

Digital tools ready for a cost-effective decommissioning

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General perception about decommissioning :

- Low cost business
- Low technology level
- Limited or no engineering
"blue color work"



Digitalization??

Ongoing Decommissioning Projects

Sellafield (UK)
Decommissioning
Delivery Partner
(DDP) (2016-26)



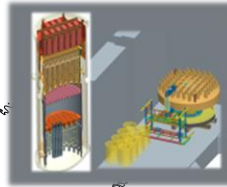
KKM (CH)
Fuel Channels
Segmentation



Barsebäck 1 & 2 (Sweden)
Reactor internals
Segmentation (2015 -)



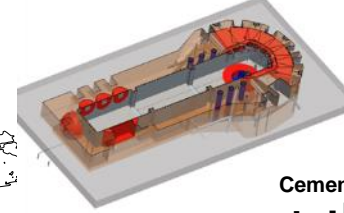
KKP 1 (Germany)
RVI and RV Segmentation
and Packaging (2015 -)



GKNI (Germany)
RVI and RV Segmentation
and Packaging (2015 -)



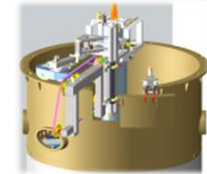
SVAFO (Sweden)
Bioshield demolition (2016 -)



Sanmen (China)
Waste Treatment Centre



EDF Chooz A (France)
RVI and RV
Segmentation
(2010 -)



Grand Gulf (USA)
Steam Dryer
segmentation (2012)



**El Cabril
Repository
(Spain)**
4-Year Operation
and
Engineering
Support (2013-)



**ATC (Spain) Centralized
Interim Storage for Spent Fuel
and High Level Waste (2013-)**



**Zorita (Spain) RVI
and RV
Segmentation and
Packaging
(2011 - 15)**



ISPRA (Italy)
Decommissioning
Studies (2010 - 14)



Kozloduy (Bulgaria)
LILW Repository Design
(2012 - 15)



Cementation Facilities (China)

- Fuqing 5 & 6 (contracted)
- Fuqing 1,2,3,4
- Changjiang 1&2
- Fangjiashan 1&2
- Hongyanhe 1, 2, 3, 4
- Yangjiang 1 & 2
- Ningde 1 & 2



Fukushima Unit 3 (Japan)
Spent Fuel removal (2012 - 14)




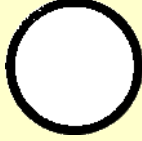


Decommissioning Plans:

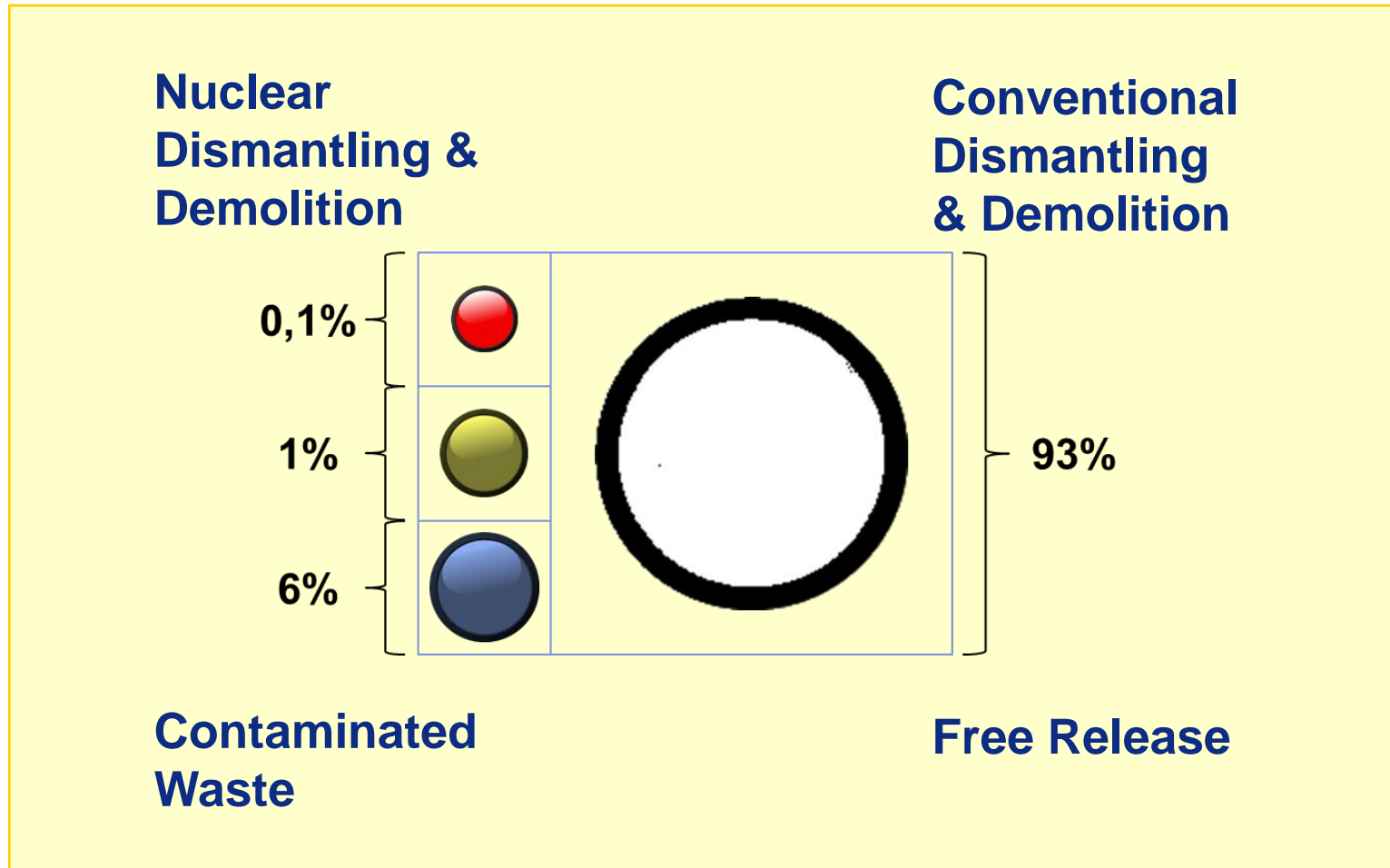
- Bohunice, Slovakia (2013-14)
- Chinshan, Taiwan (2014-16)
- Kousheng, Taiwan (2016-18)

Waste Classification - Definitions

Buildings/materials/components categorized according to plant contamination definitions (Blue, Yellow, Red) and conventional (White):

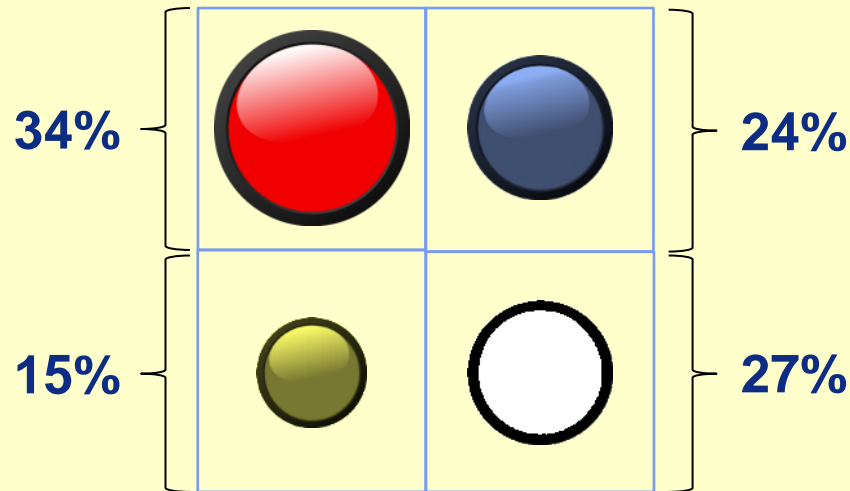
	Red - Highly contaminated/activated <ul style="list-style-type: none">- Reactor Vessel and internals- Primary Process Systems- Biological Shield
	Yellow - Medium contamination <ul style="list-style-type: none">- Process systems- Buildings and structures- Turbine and Turbine Systems (BWR)
	Blue – Low contamination <ul style="list-style-type: none">- Buildings and structures- BoP Systems- Turbine and Turbine Systems (BWR)
	White – Conventional handling <ul style="list-style-type: none">- Buildings and structures- BoP Systems- Turbine and Turbine Systems (PWR)

Waste by Volume



Waste by Monetary Volume

Decommissioning cost for a Swedish NPP approx. 2 billion SEK per plant (fuel and waste disposal not included)



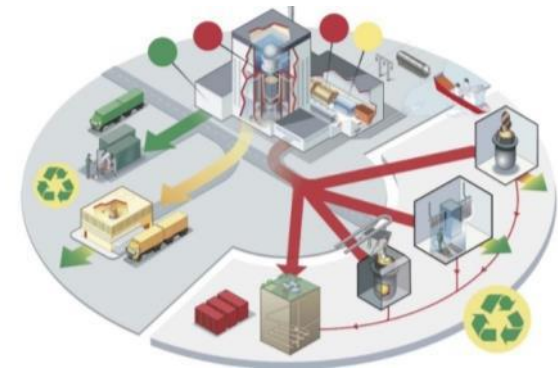
7% of the waste generates > 70% of the cost!

Decommissioning - Success Factors

Digitalization

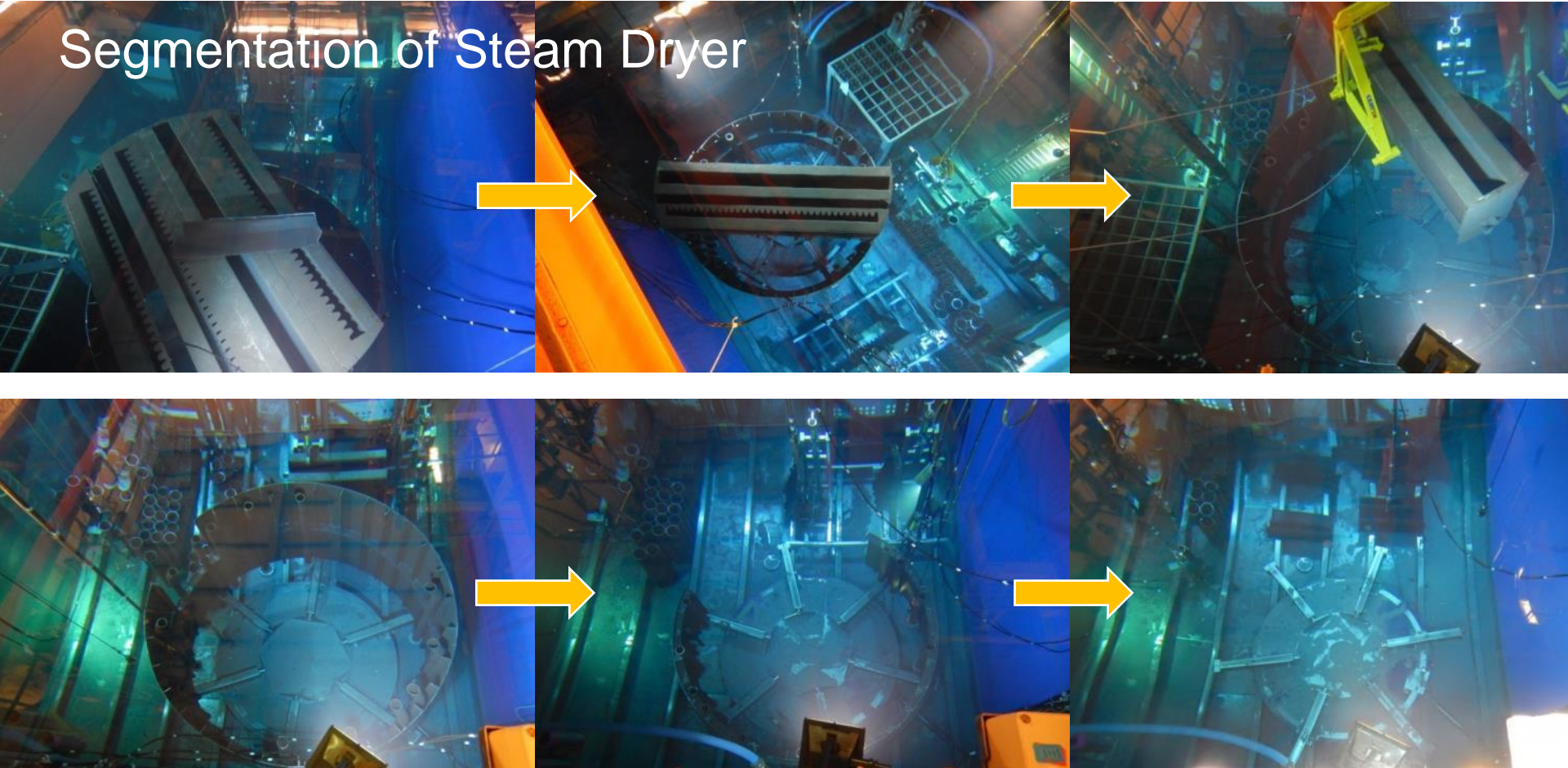
Safe, fast and cost effective:

- Significant scope – possibilities to optimize
- Planning/logistics – **digital mappings, simulations, use of VR/AR**
- Waste driven decommissioning - from characterization to free release
- Integrated dismantling – material and waste **optimization/management**
- Use of conventional techniques and experience in combination with necessary nuclear procedures
- Environmental aspects - dismantling, hazardous materials, recycling
- **Detailed upfront simulations - tooling, procedures, radiation, handling, transportation etc.**

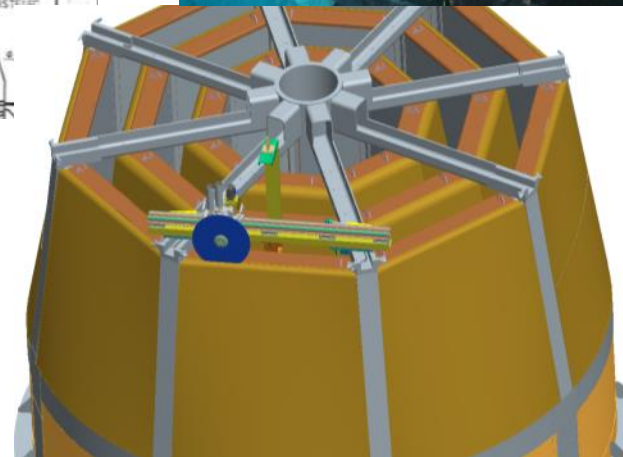
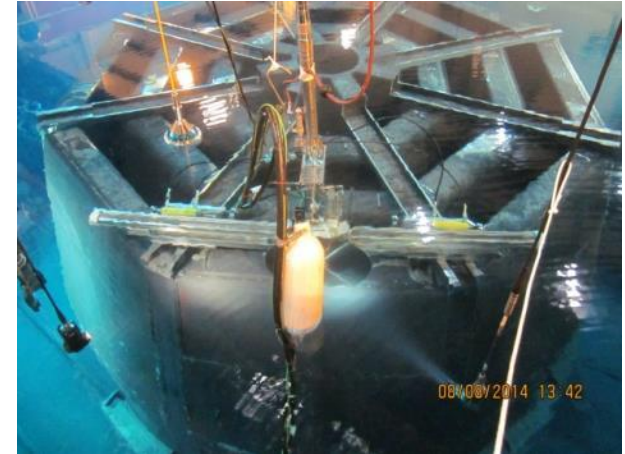
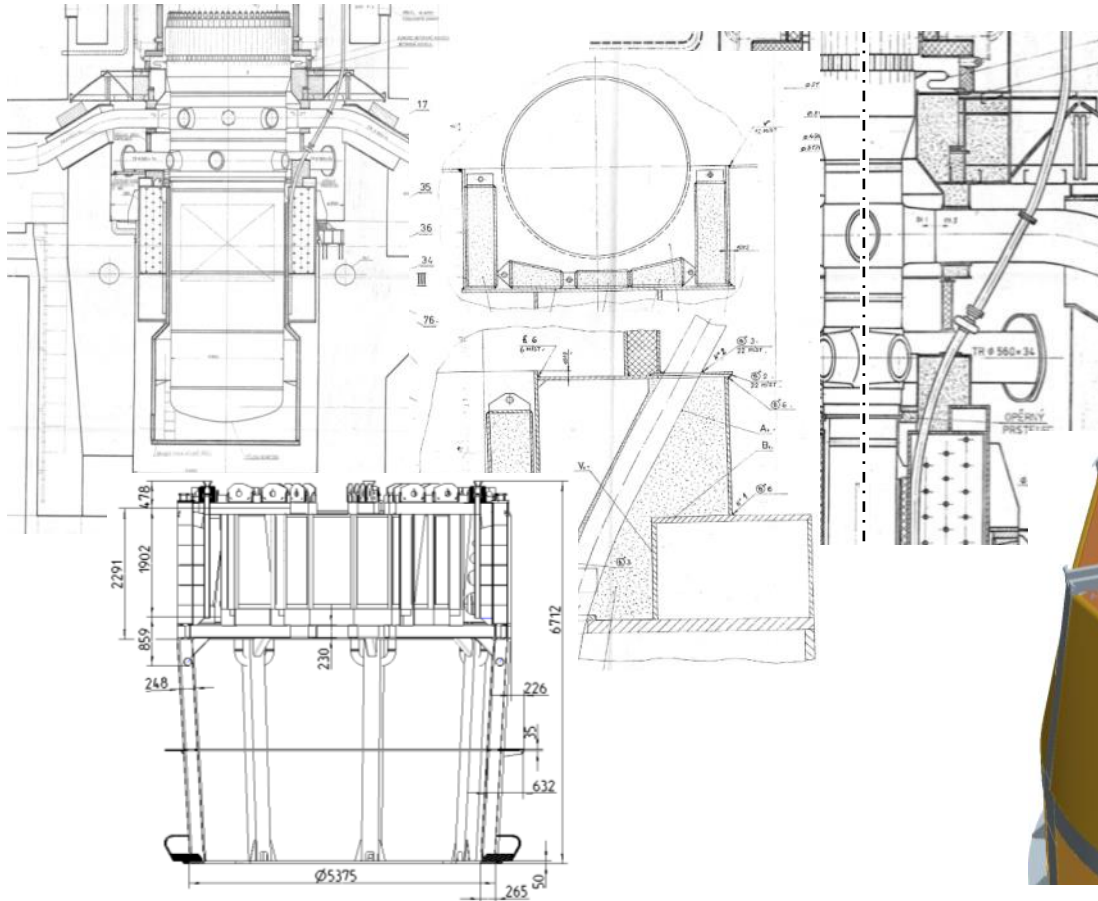


Digitalization - CAD for Major Components

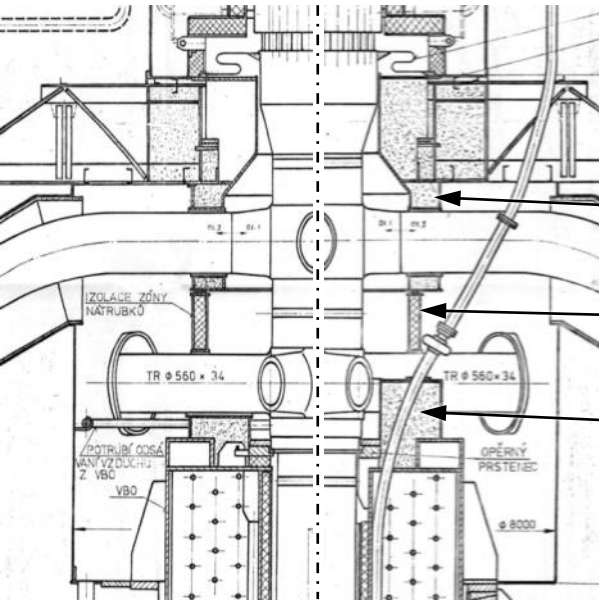
Segmentation of Steam Dryer



Digitalization - Drawings to 3D CAD Models



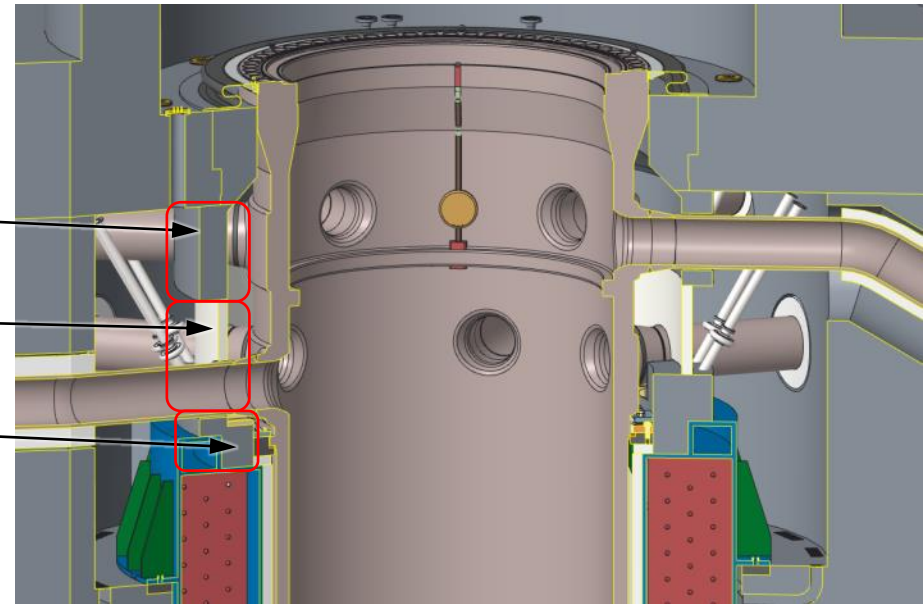
Cutting Planning in 3D CAD Models



Remove Hot-Leg Ring
Cast concrete

Remove Insulation Ring
Insulation with metal plates

Remove Cold-Leg Ring
Cast concrete

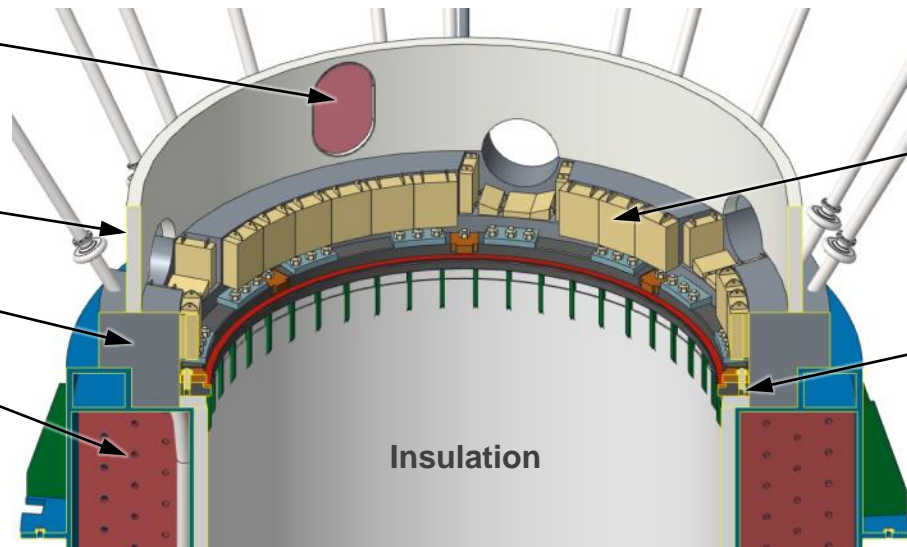


Insulation ring hatch

Insulation ring

Ring around Cold-leg

Water Protection Barrier

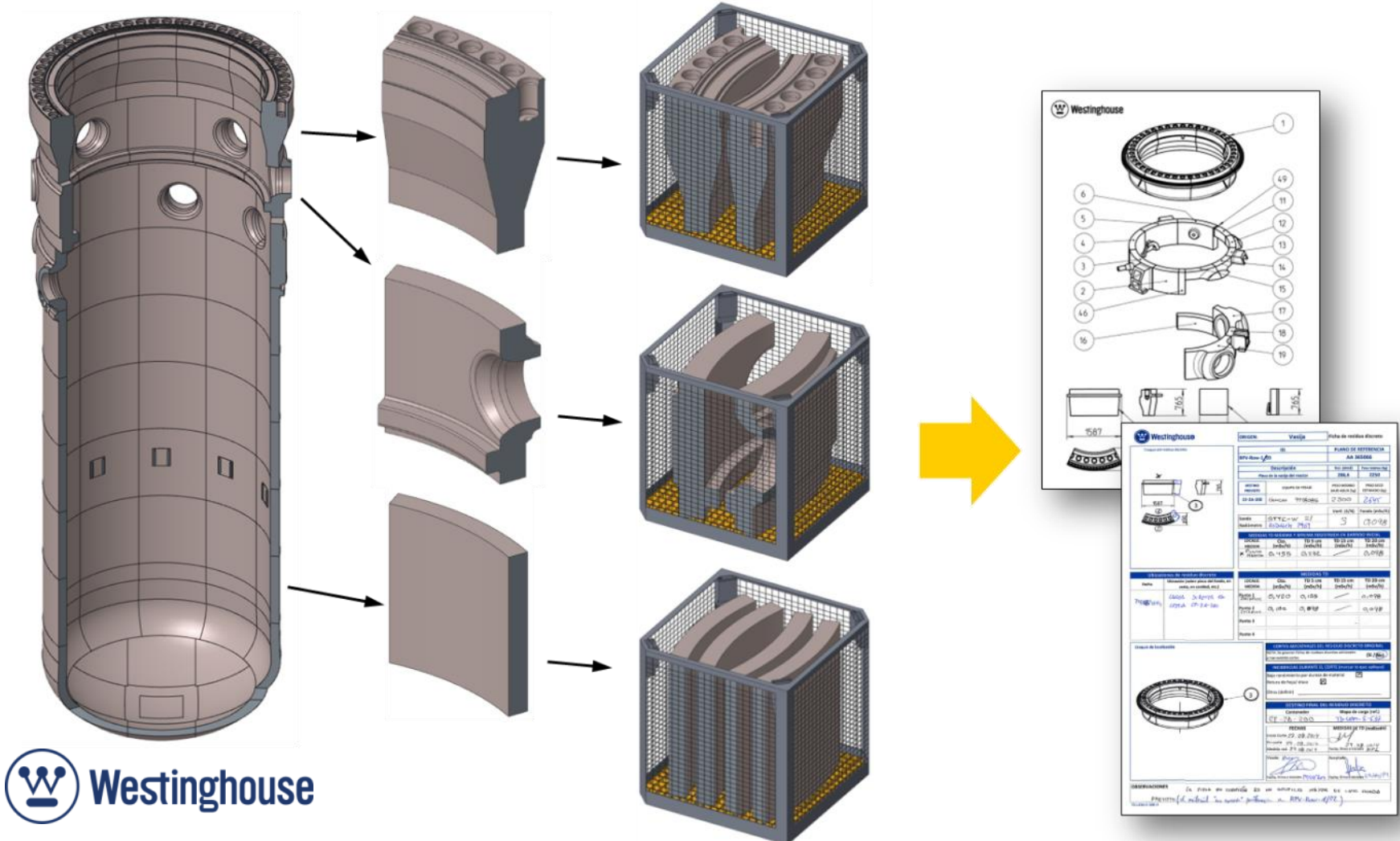


Insulation blocks

RPV support ring and locks

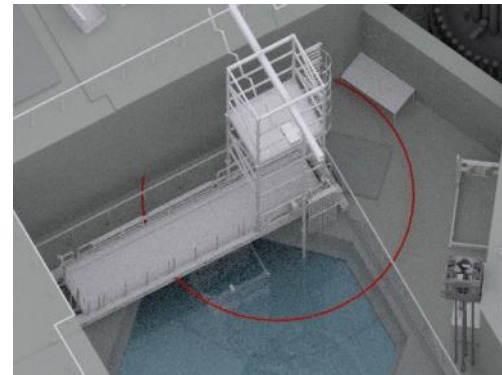
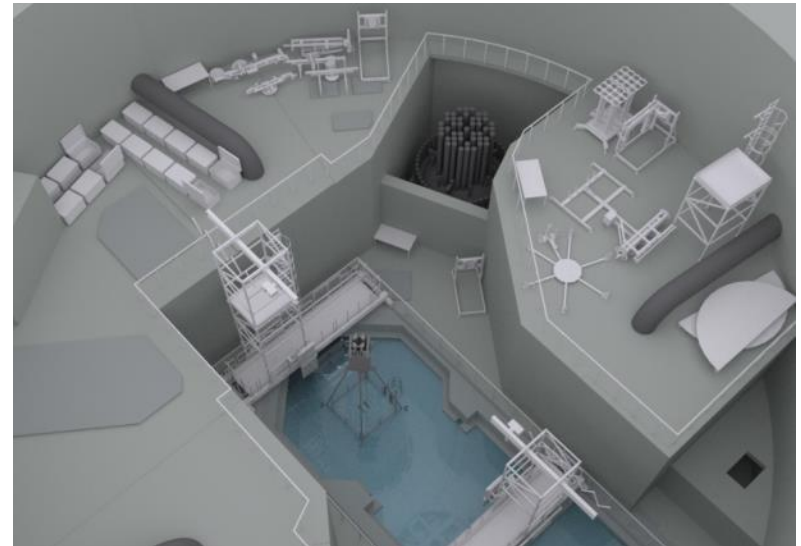
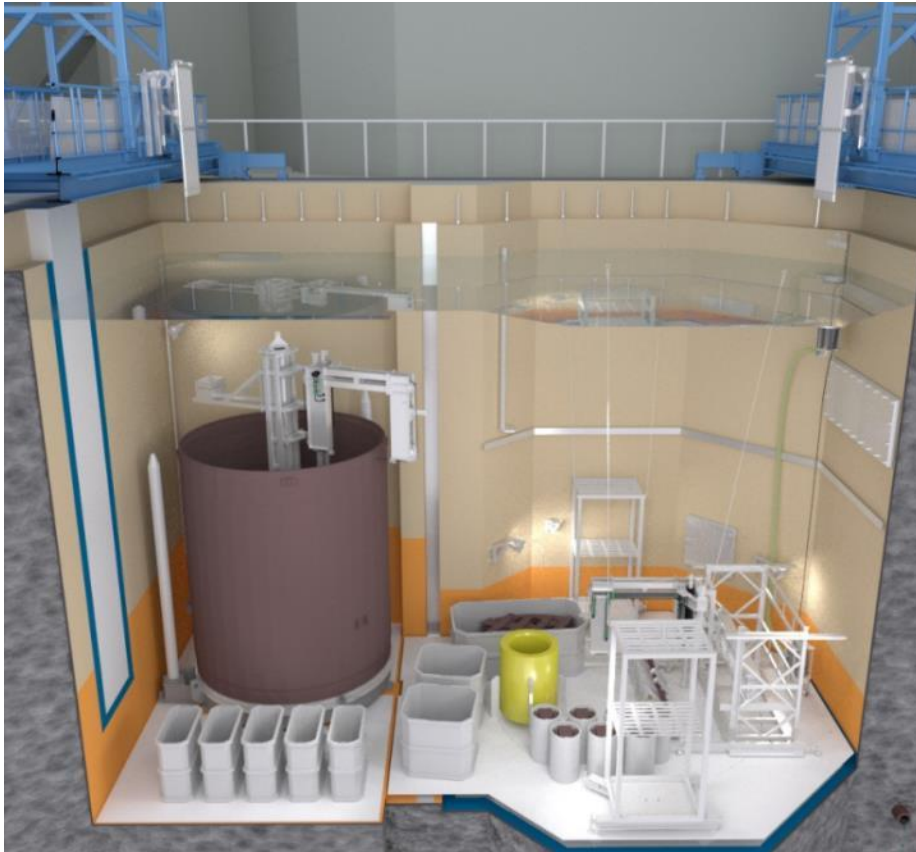
Cutting and packaging –upfront preparation

Optimization of cutting and packing, including dose calculations and documentation

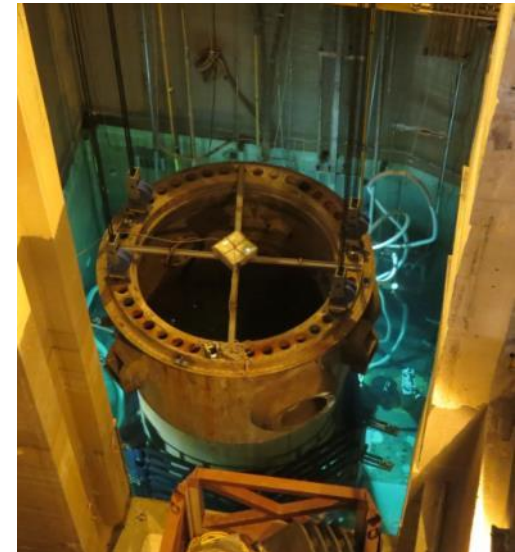
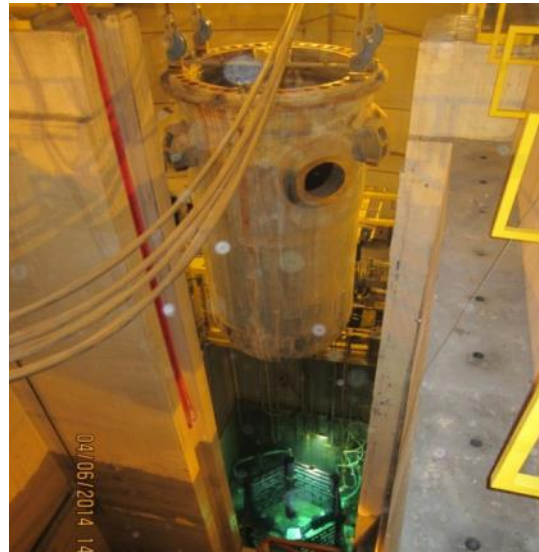


Sequence/Layout and Storage Planning

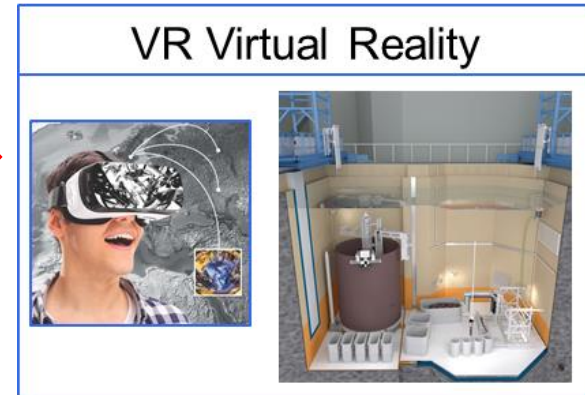
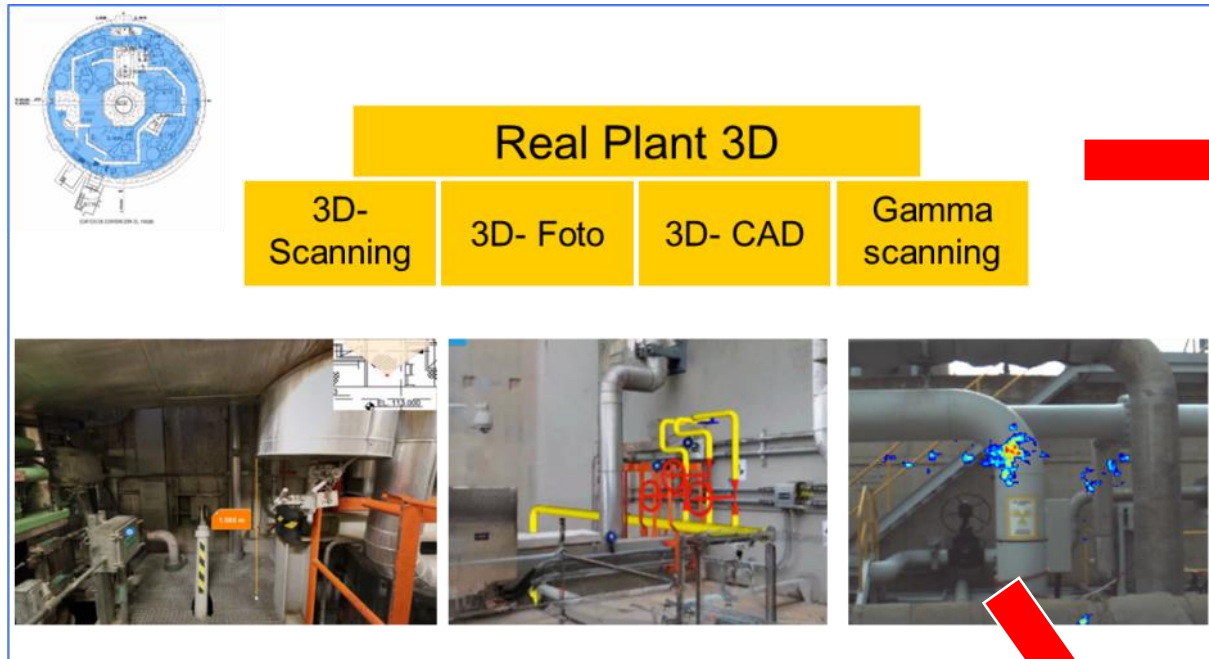
In CAD systems, VR as a complement



Lifting RPV – CAD simulations and Laser scanings

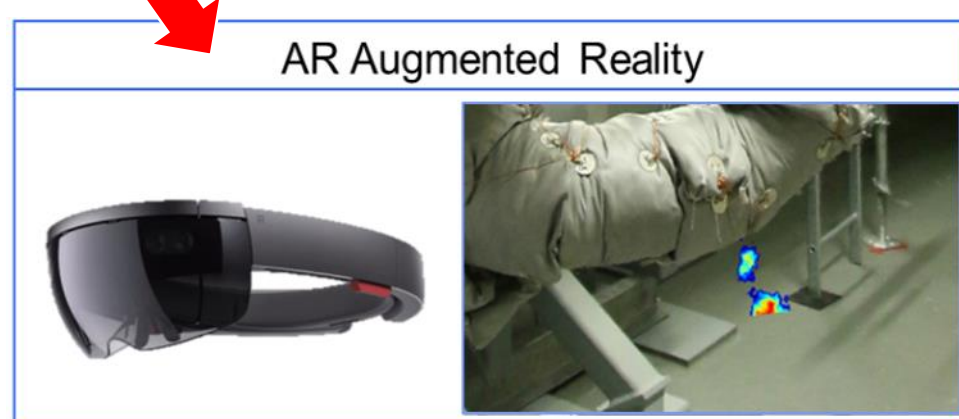


Point Cloud solutions for buildings and rooms

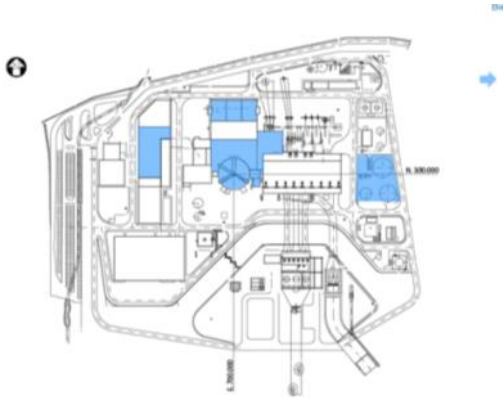


Several commercial products available

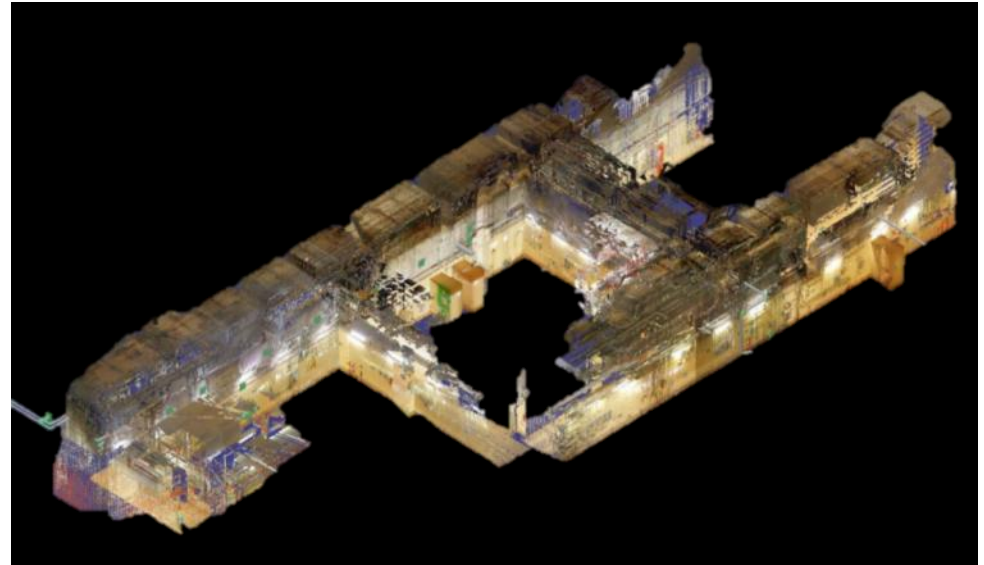
- Laser scanning/high-resolution photos
- Photogrammetry
- 360° filming
- VR/AR



Point Cloud solutions for buildings and rooms



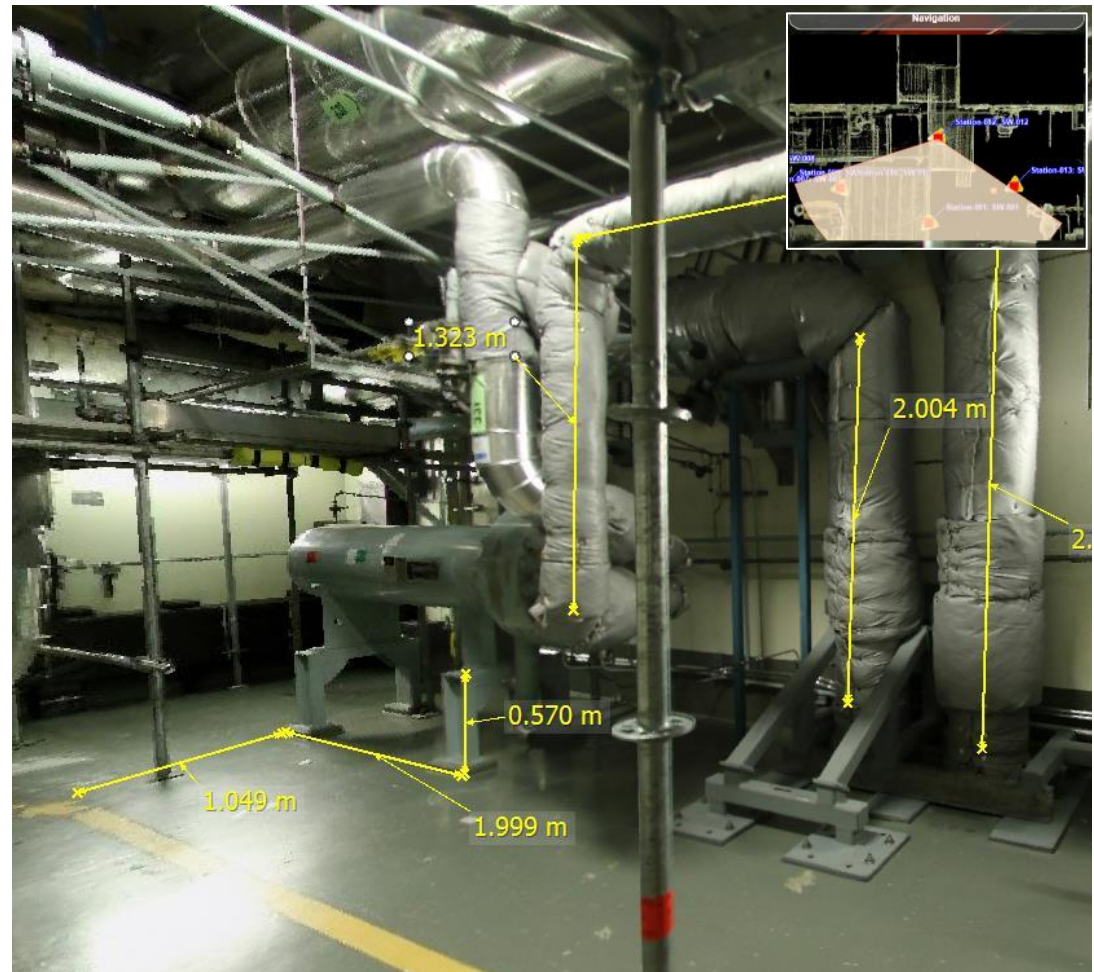
From plant layout to specific buildings and rooms



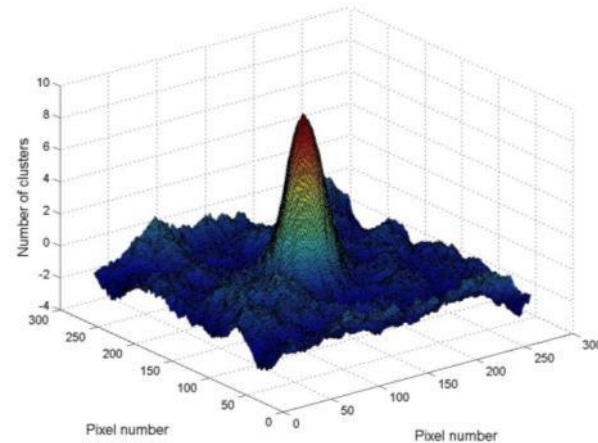
Point Cloud solutions for buildings and rooms

Laser scanning and high resolution 3D Photo:

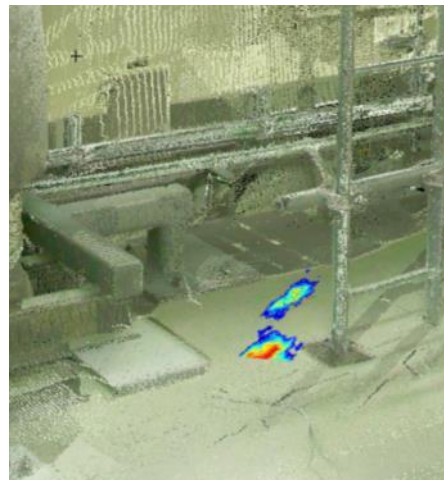
- Google Street view
- Measurement directly in the picture
- In-build navigation tool
- Possible to add dose information



Point Cloud solutions – Gamma scanning



Multiple gamma camera 2D pictures are transformed to 3D and incorporated into the cloud points:



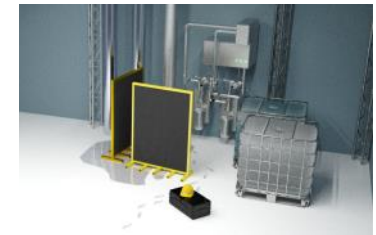
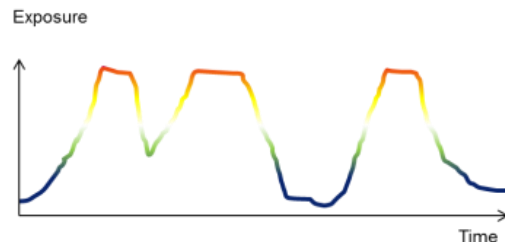
Radiation simulations and VR applications

Dose rate simulations based on gamma measurements

- separation of system parts/components for different waste routes



Dose simulations (exposure, shielding, procedures, training)



Summary

- Digitalization key for a safe, fast and cost effective decommissioning
- Several commercial products available on the market
- Digitalized plant information makes it possible for upfront simulations to optimize schedule, technology and costs
 - Major components as RPV, RPI etc. digitalization via drawings to CAD
 - Buildings and rooms, digitalization via point cloud solutions
 - Dose information and measurements, gamma camera solutions

**No longer fancy tools – already
efficient productions tools !**