PREDEC 2016

International Symposium on PREparation for DECommissioning

Virtual Reality: a way to prepare and optimize operations in decommissioning projects

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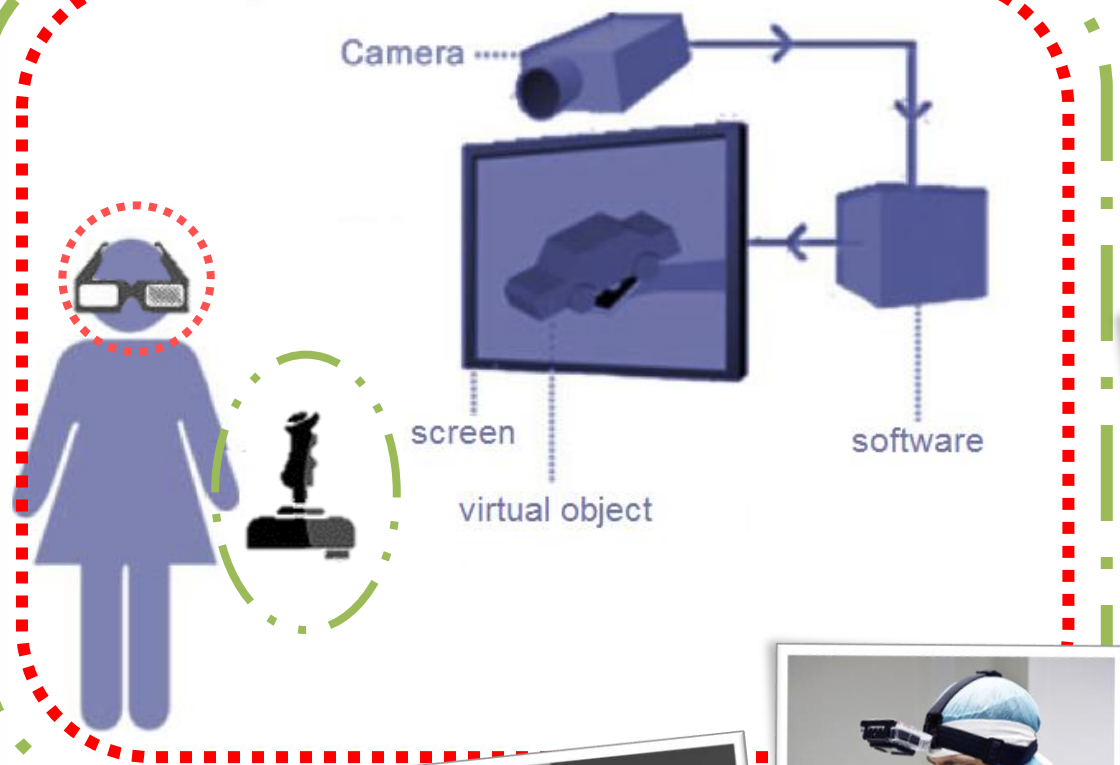
1. VR: definition and purposes

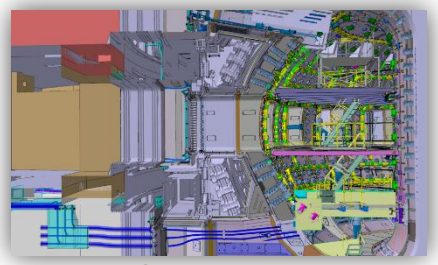


Immersive simulation

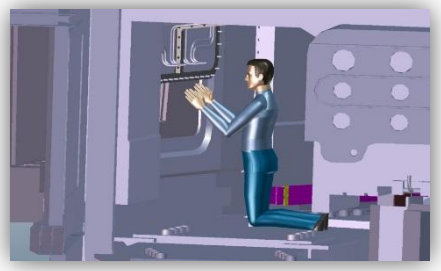
Interactive simulation

1. VR: definition and purposes

Why use Virtual Reality in a nuclear facility?

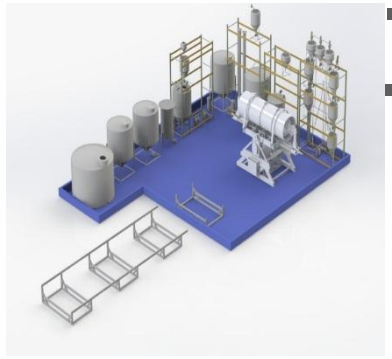


ITER facility design



DESIGN

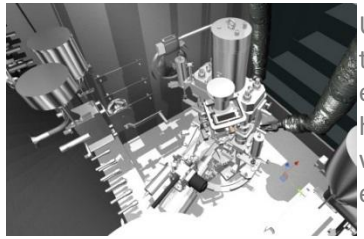
BUILDING



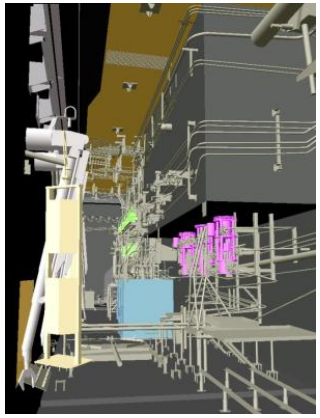
Use of VR in DAHER nuclear cylinder wash plant

Nuclear facility life cycle

OPERATION

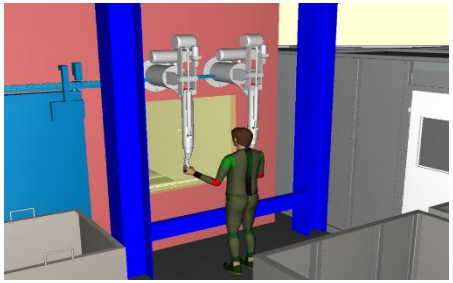


Use of VR to refit an existing hot cell with new equipment



APM Cell 414 dismantling

DISMANTLING



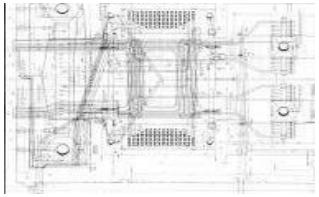
Use of VR to train operators

1. VR: definition and purposes

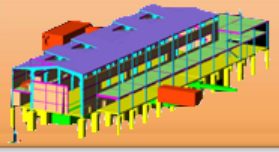
VR applied to decommissioning projects:

INPUT DATA

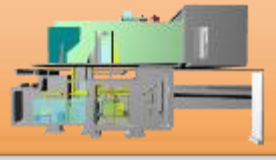

photogrammetry


2D plans


Laser scanning



Digital mockup



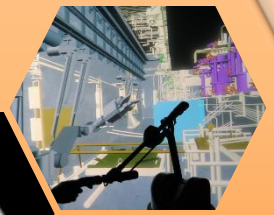
Studies


New equipment design

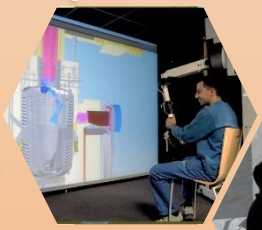

Remote handing simulation


Dose rate simulation


Human operation simulation


Whole scenario simulation

Implementation


Operator training


Assistance for real operations

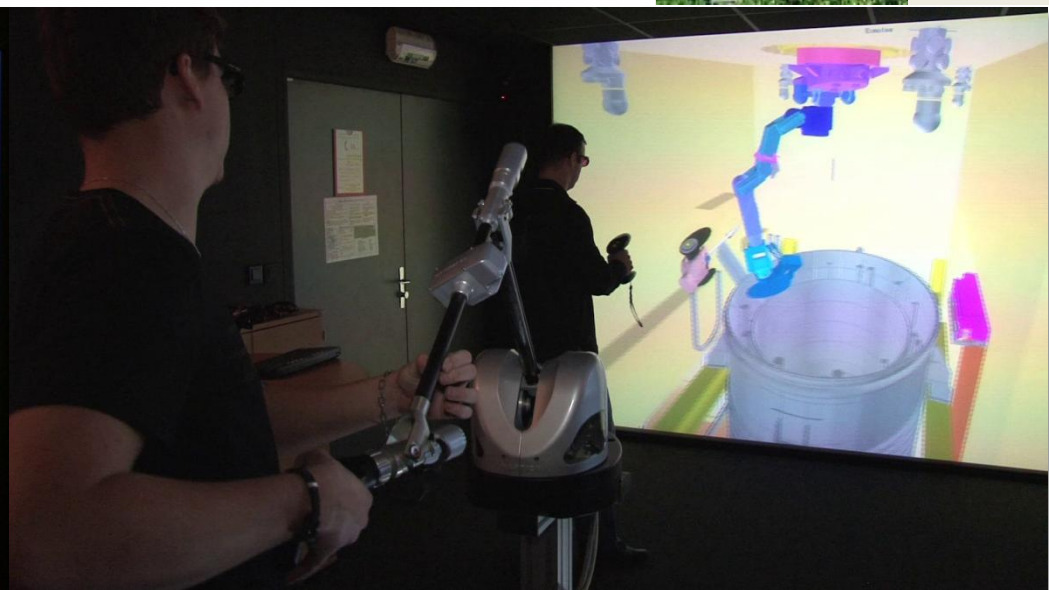
2. The Marcoule immersive room

A resource pooling between decommissioning projects in Marcoule

Objectives:

- ✓ validate intervention scenarios, by simulating at scale one
- ✓ verify accessibility
- ✓ show scenarios in a more user-friendly way
- ✓ communication tool
- ✓ train workers and point out risks

→since 2009: the Marcoule immersive room called Presage room

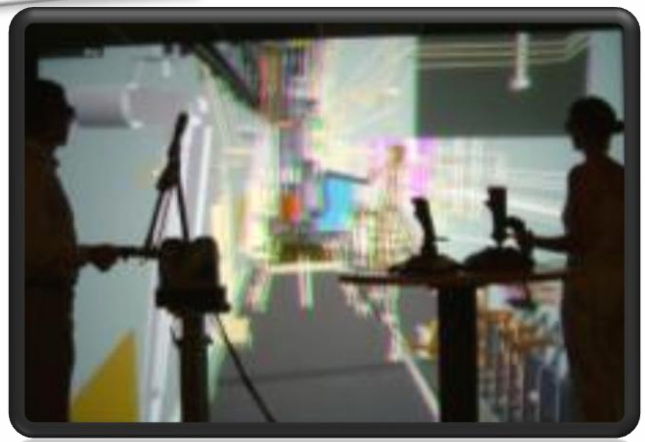


2. The Marcoule immersive room

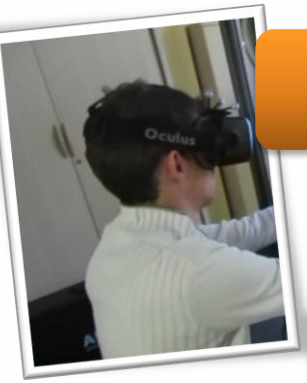
Hardware

Image wall
(3.7m x 2.3m)

Interactive sound



Stereoscopic vision



Immersive headset

Motion capture system

2 force feedback interfaces

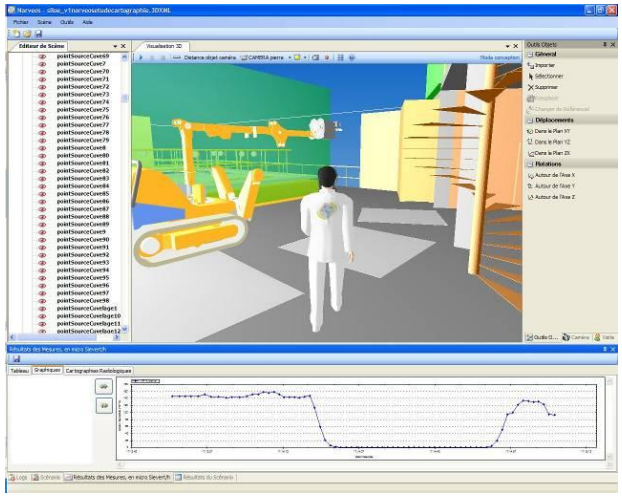
2. The Marcoule immersive room

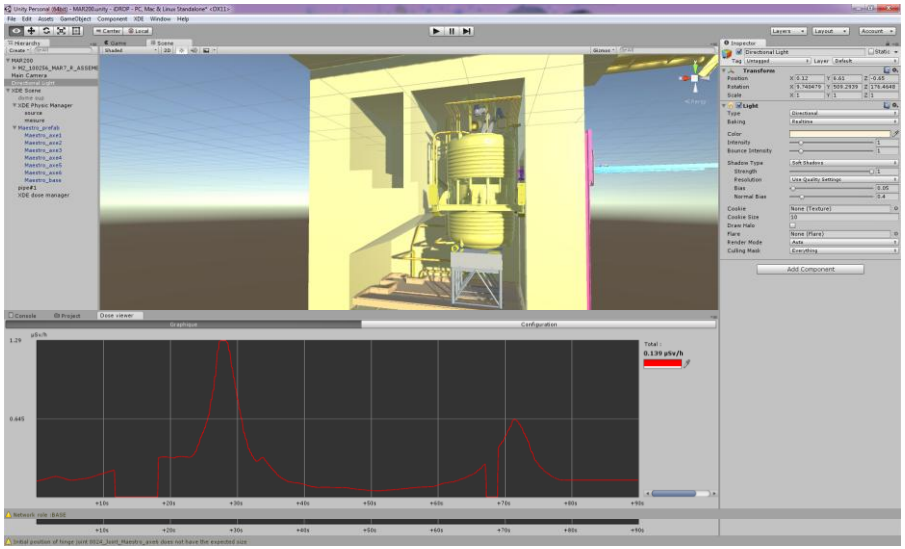
Software

New software development:

- Global approach simulation usable in nuclear facilities (gamma radiation)
  - ➥**dose rate, remote handling, human operations**
- Developed by the CEA (DRT LIST and DEN)

NARVEOS

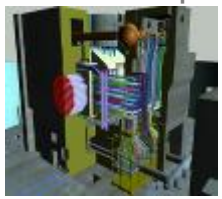




2. The Marcoule immersive room

Software

3D mockup



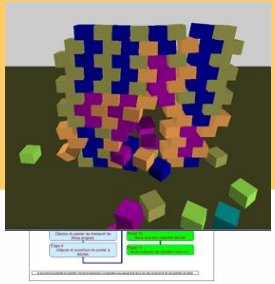
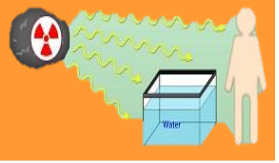
Radiological cartography

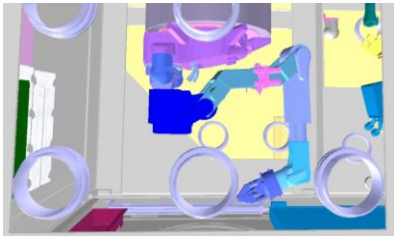
Scenario

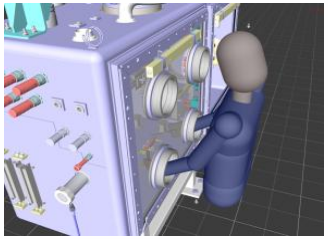
idrop

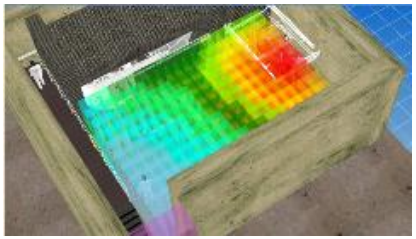
Unity 3D

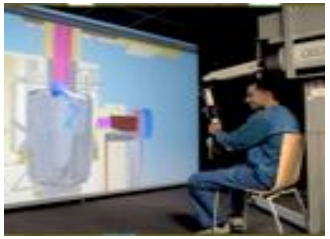
3D model import, sound, animation, lights, cameras, textures…

Physics module	Robotics module	Virtual human module	Dose rate simulation module	Immersive module
				





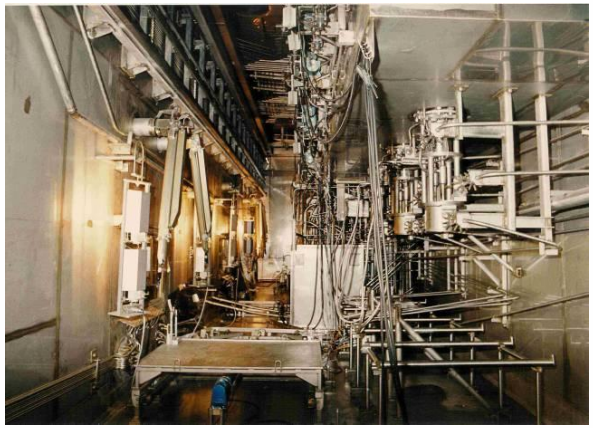


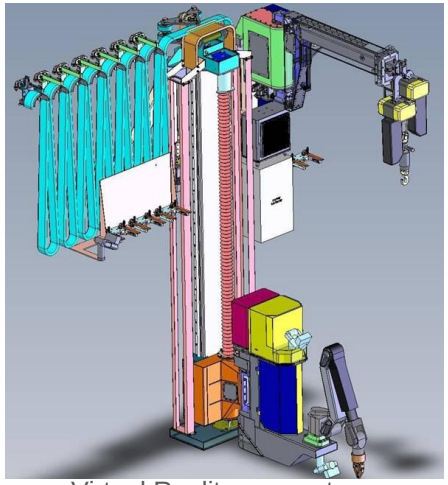


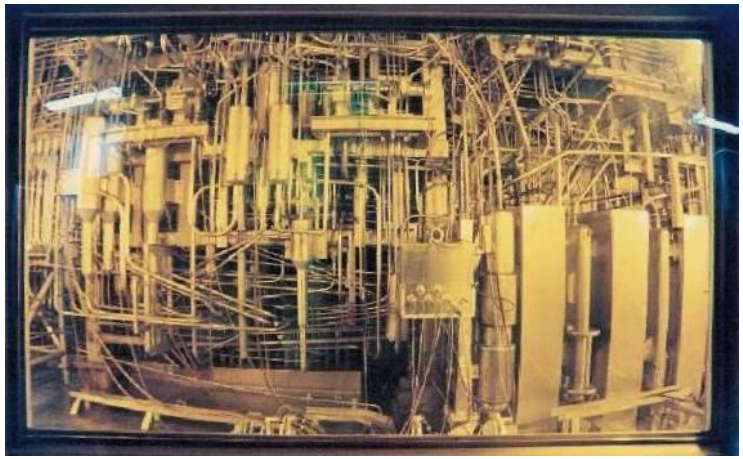
3. Lessons learned from two dismantling projects

Example #1: APM Cell 414 dismantling scenario studies

- Chemical cell used to cut and dissolve spent nuclear fuel
- Very large:
  - ✓ 20m long, 4m wide, 6m high
  - ✓ 5kms of pipes
  - ✓ 18 tons of waste
- Highly radioactive cell (no human entry)
  - ✓ ambient dose rate: 15-25mGy/h
  - ✓ contact dose rate: up to 2500 mGy/h
- Dismantling based on a remote handling system







3. Lessons learned from two dismantling projects

Example #1: APM Cell 414 dismantling scenario studies

Step 1: 3D reconstruction via photogrammetry
→1 week for the photo campaign, 3 weeks for rebuilding

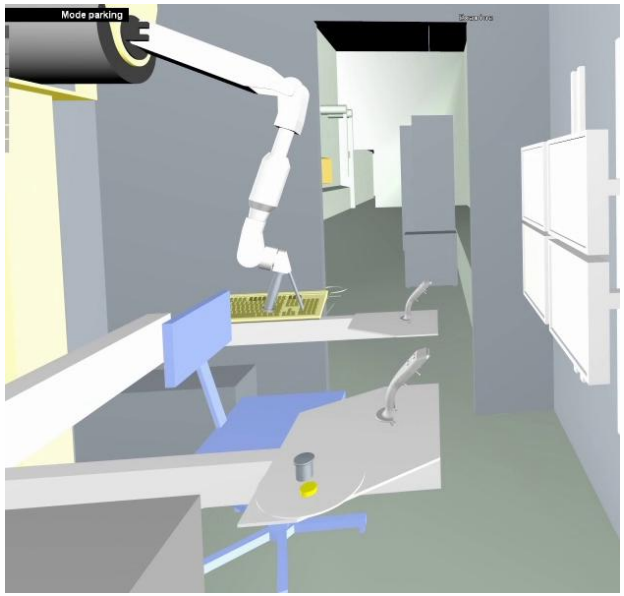
→ **60% of pipes rebuilt**
→ **Mockup precision: 3 cm**

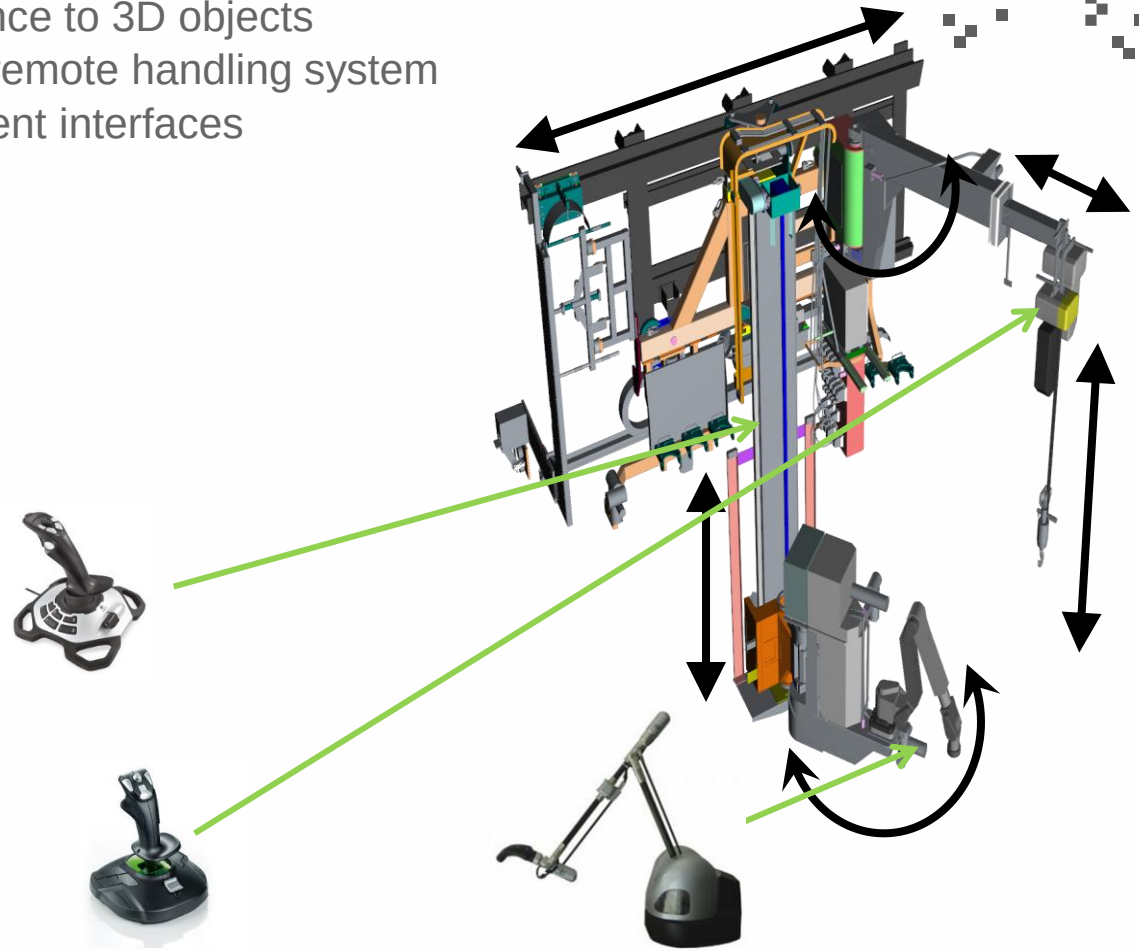
3. Lessons learned from two dismantling projects

Example #1: APM Cell 414 dismantling scenario studies

Step 2: preparation of VR simulation

- Give a physical existence to 3D objects
- Create kinematics for remote handling system
- Pilot motion with different interfaces



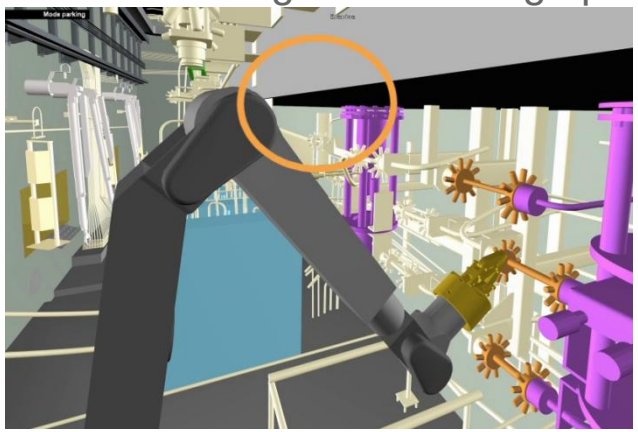


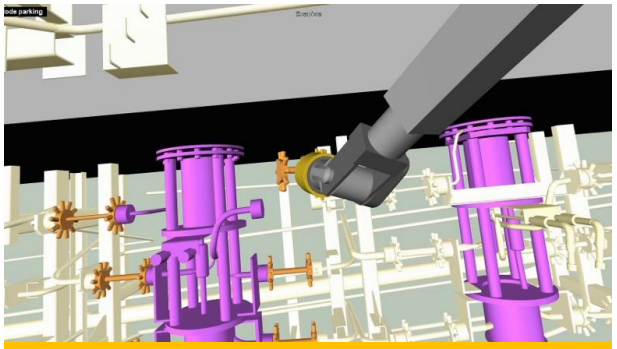
3. Lessons learned from two dismantling projects

Example #1: APM Cell 414 dismantling scenario studies

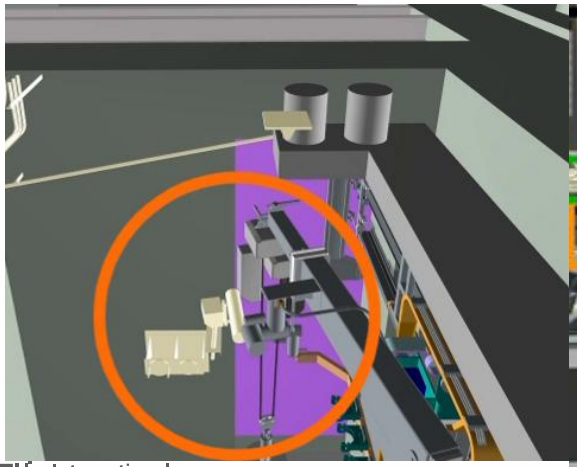
Step 3: scenario simulation

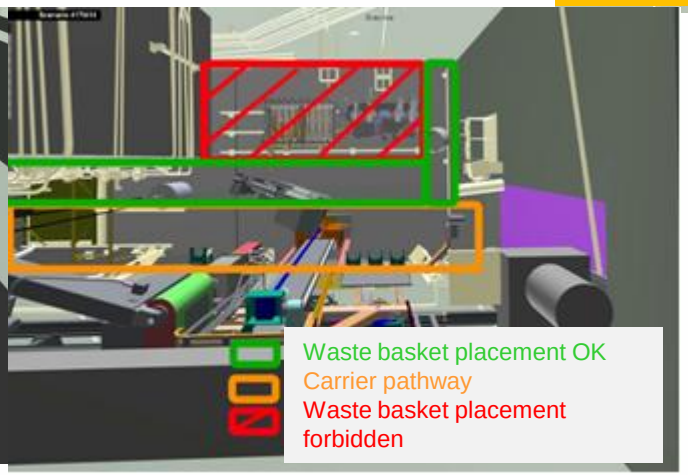
- Verify operational trajectories and maintenance operations on carrier with force feedback
- Example: verification of centrifuge dismantling operations



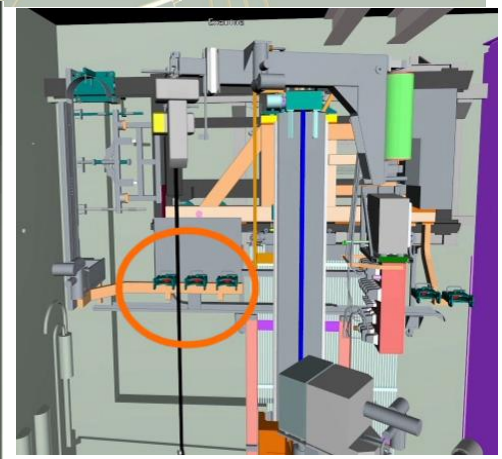


Caution: Maestro clearance very limited under the jutting block





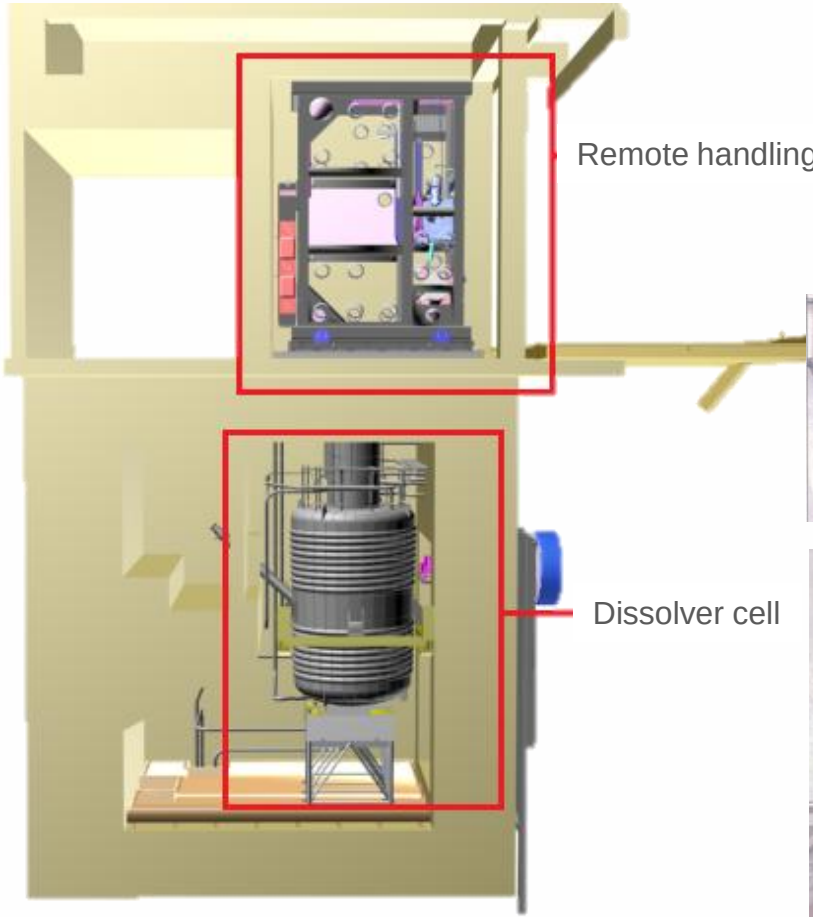
Waste basket placement OK
Carrier pathway
Waste basket placement forbidden



3. Lessons learned from two dismantling projects

Example #2: MAR200 dissolver blind cell dismantling scenario studies

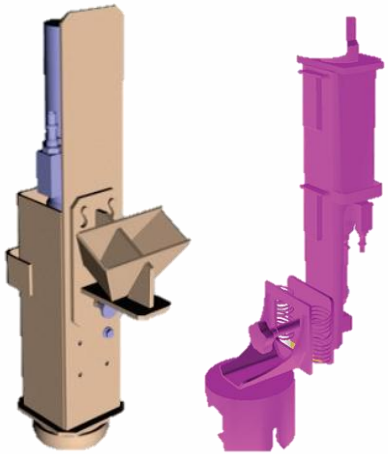
- Blind cell used for spent fuel dissolution
- High radioactivity
- Dismantling based on a remote handling system (MAESTRO system and carrier)



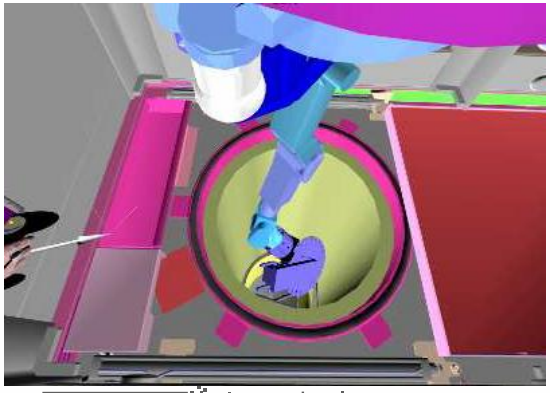
3. Lessons learned from two dismantling projects

Example #2: MAR200 dissolver blind cell dismantling scenario studies

Test #1: modification of laser torch design



Test #4: cell entrance with the hydraulic grinder



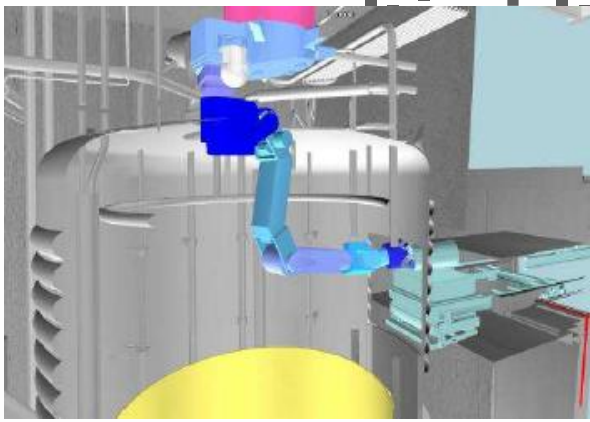
VR simulation requested by a cleanup company to:

- Validate carrier design
- Optimize component positions: tools, rack, cameras, lights…
- Study accessibility: tool grasp, Maestro arm cell entrance
- Study cutting processes

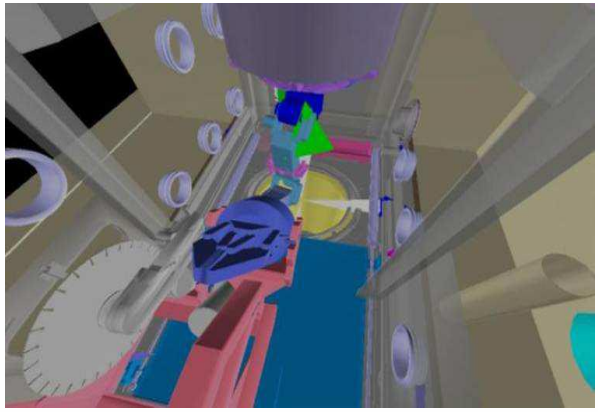
A few figures:

- 15 days to prepare the simulation
- 4 separate days necessary to test all points
- Several problems found and solved

Test #2: waste removal verification



Test #3: point of view from the hoist camera

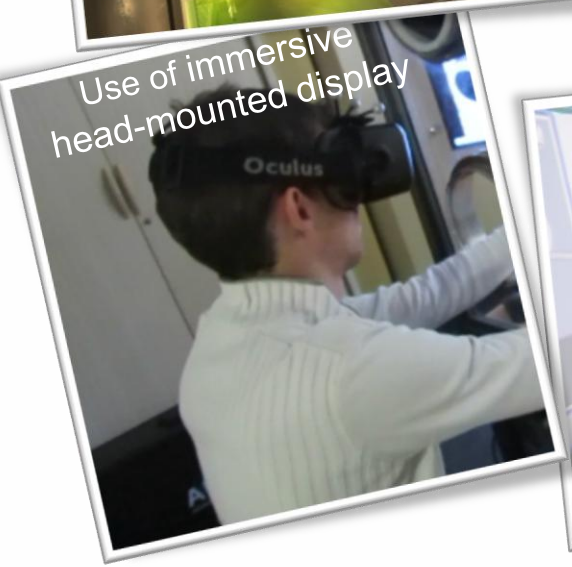


Example #2: MAR200 dissolver blind cell dismantling scenario studies

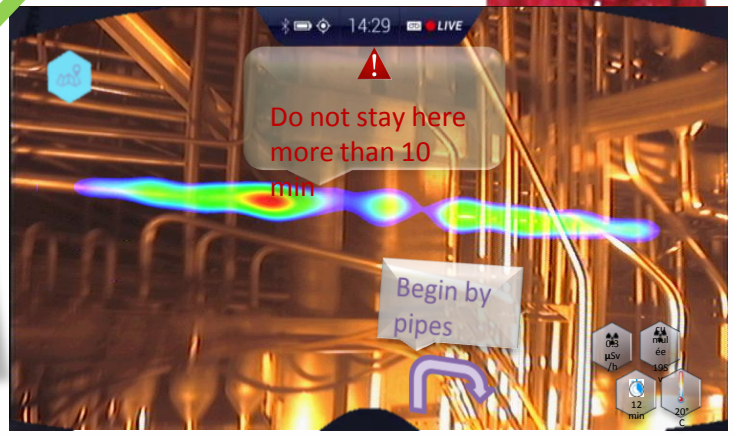
4. Conclusion and perspectives

Wider uses of VR to prepare decommissioning projects

Now…



In the future…

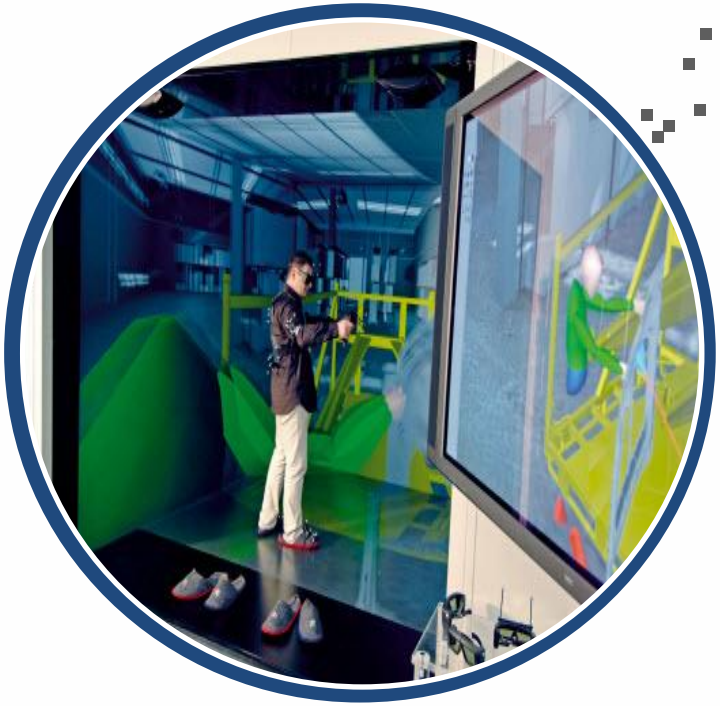


Augmented Reality mask displaying hot spots, dosimeter, thermometers, clock, procedure…

4. Conclusion and perspectives

Virtual Reality simulations can be used in decommissioning projects.

→ Decrease costs by optimizing operations and foreseeing technical issues.



TODAY…

Virtual Reality is a very efficient, very fast, very reactive tool which is becoming more and more user friendly and available!

TOMORROW… even more immersion!

- Virtual Reality: prepare scenarios
- Mixed Reality: train operators
- Augmented Reality: assist during implementation
- Realistic Physics: more and more accurate (cutting, friction, dispersion…)

4. Conclusion and perspectives

Thank you for your attention!

Any questions?