuclear Decommissioning Ontology

Implementation of the Decom Core Ontology

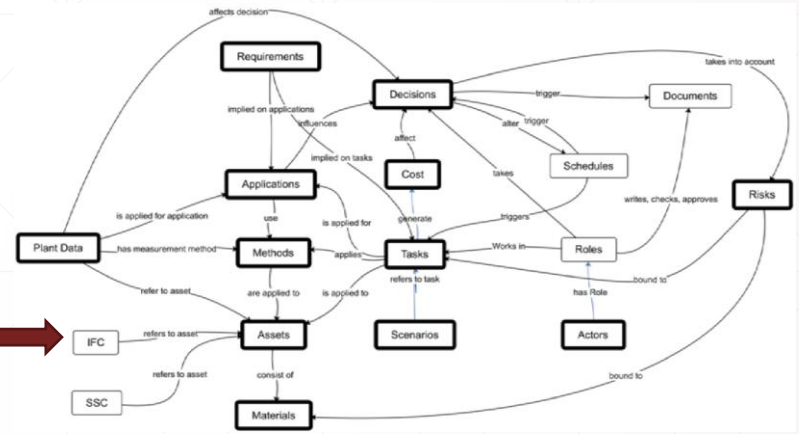
PLEIADES
Smarter Plant Decommissioning

[1] PLEIADES partners

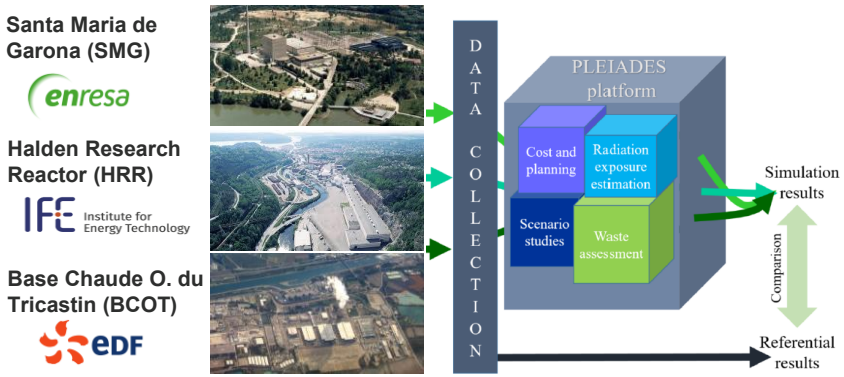
[2]



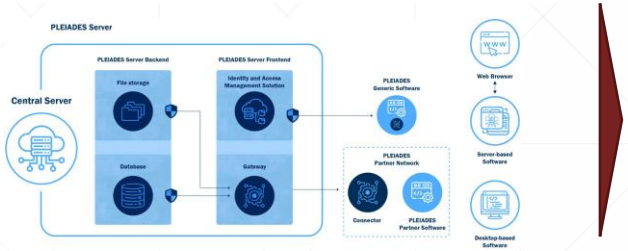
[4] Decommissioning core ontology



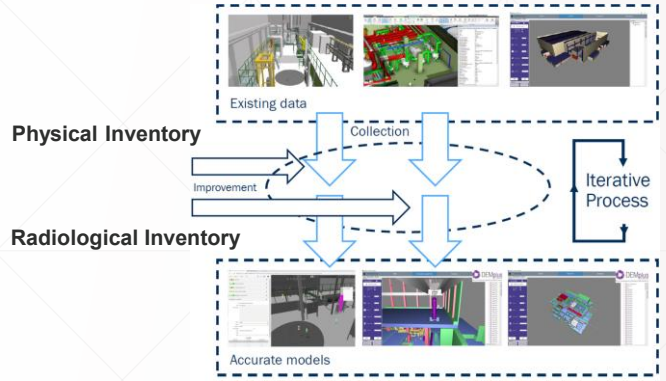
[5] Decommissioning core ontology



[3] Implementation of PLEIADES on real use cases (Fig. 2)



[6] Server architecture in PLEIADES (Fig. 4)



[6] Use cases 3D models and data in PLEIADES (Fig. 3)

3. Development of a Common Nuclear Decommissioning Ontology

The Project DORADO

Digital twins and **O**ntology for **R**obot **A**ssisted **D**ecommissioning **O**perations

Digital twins and Ontology for Robot Assisted Decommissioning Operations
DORADO

DORADO Partners

VTT, IFE, KIT Karlsruher Institut für Technologie, wai, ASNR, iUS, AMPHOS 21 Scientific and Strategic Environmental Consulting, SPIX Industry, Université de Strasbourg, sck cen, Catenda, EPRI

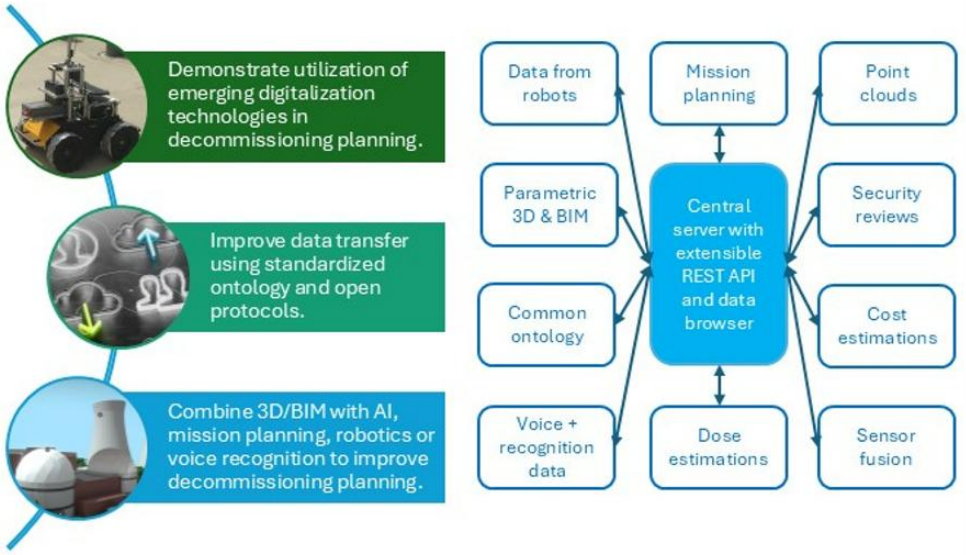
Key facts

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

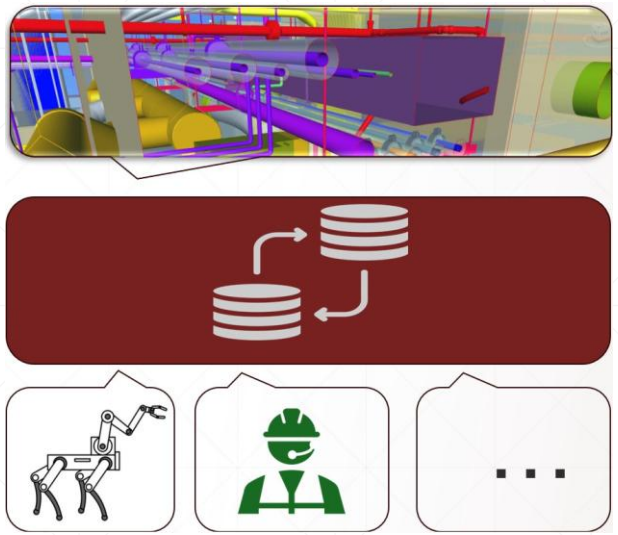
1) Integrate emerging digital technologies into one coherent platform to support decommissioning planning.
2) Extend decommissioning ontology and data transfer protocols to cover new use cases.
3) Describe extensible API to provide standardized data exchange between tools used in decommissioning planning.

[15] www.dorado-project.eu

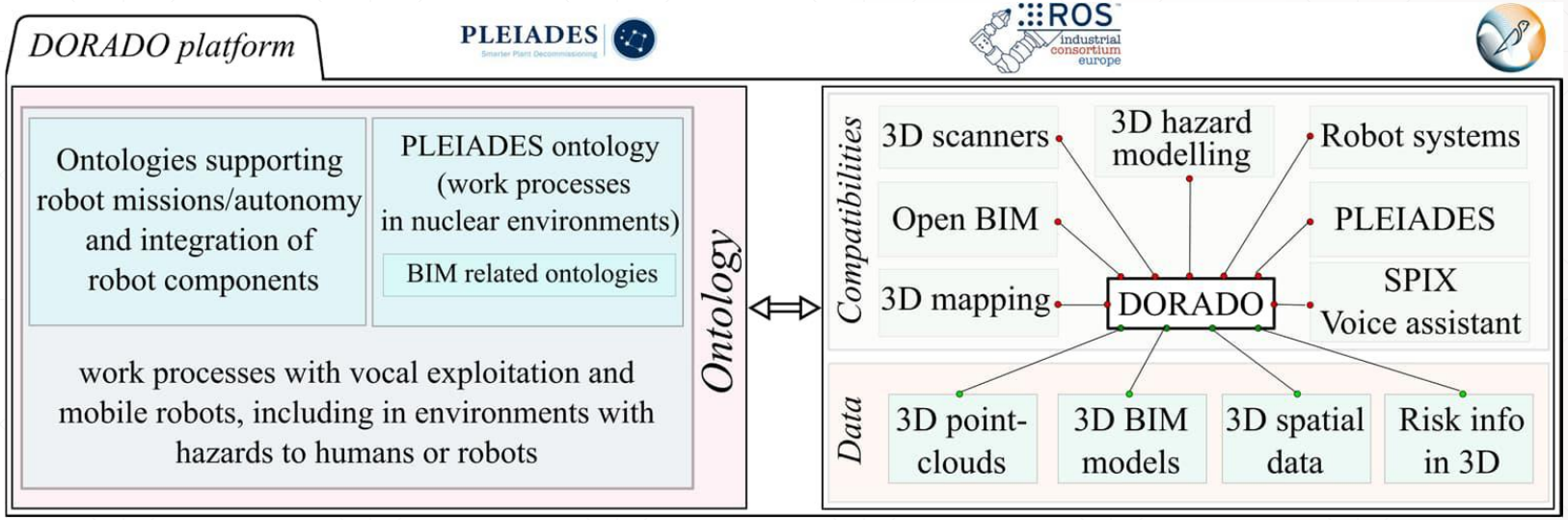
[16] Antti Räty & DORADO consortium. Euratom project DORADO. Digidecom2024 conference, November 2024. Halden, Norway

3. Development of a Common Nuclear Decommissioning Ontology

Data Compatibility and Ontology



[17] A. Räty, M. Becker, F. Borrmann, J. Ridao & DORADO consortium. Digital technologies in DORADO project. 3rd webinar, April 8, 2025



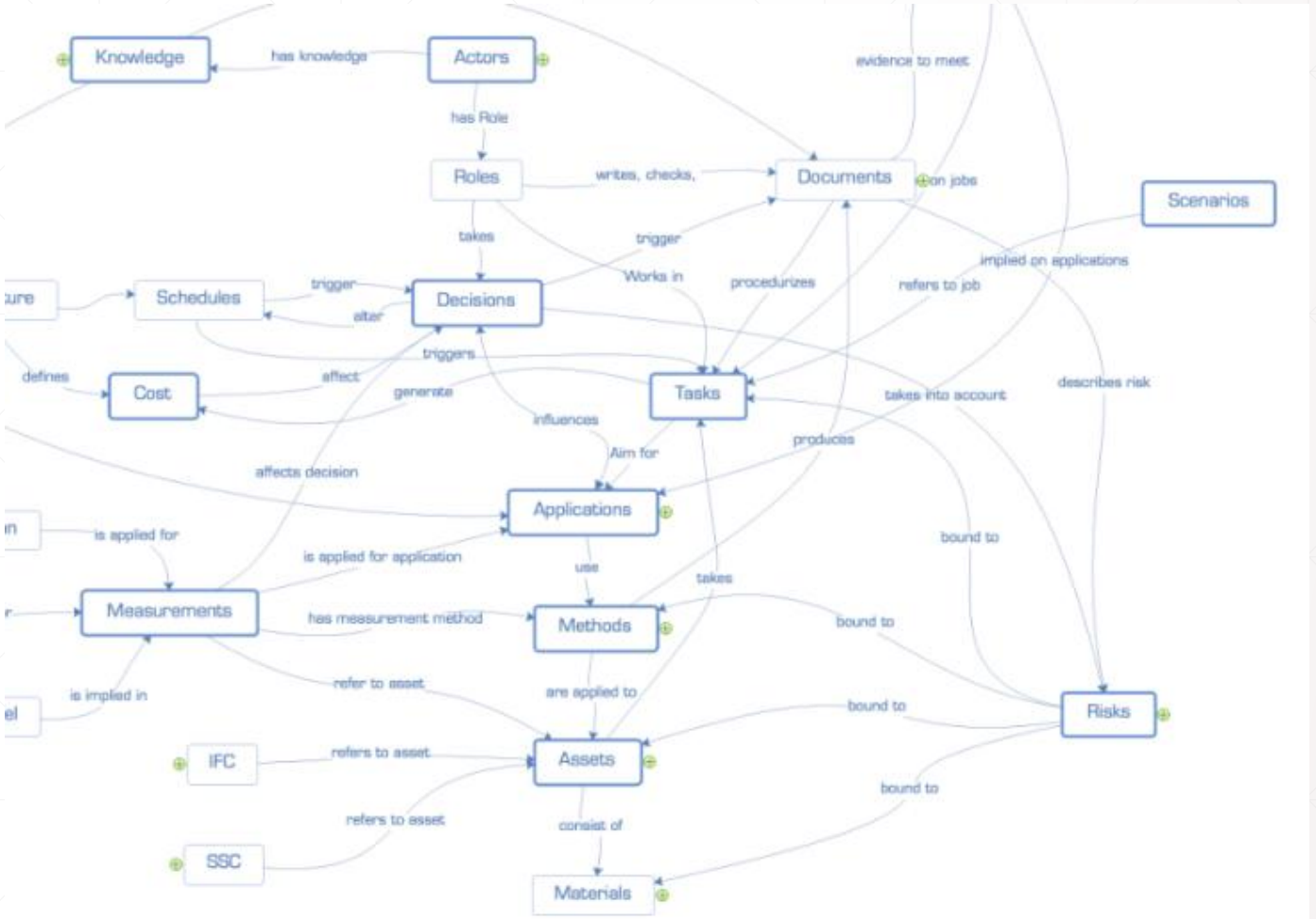
[18] Existing taxonomies and ontologies related to DORADO

- In Nuclear Decommissioning Projects, different data coming from different agents (workers, robots, software entities...) exists:
  - Management of this data is crucial for safety and productivity;
  - It is necessary to maintain a comon knowledge representation and a stardardised data storage and exchange among agents;
  - Data needs to be up-to-date and accessible to different stakehoders:
- BIM (Building Information Modeling) and Digital Twins are used in different steps of large projects:
  - Common language protocols are needed to ensure the coherence of the data.
- DORADO proposes a platform to share/consume data across a wide variety of actors.

3. Development of a Common Nuclear Decommissioning Ontology

Ontology-Based Approach

- Ontology helps to find common definitions and wording;
- Ontology defines the basis for data structure development;
- Shown DORADO ontology has common members with the Decom Core Ontology from the PLEIADES project. Examples:
  - Actor
  - Room (as part of IFC)
  - Risk
- While the Decom Core Ontology is focusing on the project, DORADO is adding the mission planning and feedback part;
- Compatible with:
  - IAEA IDN Wiki
  - NEA
  - EU-JRC ontology research
  - ...



[19] Ontology-Based Approach

4. Interaction with Other Groups

International Working Groups

- Since the beginning, the Ontology has been presented at numerous international conferences and workshops, like:
  - DigiDECOM Community, Halden (Norway) [20];
  - Technical Meetings in the IAEA (Vienna) [21];
  - DMaLSE International Workshop (Nice) [22];
  - Meetings of the Spanish Nuclear Society (Spain) [23].
  - ...
- These participations have allowed the team to exchange knowledge with international groups and work towards a common understanding for nuclear decommissioning activities.

[23]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5. Summary and Conclusions

- Nuclear decommissioning is a complex task with decade durations and multiproject programmes;
- Digitalisation, automation and robotisation require a common understanding of the task and the necessary steps;
- Because of the inevitable risks in such programmes, the different vulnerabilities and abilities of humans and robots have to be taken into account during mission planning and deployment;

- The PLEIADES and DORADO projects have shown that the interaction of software systems profits significantly from an ontology-based approach;
- The ontology also allowed the participating organisations to find common grounds for definitions in order to ease communication;
- The usage of definitions instead of terms allowed an easier alignment with internal terms of each organisation and the implicit ontologies in existing software solutions;
- In some aspects, the ontology also supported the communication between subject matter experts and software developers.

6. References

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[3] [6] Marie-Benedicte Jacques, Antti Räty, Joseph A. Ridao Cabrerizo, Dusan Daniska. European Collaborations for Safe and Efficient Dismantling: Digital twins, Ontology and Data Exchange, EPJ Nuclear Sci. Technol. 11, 19 (2025). https://doi.org/10.1051/epjn/2025022

[4] [14] F. Borrmann, F. Becker, V. Hein, I. Szöke, M.-B. Jacques, J.A. Ridao, D. Daniska, F. Patrice. An international approach to nuclear decommissioning ontology, in DEM 2021 – International Conference on Decommissioning Challenges. France, Avignon, 2021 September 13-15 (2021)

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[7] [8] [9] [11] World Nuclear Industry Status Report 2025, https://www.worldnuclearreport.org/

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[13] Maarten Becker, Franz Borrmann. Ontology for mission planning in nuclear decommissioning. DORADO – Third webinar presenting digital technologies.

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[17] A. Räty, M. Becker, F. Borrmann, J. Ridao & DORADO consortium. Digital technologies in DORADO project. 3rd webinar, April 8, 2025

[19] A. Räty, O. Zahra, P. Honkamaa, J. Ridao, D. Daniska (2025). Euratom Project DORADO: Applying Digital Twins and Dedicated Ontology for Robot Assisted Decommissioning Operations

Thank you for your attention!

Any questions?