

# Digital innovation for robotics applications in decommissioning



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# The market need

## In general:

- Technologies like IoT, sensor tech and UVs\* are overcoming the primary obstacle (i.e. acquisition of 3D input) for enabling **integrated digital support systems**
- **Robots are becoming feasible alternatives to humans** in **Dangerous, Dirty, Dull, Dear** (the 4 Ds) and Strenuous jobs

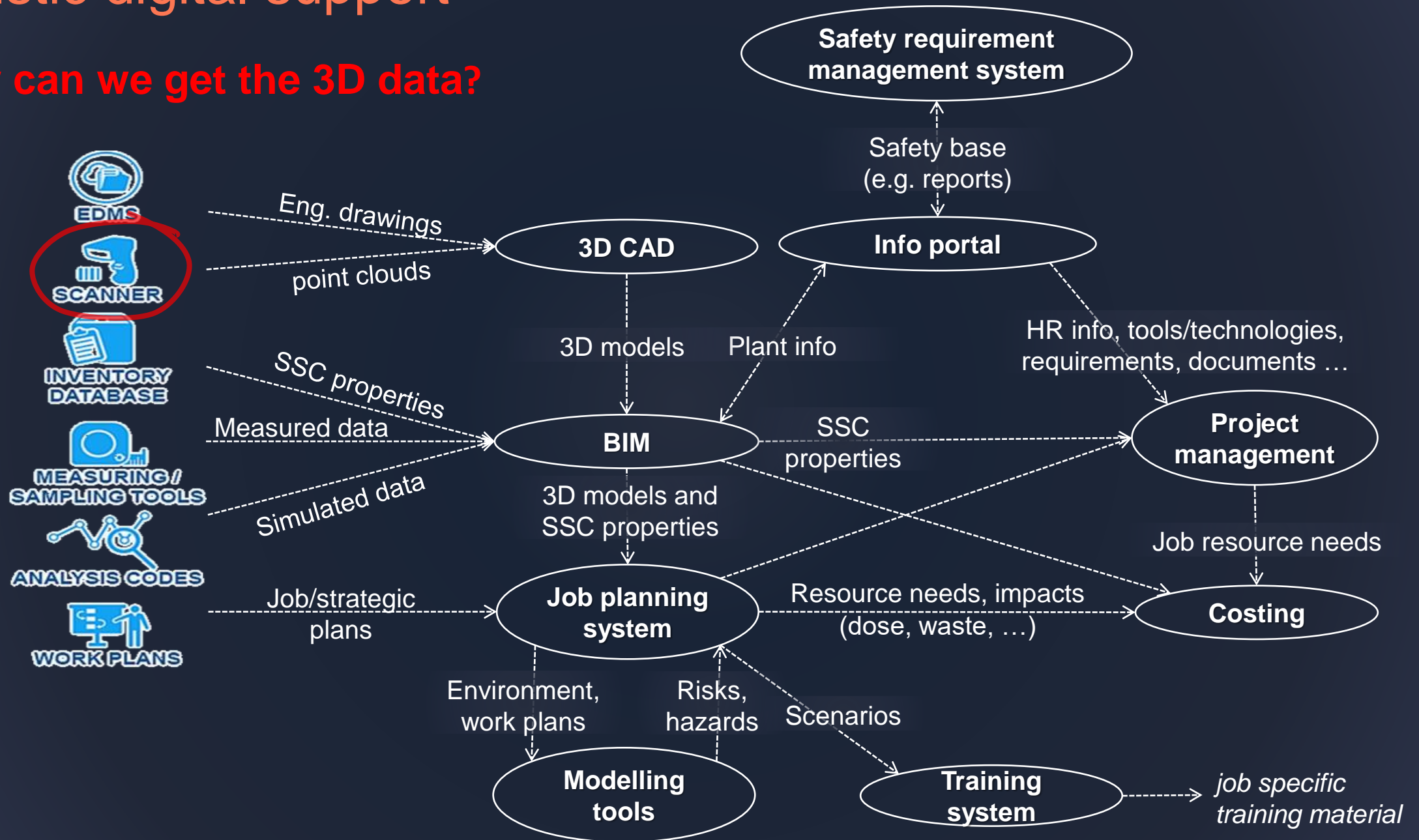
## In environments with industrial hazards e.g., nuclear decom:

- Integration with **hazard awareness** ('hazard intelligence') has high potential

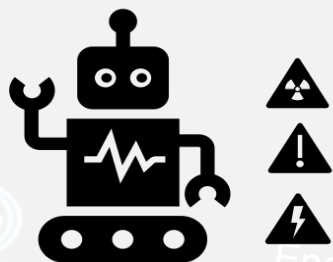
*\*UV: Unmanned Vehicle*

# Holistic digital support

## How can we get the 3D data?



# Holistic digital support with robots



Unmanned Robotics  
& Sensing

Targeted & regular surveys

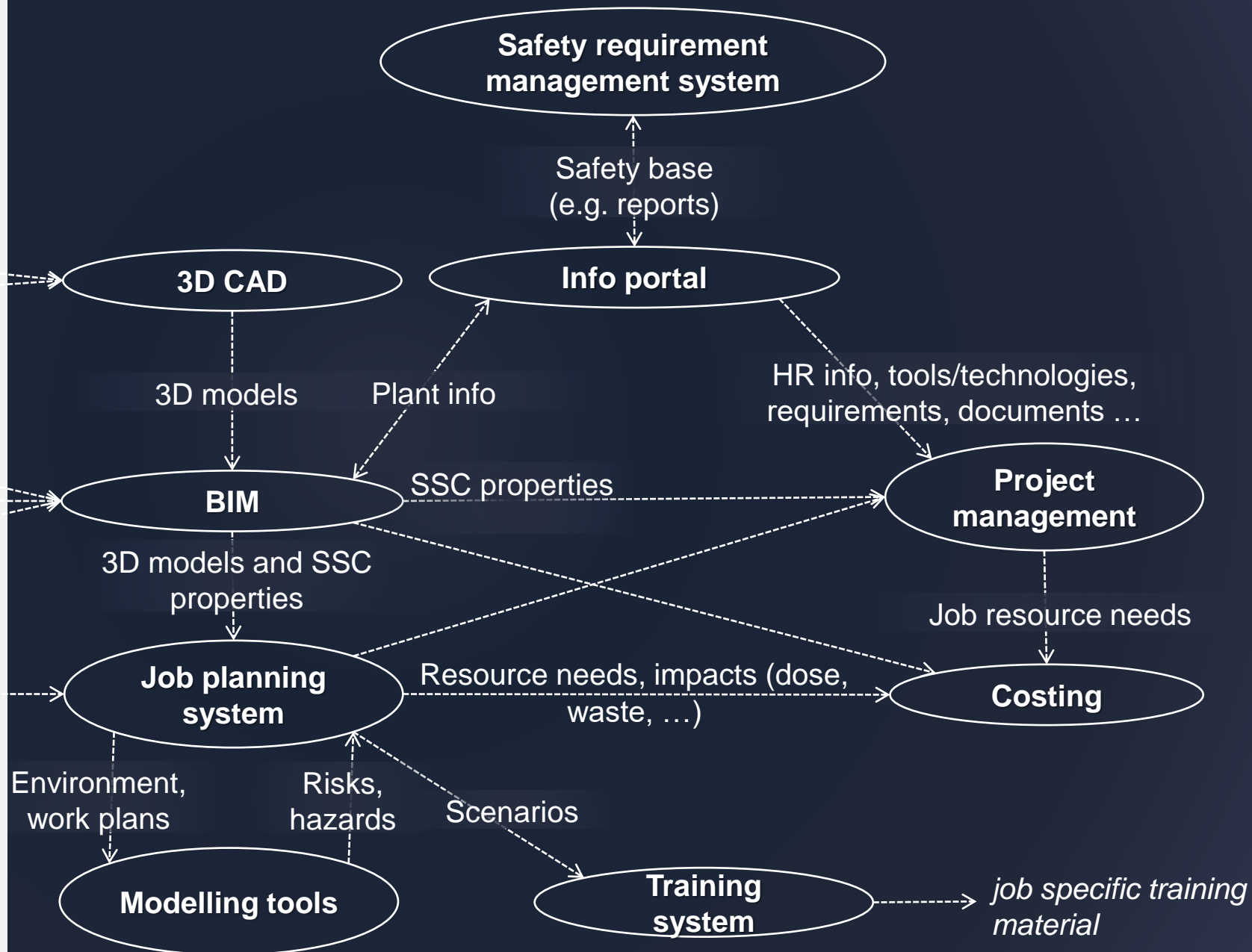
- Update **facility/site** model

- 3D scans
- photos, videos, ...

- Update **hazard** map

- Measurements & samples (radiological / other)
- Detect other dangers

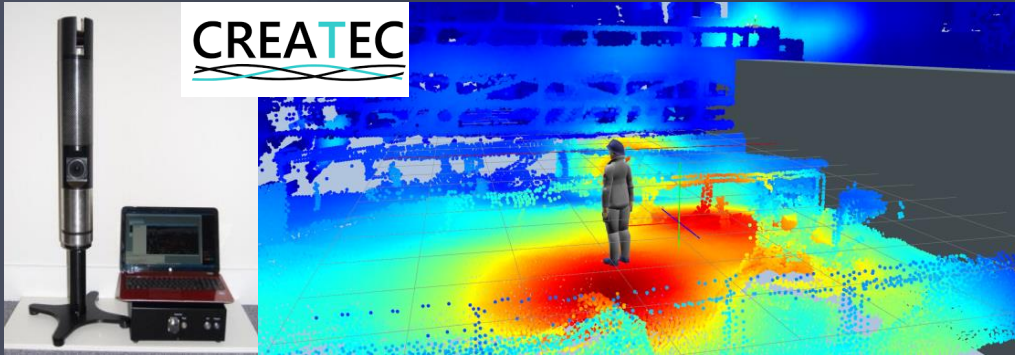
- **Other** info





# Robots and sensors for 3D support

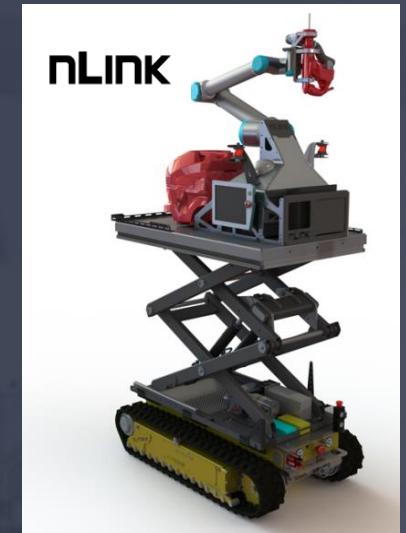
- New cheap tech for 3D data



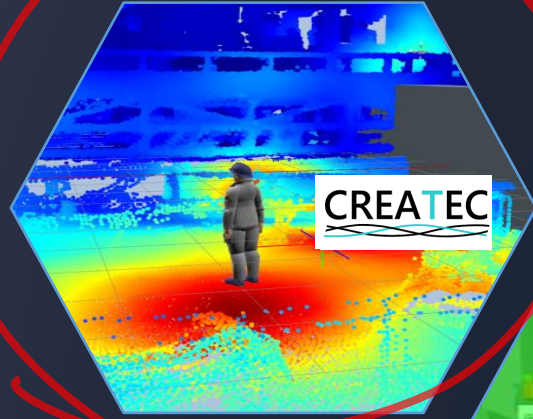
- New tech integrating 3D data acquisition into hazard mapping



- New tech for deploying sensors/samplers – remote/robotic/autonomous systems



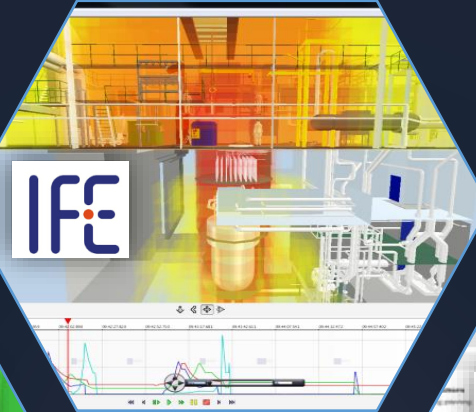
3D radiological mapping  
**N-Visage/Recon**



Characterisation  
**RadPIM**  
(VRdose family)



Job planning  
**VRdose**



Costing  
**Aquila costing**



Scheduling  
**Standard PM tools + Live**



BIM  
**BimSync**



Training  
**Simulation Editor**  
(VRdose family)

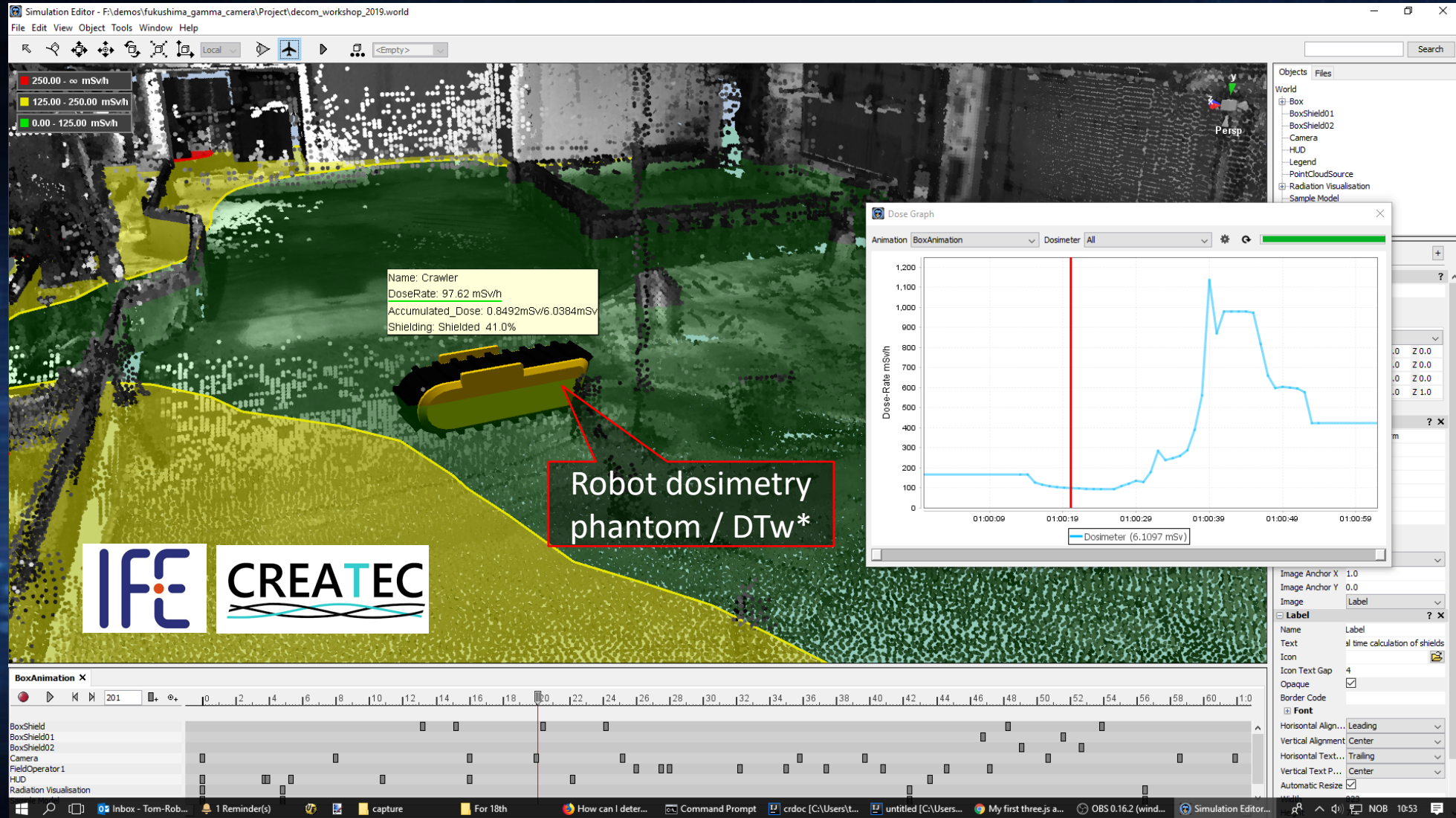


Info Management  
**iUS IMS**

Safety demonstration  
**InStructT**



# 3D digital support based on activity point clouds



Simulation of radiation burden to robot in Fukushima

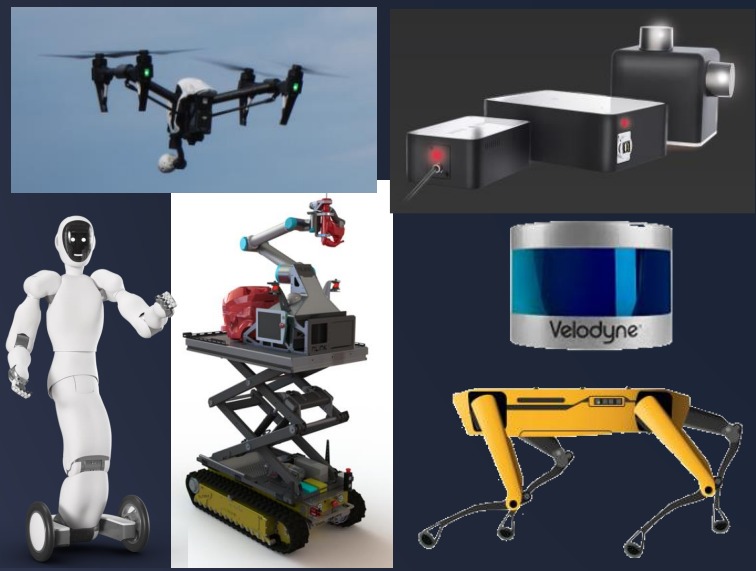
\*DTw: Digital Twin

# Robots digitalisation

Support design, testing,  
safety demonstration,  
control,  
training,  
...

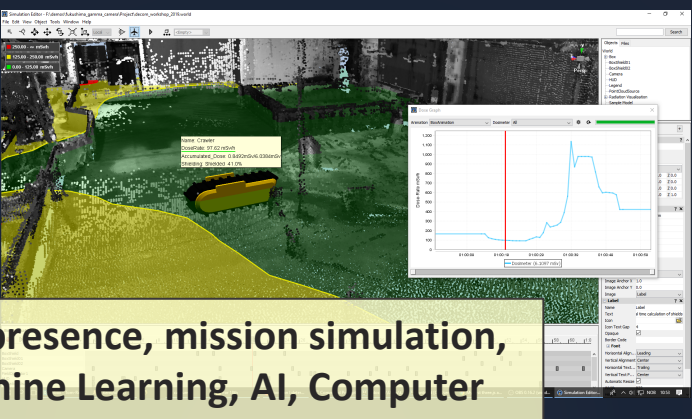
Input data

## Robots & sensors

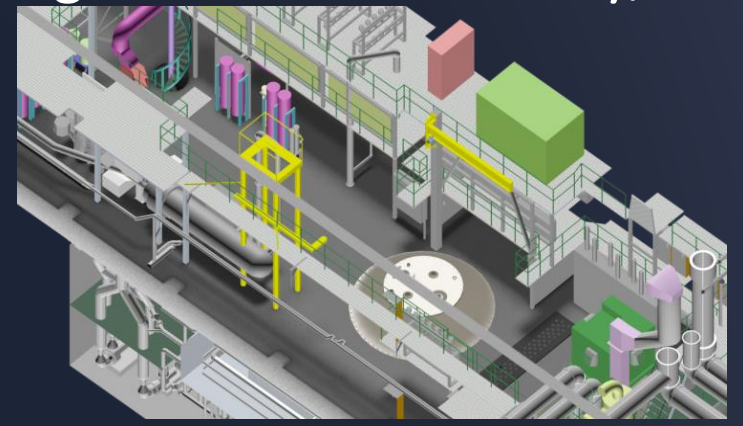


## Digital support platform

Telepresence, mission simulation,  
Machine Learning, AI, Computer  
Vision, miXed Reality, SLAM,  
Radiation hardening, ...



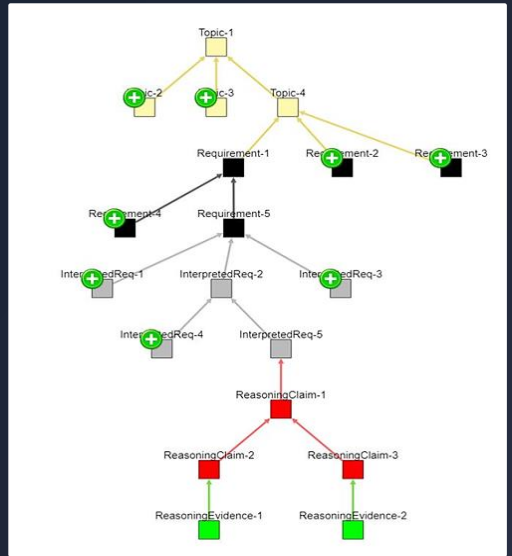
## Digital twin of the facility/site



## Digital twins of robot systems and components



## Safety assurance

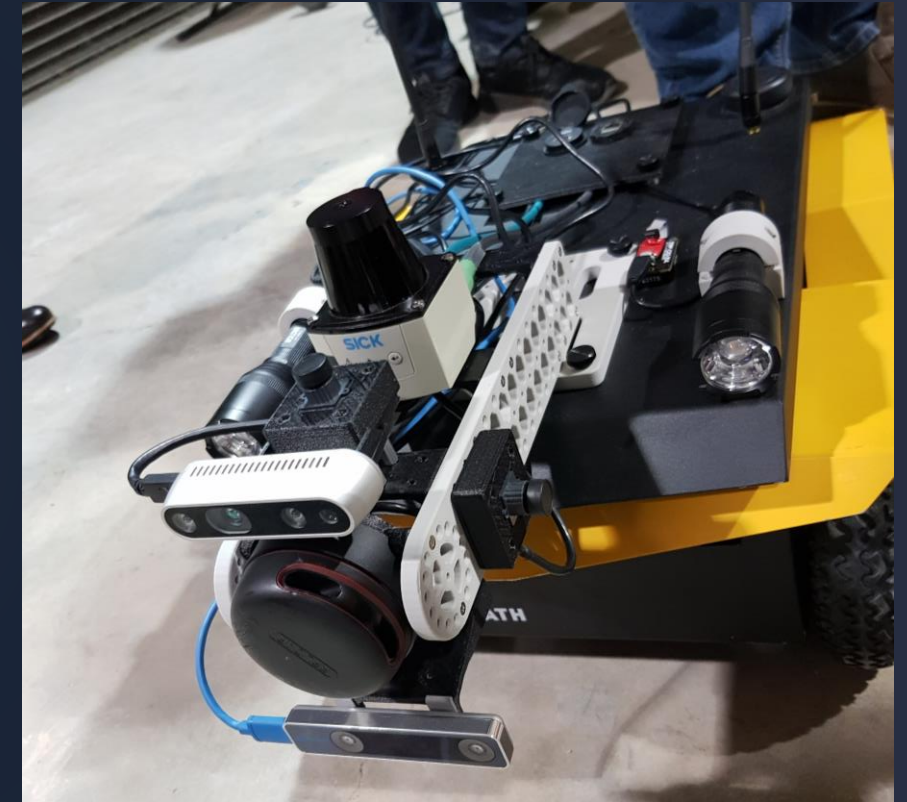




# Modular UV based support systems for decom

## What tech do we need?

1. Base platform (UGV, UAV, ...)\*
2. Sensors for mapping the environment and localisation (SLAM, LIDAR, ...)
3. System for **mission planning & control** (various levels of automation)
4. Sensors for **mapping hazards** + integration with hazard modelling
5. Tools e.g. grippers, samplers, ...



*Courtesy of Florida International University*

\*UGV: Unmanned Ground Vehicle  
UAV: Unmanned Aerial Vehicle (drones)

## What else do we need to think about?

1. Safety issues – approval by relevant authority
2. Security issues incl. cyber – open easy to access vs. vulnerability
3. Cost efficiency:
  - protection from degradation/contamination vs. cost (incl. secondary waste)
  - Investment (hardware, training, other) vs. return of value
4. *Organisational* issues – integration into overall capability (e.g. training)
5. *Environmental* issues – production of hardware, disposal, ...
6. *Human and ethical* issues



# RoboDecom: Advanced hazard aware robot system decommissioning

## Modular integration of

- UGVs and humanoid robots
- + 3D scanning tech
- + Advanced robot control systems
- + Hazard modelling/visualisation

Demonstrate feasibility and safety in industrial conditions (nuclear environment)

Decom.  
market  
needs

UVs with  
autonomy/remote  
control

UAV



Ground vehicle  
(with arm)



Localisation  
(sensors, LIDAR)

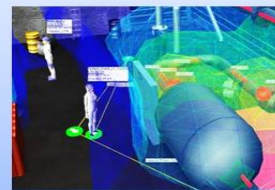


Digital platform  
(remote control,  
autonomy)

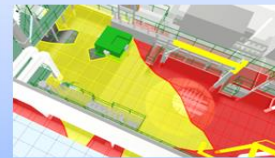
Control



Mission planning



Data analyses /  
visualisation



Measuring/  
sampling  
equipment & more

Detectors/  
sensors



Samplers



Machines



## **Solutions**

- Site exploration
- Radiological mapping
- Emergency management
- Assistance for humans
- ...



# Robot ecosystem for decom

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UAVs capable of taking sensors (etc.) high (indoor/outdoor)



Larger modular systems with high reach and good payload capacity (can operate machines)



RoboDecom

Small UGVs capable to carry sensors and small grippers



Miniature / small specialized robots crawl into narrow spaces (e.g. inside pipes) adhere onto walls, ...



RoboDecom

Humanoids taking advantage of ergonomics designed for humans + natural telepresence

UGVs capable to climb stairs and navigate difficult terrain



# RoboDecom prototype 1

LiveDecom /  
PLEIADES  
suite

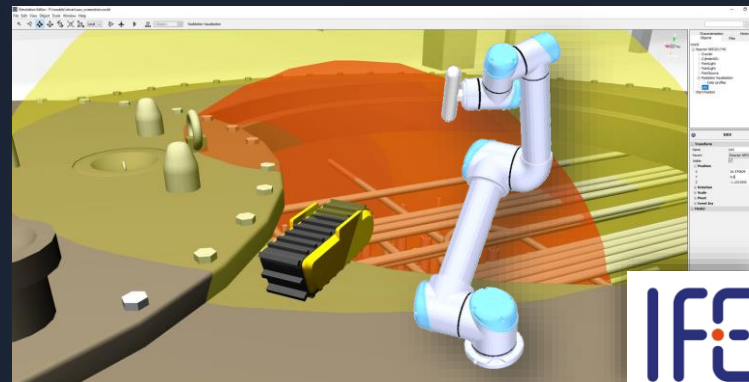
Hazard  
sensor



UGV system



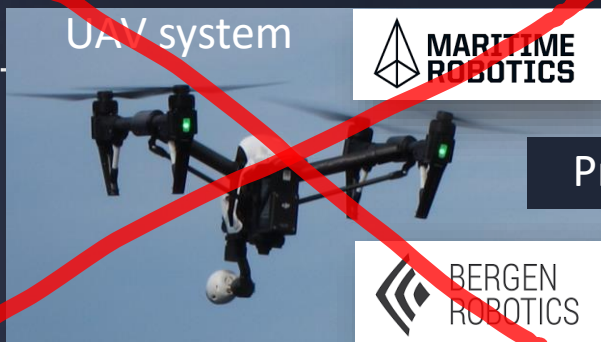
3D rad. sim based  
digital platform



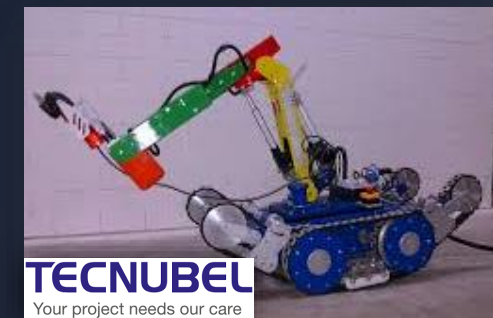
Sensor and Avoid  
Path planning  
Wireless com.



UAV system

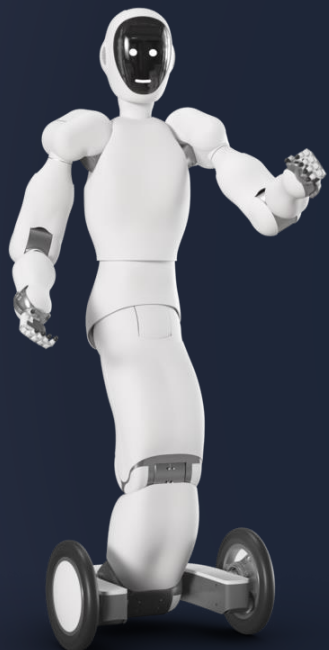


Prototype 2



# RoboDecom prototype 2

EVE



- + Input from previous 3D mapping
- + rad. sensors carried by EVE?



=

Hazard vision augmented  
telepresence  
*with autonomy in the future*

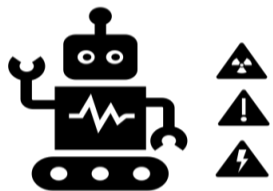






# Application for emergency management

*To create an innovative cyber-physical system supporting first responders in complex emergency scenarios*



1. Unmanned Robotics & Sensing



2. Digital twin & Hazard simulation



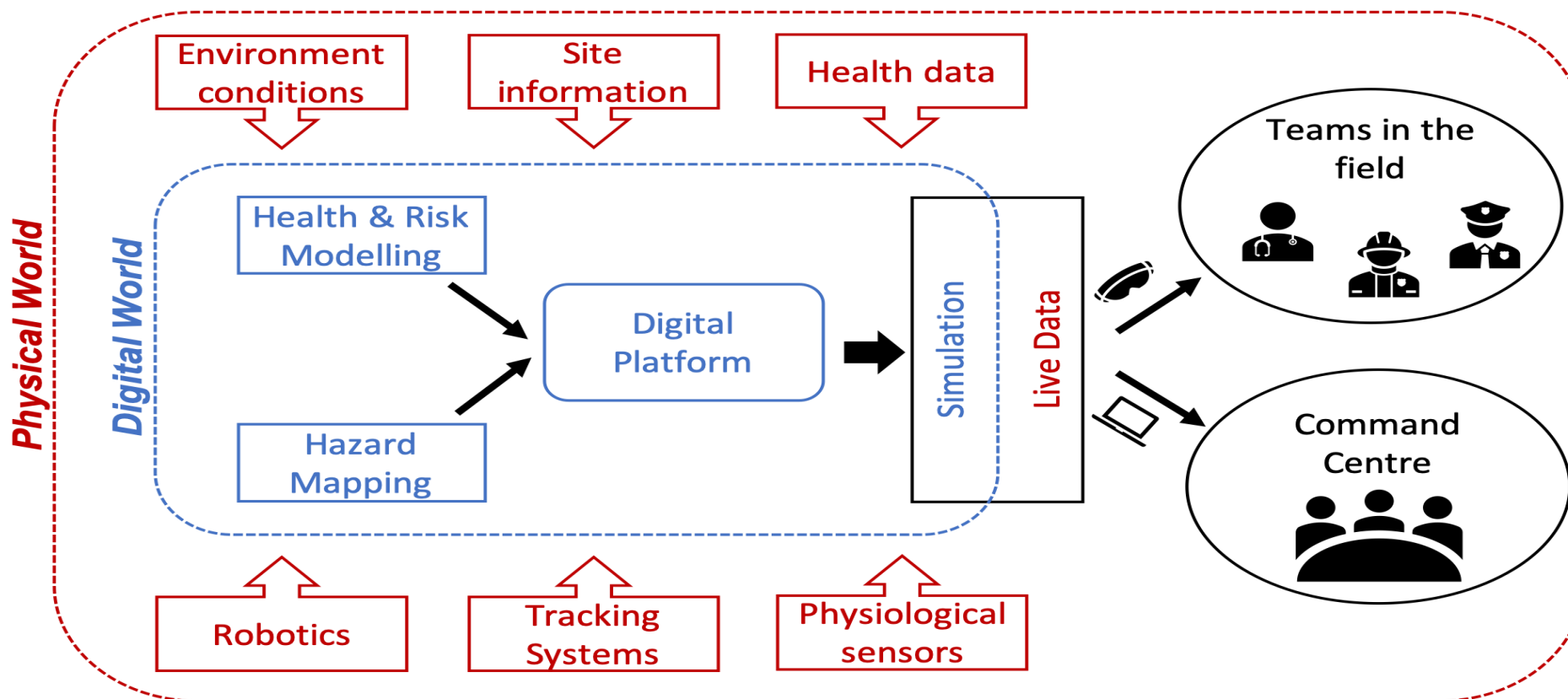
3. Acceptance



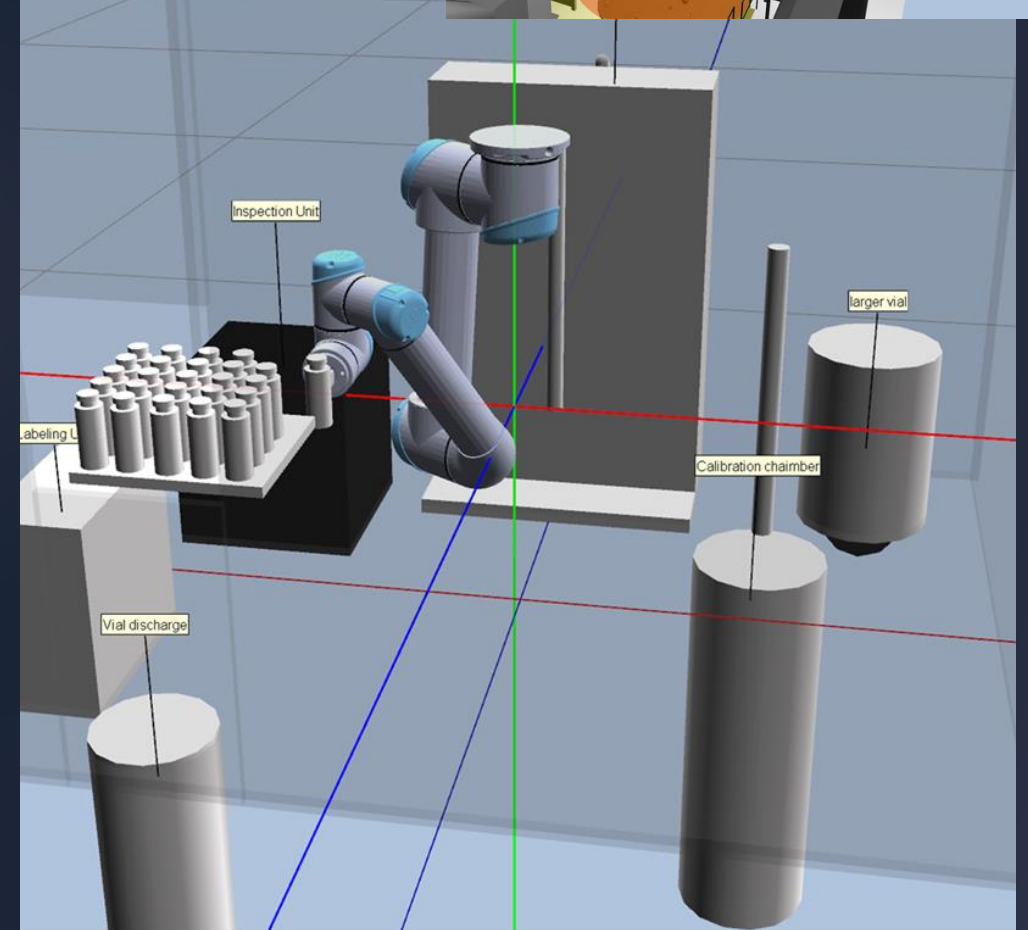
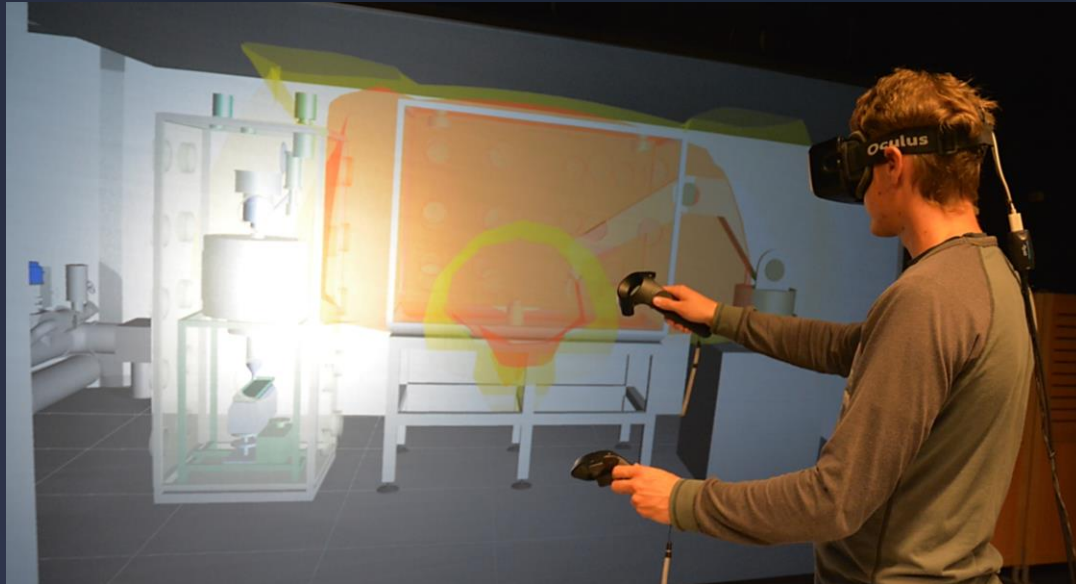
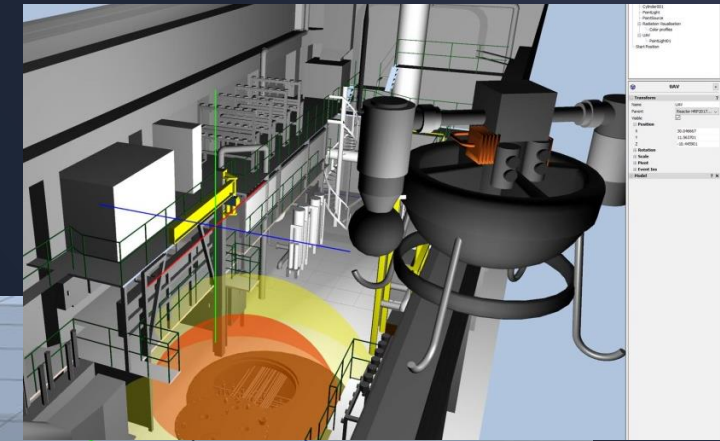
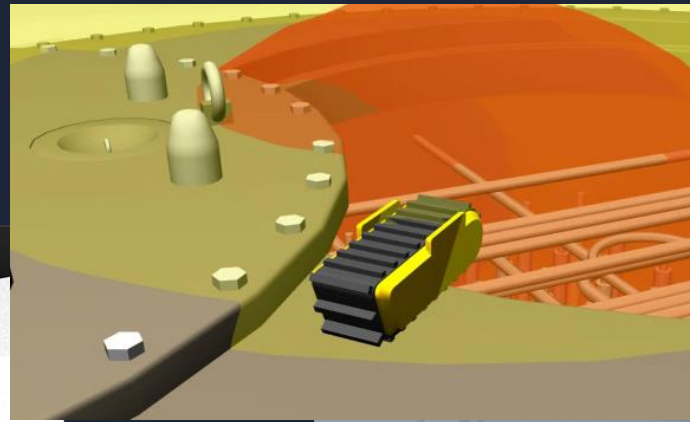
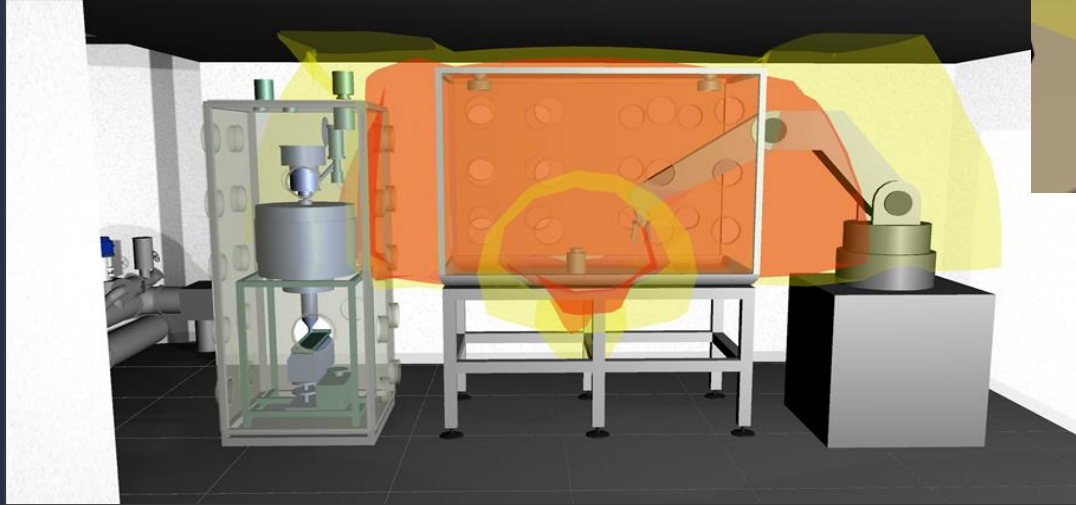
4. Decision making



5. Training



# Digital twins for robotics

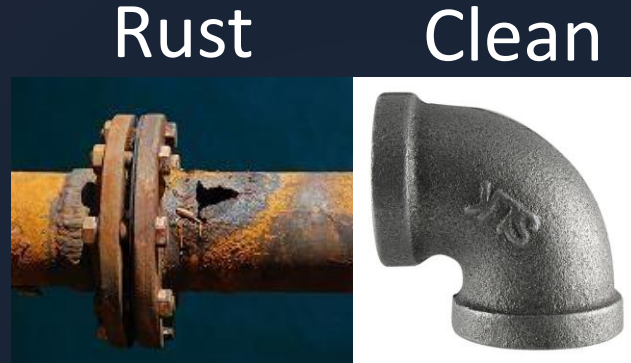




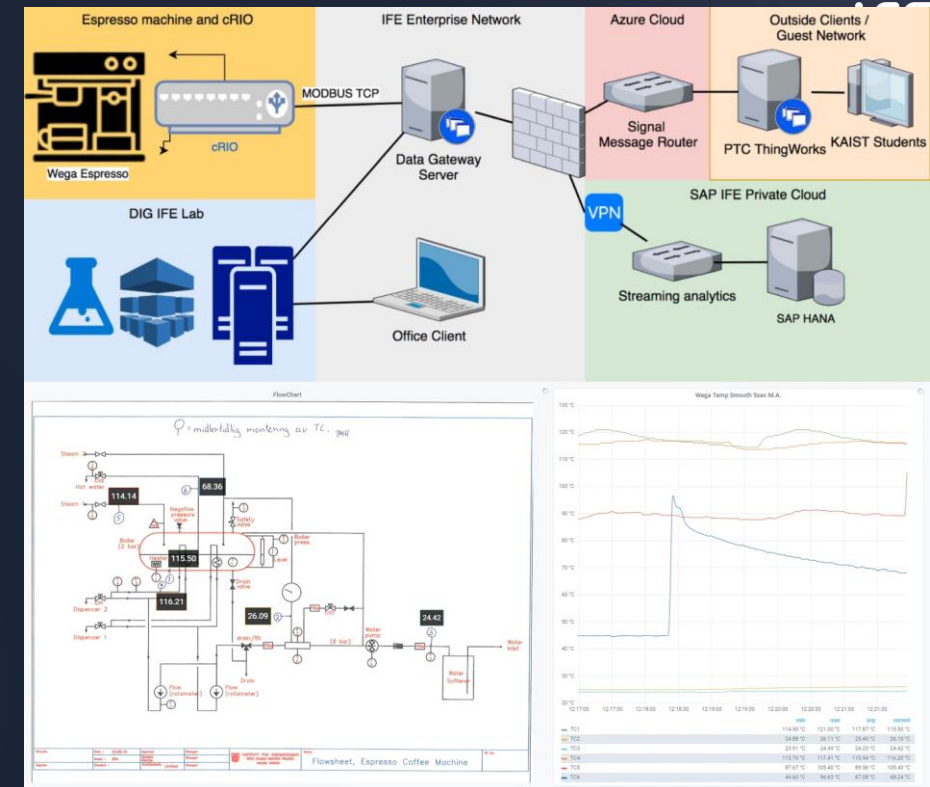
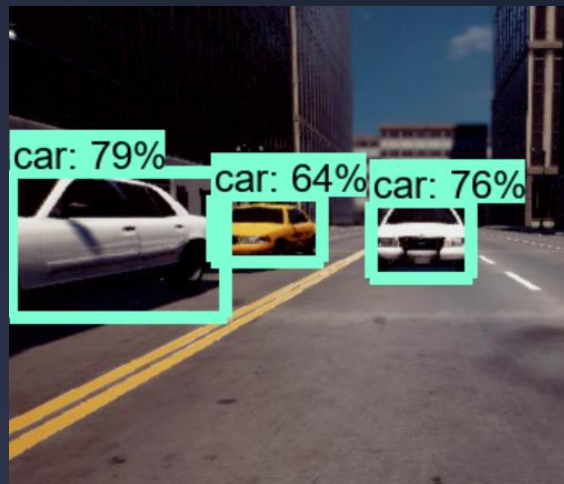
# Machine learning and AI



# Visual quality inspection for radiopharmaceuticals



# Real

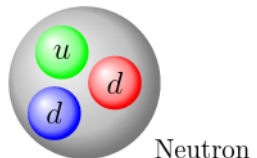
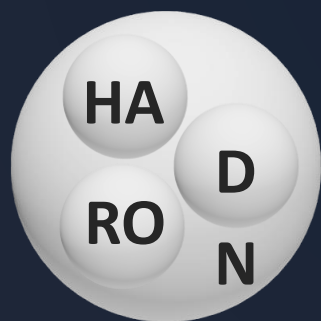


## Potholes and cracks

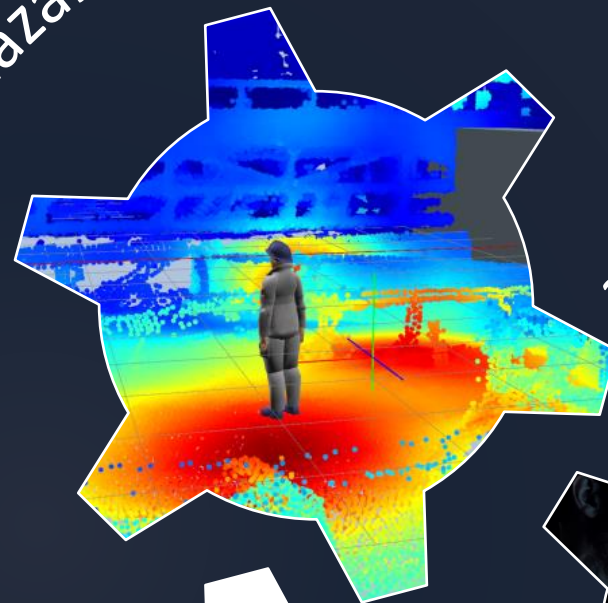




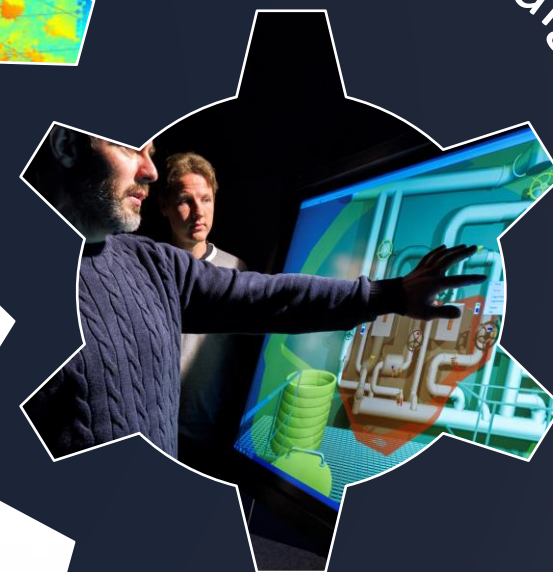
# Hazard Aware Digitalisation and Robotics in Nuclear and other domains



3D hazard modelling



3D sim. based digitalisation

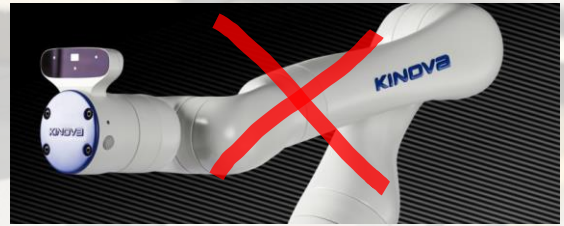
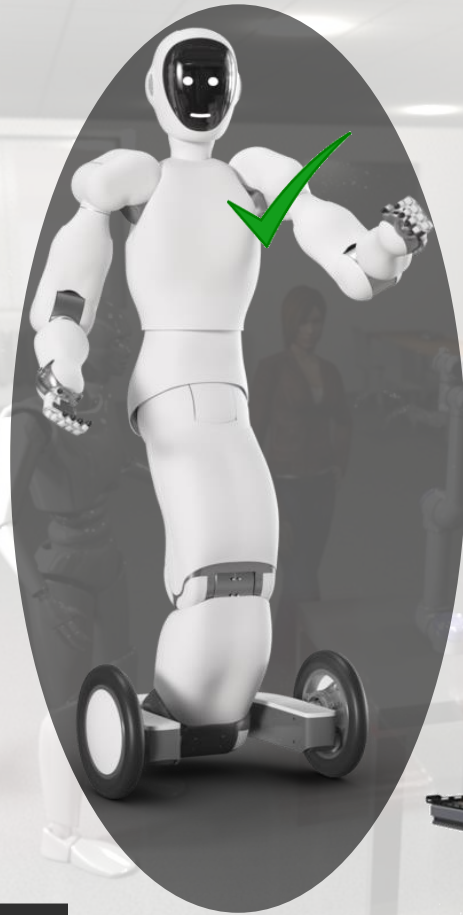
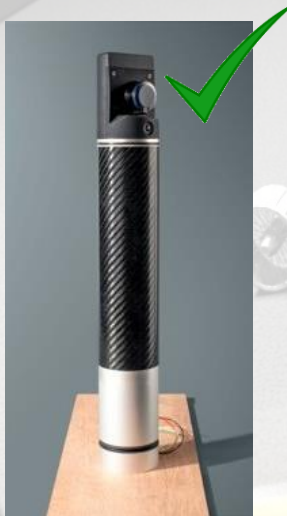
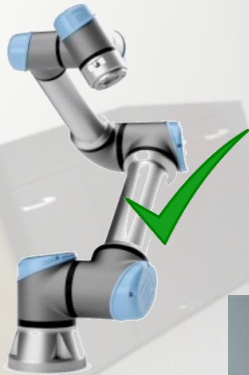
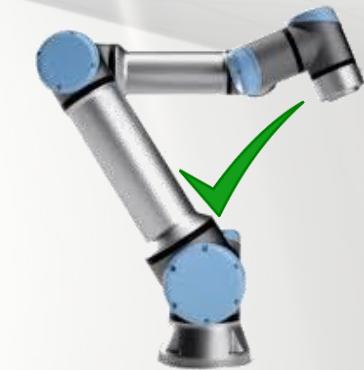


Robotics



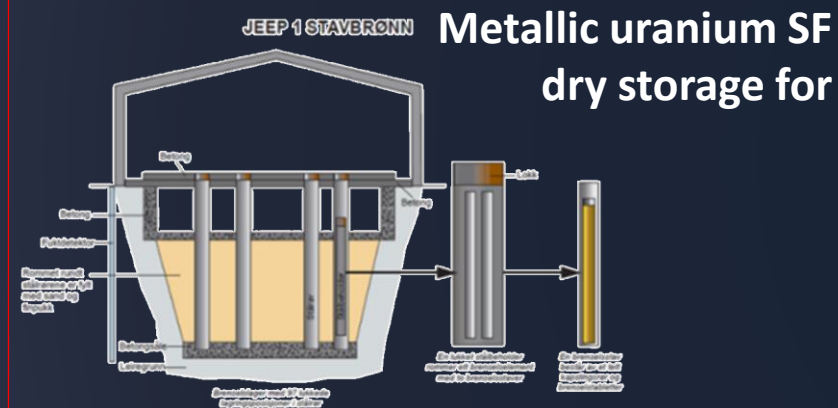
Nuclear

# HADRON lab access to equipment





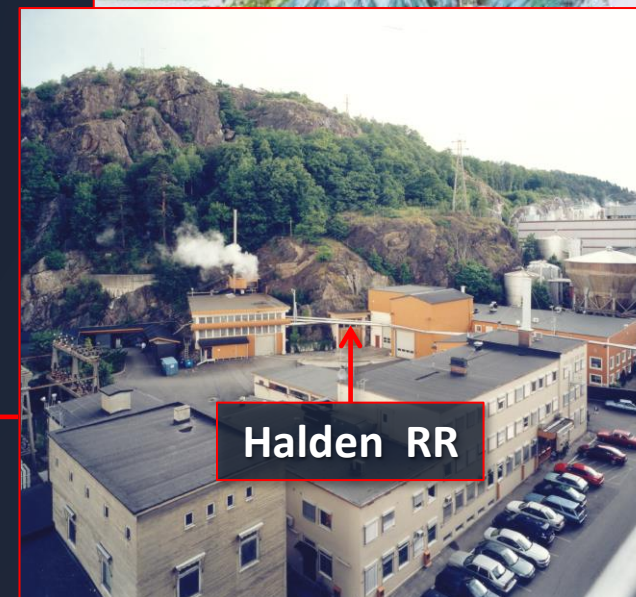
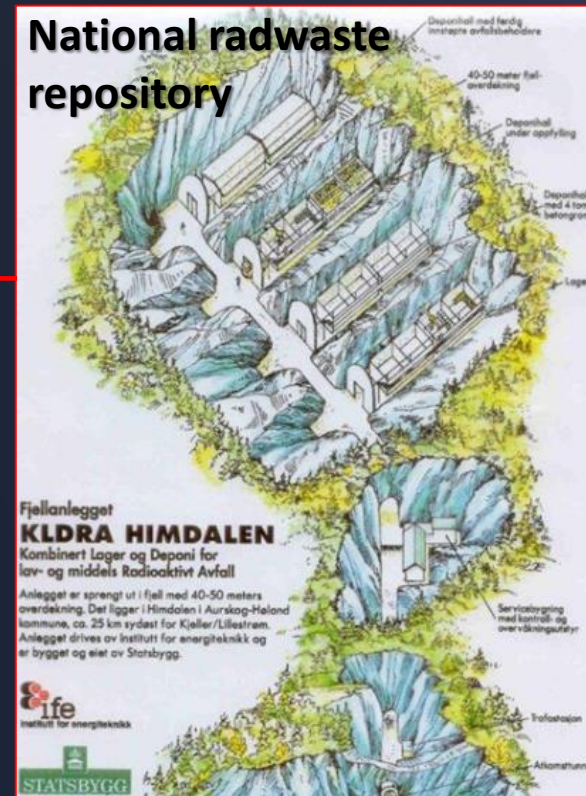
# Decommissioning at IFE



**Uranium pilot plant**



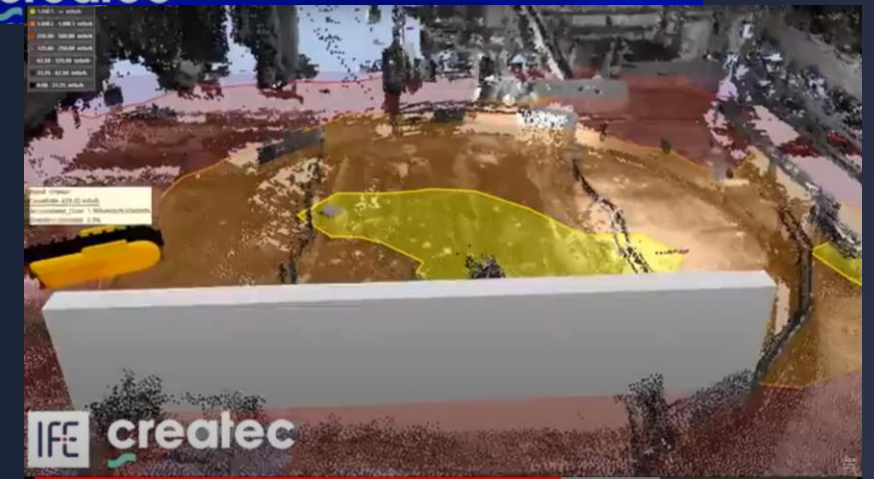
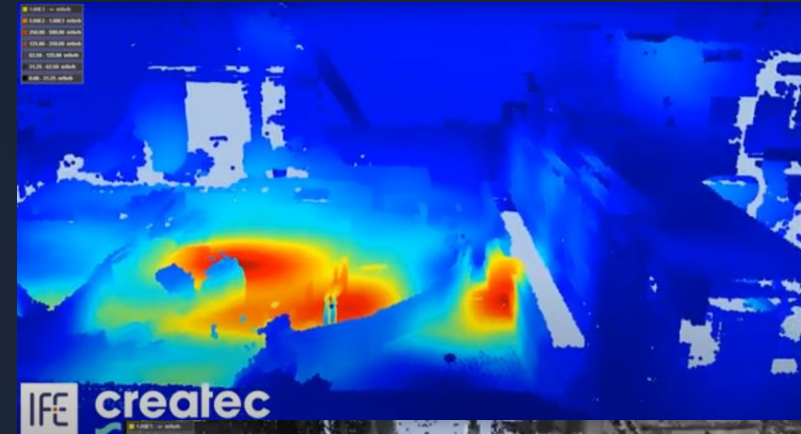
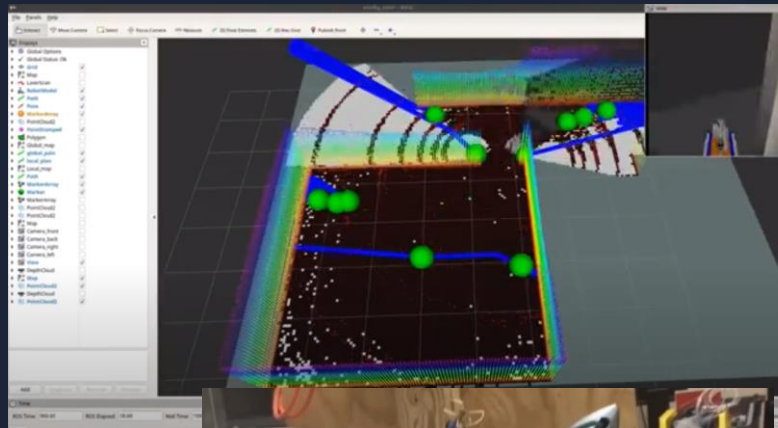
## National radwaste repository





# FIU - IFE joint student team won IAEA Challenge: Decommissioning and Environmental Remediation 2020

IAEA D&ER 2020 Challenge - Robotics, Artificial Intelligence, Digitalization, Virtual Reality



<https://www.youtube.com/watch?v=uMY0MBNUb6M&feature=youtu.be>