Digital Twins

Needs, examples and opportunities in the nuclear back-end

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IFE, Institute for Energy Technology

Renewable energy | Nuclear technology | Materials technology | Digitalization | Radiopharmacy and health | Oil and gas | Industry and environment | Safety and security

Host of the OECD NEA Halden HTO (earlier HRP) project

The first designated IAEA International Collaborating Centre in the field of nuclear decommissioning

Founding member of the
Cluster for Applied AI &
Cluster for Decom. and Repurposing

What is a Digital Twin?

Originated in 2002 (attributed to Michael Grieves, then of the University of Michigan)

First practical definition from NASA to improve physical model simulation of spacecraft in 2010

Wiki: A virtual representation that serves as the real-time digital counterpart of a physical object or process.

Gartner: A digital representation of a real-world entity or system.

75% of Organizations Implementing IoT Already Use Digital Twins or Plan to Within a Year (2019)

*Often mentioned in connection with: **Robotic process automation, Predictive analytics** and **AI***

A Digital Thread is "the use of digital tools and representations for design, evaluation, and life cycle management."

Digital Twin characteristics

Connectivity between the physical component and its digital counterpart – sensors

Homogenization of data: **Decupling** form the physical form. **Sharing** of information.

Reprogrammable and smart: Based on analysis of sensor data and predictions

Digital traces: Analysis of data on a time scale

Modularity: Customization and improvement (of specific modules only)

Simulator a machine designed to provide a realistic imitation of the controls and operation of a vehicle, aircraft, or other complex system, used for training purposes.

Degree of data & info flow

Digital Twin

Digital footprint/Shadow

Digital model e.g., CAD model of the object/process

Digital Twins

Coupled or Decoupled
One or two way connection

- Physical objects
- Physical processes
- Sensors

Physical objects/process

Digital Twin

- Digital models
- Process simulations
- Sensor data
- User interfaces
- Physics models
- Digital footprint
- AI agents
- Predictions for future
- Shared data
- Training environment
- Control interface
- …

Innovation needs and opportunities (in the nuclear back-end)

Based on OECD HRP (now HTO) interviews, DigiDecom group discussions, SHARE H2020, PLEIADES H2020, PREDIS H2020, NEA-EGRRS, …

Holistic digital transformation

Digital Twins

Robotics (process automation)

Horizon Europe: Ai, Digitalisation and Robotics

Digital Twins in the nuclear (back-end)

What, if anything, is special?

- Safety critical processes/environments => stricter requirements for qualification
- Specific (nuclear/radiological) hazards => need for specific data types, models and sensors
- High demand on value propositions => more difficult to introduce new technology

  BUT, also higher need for new techniques for safety insurance

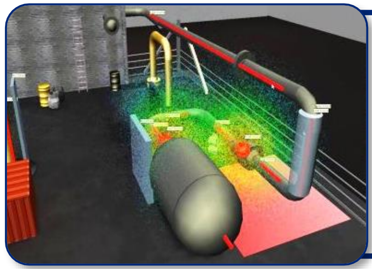
Digital Twins in the nuclear (back-end)

Some important ingredients

- BIM + Standardized, nuclear specific ontology
- Nuclear/radiological models (in addition to other)
- Framework for qualification / safety assurance
- Support for AI – e.g. Crowd sourced data
- Cyber security considerations and solutions
- Integration with robotics
- 3D and radiological mapping techniques
- Pilot applications and sharing of experience

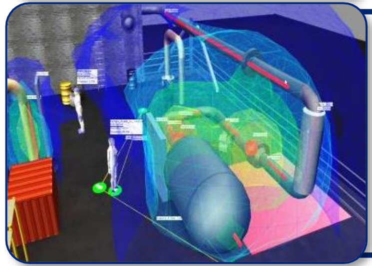
Connectivity
Homogenization of data
Reprogrammable & smart
Digital traces
Modularity

IFE VRdose™ family



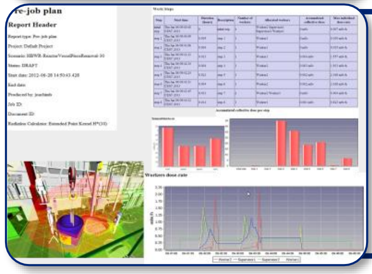
Visualize

- Environment
- Hazards (radiation)
- Work process



Optimize

- Explore (the effect of changes)
- Compare alternative scenarios

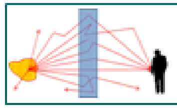


Demonstrate & document

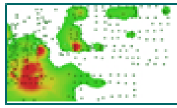
- 3D simulation (playback)
- Printer-friendly reports

Train / field support

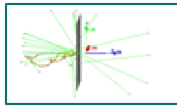
- XR interactive experience
- Trainee performance evaluation



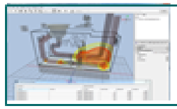
Improved deterministic radiation transport
Accuracy, applicability, output detail



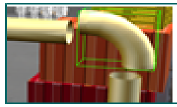
Geostatistical analyses of radiation data
Kriging and other interpolation techniques



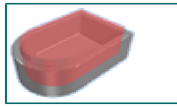
Monte Carlo radiation transport modelling
Interface with MCNP (GEANT4 in progress...)



Source deconvolution
Find activities and positions of radiation sources



3D modelling functions
Model splitting and cutting functionalities



Constructive solid geometry editor
Complex shaped radiation sources and shields

Diffuse radiation sources, enhanced reporting, import functionalities, ...

Nuclear DTw ingredients

- Nuclear ontology
- Nuclear/radiological models
- Qualification / safety assurance
- Support for AI- crowdsourcing
- Cyber security
- Integration with robotics
- 3D and radiological mapping
- Pilot applications

PLEIADES: PLatform based on Emerging and Interoperable Applications for enhanced Decommissioning processES

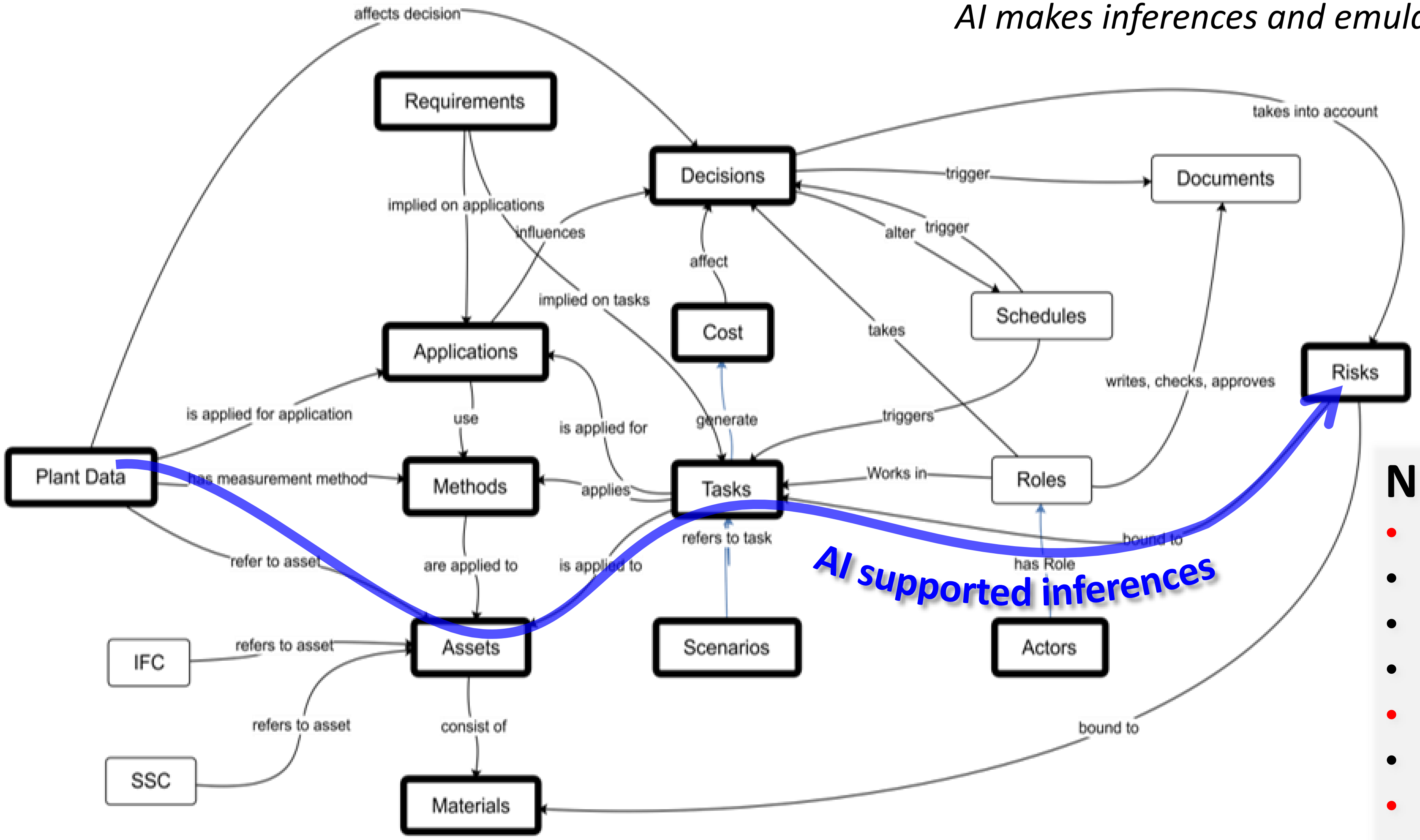
PLEIADES

Smarter Plant Decommissioning

Demonstrate a **modular** software **ecosystem** based on interconnection of front-line support tools through a decommissioning specific **ontology** building upon **open BIM** (IFC).

Otology powered AI support

Knowledge base (codified info) → Ontology (associations) →
AI makes inferences and emulates human performance



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RoboDecom project - UGV ecosystem

UGV systems

nLink

3D scanning / hazard mapping

CREATEC

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Service arms & 3D printed components

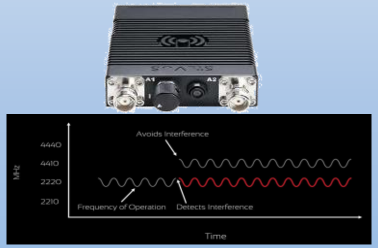
AIIinvent

Tool reck

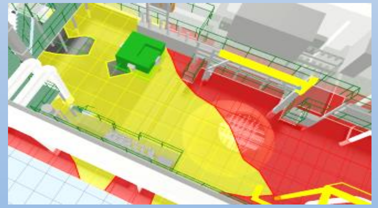
+

DTw tech enabled systems

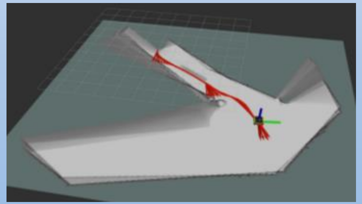
Comptology



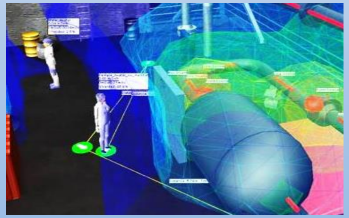
In-the-field data analyses / visualisation



SLAM



Mission planning



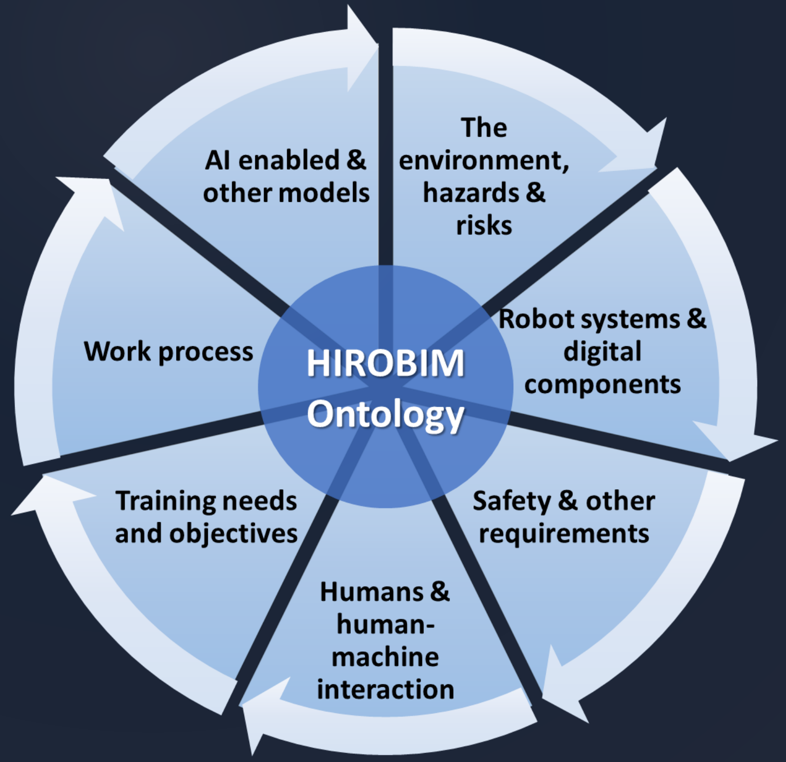
XR mission control and visualisation

IFE

SINTEF

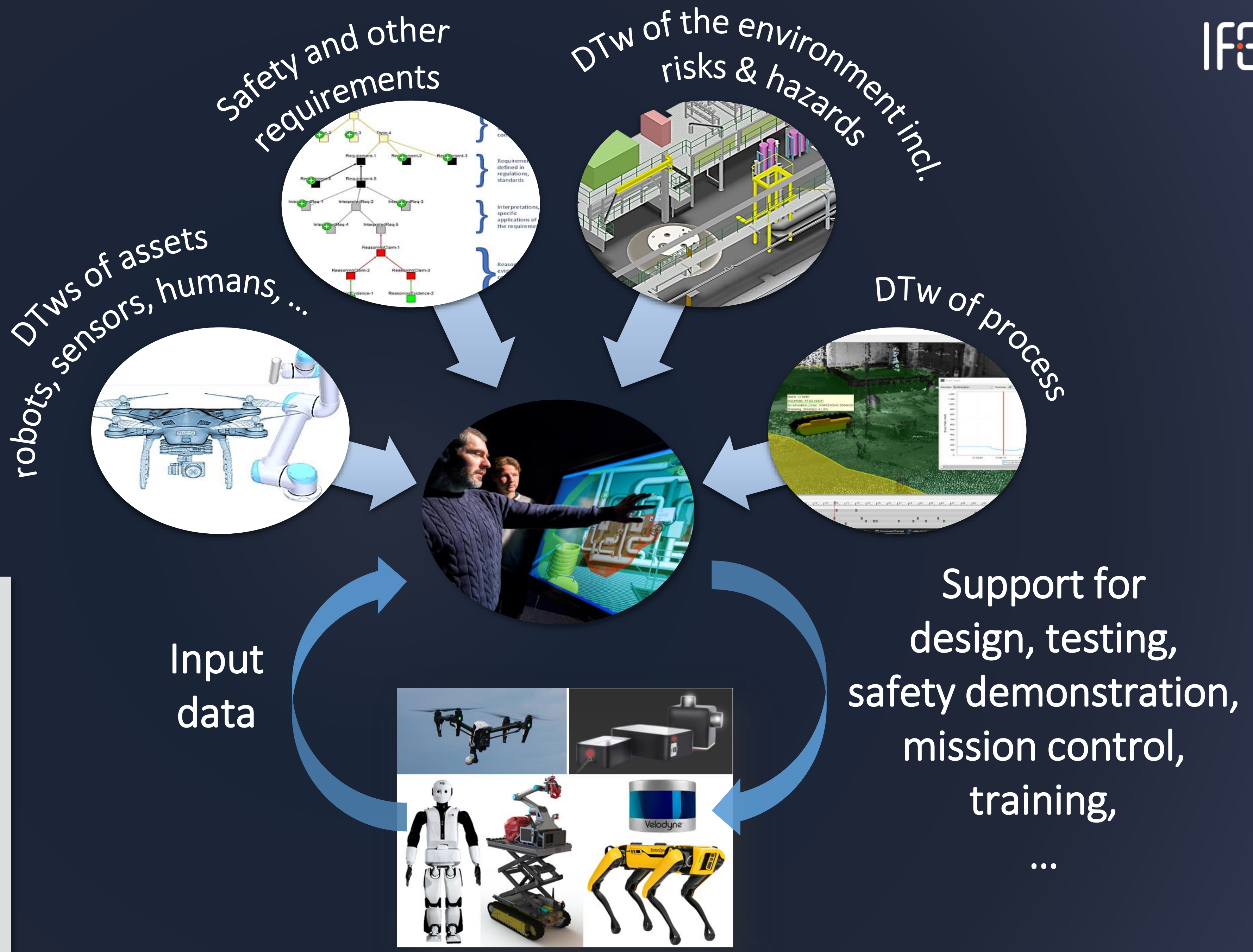
AIIinvent

HIROBIM
AI powered support for Hazard Intelligent ROBot deployments using BIM



IFE
iUS
INESCTEC
PAL ROBOTICS
Alpha Consult
Catenda
createc
cea
Puerto de Cartagena
Autoridad Portuaria de Cartagena
Schlumberger

HIROBIM & HADRON



Physical assets (robots, sensors, humans, …) and processes

Nuclear DTw ingredients
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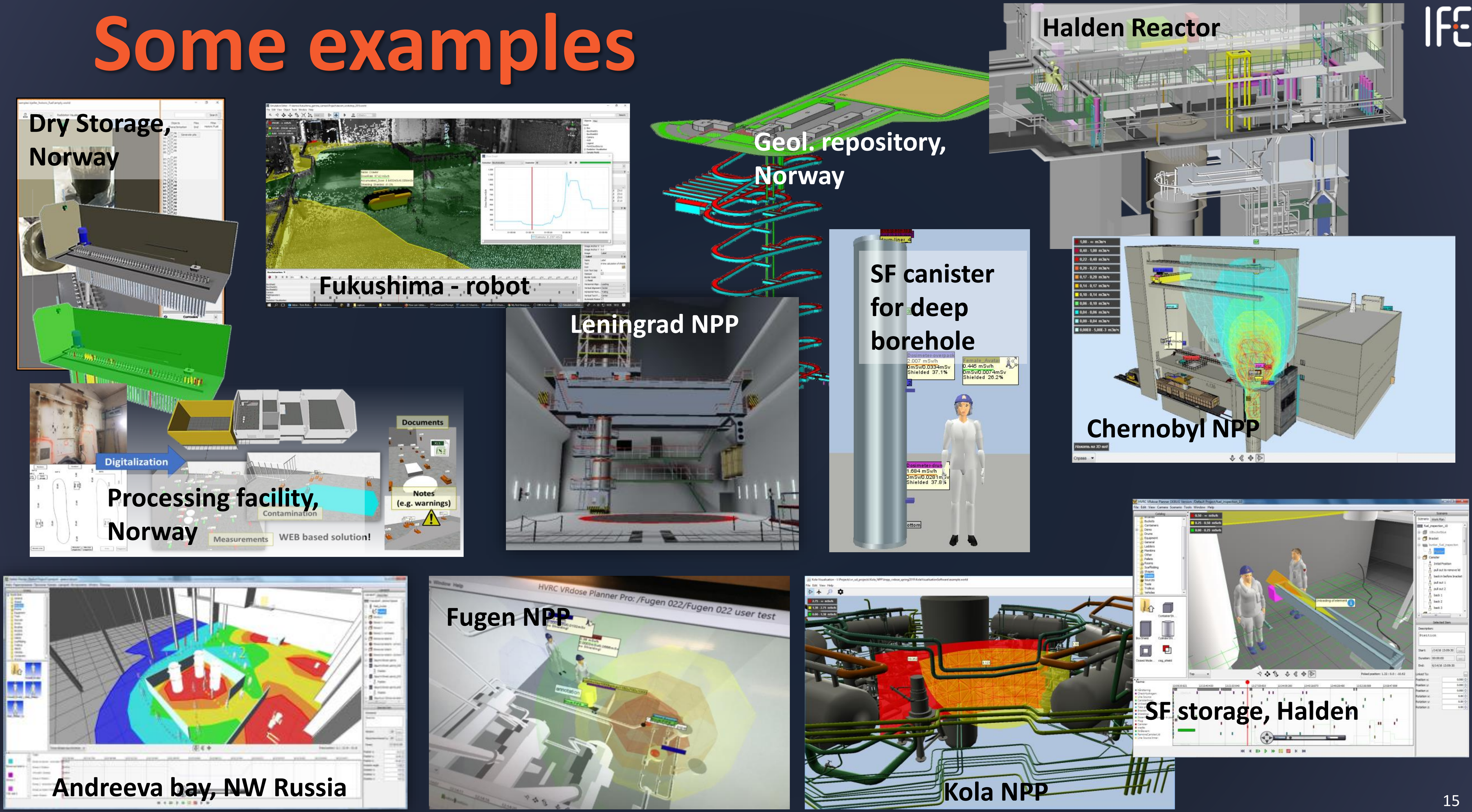
Some examples



SMART INNOVATION NORWAY | IFE | NEA NUCLEAR ENERGY AGENCY | NND NORWEGIAN NUCLEAR DECOMMISSIONING | VTT | Net Zero Technology Centre – Technology Driving Transition

HALDEN PROJECT HTO | actimondo | EPRI | Norsk Petroleumsforening

DECOM cluster for decommissioning

DigiDecom 2022

2022 October

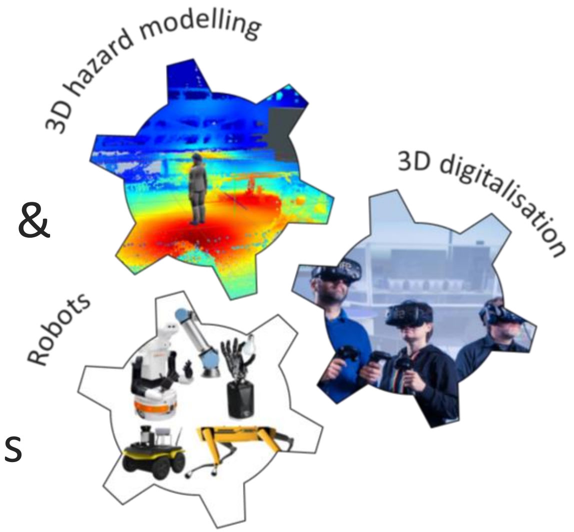
Norway - hybrid event

IAEA International Atomic Energy Agency

Institute for Energy Technology (IFE)

IAEA Collaborating Centre

Hazard
Aware
Digitalisation &
RObotics in
Nuclear &
other domains



AI, data and robotics powered transformation for a sustainable decommissioning in nuclear and other industries

www.smartinnovationnorway.com/events/digidecom-2022/