Institute for Energy Technology

Perform research and provide support for decommissioning and other projects in nuclear environments

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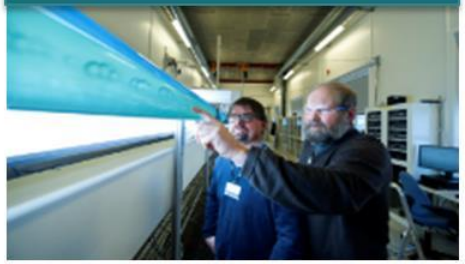
Institute for Energy Technology (IFE)

Nuclear technology

Oil & Gas



Isotope laboratories

Energy and Environment

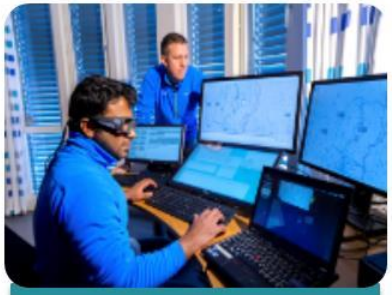
Man Technology Organization (MTO)

- Industrial psychology
- **Software Engineering**
- Systems and Interface Design

MTO labs:

VR-lab

HAMLAB



ATM lab

FutureLab

Software Engineering Division

Control Room Designs (Human Factors, Virtual Mockups)

Support for Nucl. Decom-missioning

Software Systems Dependability

Air Traffic Management

40% of budget: OECD HRP research programme

60% of budget: Projects with the Industry, Authorities, Research Council, EU

Decommissioning research at IFE

The OECD Halden Reactor Project (HRP) lead by IFE,

Sponsored by 20 countries:

Belgium, China, Czech Republic, Denmark, Finland, France, Germany, Hungary, Japan, Kazakhstan, Korea, Netherlands, Norway, Russia, Slovakia, Spain, Sweden, Switzerland, UAE, UK, USA

>100 nuclear organizations (utilities, vendors, licensing authorities and R&D centres)

AREVA, CEA, CIEMAT, CNPRI, CRIEPI, 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 …

Internally founded research into decom (2015-2017)

NKS - Nordic Nuclear Safety Research founded (2017, 2018**)**

all Nordic regulators participate + utilities, research inst., contractors

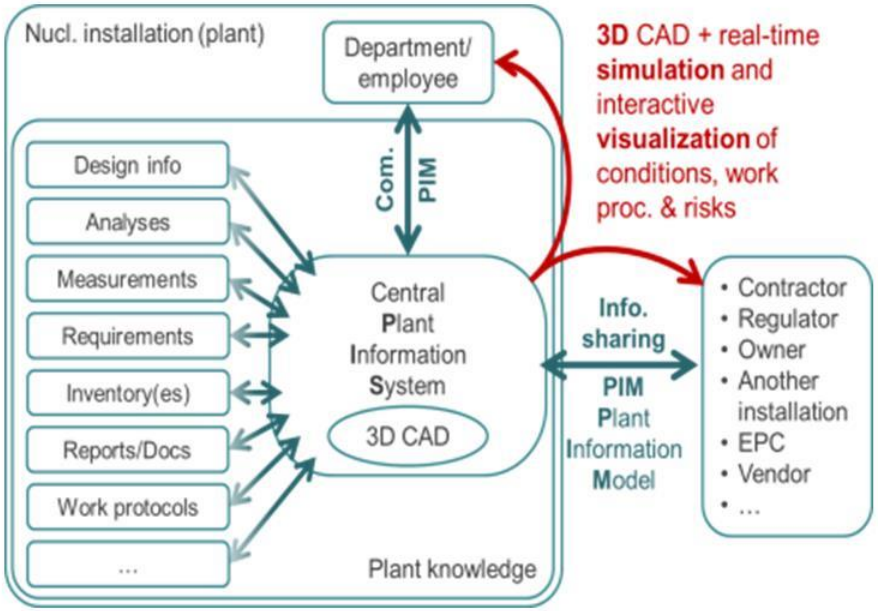
http://www.oecd-nea.org/jointproj/halden.html
http://www.ife.no/en/ife/halden/hrp/the-halden-reactor-project

Collaboration

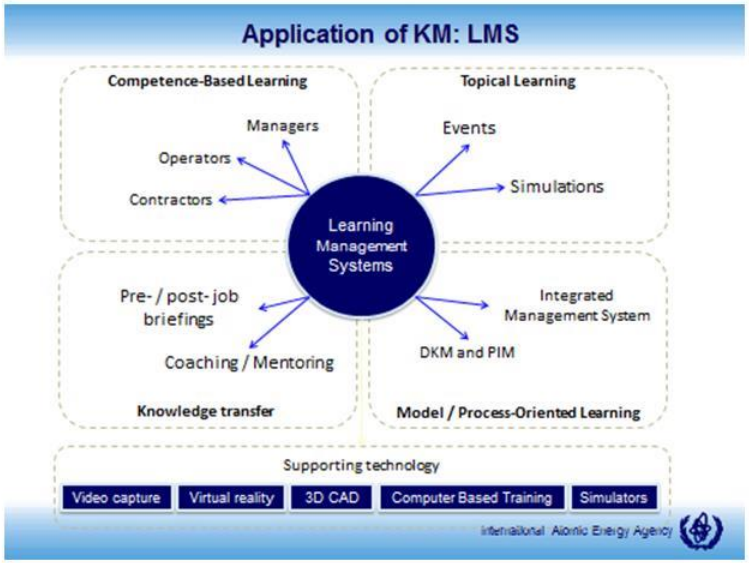
- **Hosting the OECD Halden Reactor Project (HRP)**
  - HRP affiliated to **OECD Nuclear Energy Agency (NEA)**, Working Party on Decom. and Dismantling (WPDD)
  - Collaboration with the **International Atomic Energy Agency (IAEA)** - International Decom. Network (IDN), consultancies/workshops/recommendations
- **Industrial collaborations and initiatives:**

Collaboration with IAEA

Plant Information Management



Organizational learning management



IAEA NUCLEAR ENERGY SERIES No. NG-XXXX

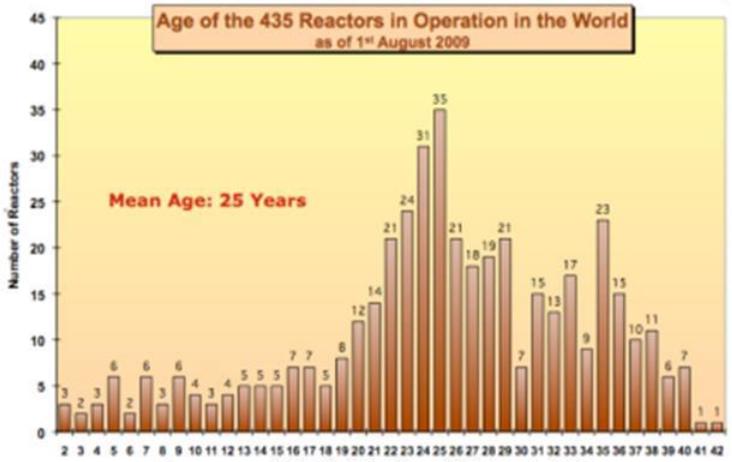
Application of Modern **Plant Information Models** to Support and Manage Design Knowledge throughout the NPP Life Cycle

SHARE initiative (co-financing decom R&D on international level)

Motivation

Aging plants, political decisions, commercial issues =>

Nuclear decom. will be a major activity Worldwide



Source: IAEA-PRIS, MSC, 2009

Decommissioning process is challenging

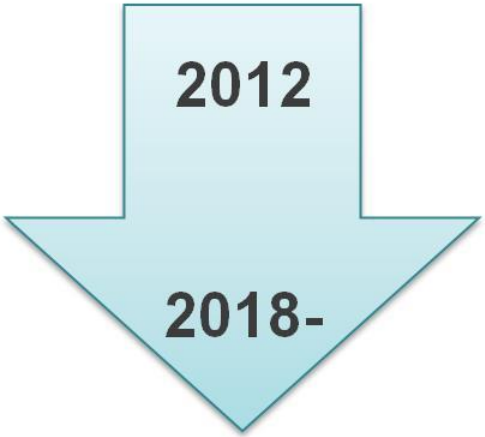
- Sporadic decom. R&D — outdated methods
- Assorted teams — communication/data exchange issues (regulators, licensees, contractors, …)
- Mixture of hazards and risks, new types of jobs
- Robotics not ready/expensive
- Low probability of accidents BUT not negligible — preparedness

Lack of efficient methods supporting a more unified and informed work process

HRP research into nuclear decommissioning

1. Investigate current challenges (gap analyses)
2. Compile lessons learned and methods available
3. Find and evaluate new concepts
4. Provide recommendations

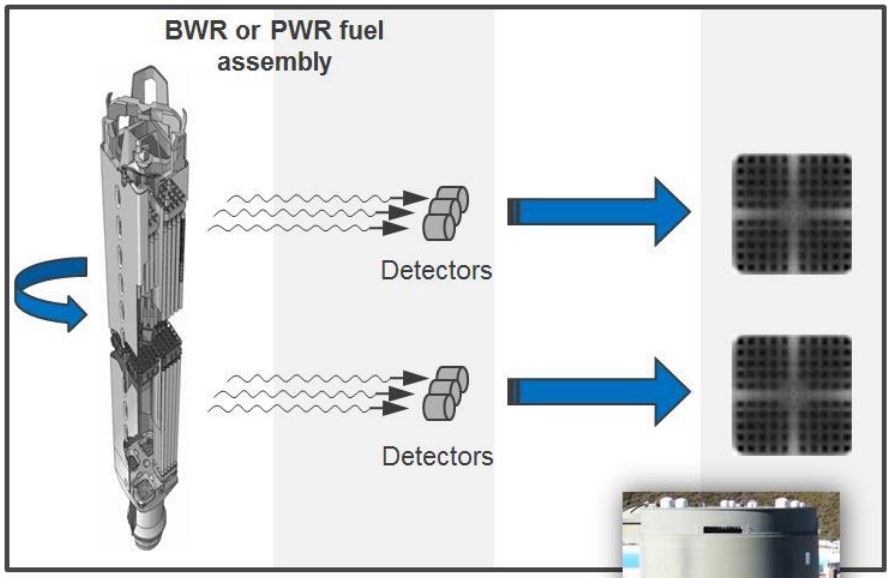
3D simulation of work procedures with radiation visualization



MTO support for improving organizational, national and international capability

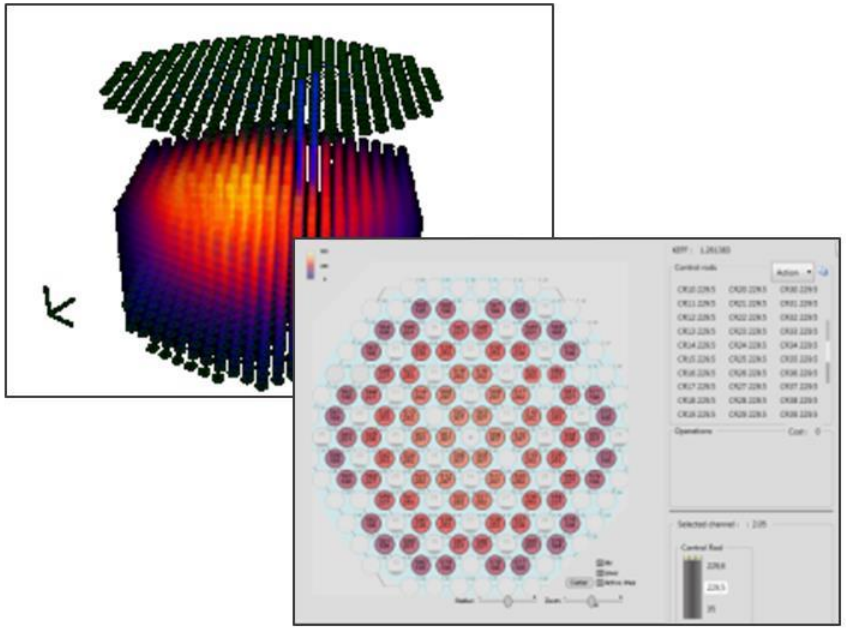
MTO: **Nuclear Technologies**

Non-destructive rod-wise characterization of spent nuclear fuel



Optimisation of SNF storage (reducing conservatism)

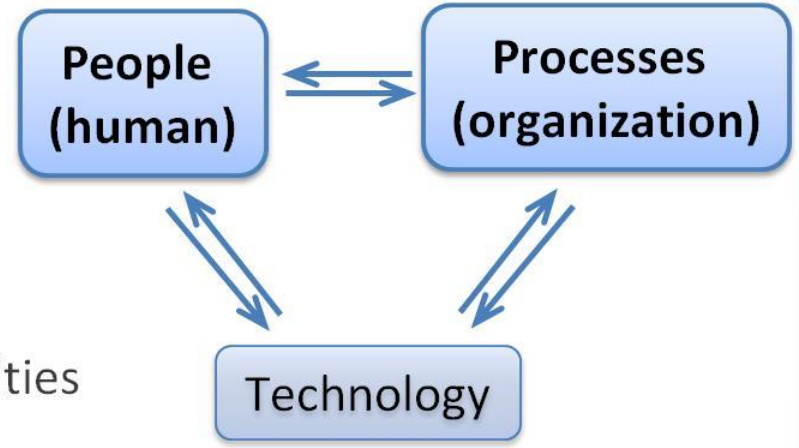
Core Data Management



Better POCO planning

M&O support for Capability Development

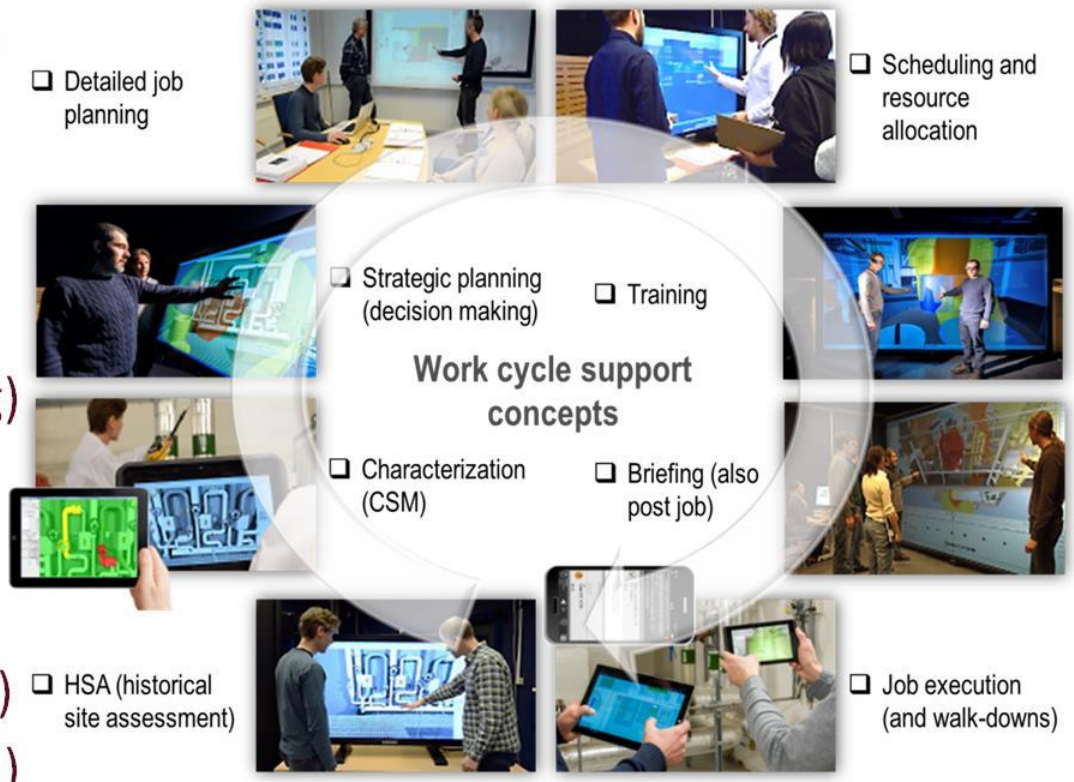
Human & Organisational considerations



- Gap analyses
  - Identification of required key capabilities
  - Evaluation of organisational maturity
- Road map for success, avoiding Human and Organisational 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

MTO support for Capability Development

- Plant Information Management (PIM)(rad. info)
- Rad. Characterization
- Informed Decision Making on strategy
- Job Planning (optimization – radiation / other hazards)
- Regulatory Communication
- Team Collaboration (planning)
- Training & Briefing
- Team Coordination
- Plant Life Cycle Management (maintenance & modification)
- Knowledge Management (KM)
- Emergency preparedness



Future of nuclear energy

Energy

Rapid growths in electricity demand

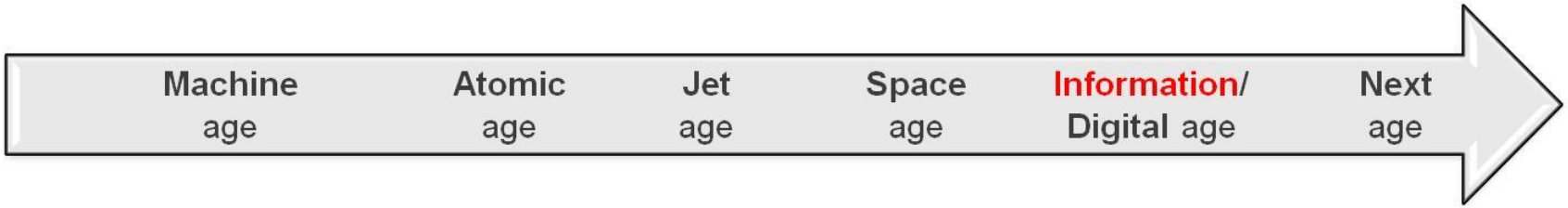
Coal plants growing but foreseen to not meet demands

Promise of near unlimited cheap power from atomic energy

Renewable energy

Promise of clean home grown electricity

Nuclear?



Nuclear energy

Obsolete / Sporadic

OR

New tech based innovation ensuring sustainability

More tech is coming in the next decades than in the last 1000 years

Information age and beyond

Information tech: exponential growths (Moore's, Metcalfe's, Gilder's and Kryder's laws)

- Digitally powered communities
- Process automation / efficiency
  - Enterprise wide info solutions
  - Data analyses, pattern recognition, advice - machine intelligence
  - Dynamic decision making
- "Smart" concept – smart infrastructure, resource allocation
- Robots and remote operations
- Wearables and embedded comp., Internet of Things, ubiquitous comp.
- 3D printing (additive manufacturing)

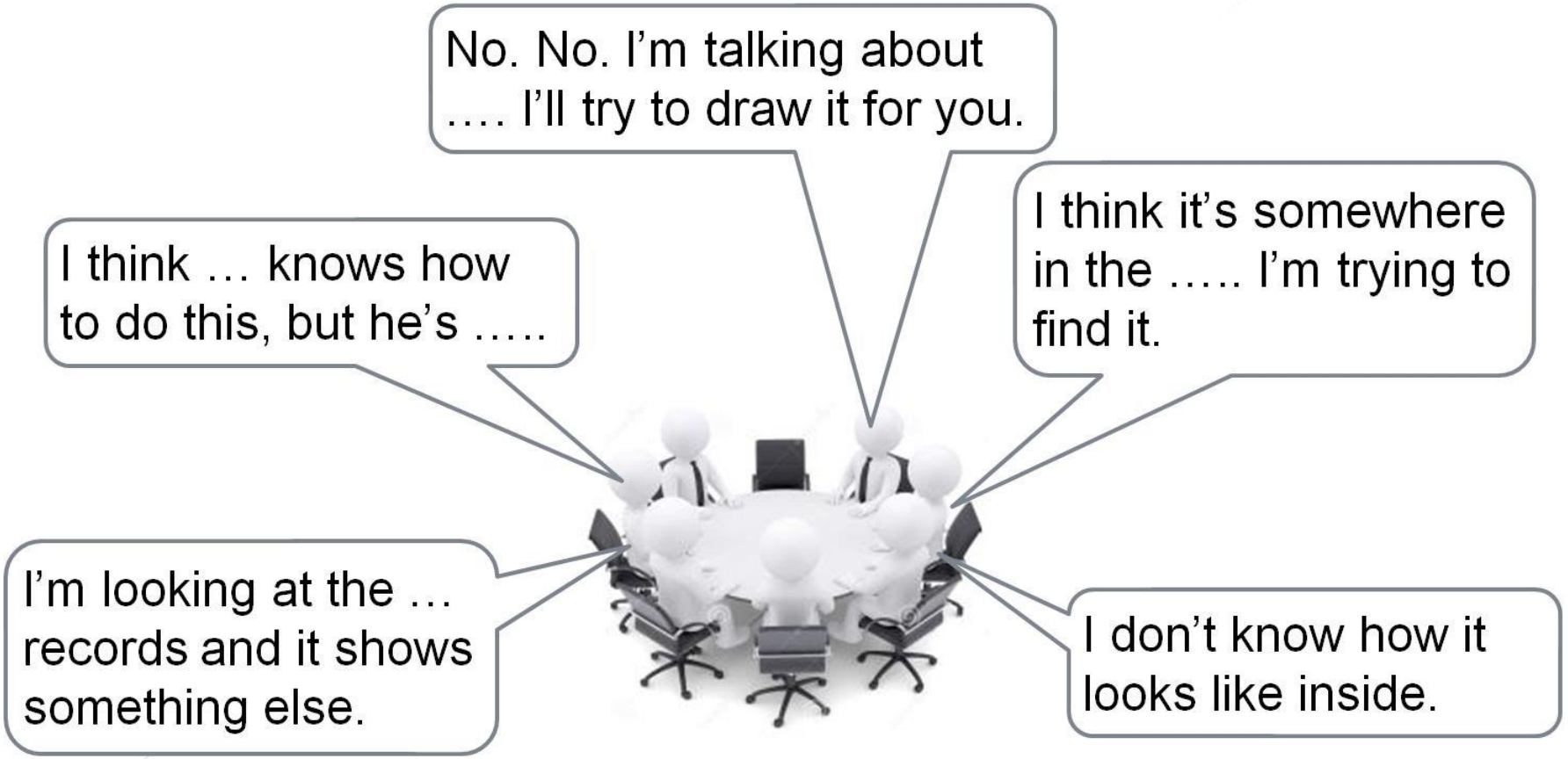
Information age and beyond (cont'd)

- Accelerating need fort ability to invent and adopt – agility, creative thinking and rapid learning VS. mainly STEM subjects
- Online platforms and E-learning VS. traditional college
- Virtual Reality VS. hands-on/field exercise

Customers/users will expect major new features in future services and products

Majority of people will be wiling to wear technology to help them do their jobs

Meeting/collaboration



Training and education

You have to remember that this is the right .... and it's important that you operate it like this.

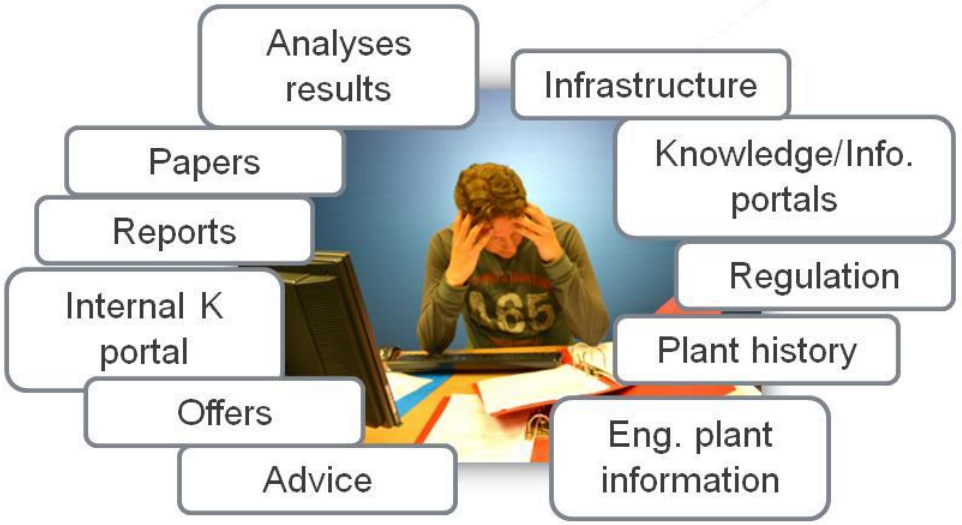
It says here that in case of …. the … shaped knob must be …

I don't see it on the drawing. Maybe behind … or the drawing is out-dated?

Information support

Available data is growing at unprecedented rate =>

unique opportunities for greater understanding and more informed strategy



Distributed, embedded experiences VS. traditional soft applications

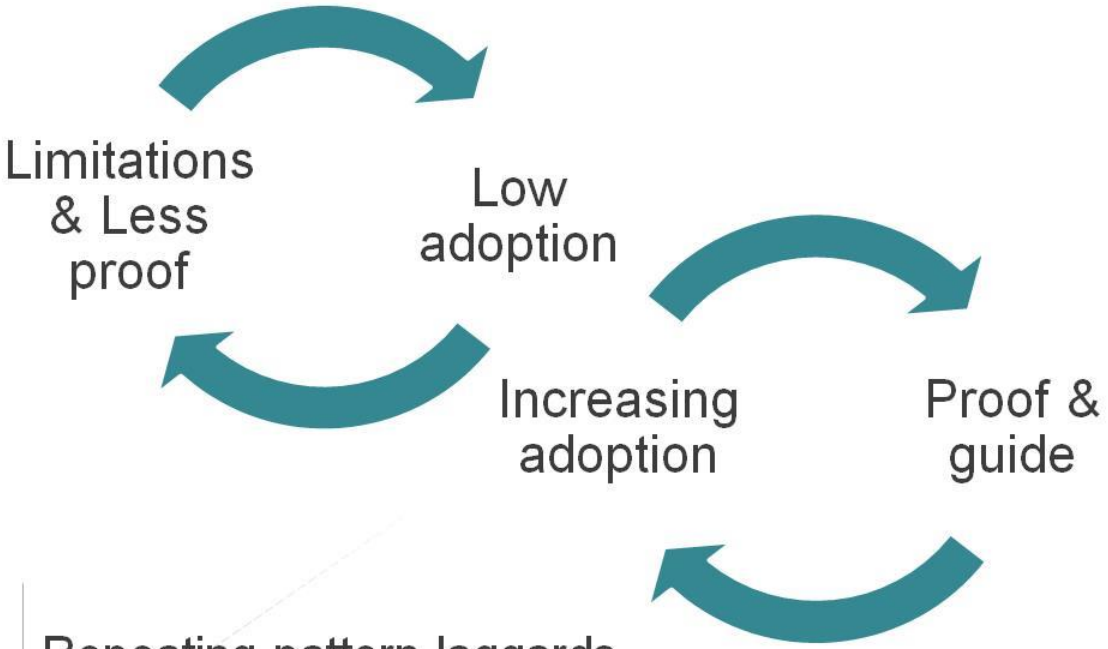
Input via sensors and analyses (e.g. behavioral and location based) VS. traditional (mouse, keyboard) and touch screen

Embedded, frictionless, contextualized and personalized information

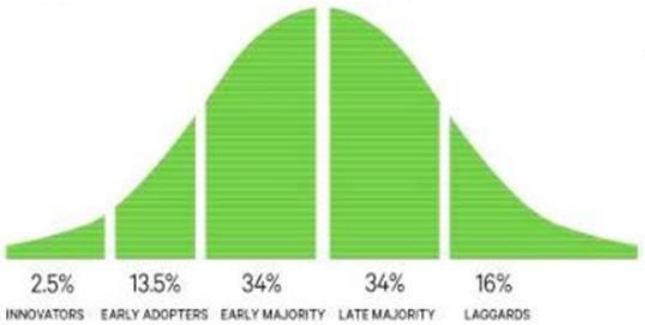
The challenge

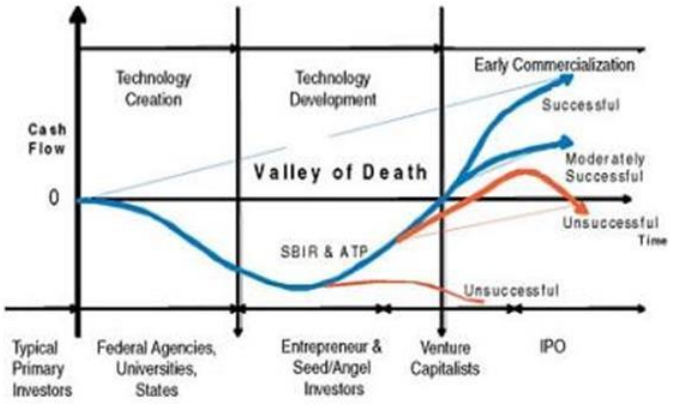
New techniques:

- Compatibility with old systems / input data
- Readiness for complex real-life situations
- Availability of tested guidance



Repeating pattern laggards ("Luddites"/"Neo-Luddites")

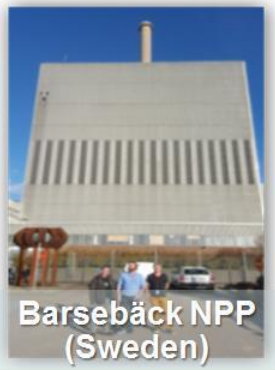




SOURCE: L.M. Murphy and P. L. Edwards, *Bridging the Valley of Death—Transitioning from Public to Private Sector Financing*, Golden, CO: National Renewable Energy Laboratory, May 2003.

Interviews with decommissioners


Ringhals NPP (Sweden)


Barsebäck NPP (Sweden)

AREVA Germany


EC JRC (Italy)

SSM (Sweden)

VTT (Finalnd)


CEA (& NUVIA) (France)


NNL & Sellafield (UK)

Planning: IRSN, EDF (FR & UK), NRG, VUJE + DECOM, Oskarshamn NPP, UJV, NRC, DOE, EPRI, INPO, …

Some general 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

Some general findings (cont'd)

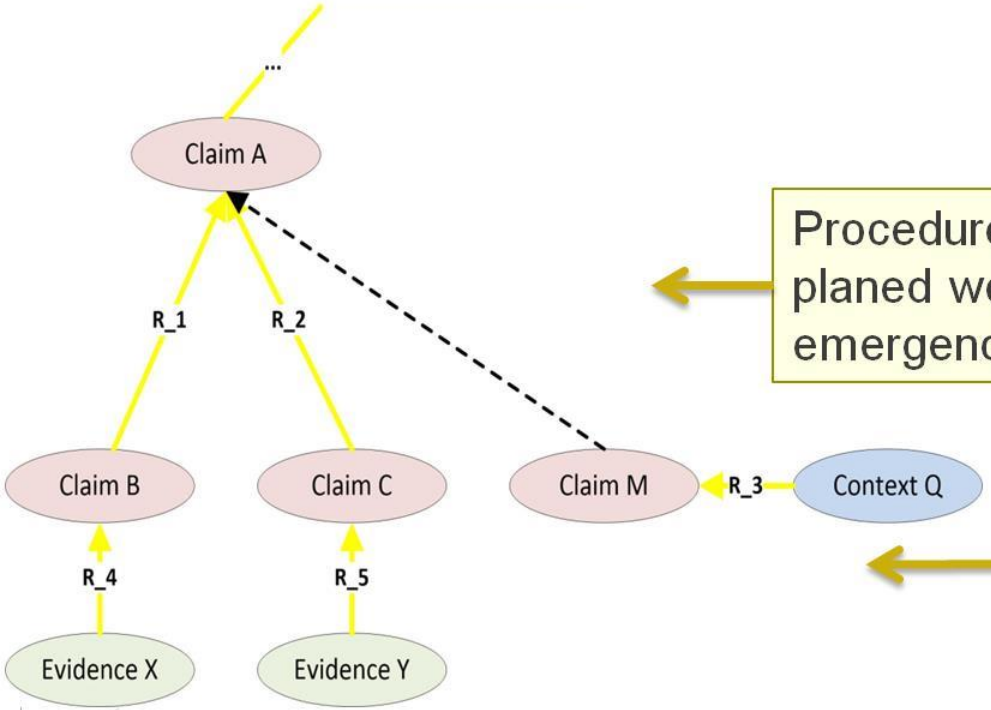
- As opposed to cutting, robotic and similar modern technologies, advanced info techniques are rarely used –> Knowledge Management is a general problem
  - Safety and cost (feasibility) assessment and comparison
  - Risk monitoring – team briefing and coordination
  - Training: decentralised, costly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

Decom is a challenge for regulators too

Safety demonstration - safety argumentation

… Claim A [unfolded] … because Claim B and Claim C [R_1 & R_2]. Claim B and Claim C together are equivalent with Claim A [Claim M] because we know [R_3] … Context Q [unfolded] …. … Text with no safety argument relevance … … Claim B [unfolded] … because of [R_4] Evidence X. … Claim C [unfolded] … because of [R_5] Evidence Y.

Excerpt from a theoretical safety demonstration document.



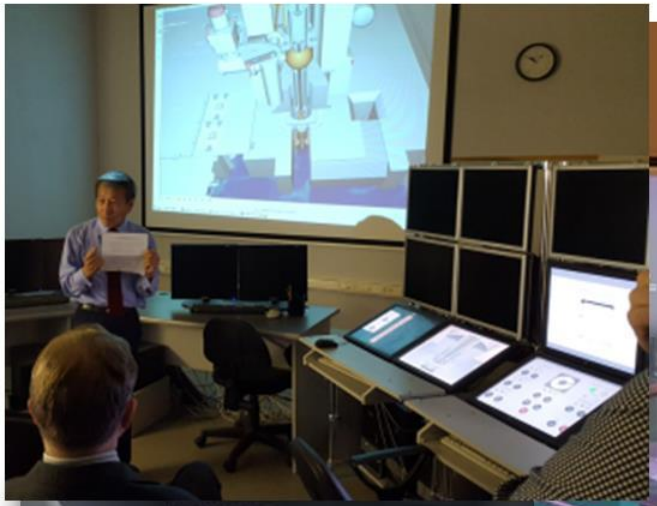
Procedures for planed work and emergencies

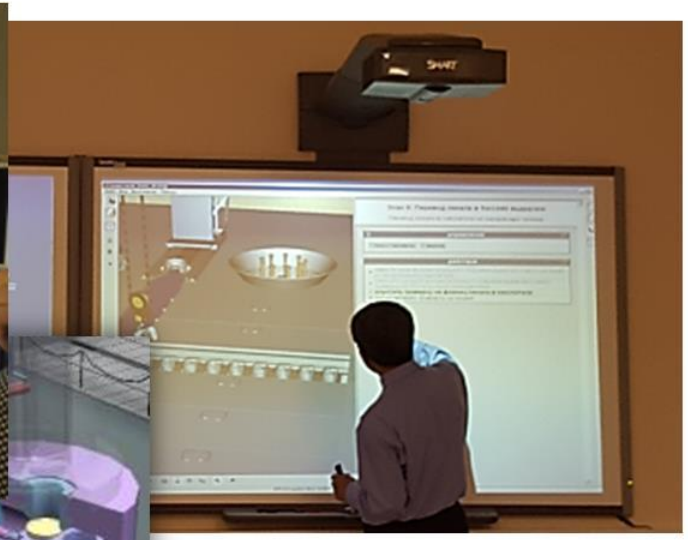
Plant safety information

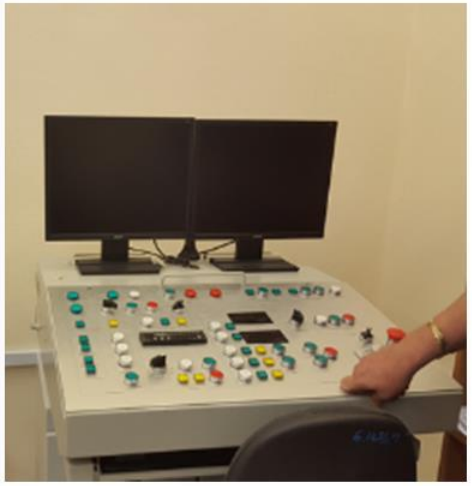
Real-life applications

Leningrad NPP, Cherobyl NPP, Fugen NPP, Andreeva Bay, IFE Kjeller, Halden Reactor, NNL, Ringhals NPP (test), EC JRC (test) → Lessons learned!

Leningrad NPP (1999- 2010, 2014 -)





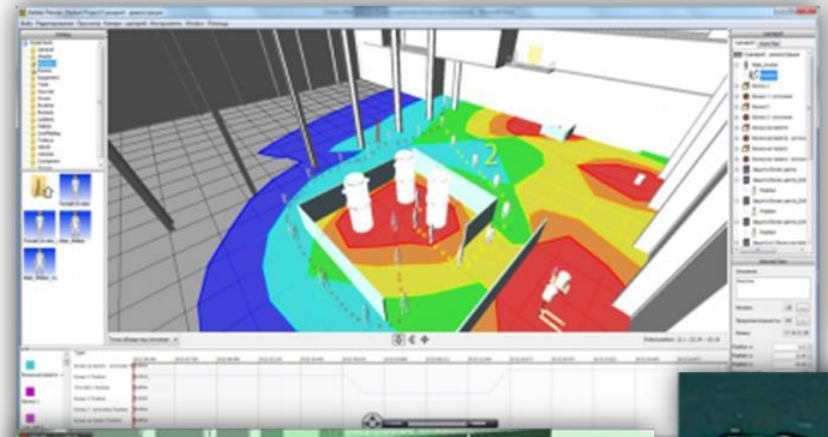


- Decom. planned from 2018
- Out-dated **design information** management
- Lack of advanced methods **for safety planning** (e.g. rad. protection)

Support for 3D decom. job

- planning (incl. rad. protection),
- training, and
- demonstration.

Andreeva bay, NW Russia (2011-)



- **Most dangerous** nucl. site in the NW Russia
- Effective **regulatory supervision** is required
- **Unique challenges** requiring innovative solutions for ensuring ALARA

Support for 3D job

- planning (incl. rad. protection),
- training, and
- demonstration (regulatory control

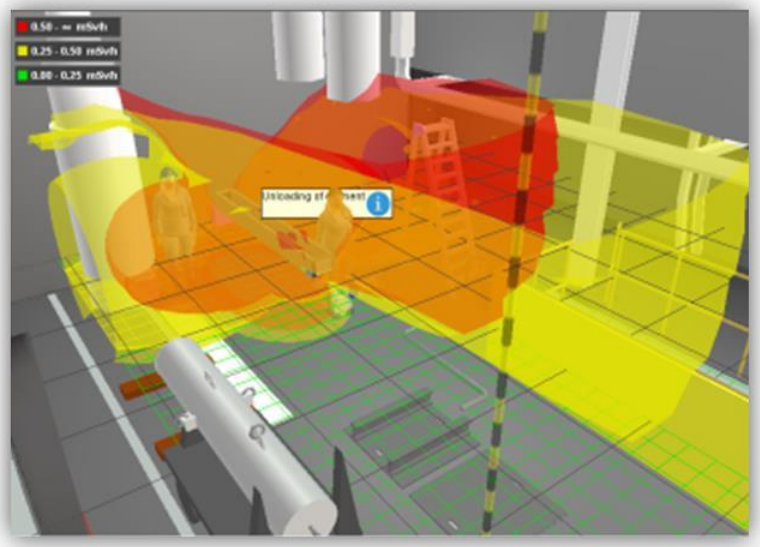
Fugen NPP (2004, 2014 -)

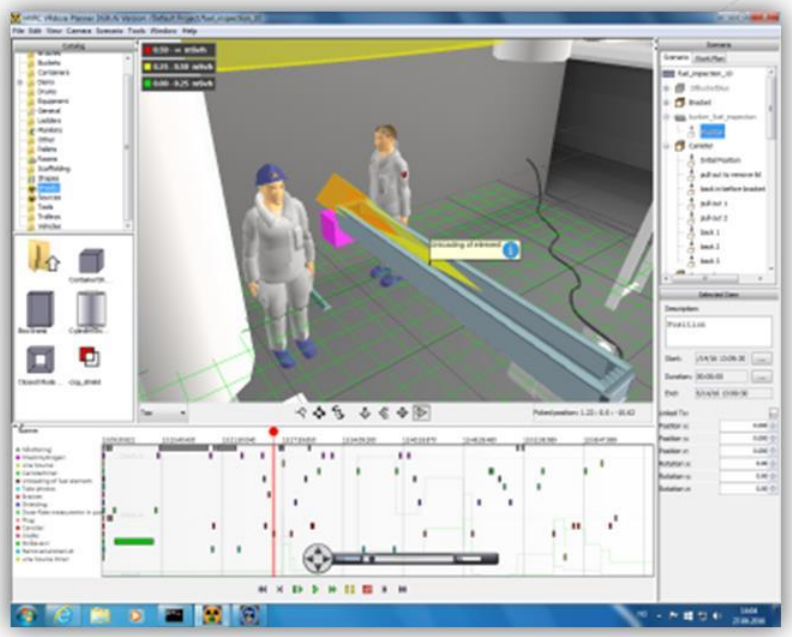
Advanced solutions for establishing an effective **KM system** for decom. and **planning decom. jobs**.

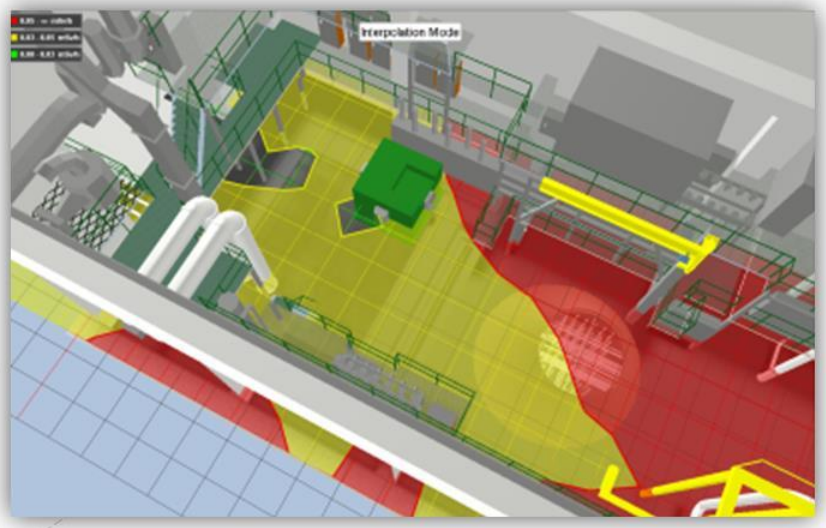
3D support for

- Building a knowledge base for planning decom.
- Collaborative strategic planning
- ALARA planning of decom. jobs.

Halden Reactor (2016-)







Better methods are needed for developing safety case for inspection of historic fuel.

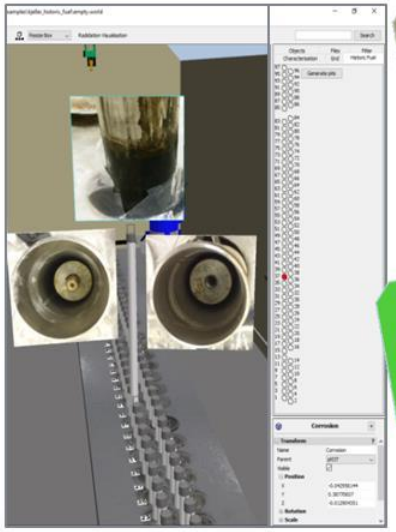
Scenario simulation and analyses using VRdose

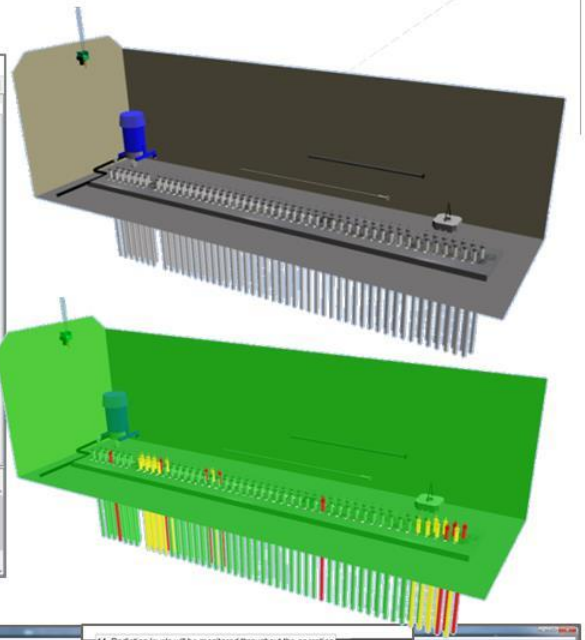
Reduction of background in the reactor hall.

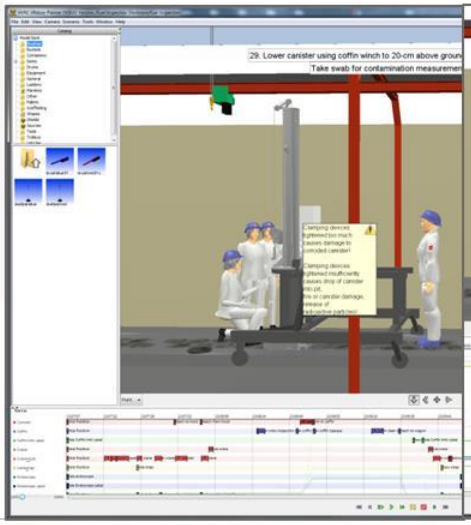
VRdose and geostatistical analyses

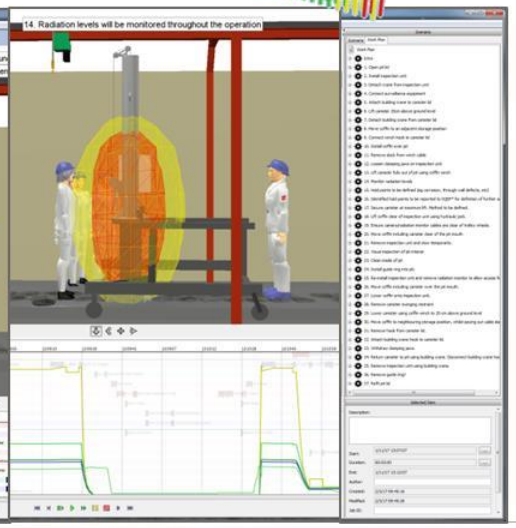
Management of historical fuel at IFE

Support for PIM, safety planning, and communication:









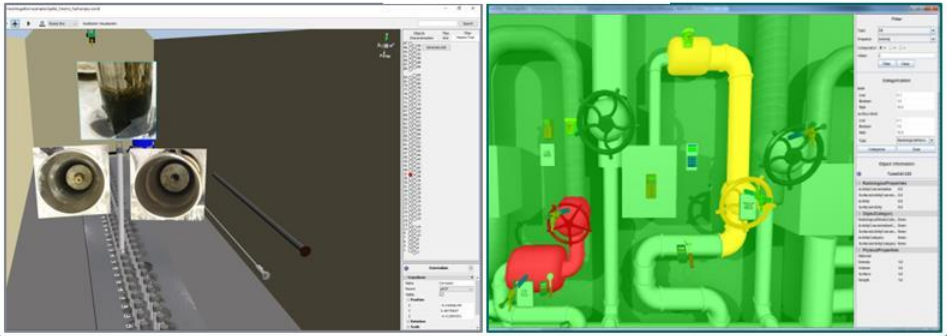
Demos

3 Use cases:

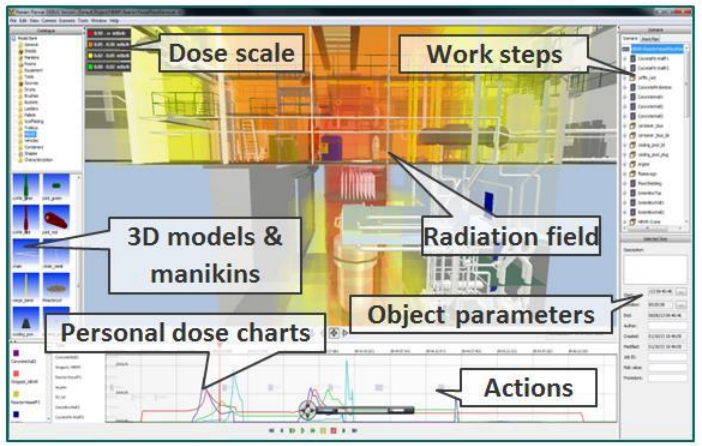
1. Historical fuels inspection at IFE
2. POCO and SNF management
3. Safety argumentation

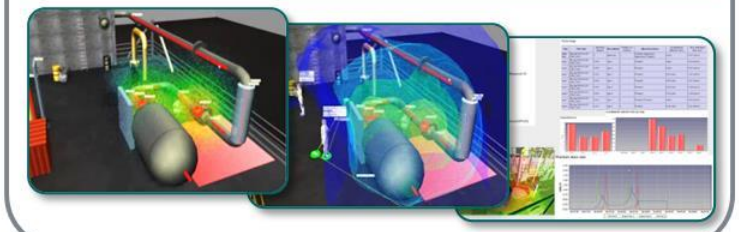
Tool/Techniques:

RadPIM



VRdose & Pro





Immersive solutions