WP15 DITOCO2030

DITOCO-HERMES JOINT SESSION:

DTwin Insights. Industrial innovation meets nuclear waste challenges. Use cases, functionalities needs and requirements for the sensible implementation of DTwins in DGRs

Co-funded by the European Union under Grant Agreement n° 101166718

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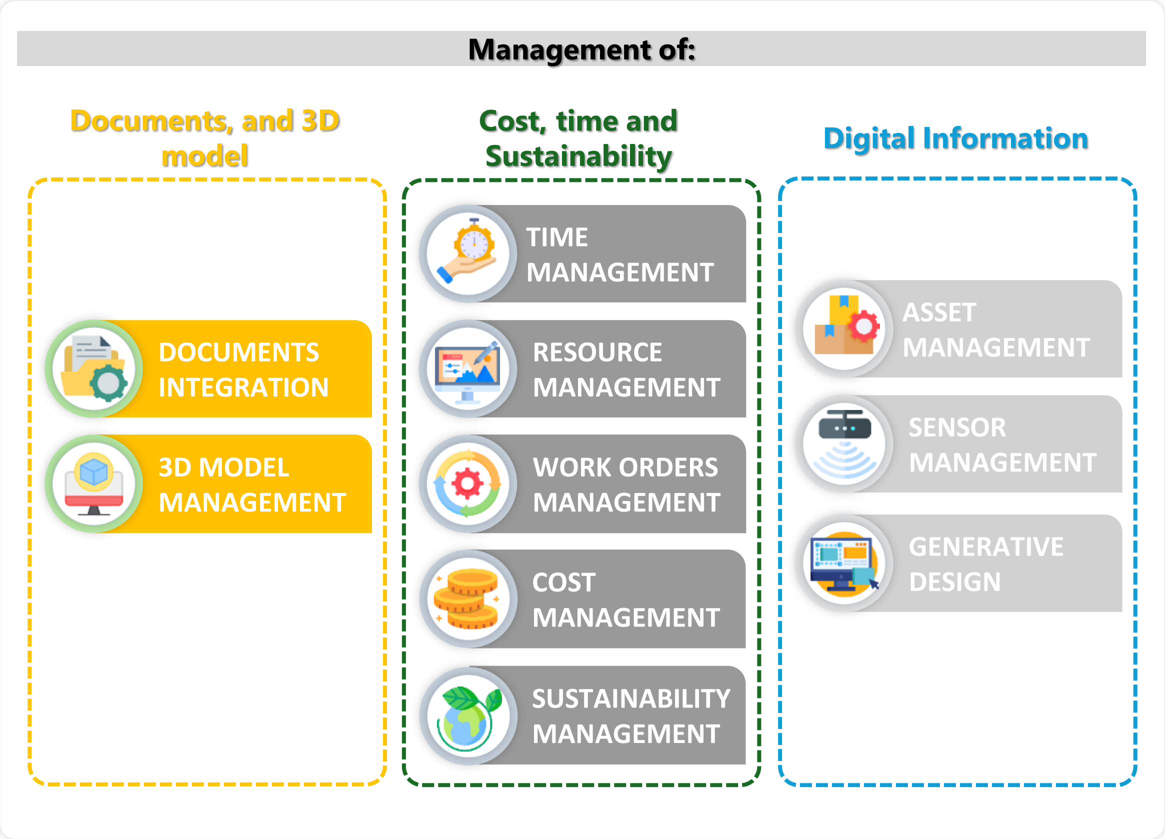
01 – INTRO

DIGITAL TWIN: There are multiple definitions and understanding for digital-twins and we would like to bring in an overview from the industry and its connection to nuclear waste management as well as some examples of their current and potential implementation in DGRs.

INDUSTRIAL INNOVATION MEETS NUCLEAR WASTE CHALLENGES

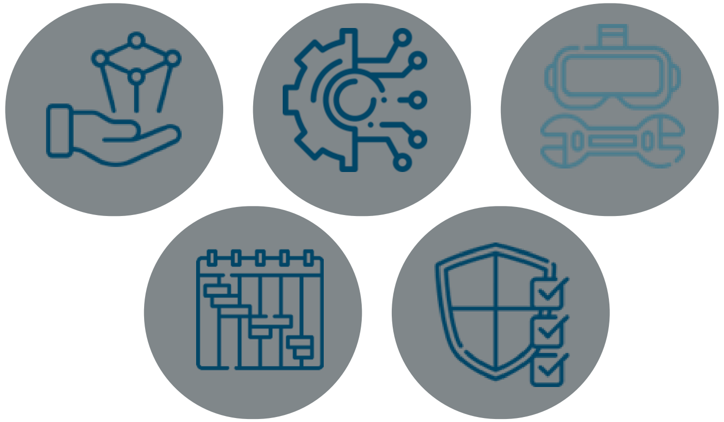
01 – INDUSTRIAL INNOVATION MEETS NW CHALLENGES

DIGITAL TWIN framework is structured to interconnect involved stakeholders of a project, enabling seamless data flow and connectivity while facilitating integrated management, consumption, and use of information instead of isolated processes. Thanks to its flexibility and adaptability, digital twins can integrate effortlessly with any industry need due to its principle of digital information.



DESIGN MODIFICATIONS

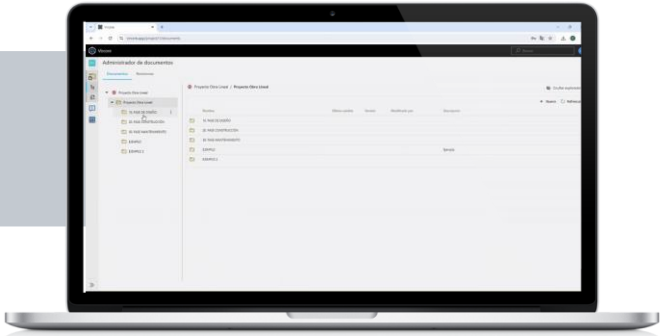
Simulation
Generative Design
AR
Planning
License



DOCUMENT MANAGEMENT

DESIRED FEATURES

- Access control, traceability, audit and change management
- Information container approach, versioning and metadata
- Bi-directional linkage with other elements within the database
- Filtering and searching options guaranteeing quick information retrieval

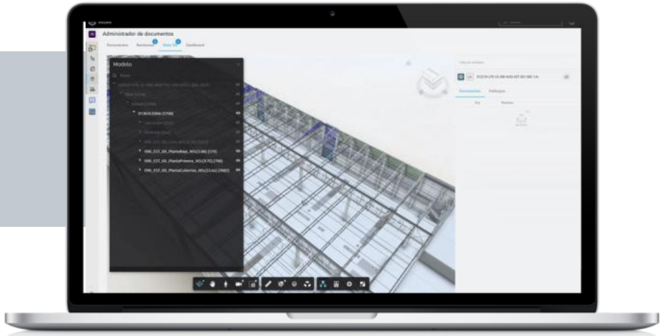


The Document Manager is a **centralized system that ensures file integrity, availability, and security throughout the project**. It supports flexible folder structures, version control, and metadata-based organization, enabling quick search, traceability, and compliance with naming standards, while simplifying document linking and collaboration.

3D PARAMETRIC MODELS MANAGEMENT

DESIRED FEATURES

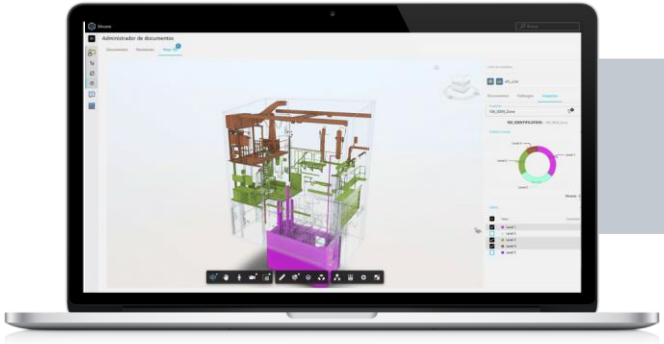
- OPEN BIM and Native Formats
- Advanced Visualization
- Model Federation
- 3D + Linking to Documents / Data
- Inventory Integration
- Scheduling Integration
- Cost estimation Integration
- Integration with other Modules
- Version Control



To **manage and coordinate BIM models** with structured storage, version control, and model federation within a **centralized repository**. It enables discipline-specific model integration, supports clash detection and issue tracking, and provides centralized access for improved collaboration and model accuracy.

MODEL QUERYING

A **centralized platform enabling queries on facility models**, including design data, geometry, and linked documentation, will be essential. As data accumulates throughout the lifecycle, the platform will serve as a complete historical record of design, construction, and maintenance, ultimately forming a digital twin of the built asset.



DESIRED FEATURES

- Overview (including sections).
- Taking measurements.
- Viewing the main properties of each element.
- Searching by type (e.g., material).
- Two-way access from model elements to:
- Linked assets, Documents, Incidents
- Planning tasks

DIVULGATIVE CONTENT

To enable **immersive exploration** of the 3D component of Digital Twins through interactive 3D **visualization and guided walkthroughs**. It allows teams to validate designs, navigate spaces, and collaborate using tools like annotations, layer control, and model comparison.

DESIRED FEATURES

- Walkthroughs for design or operation validation
- Section cuts, measurements, and model annotations
- Layer and discipline toggling (e.g., architectural, MEP, structural)
- Camera presets and guided tours
- Model version comparison

CONSTRUCTION ENRICHMENT

Tracking
Plan Monitoring
Cost Management
Issue Management
QA

PROJECT PLAN MANAGEMENT

To optimize **project management with task creation, real-time scheduling, and 4D simulations linked to 3D models**. It enhances resource allocation by assigning specific teams and provides a graphical dashboard for real-time tracking and project optimization.

DESIRED FEATURES

- Collaborative Planning
- Import or Create from Scratch
- Calendar Management
- Dependency Management
- Resources Management
- Cost Management
- 4D / BIM Model Integration

COST MANAGEMENT

DESIRED FEATURES

- Collaborative Cost Estimation
- Import BC3 or from Scratch
- Budget Comparison
- Certifications Management
- Advanced Report Generation
- BIM-5D Model Integration

Enables detailed, **collaborative cost control** with support for OpenBIM (BC3), .xls, and .csv formats. It offers real-time editing, budget comparison, and design-linked analysis, helping teams make informed decisions. Automated invoicing and customizable reports in PDF/Word formats ensure clear, efficient cost tracking across the project lifecycle.

AUGMENTED REALITY / VIRTUAL REALITY

DESIRED FEATURES

On-site data access:

- Display of real-time data and access associated documentation like specifications and manuals.

Job tracking:

- Visualization of designs in real-world
- Validation of correspondence between design and execution.

Training:

- Use by technicians to gain detailed knowledge of the project.

Augmented Reality

Virtual Reality

Based on **immersive environments** that enables **visualization, interaction, and analysis of digital models** in virtual reality (VR) and augmented reality (AR). It enhances project understanding, supports collaborative review, and optimizes design, construction, and maintenance processes through interactive experiences.

OPERATION, MAINTENANCE AND MONITORING

Monitoring
Asset Manager
QA
Decommissioning and dismantling

AUGMENTED REALITY / VIRTUAL REALITY

MAIN FEATURES

On-site data access:

- Display of real-time data and access associated documentation like specifications and manuals.

Job tracking:

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Identification | **Characterization** | **Waste Package Generation** | **Transport** | **Treatment** | **Storage**

SENSORS MANAGEMENT

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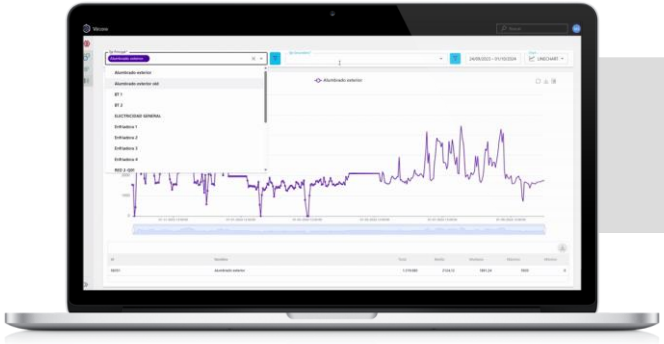

DESIRED FEATURES

- Collaborative Planning
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- Calendar Management
- Dependency Management
- Resources Management
- Cost Management
- 4D / BIM Model Integration

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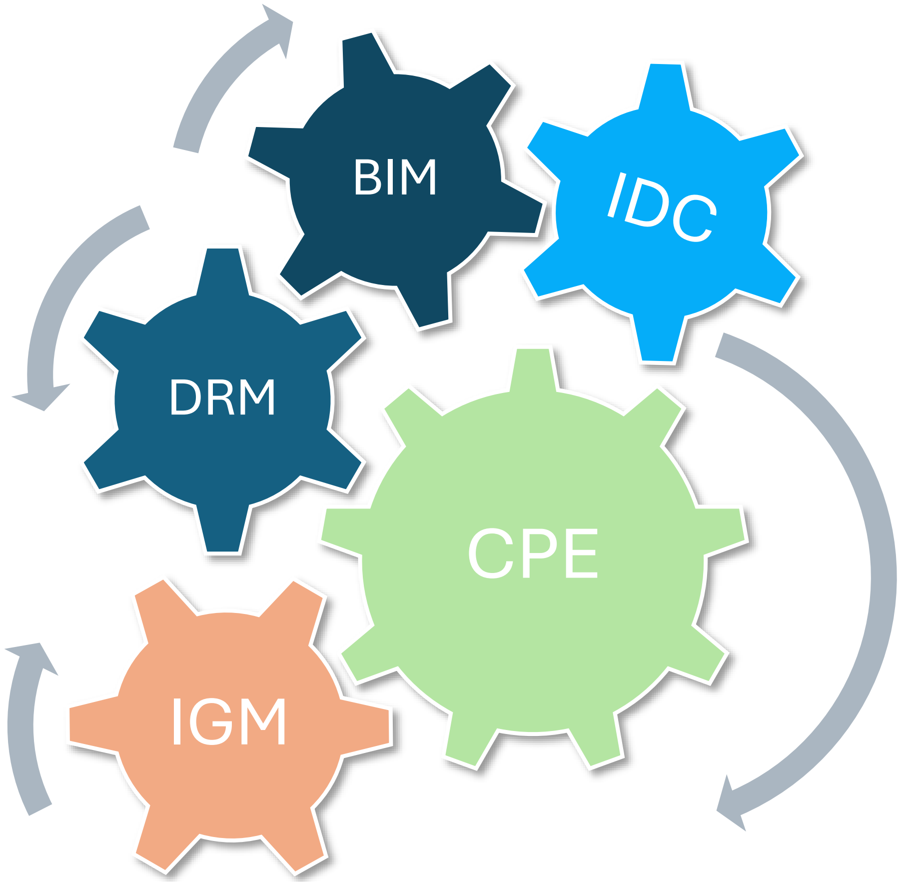
DEEP GEOLOGICAL REPOSITORIES DT SUCCESS STORIES

NAGRA'S INTEGRATED DIGITAL ENVIRONMENT



- **Integrated Geo-Model (IGM)**

→ *Subsurface representation and evolution*

- **Building Information Modelling (BIM)**

→ *Engineering design and construction information*

- **Dynamic Repository Modelling (DRM)**

→ *Safety and Performance Assessment*

Main modelling components

- **Common Project Environment (CPE)**

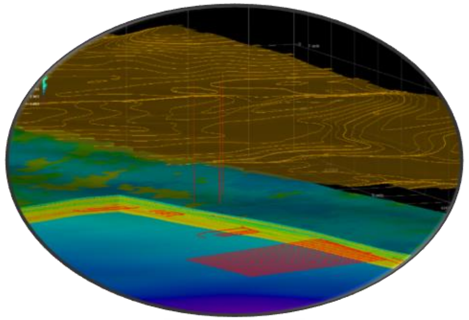
→ *Reference configuration, requirements and change*

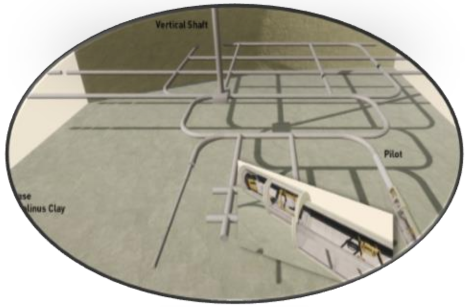
- **Information & Data Centre (IDC)**

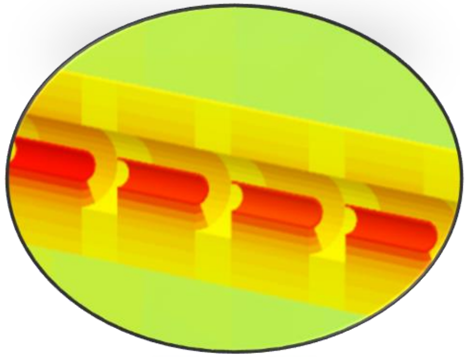
→ *Storage, archiving, provenance*

"Anchors"

HOW IS THIS UTILISED IN THE SWISS PROGRAMME



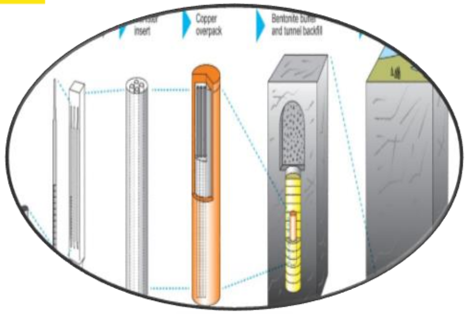


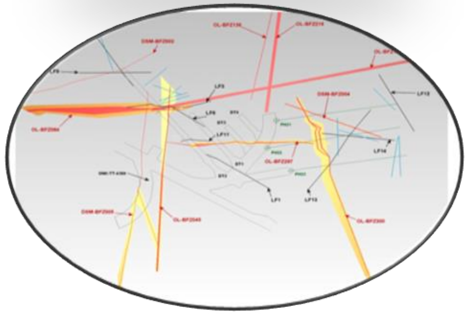


- Streamlining of data, resources & analyses
- Access to entire organization via “single-source-of-truth”
- Implementation digital engineering
- Implementation digital safety case
- End-to-end integration
- Change & configuration management

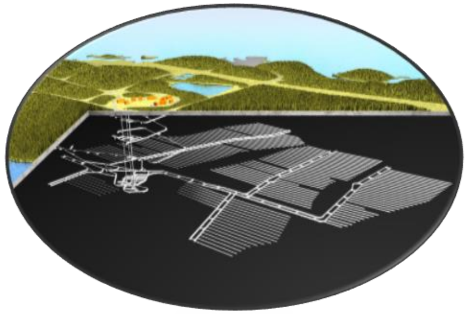
- Project development towards construction
- Repository optimization
- RD&D needs

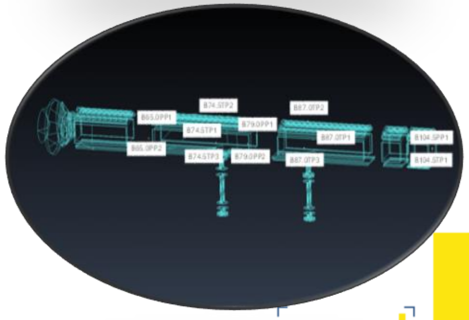
MITTA'S DIGITAL TWIN APPLICATION IN DGR





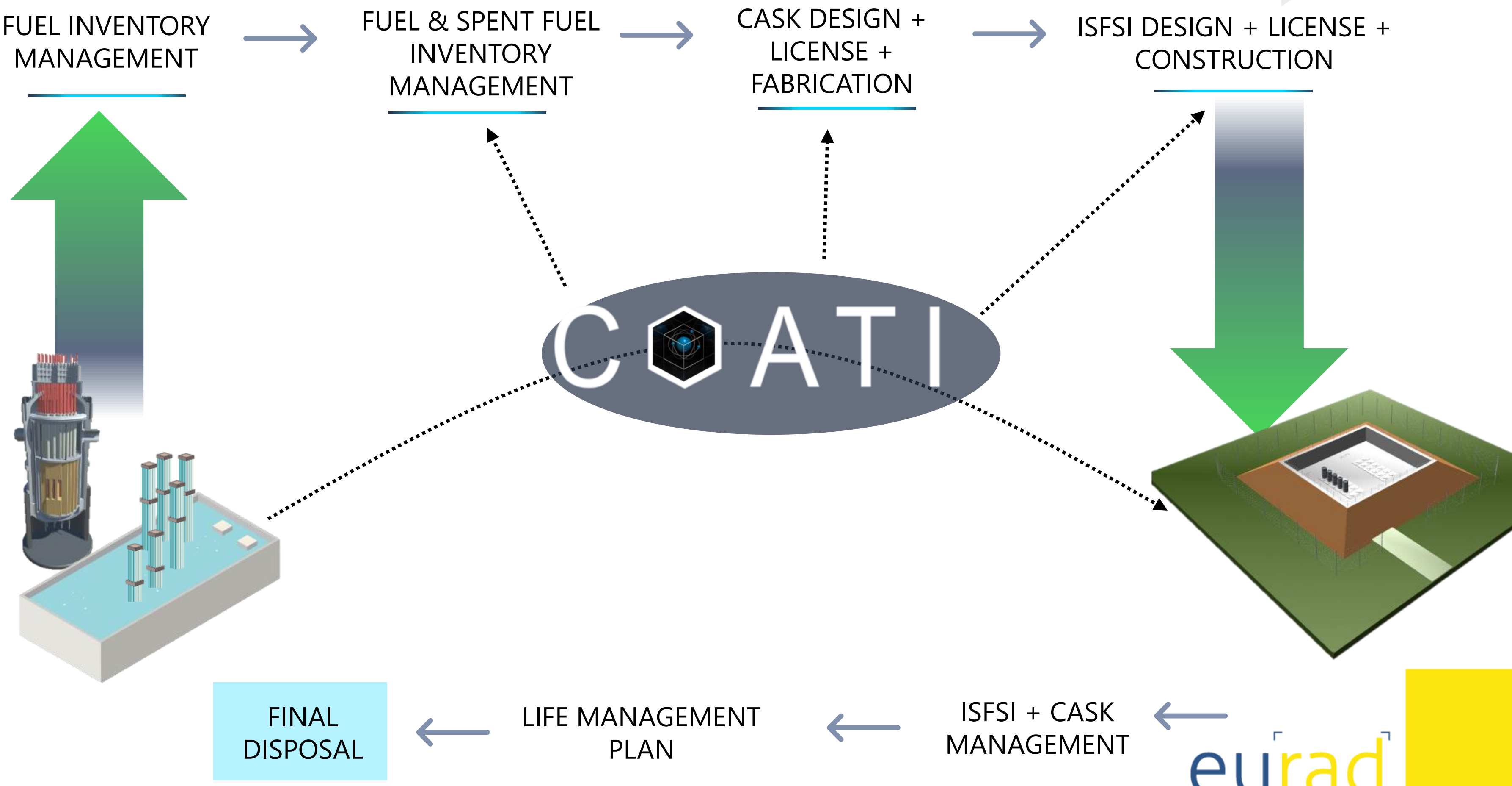
- Thermo-hydro-mechanical simulations - 5 degrees of freedom
- Simulation – CODE_BRIGHT
- Geometry definition for each canister dimension
  - Simulation on real geometry based on CAD files
  - CAD postprocessing required. Coordinate transformation
  - Mesh Generator GiD / FLAC / PLAXIS CONSIDERED
- Transformation process. CAD (dxf/dgn) → RHINO→ IGES → GiD
- Include fractures with the right positioning and orientation.
- Fracture simulation
  - Sensors identified with elements of the mesh. Compare sensor and simulation data.
  - Scalar, vectorial and tensorial measurements





COATI

COATI, by its Spanish acronym: ***C****arga* ***O****ptimizada de un* ***ATI,*** is an informatic system that Supports the management of spent fuel stored in nuclear power plant pools, helping to optimize ISFSI loading and minimize operational costs after final shutdown. Software supported by **VIRCORE** environment.



POTENTIAL FUNCTIONALITIES AND EXPECTATIONS

NAGRA'S DESIRED FUNCTIONALITIES / EXPECTATIONS ON DT

- **Compatibility with industry standards and evolving project requirements**
- **Cutting-edge technologies (e.g., high-fidelity modelling, leveraging AI/ML and AR/VR, data quality management, digital thread integration, etc.)**
- **Flexible, scalable, maintainable, upgradable, interoperable tools**
- **Full connectivity, control and access within our organization's digital ecosystem**
- **Compliance with regulatory frameworks and requirements**
- **Compatibility with IT workflows and requirements, robust cybersecurity and access controls**
- **Intuitive user interfaces with role-based access, customizable workflows and knowledge transfer support**

…And numerous specific functionalities (safety, cost/ROI tracking, resources tracking, …)

OTHER WMOS'S DESIRED FUNCTIONALITIES / EXPECTATIONS ON DT

- Collaborative working
- Single source of truth
- Linkage and traceability across deliverables, reports, input data and hypothesis during the whole lifecycle of the asset. - Bi-directional linkage across entities in the system.
- Process simulations, minimize dose rates in the performance of activities.
- Estimation of the amount of waste allocated to each waste route and simulation of the effects of different treatments in the overall cost and declassification of materials.
- Remote understanding and control of the process and activities occurring in the plant.
- Track record / traceability of components during the operating lifespan, removal, treatment, segmentation and packaging.
- Resource allocation. Multiproject planning connecter to workorders, project plan tasks, reports etc.
- Sensoring and real-time decision making supported AI generated projections and simulations

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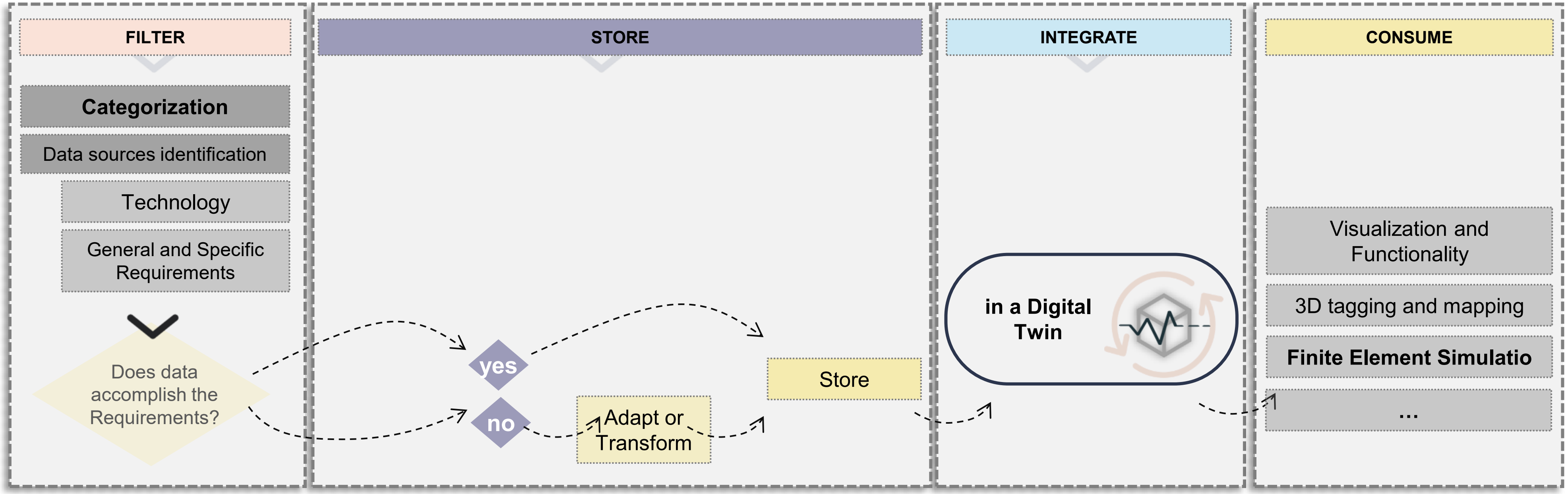
STANDARDIZATION AND REQUIREMENTS

A fully simulated reality depends on high-quality, consistent input data. The first step is to **Identify Data Sources, locates and categorizes relevant inputs**, recognizing a "Layering System" of data. These layers include location-based data, 3D visual reality capture, IoT, P&IDs, 3D models, geological information, image databases, live sensors, and more, ensuring a comprehensive digital asset map for integration.



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Recognize and understand general data integration landscape.

Identify data sources

Fully Simulated reality

Identify workflows, layers, sources and general data included for its consumption within the DRE of Fully simulated Reality.

IoT and Design data

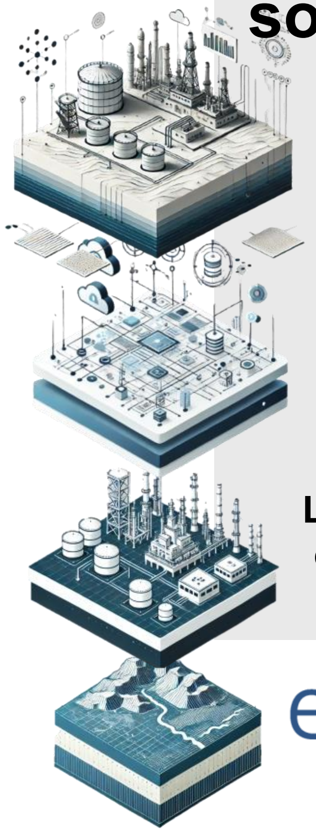
Identify data that is feeding and enriching the system. This may include real-time sensors, or connected devices as well digital representations of physical structures, systems or objects included 2D and 3D files, engineering draws, P&IDs, 3D models, Specifications, etc.

3D Visual Reality Capture

Identify data directly captured from **Reality**. Coming form high-fidelity representations of physical environments. This may include 3D scanning and imaging, laser, drone, etc.

Location

Detect location or physical world data. This may include data that defines its position, geography, coordinates, assets, environment or Geospatial data.



Locate and categorize data.

To ensure the efficient management of assets, **it is essential to adopt a coding system and a classification system that allows each asset to be uniquely identified throughout its entire lifecycle, along with the data that must be associated with it at each stage of the lifecycle**.

Coding & Naming System

The adoption of a coding system allows the establishment of coding guidelines for assets, their properties, and classification levels, ensuring that all stakeholders use a common nomenclature. This facilitates the identification, location, and management of assets and their data.

Parameterization of the Unique Code

Identifying the information or data that should be included in the asset's unique identification code, based on the concatenation of fields.

Parameterization of the coding

Identifying the information to be included in the classifications of the assets, enabling quick searches and efficient management of homogeneous data.

Coding length

Limiting the length of the name or value, using domain tables to ensure consistency in the nomenclature.

Configuring the coding

Developing a model with coding associated with each classification approach and asset phase, ensuring uniformity in the data.

Classification System

This proposal is based on the **implementation of a structured classification system for asset categorization**, ensuring standardization of criteria and codes.

It is essential to conduct a thorough analysis of the nuclear sector existing classification and identification system used for categorizing operational systems and components. It must evaluate the classification approaches applied (function, material, location, discipline, related to safety etc.) and assess their impact on both the physical asset inventory and the adopted coding framework. Furthermore, it is essential to assess the cross-impact of classification on other information systems related to procurement and warehouse management, ensuring data consistency and seamless integration at the corporate level.

Main advantages

- Standardization and harmonization of criteria
- Enhanced search, filtering and analysis
- Integration of information and data with assets
- Interoperability of data across systems
- Support for predictive maintenance and strategic planning

CFIHOS

- *Capital Facilities Information Handover Specification*
- *KKS - Kraftwerk-Kennzeichensystem)*
- *NAICS - (North American Industry Classification System)*

Interoperability and information exchange must be guaranteed within today's technological ecosystem. Therefore, it is essential to adopt a solution focused on compatibility with open standards. The proposed solutions will be compatible with various open market standards for consuming data and information required for project development.

Open Standards

2D / 3D Models

1. **IFC** (Industry Foundation Classes)
2. **STEP** (Standard for the Exchange of Product Model Data)
3. **DXF** (Drawing Exchange Format)
4. **STL** (Stereolithography)
5. IDS

Process and Control Data Exchange

1. **OPC** (OLE for Process Control)
2. **BPCS** (Basic Process Control System)

Asset Management & Maintenance

1. **MIMOSA** (Maintenance, Integrity and Management of Asset Systems)
   1. **OSI-PI** (Open System Interconnection Process Integration)
   2. **OpenO&M** (Open Operations and Maintenance)
   3. **ISO 15926**

Interoperability with Open Standards

P&IDs

1. **XML** (Extensible Markup Language)
2. **ISO 15926**: Industrial automation systems and integration — Integration of life-cycle data for process plants including oil and gas production facilities

GIS

1. **GML** (Geography Markup Language)
2. **Shapefile** (.shp, .shx, .dbf, Esri)
3. **GeoJSON** (web)

Legacy info Update Strategy

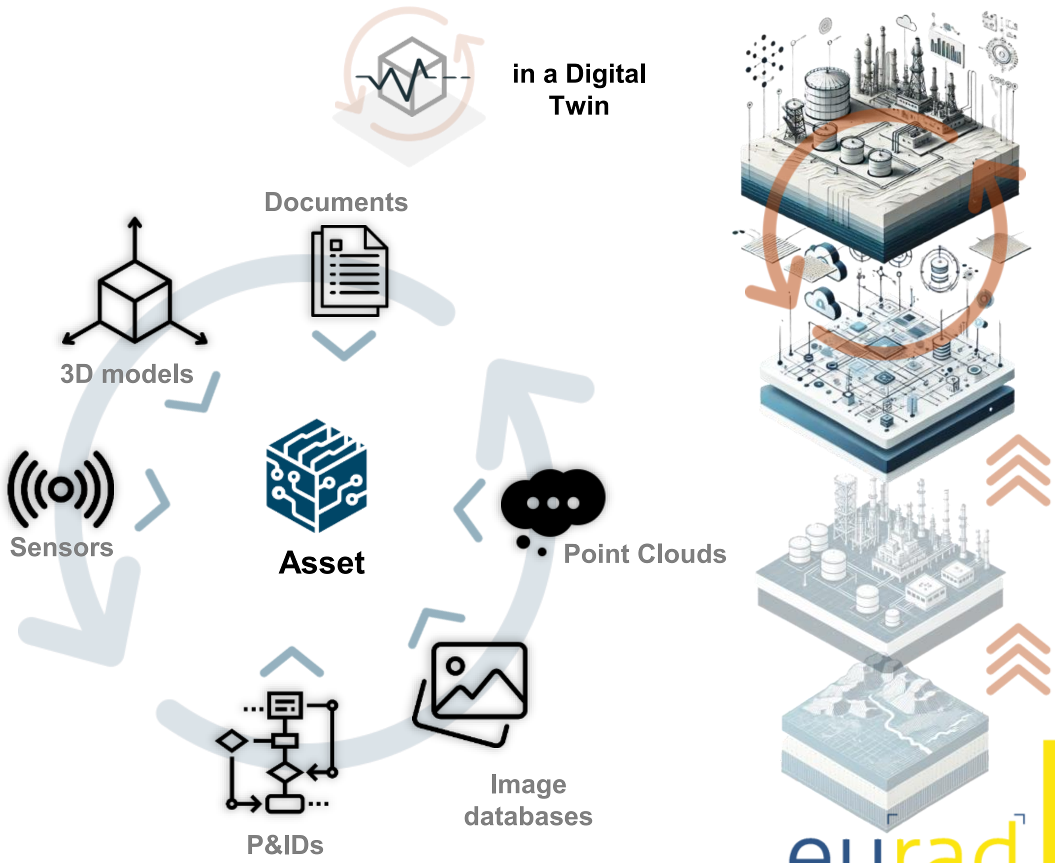
1. Identify existing **models and data sources**
2. **GAP analysis.** Background info – proposed.
3. **Matching and mapping** of identification codes across systems.
4. **Strategy proposal (**open formats, migration to desired proprietary formats**) for**
   1. Geometric Information
   2. Data
   3. Hard copies

Digital Twin Creation

All information will be integrated by establishing **bidirectional links** between the different managed items, ensuring that the **data is interconnected for collective consumption**. This will ensure that data is not handled in isolation, but rather that the benefits of global data consumption are maximized, supporting informed decision-making and process optimization through a unified data view.

At this stage, the **relationships** between the digital representation of assets, point clouds, documentation (reports, technical sheets, 2D models, etc.), incidents and work orders, planning tasks, and others will be established.

Development and implementation of **auditing mechanisms** for the relationships between the different entities managed by the solution, aiming to ensure that these relationships are appropriate, and that data consumption is guaranteed to be **unified and centralized**.



So....

W win

Q&A