Institute for Energy Technology

Digital technology enabled new concepts supporting planning and cross-cutting issues in nuclear decommissioning

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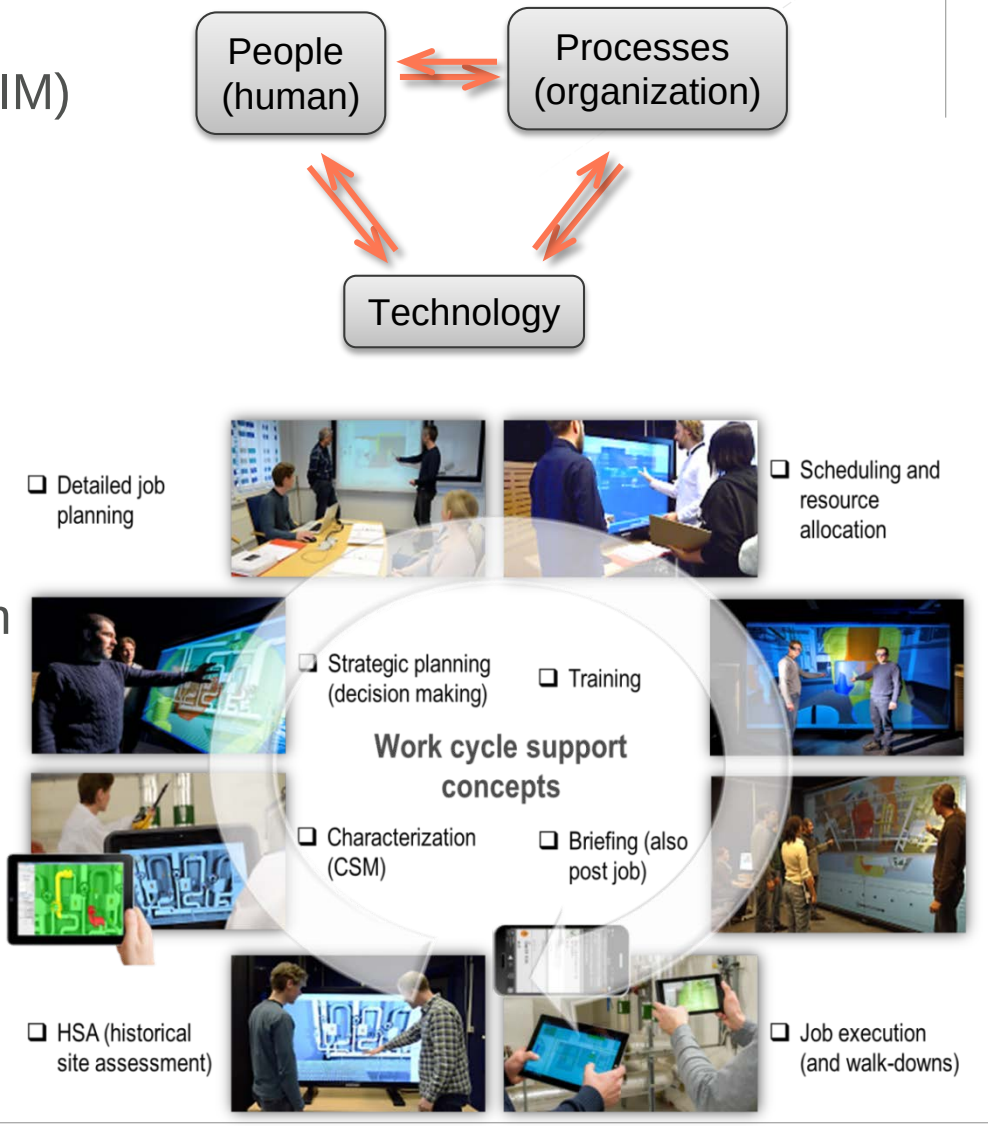
Digitally enhanced support concepts

- Plant information management (PIM)
- Rad. characterization
- Informed decision making
- Job planning (optimization: risk/hazards - costs)
- Regulatory interaction
- Team collaboration & coordination
- Training & Briefing
- Knowledge Management (KM)
- Emergency preparedness
- Automation

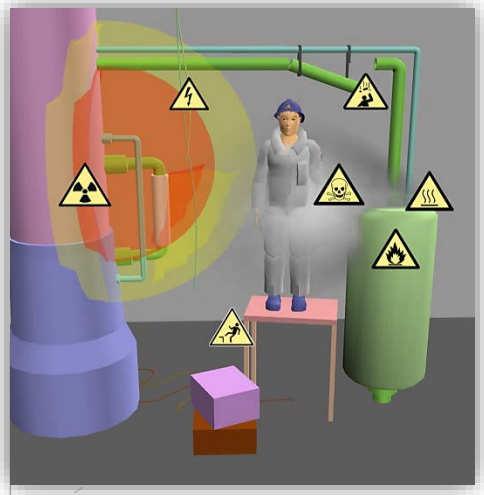


The OECD Halden Reactor Project (HRP)

>100 nuclear organizations from 20 countries

utilities, vendors, licensing authorities and R&D centres:

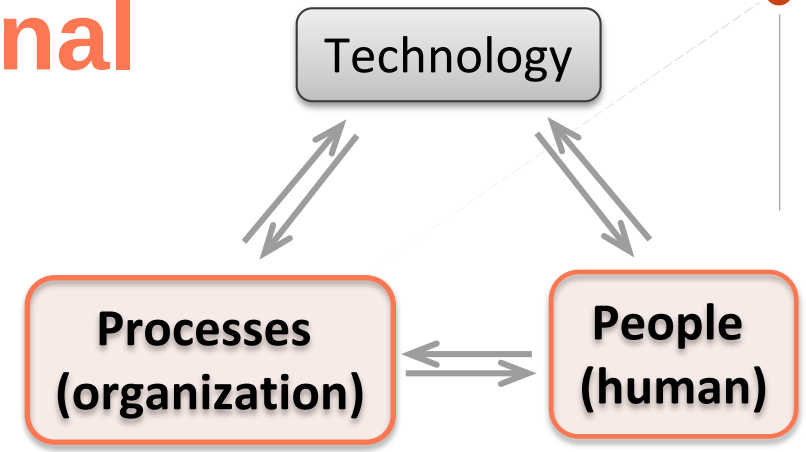
CEA, CIEMAT, CNPRI, CRIEPI, FRAMATOM, DTU, EDF, E.ON, ENSI, EPRI, EU JRC, FANR, GE/GNF, GRS, IRSN, JAEA, KAERI, Kazatomprom, MEE, Mitsubishi, MTA EK, NNL, NRA, NRG, PSI, SCK/CEN, SNERDI, SSM, TVEL, UJV, US DOE, US NRC, VUJE, Westinghouse …



Safety management for decommissioning

Training for normal work and emergencies in decom.

Human & Organizational factors



- Gap analyses
  - Identification of required key capabilities
  - Evaluation of organisational maturity
- Capability development - road map for minimising H&O issues
  - Staffing – optimisation: knowledge and skill requirements vs. availability and costs
  - Training of staff: skill needs and preparedness
  - Change (transition) management:
    - timely planning and allocation of roles and responsibilities
    - clear communication, motivation and career planning

Organisational issues

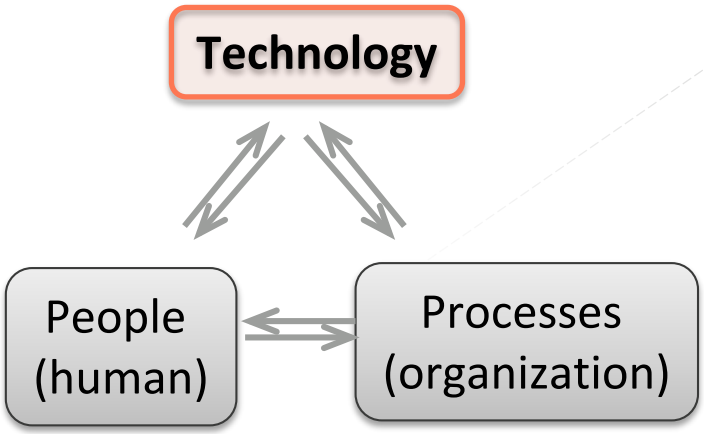
Planning for decom

- When to **start** planning (When is early enough)?
- When/what to **communicate** with the staff?
- What is the **optimal detail** of planning in the different stages?
- What is the best **organisational structure** (departments, locations, people)
- How to ensure a smooth **regulatory acceptance** process?
- What is the best **team composition** (in-house, contractors)?
- What **expertise** is required and when (workforce planning)?
- What kind og **training** is required?
- How to measure/monitor organisational **KPIs** (safety culture)?
- Which influence the different **characteristics** have on project performance?
- How to **preserve** experience (who is responsible)?

Organisational issues

- Is there a **general recipe** for all this or it's different in each case (project), company, country,…?
- How to **draw conclusions** (answers) from on-going/completed projects? – Is benchmarking reliable?
- Are there relevant lessons learned from **other industries** (e.g. oil&gas)? – severe accidents vs. accidents in nuclear decom.
- What **research** could contribute to answering these questions?
- Is it possible to develop **guidance** or **coaching** is the answer (both utility and regulator)?
- Research for future: robotics (automation), HMI, process control, ???

Technology



Radiological modelling

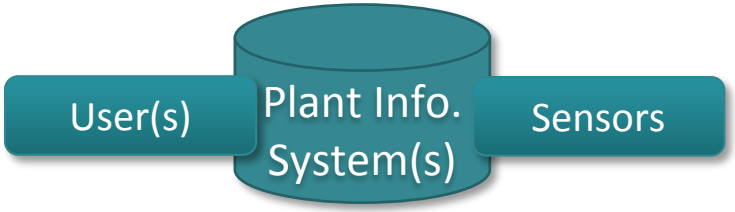
- Real time deterministic radiation transport
- Geostatistical analyses
- Monte Carlo radiation transport
- Source deconvolution
- Internal dosimetry New!

IT

- 3D modelling
- Virtual and Augmented reality
- Advanced user interfaces
- Mobile and wearable devices

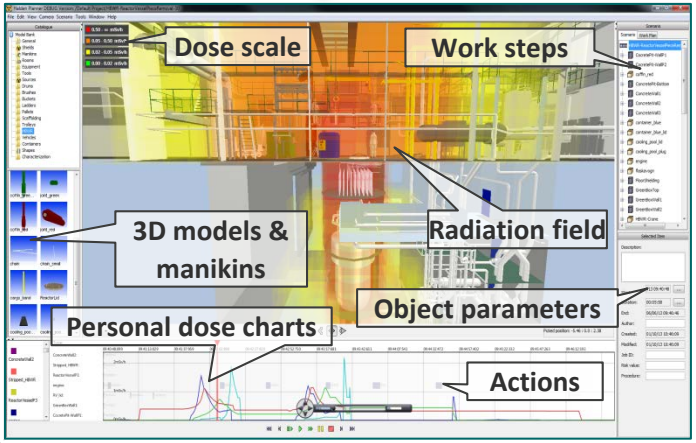
- Sematic web technology Starting!
- Robotics: digitalization, sensors, control Starting!
- Rad. mapping with gamma cameras Starting!

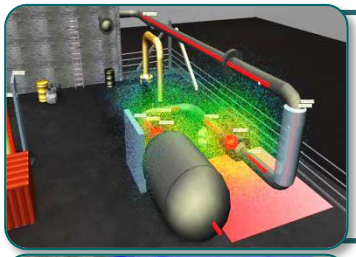
Scenario (safety) analyses



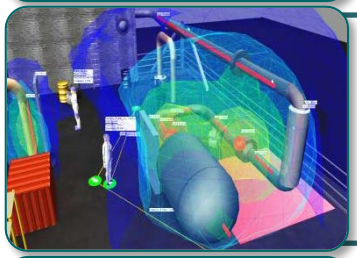
Plant information
- 3D models,
- Radiological data,
- Structure/component properties, …

Work plan

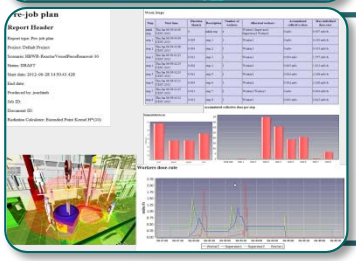




Visualize
- The environment (digital model),
- Radiation emission/exposure, and
- Work scenarios (3D technology)



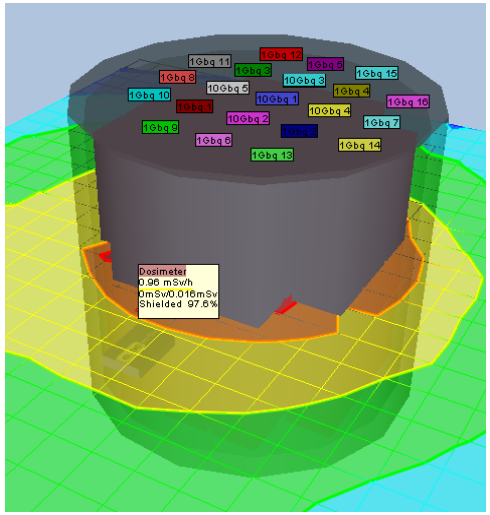
Optimize
- Modify (with interactive real-time 3D visualisation)
- Compare alternative scenarios

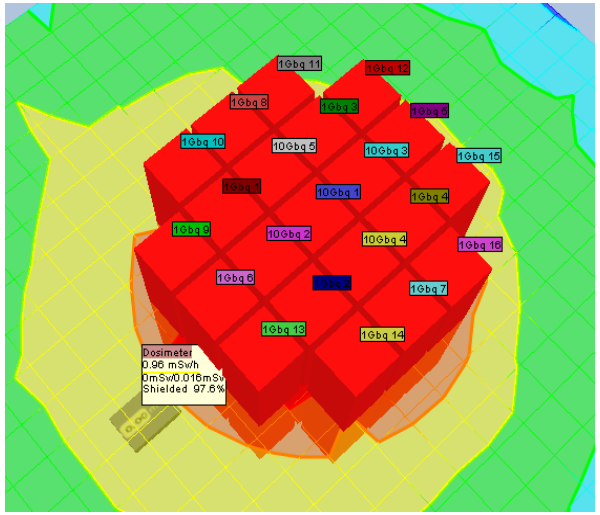


Demonstrate & document
- Playback with interactive navigation and visualisation
- Output printer-friendly reports

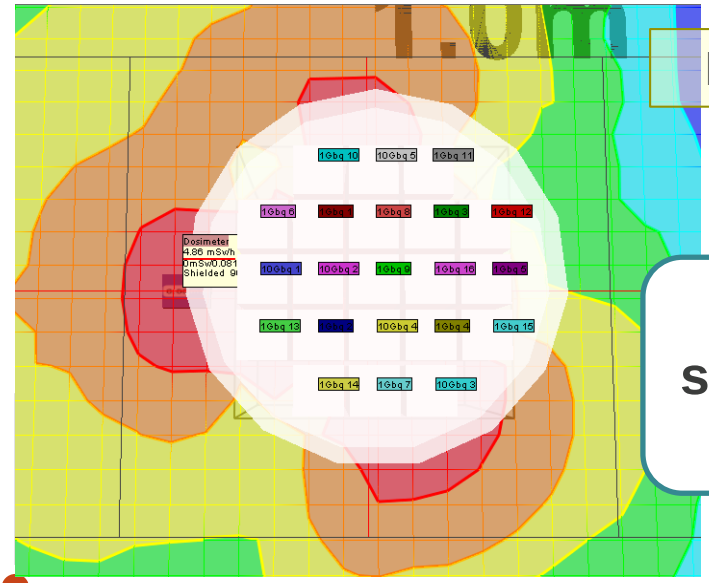
- Optimal work procedure
- Worker dose/risks
- Comparison of alternatives
- Documents
- Demonstrations (interactive simulations, videos, …)

Shielding & Waste packaging studies





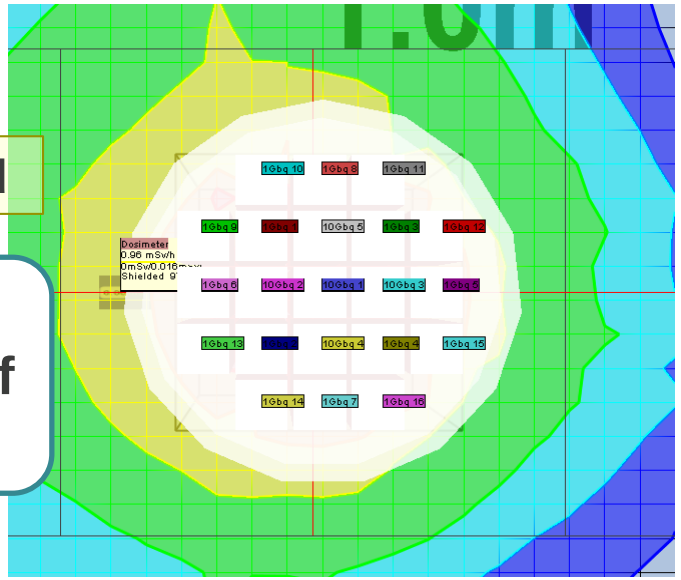
- MOSAIC type shielded container
- 21 slab-like waste pieces
- 5 pieces 10GBq Co-60
- the rest 1GBq Co-60



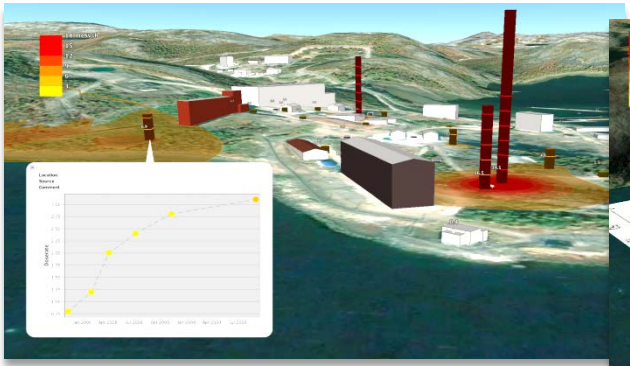
Random

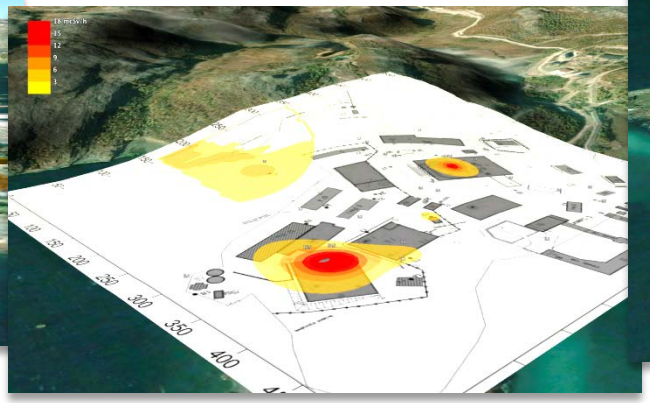
Optimized

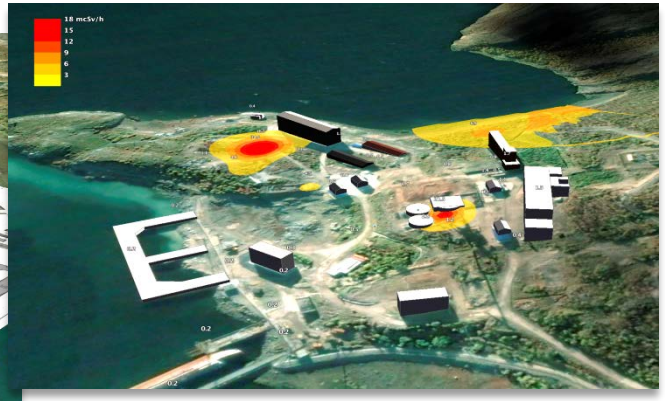
Exploiting shielding effect of heavy waste

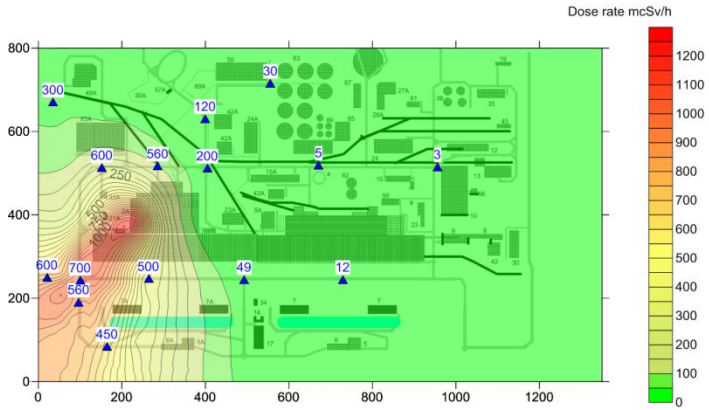


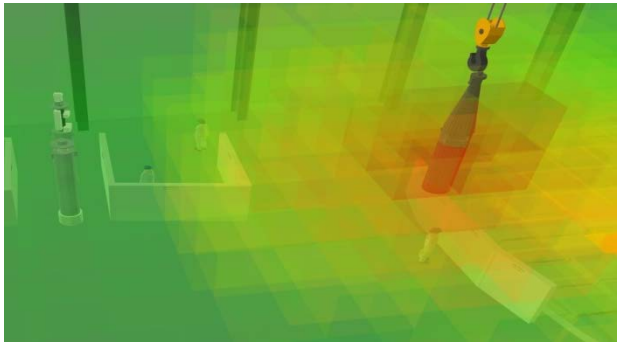
Environmental modelling & Geostatistics



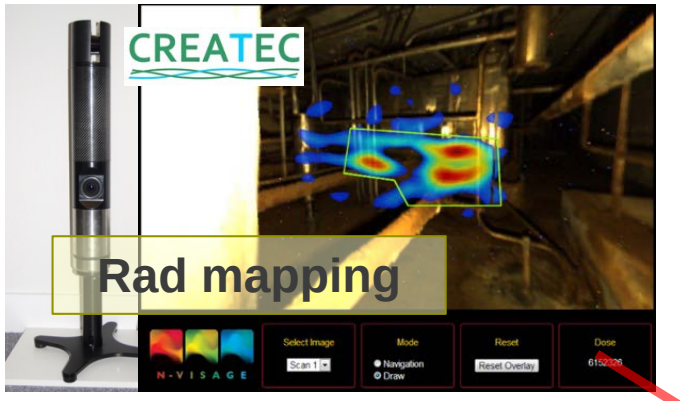








Integration with BIM systems and sensors

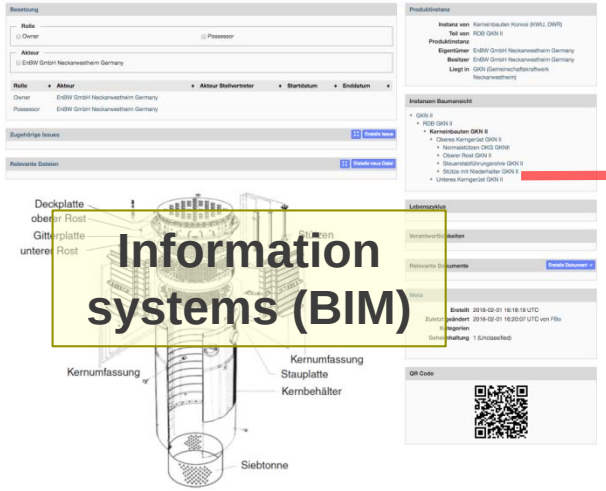


Rad mapping

3D laser scanning

360 photos

Sensors/ beacons

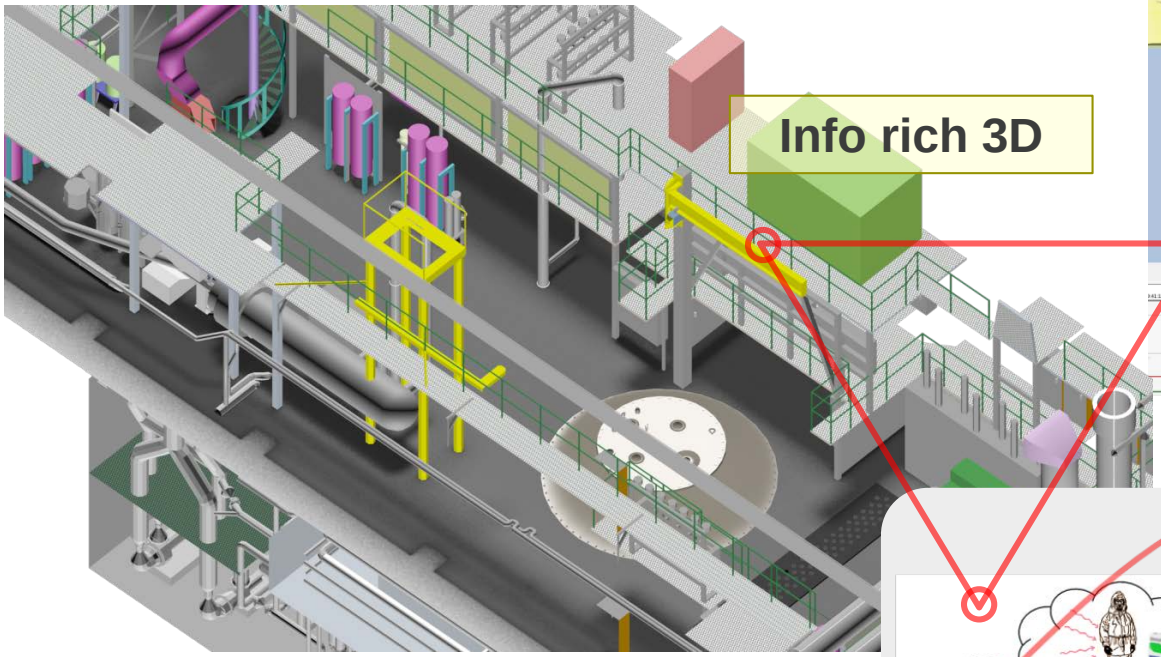


Information systems (BIM)

Digital experience (digital twin)

How to acquire and update input?

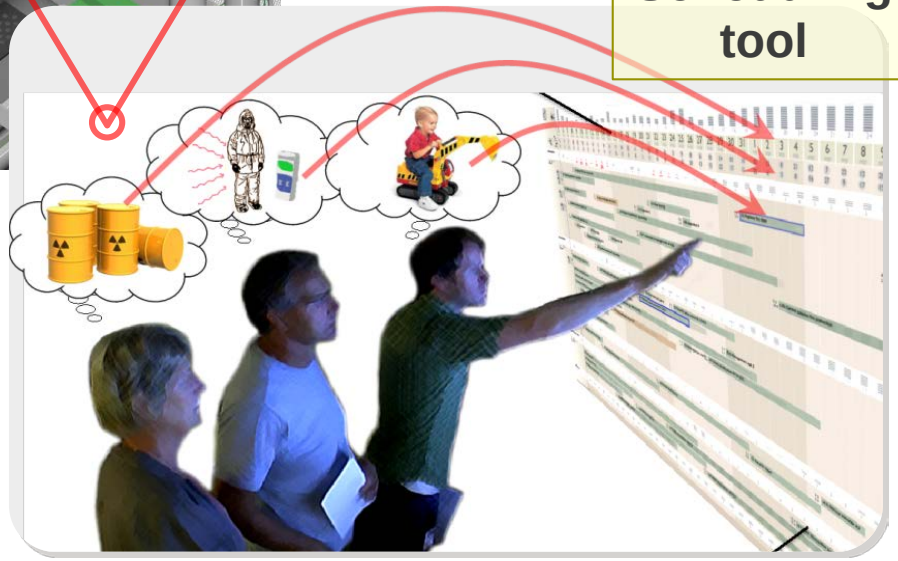
Project management



Info rich 3D

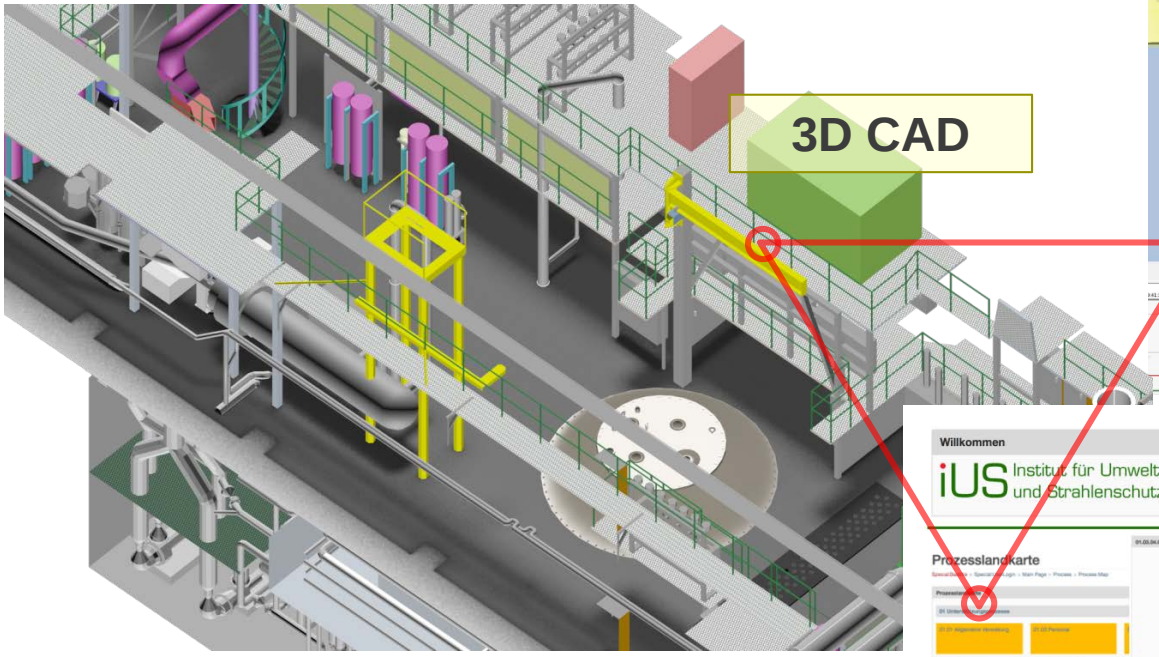
Simulation
(risk, hazards, costs, …)

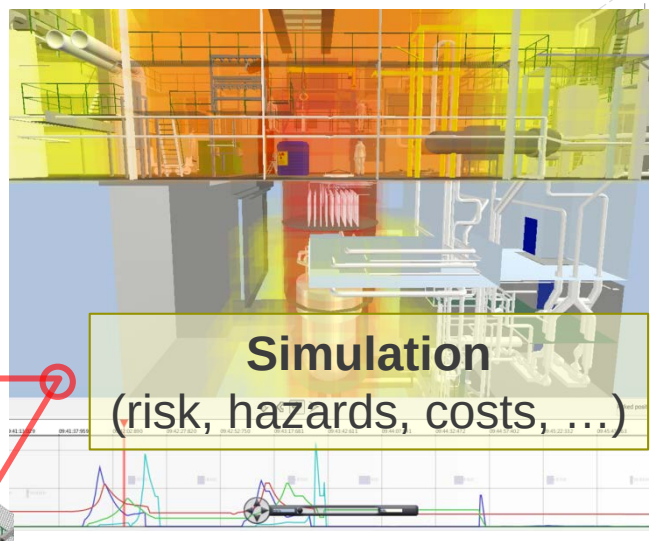
Scheduling tool

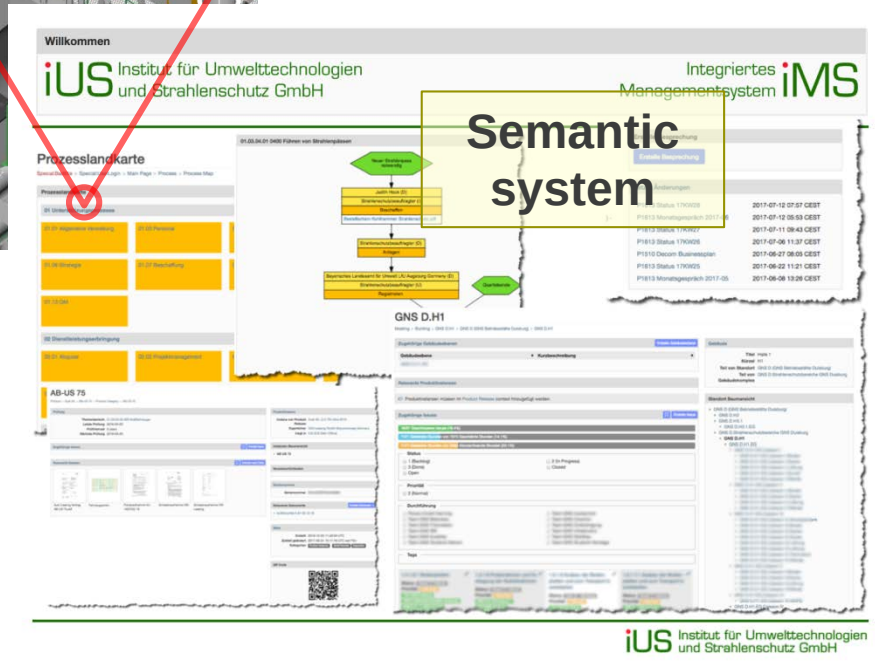


Accessibility (semantic)
Visualization (3D CAD)
Applicability (simulation)
of information

Safety management

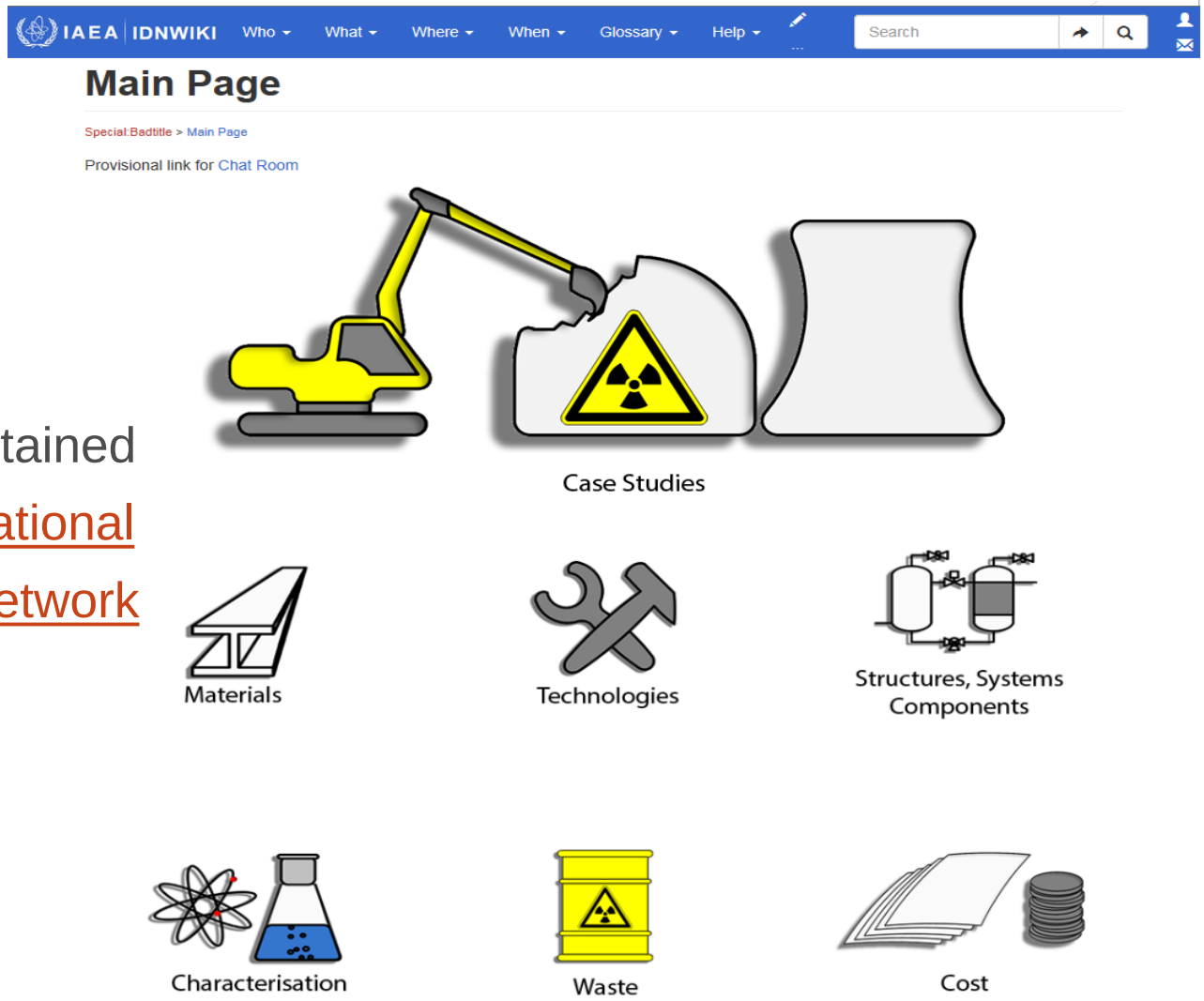






Accessibility (semantic)
Visualization (3D CAD)
Applicability (simulation)
of information

IDN Wiki

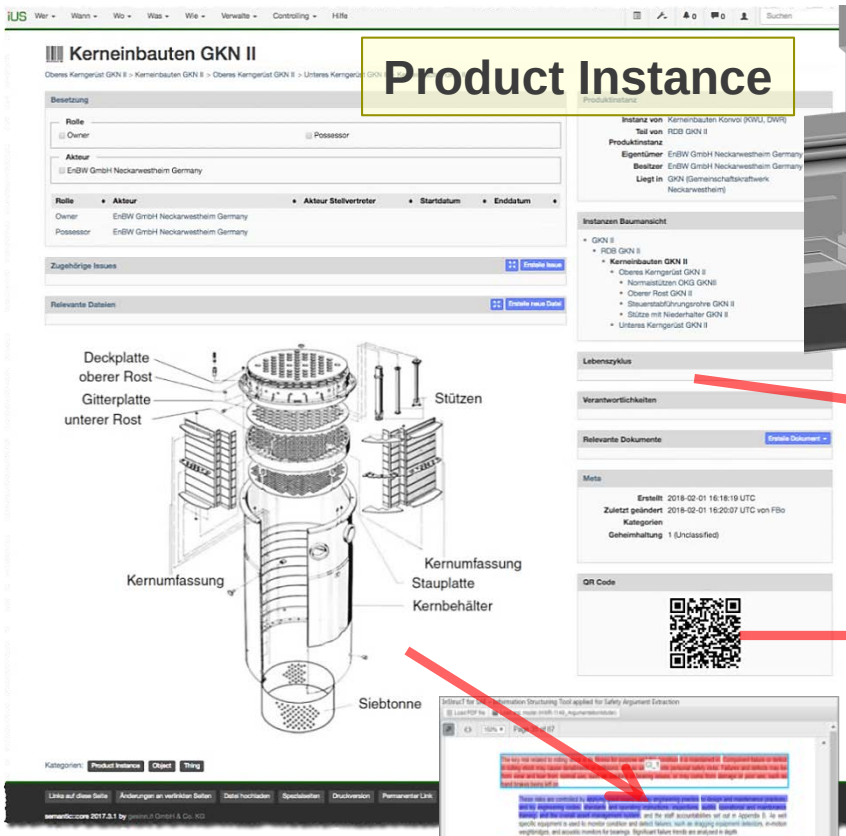


The IDN Wiki is based on MediaWiki software (works like Wikipedia) and maintained by the IAEA's International Decommissioning Network (IDN) on the IAEA CONNECT platform.

Designed by

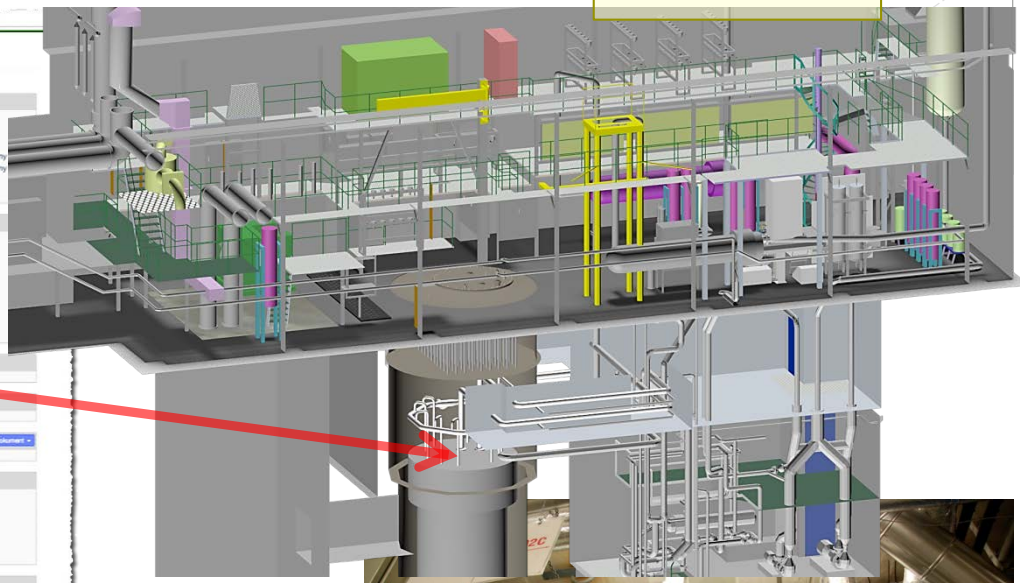
https://nucleus.iaea.org/sites/connect/IDNpublic/Pages/IDN-Wiki-Introduction.aspx

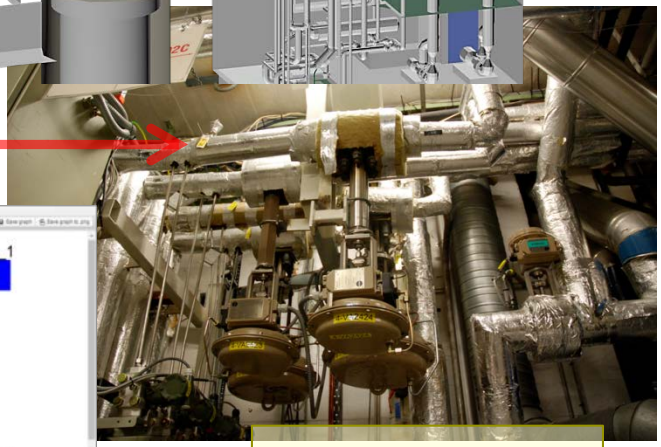
Safety reporting



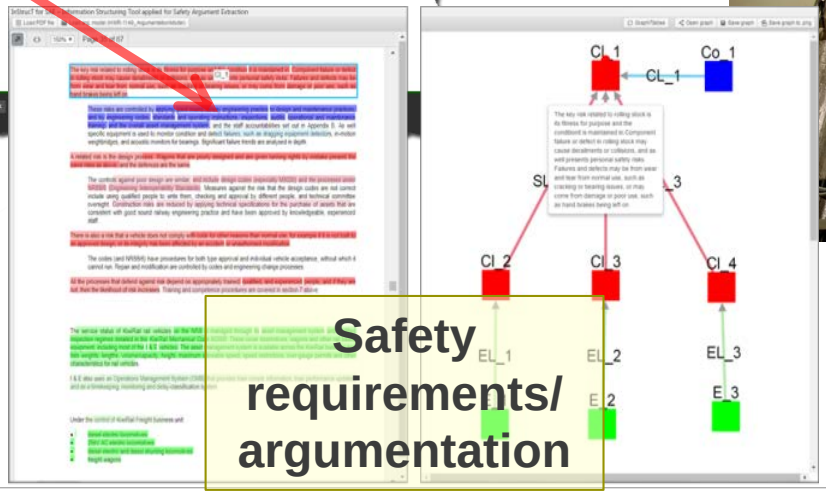
Product Instance

3D CAD



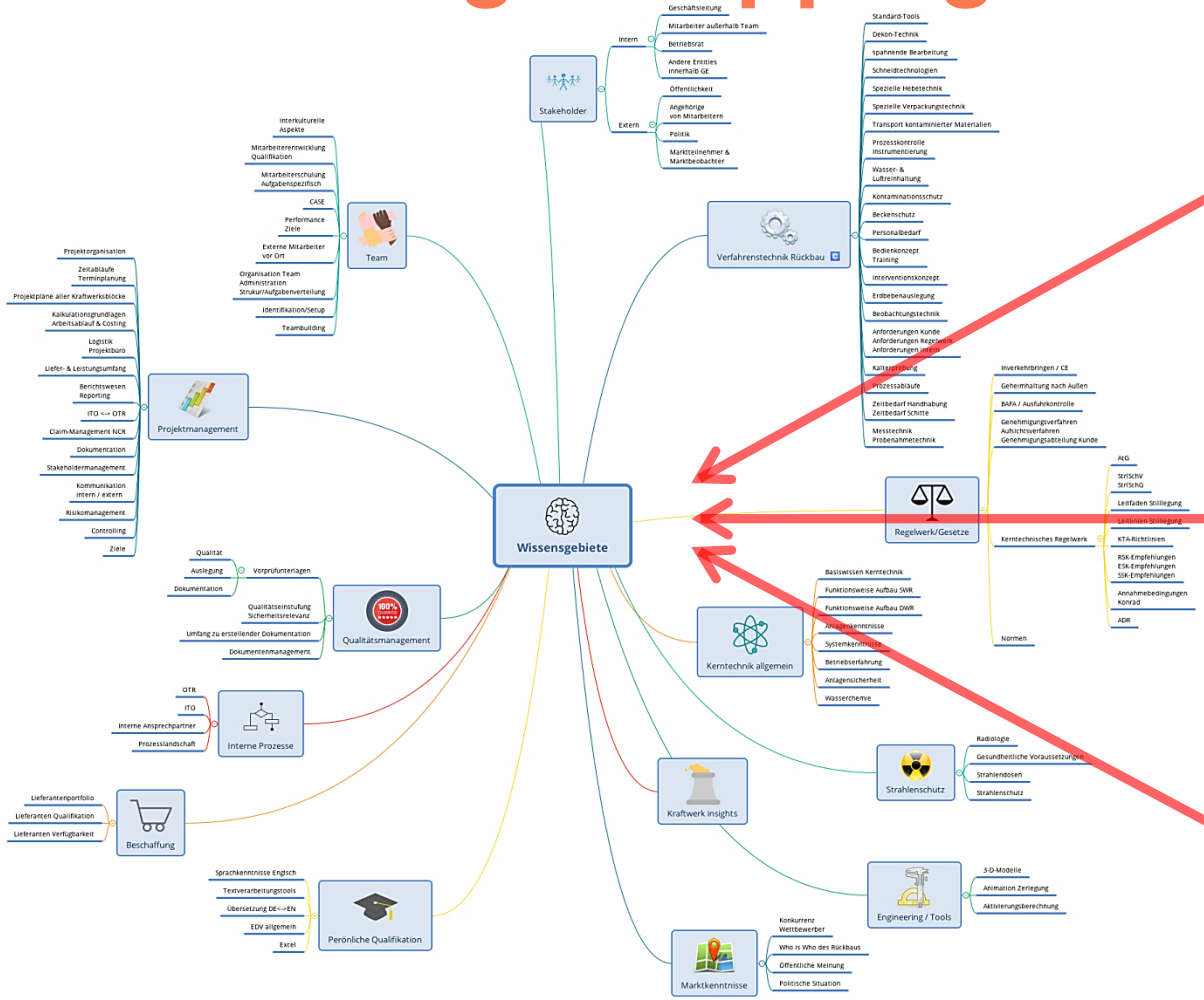


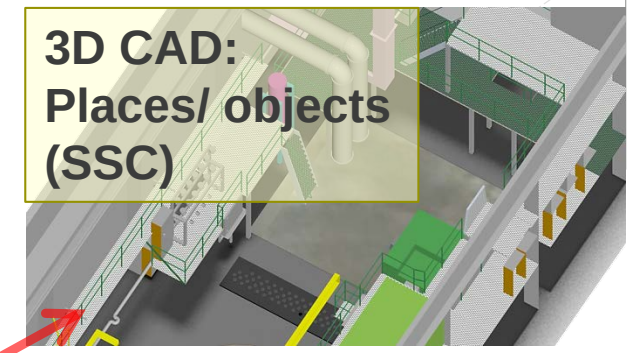
Photos / physical objects

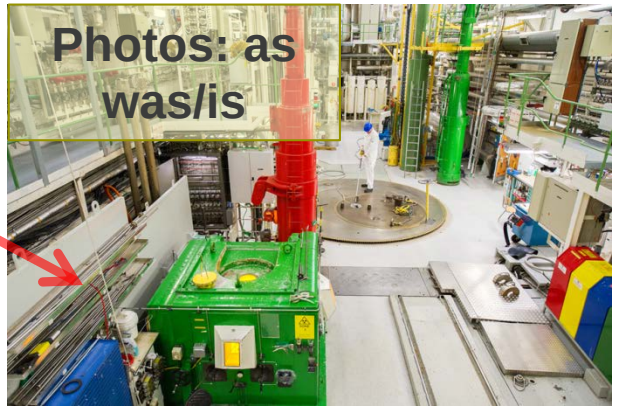


Safety requirements/ argumentation

Workforce planning /knowledge mapping







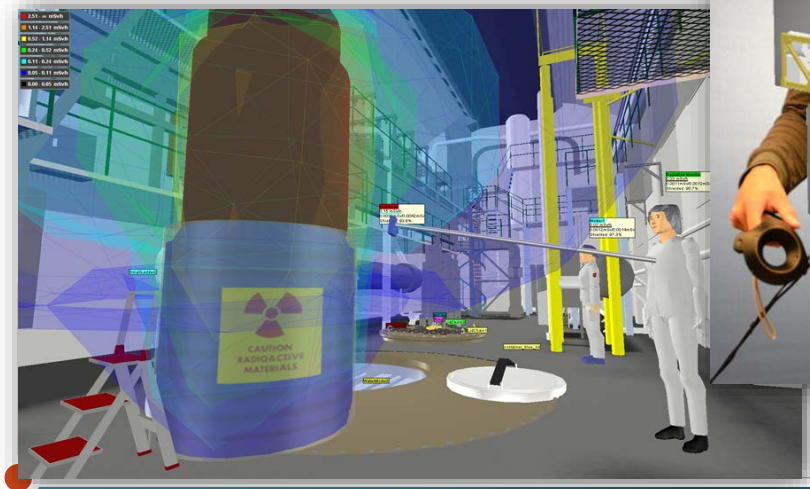
Process planning / control

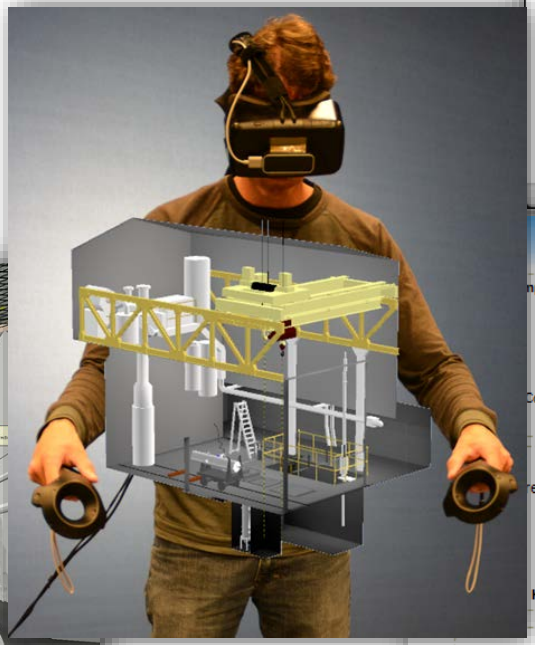
Konrad-Container

iUS Institut für Umwelttechnologien und Strahlenschutz GmbH

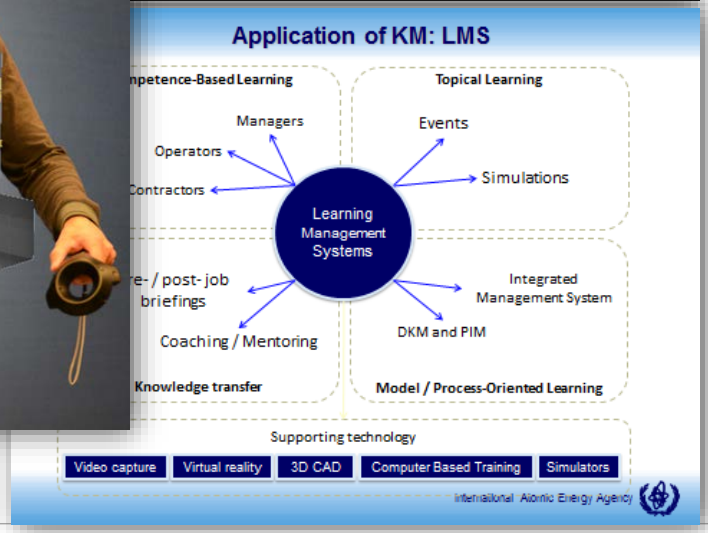
Training & Education

- Online platforms / E-learning
- Organizational learning management
- Mixed Reality
  - site/job specific training
  - emergency training
  - refresher training
  - deep training

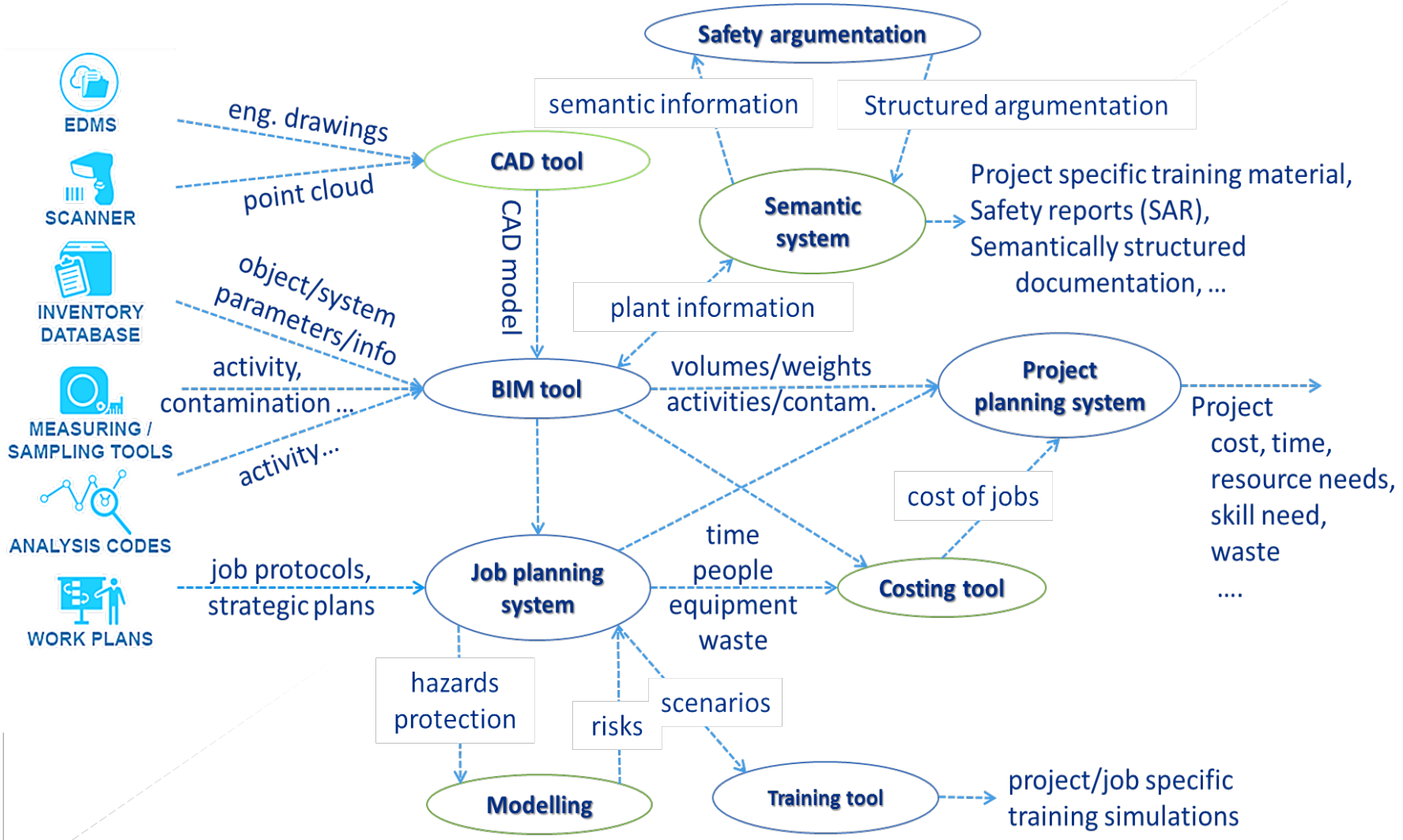




CLP4NET

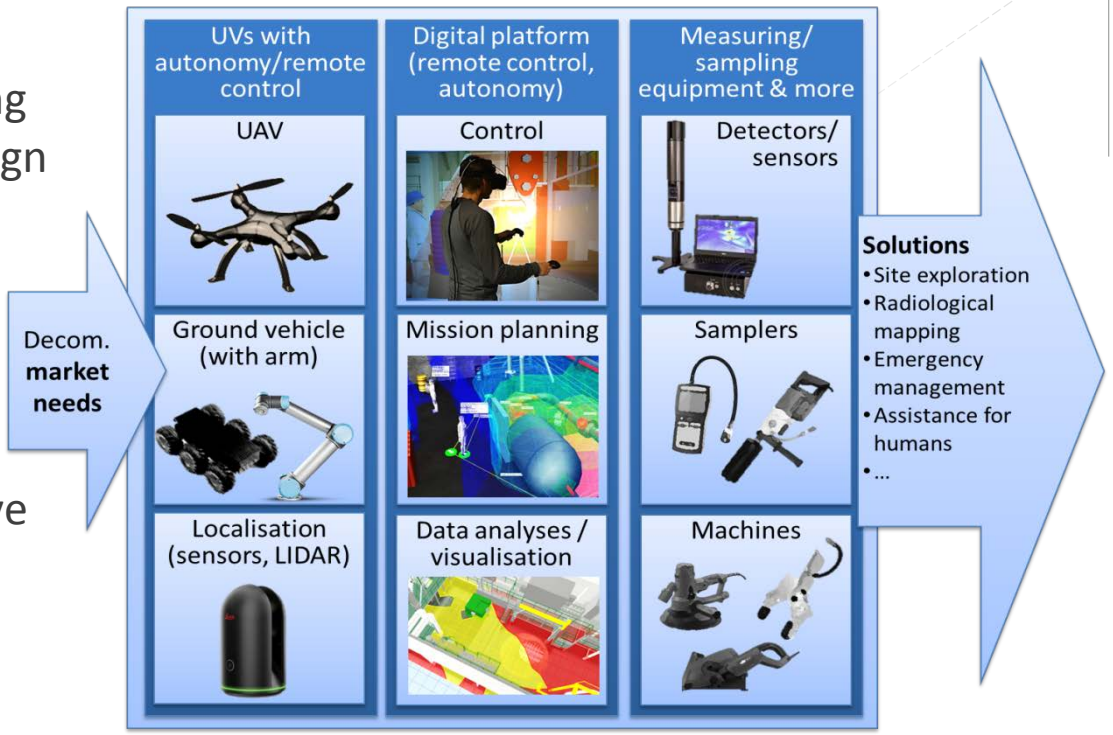


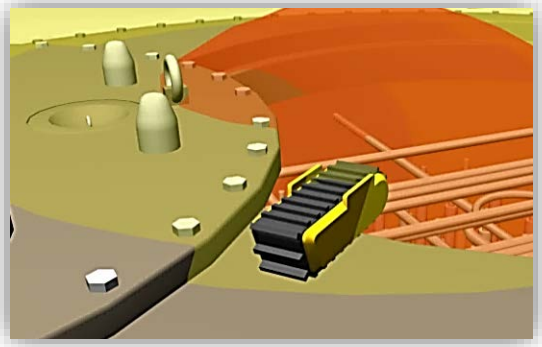
Information management

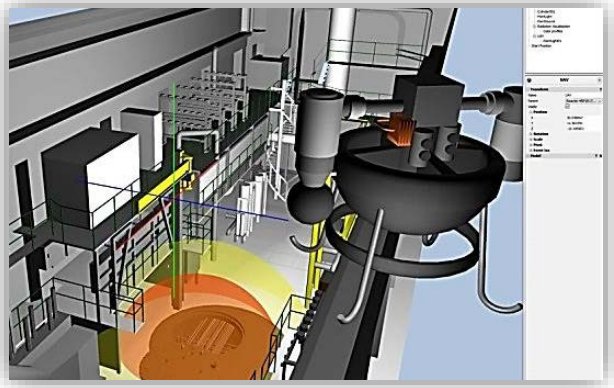


Robotics

- Integrate standard / emerging equipment in a modular design
- Integrate digital, sensor and robotic tech
- Enable high autonomy
- Prove safety/security
- Validate in the field and prove efficiency
- Full scope support: design, training, control, …
- Guidance for application to specific needs



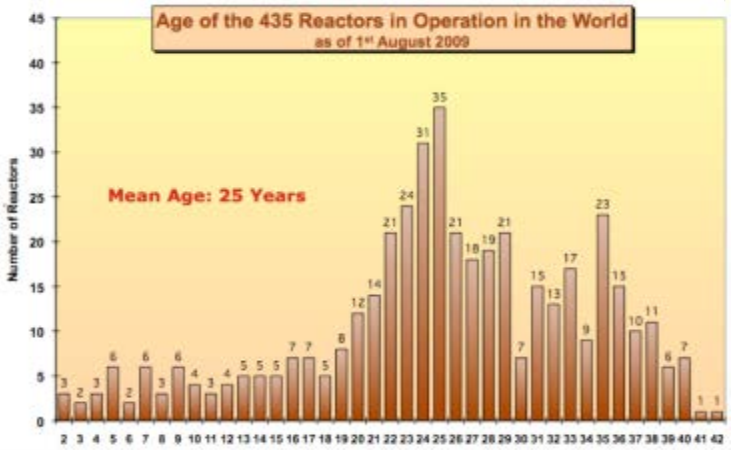




Why is research needed?

Aging plants, political decisions, commercial issues =>

Nuclear decom. will be a major activity Worldwide



Source: IAEA-PRIS, MSC, 2009

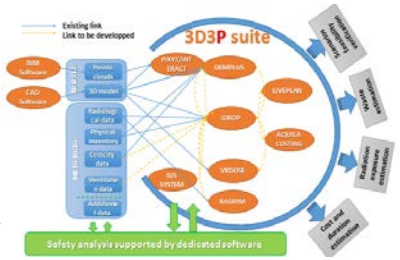
Decommissioning process has to be modernized

- Sporadic decom. R&D — outdated methods
- Assorted teams — communication/data exchange issues (regulators, licensees, contractors, …)
- Mixture of hazards and risks, new types of jobs
- Robotics not ready/expensive
- Low probability of accidents BUT not negligible — preparedness

Collaboration with the IAEA

IAEA
International Atomic Energy Agency

- Important member of the **International Decommissioning Network** (IDN) of the IAEA
- Participated in IAEA coordinated **technical meetings and publications**
- Organized **events** jointly with the IAEA
- Important participant in **IAEA supported international project consortia**:



SHARE: Development of a roadmap for decommissioning research aiming at safety improvement, environmental impact minimisation and cost reduction

3D3P: 3D Digitally enhanced Decommissioning Planning

IAEA collaborative project activities *(under development)*

Activity
1. Strategic **planning** techniques (site and project level). Application for holistic safety and efficiency management, and comparison of various strategies
2. **Knowledge and workforce management** (with information/knowledge centric plant info, PIM, concepts)
3. **Training** of field workers (normal and emergency) with interactive and immersive digitally enhanced methods.
4. **Safety demonstration** and documentation with structured safety argumentation models and 3D modelling
5. **International competence** building relating for use of digital technologies in decom (secondee programme, the eLearning material).
6. **Workshops** (DigiDecom), **training courses** (ELINDER?), **school** (KM for decom)

Invitation

Digitalisation for nuclear decommissioning (2019)

Workshop on
Advanced methods for knowledge management, training and education for nuclear decommissioning

Tentative date/venue :

2019 June 18-20

Halden, Norway


Photo: Joachim Bratteli / IFE

Based on feedback from the participants of our first event under the umbrella of **digitalisation for nuclear decommissioning** (www.ife.no/hrpdecom2017), we are organising this third event for 2019 www.ife.no/digidecom2019. (see also: www.ife.no/digidecom2018).

A growing shortage of skilled nuclear decommissioning specialists is foreseen in the upcoming decades, due to the rapidly increasing demand and low supply (resulting from social and political trends). The workshop will bring together a multidisciplinary group representing the professional community working on implementation and oversight of decommissioning for discussing opportunities and lessons learned from innovative digital methods for knowledge management, training and education in nuclear decommissioning.

The workshop aims at taking advantage of technologies like **storytelling, serious games, 3D simulation, digital twin, and virtual/augmented reality** allowing the participants to:

- **Demonstrate** technology, tools and methods
  - Software and tech support will be provided by IFE
  - Best demos will be rewarded!
- **Share** interesting technical solutions
  - Input will be provided for IFE beforehand
  - Technical demos will be prepared in groups
  - Selected demos will be rewarded!
- **Experience**
  - Become immersed in 3D interactive virtual decommissioning sites: explore site, control equipment e.g. robotic/remote equipment, …
  - Be engaged in entertaining stories from our experience through serious gaming
  - Participate in virtual/augmented tour of our facilities

Rewards may include a gift pack, 2 year license for the VRdose® tool (www.ife.no/vrdose_overview), *exemption from registration fee…*

Organising committee: **digidecom@ife.no**

International advisors: G Kwong (OECD NEA), PJ O'Sullivan (IAEA), V Michal (IAEA), A Ganesan (IAEA), O Glöckler (IAEA), V Ljubenov (IAEA), R Reid (EPRI), J. de Grosbois (indep. consultant)

Chairman: I Szőke, Institute for Energy Technology, Norway

Digitalisation for Decommissioning S?

This cou… on digitalisation of the nuclear dec… ng p… ss from early planning (during o… n) u… the … site release, with special focus on … egrate… digit… concepts enabling holistic mana… ent o… ject and … afety.

Techno… es include… odelling and simulation, semanti… inform… chnology, physics modelling, digital twin… ess simulation and visualisation, immersive p… ce and advanced user interfaces.

Application … s include: information management (BIM/PIM), sit… odelling, strat… nd work planning, safety assessm… and … tration, emergency preparedness, trainin… ng of w… ers, robotics, as well as team coordi… and mo…

Trainees will solve exampl… teractive group sessions using digital te…

The course will also take … vantag… storyt… , serious games, and mixed reality for pr… … engaging deep learning experience b… eal-life … roject experience.

Norway

Next courses:
2018 Spring

Language: English

Expected audience: All profession… ed in plann… or overseeing decommissioning, as … as profession… starting a career in decommissioning
Education level: EQF Level 6 or 7

Learning outcomes from the course:

- ✓ Overview of the international landscape … art… d app… ion of digital technologies for nuclear decommissioning
- ✓ International overview of available technolo… as we… needs and trends for future development and application
- ✓ Understanding of the regulatory aspects of digi… ion for … ning
- ✓ Overview of digital technologies applied in the Oil&G…
- ✓ Lessons learned from application of digitalization t… mi… oning … waste management in Norway
- ✓ International experience from application of digitalization f… … oning of hazardous legacy nuclear sites (including Chernobyl NPP)
- ✓ Skills in application of digital technology for different asp… of decommis…
- ✓ Learnings from experiencing examples and solving problem… through immersive (gaming) experiences based on international real-life projects

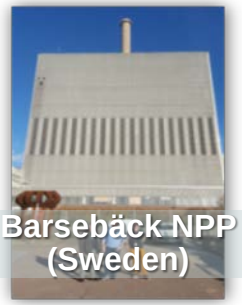
Price:
Will be defined in due time

Institute for Energy Technology

HRP and Nordic surveys

Interviews with decommissioners


Ringhals NPP (Sweden)

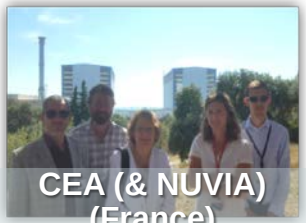

Barsebäck NPP (Sweden)

AREVA Germany


EC JRC (Italy)


SSM (Sweden)

VTT (Finalnd)


CEA (& NUVIA) (France)


NNL & Sellafield (UK)


EDF (Lyon, France)


IRSN (France)

Interviews - findings

- **National/international infrastructure** (e.g. final disposal) and regulatory framework not keeping up with needs / not flexible enough.
- **Contracting** and **regulatory acceptance** process is slow – communicating and evaluating offers/reports.
- Redundancy and inadequate founding in **R&D** into decom.
- Good opportunities for remote and **robotic technologies**, BUT manual work will continue to be used.
- Innovative methods based on systemic **MTO thinking** is rarely applied – e.g. smart logistics / resource allocation

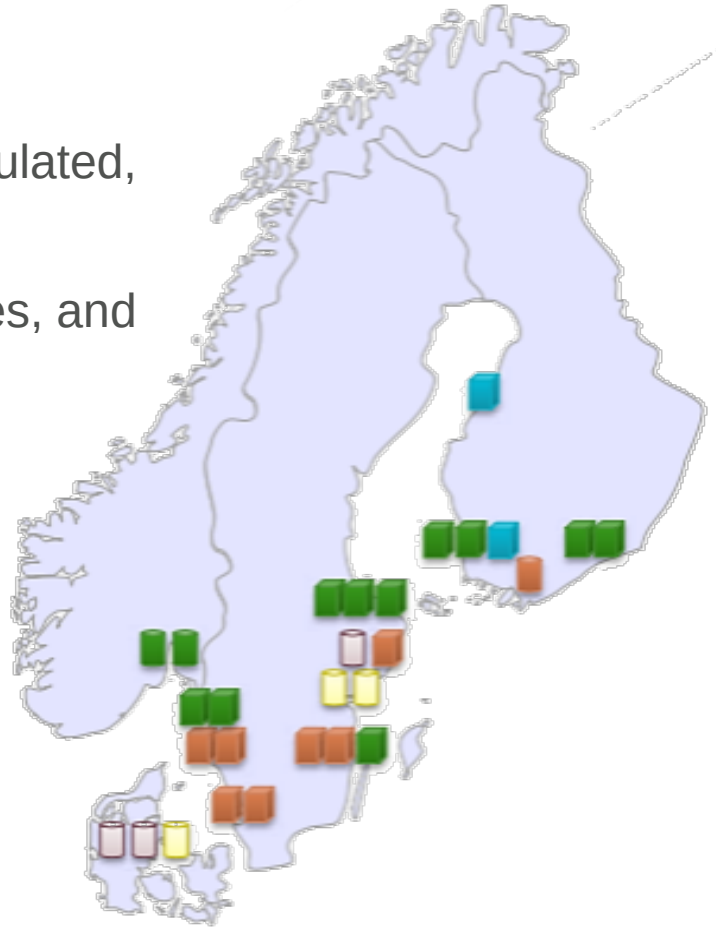
Interviews - findings

- As opposed to cutting, robotic and similar modern technologies, advanced info techniques are rarely used –> **Knowledge Management** is a general problem
  - Safety and cost (feasibility) assessment and comparison
  - Risk monitoring – team briefing and coordination
  - Training: decentralised, costly ***/*** inefficient out-dated methods
  - Data management (big data, data mining, data filtration and representation)

Nordic survey

Challenges and opportunities for improving Nordic nuclear decommissioning

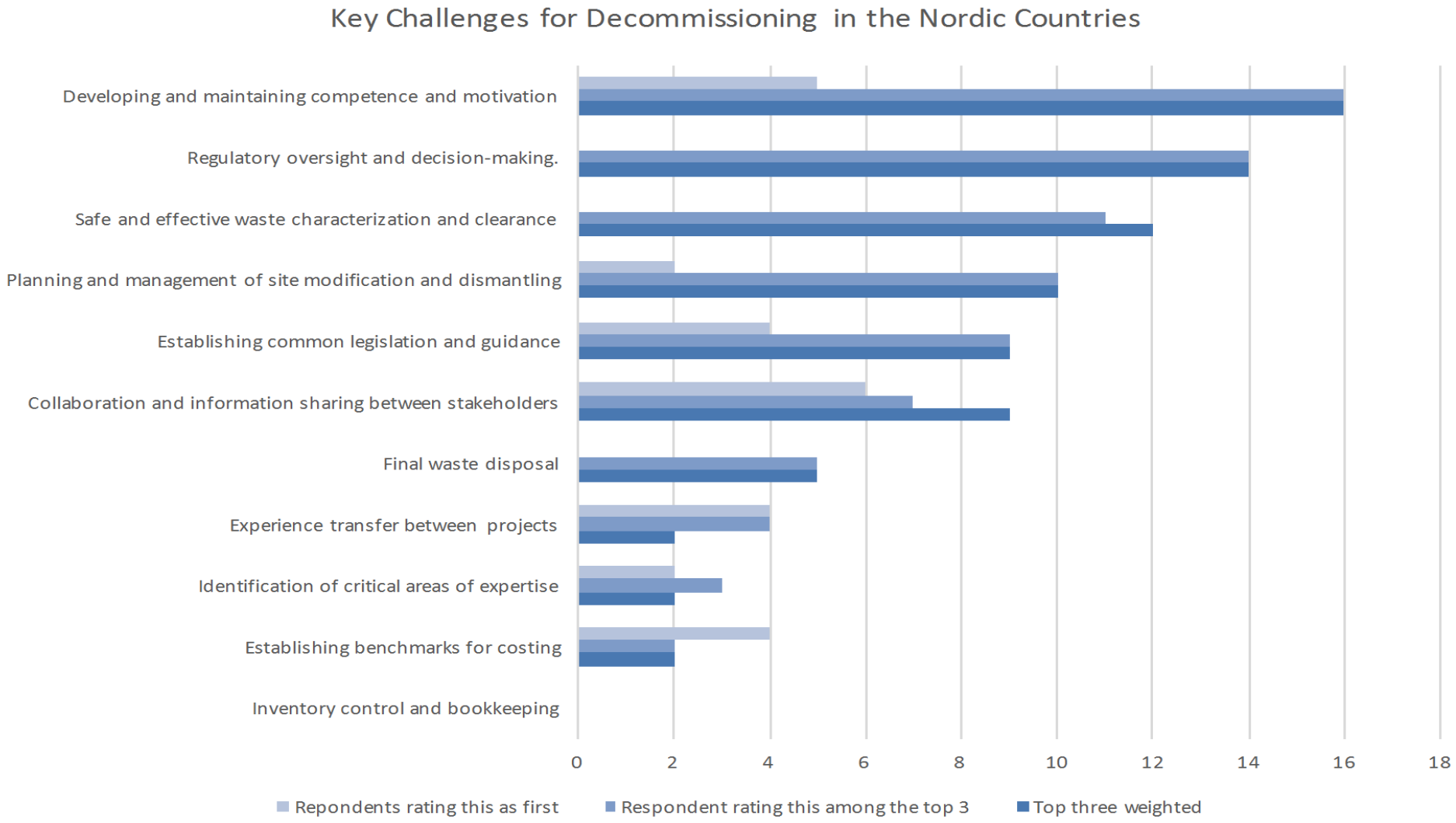
- Nordic study on how decommissioning is regulated, planned and performed,
- Identify main challenges, collect best practices, and
- Foster collaboration by fostering sharing of experiences between the Nordic participants.

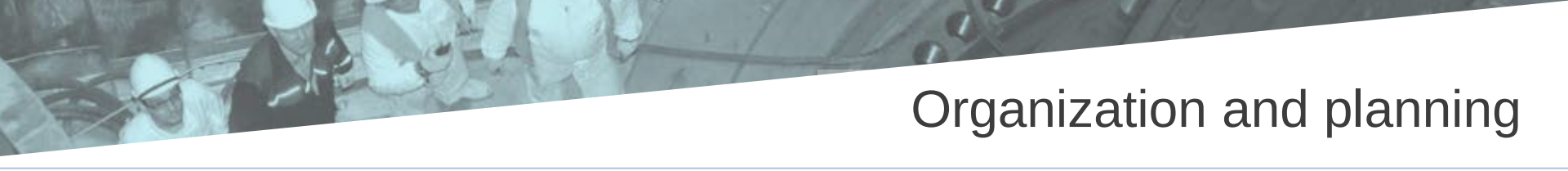


Activities:

- 1. Decommissioning of Nordic legacy sites
- 2. Large scale decommissioning in a Nordic setting
- 3. Nordic collaboration arena

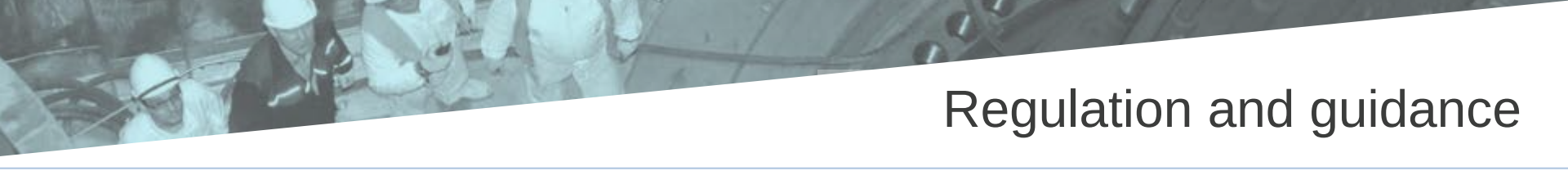
Key challenges





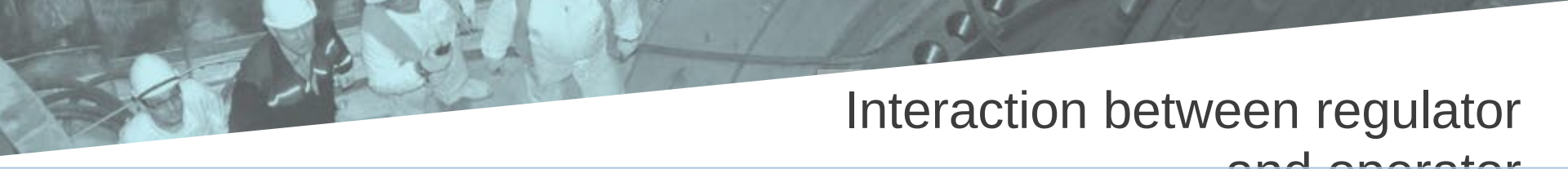
Organization and planning

- Challenges
  - Lack of decom. experience in Nordic countries
  - The scale of the decom. projects
  - Logistics planning
  - Lack of national final waste repository (delay plans and increase costs)
  - Decom. of different units at different times
- Good practices
  - Planning for decom. should start early



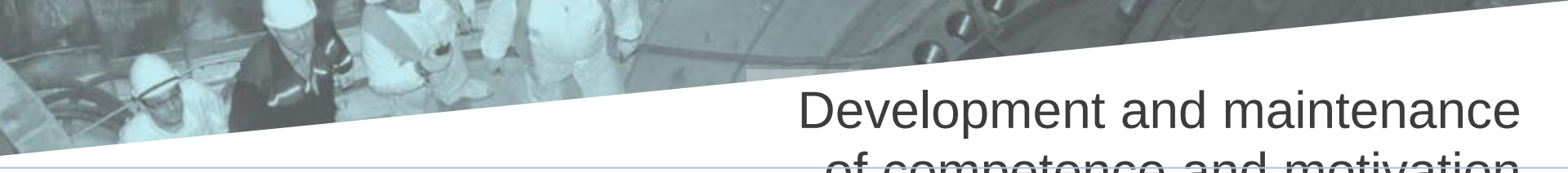
Regulation and guidance

- Challenges
  - Lack of regulatory experience (decom. will be a learning experience for the regulator too)
  - Lack of regulatory guidelines (application/interpretation of regulation)
  - Need for clear and effective reporting and decision making processes (safety demonstration)
  - Regulatory framework may be especially challenging for legacy sites
- Good practices
  - Some decom. experience exists for research reactors
  - Recommendation on reference levels from ICRP



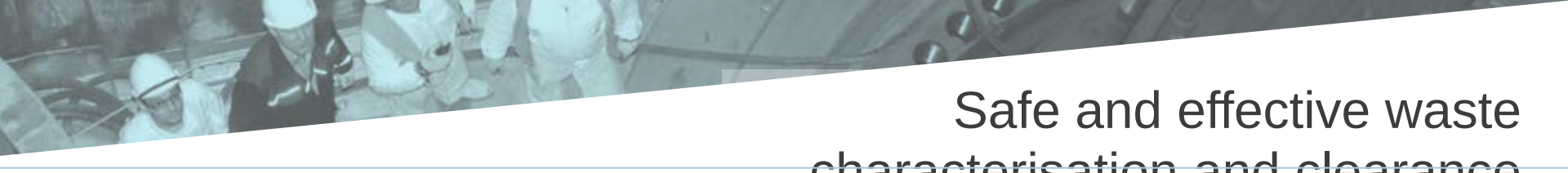
Interaction between regulator and operator

- Challenges
  - Interpretation of regulation in practice - Need for more flexible approach?
  - Need to understand each other's roles
    - Calibrate expectations, optimise communication
    - What are contractors' role in this interaction?
  - Need for more efficient process to handle “small” issues quickly
- Good practices
  - Important to build and maintain a relationship based on trust
  - Active, open information exchange between regulator and operator
  - Local representative from regulator
  - Graded approach (especially for legacy projects)



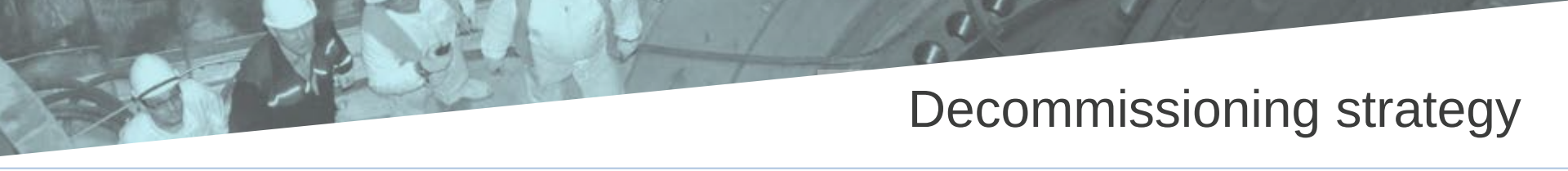
Development and maintenance of competence and motivation

- Challenges
  - Do existing staff have the right competence and motivation?
  - How to maintain tech. and scientific competence at the regulator?
  - Lack of nuclear education on a national level
  - Contractors may lack nuclear experience
- Good practices
  - Recognise as an essential part of safety and efficiency
  - Utilise competence across the Nordic countries
  - Close interaction (and workforce mobility) between regulator and operator



Safe and effective waste characterisation and clearance

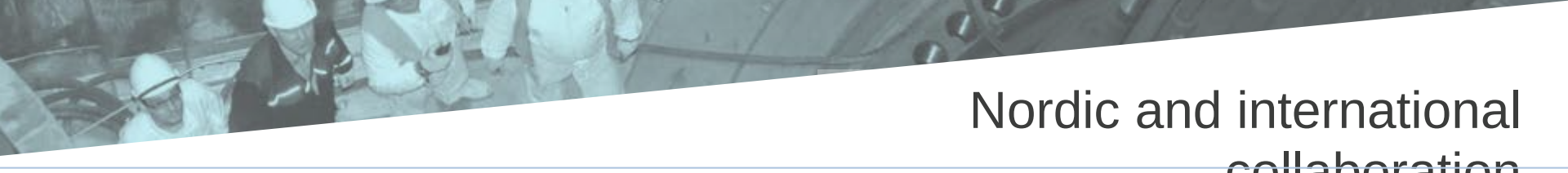
- Challenges
  - Compared to operation, decom. produces larger amounts, and new kinds of waste
  - More effective waste characterization methods are needed
  - Reuse (free release) can reduce costs, but challenging
- Good practices
  - Start planning for waste management early (early characterisation)
    - Waste acceptance criteria for future depositories?



Decommissioning strategy

- Preference for immediate decom.
  - Economical and more efficient
  - Low competence and knowledge loss
  - Low chance for change in regulation
  - Don't have to do modifications later

  BUT not always possible/optimal!
- Exceptions:
  - Olkiluoto 3 will operate until 2090, all three units will be decommissioned at same time
  - Barsebäck: political decision to use deferred decom.



Nordic and international collaboration

- There is a desire to collaborate across Nordic countries
- NKS meetings support informal discussions
- All can gain from sharing experiences
- Transferring lessons from international experience may be limited
  - Differences in legislation, clearance levels, waste management
  - Lessons from guidance level transfer easier than legislative level (Easiest to transfer technical lessons. Strategic issues are more difficult).