

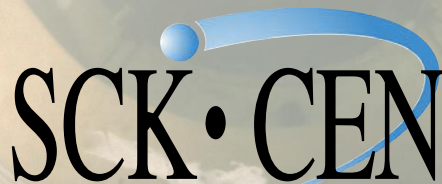
# Decommissioning nuclear installations ?



**Yes, we can !**

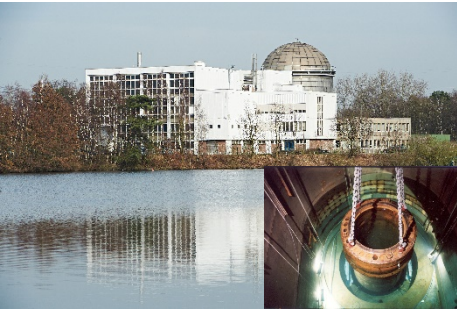
The Belgian D&D experience & skills

Vincent MASSAUT  
Deputy Director BD&S  
[vmassaut@sckcen.be](mailto:vmassaut@sckcen.be)



STUDIECENTRUM VOOR KERNENERGIE  
CENTRE D'ETUDE DE L'ENERGIE NUCLEAIRE

# Several large experience have led to an extended capacity



- The BR3-PWR decommissioning: an European pilot project;



- The Eurochemic reprocessing plant: pilot project on a pilot plant & industrial developments;



- The Belgonucleaire MOX fabrication plant: the birth of a Belgian platform;
- Towards international market ?

# The BR3 PWR decommissioning project: an European pilot-project

First PWR in Europe, first to be dismantled



- **Type:** Pressurized Water Reactor (Westinghouse)
- **Power:** 40.9 MW<sub>th</sub>, 10.5 MW<sub>e</sub> (net)
- Operating **life** of 25 years (1962-1987)



## A bit of history...

- Within the EC RTD framework programmes (FP3) the Commission launched an ambitious programme of R&D and demonstration of D&D at the end of the 80's begin of the 90's,
- End of 1989, the EC selected 4 projects as "pilot demonstration projects of D&D".
- BR3 was selected as one of the 4 of these important projects.
- This was on-going in parallel with several smaller R&D projects on D&D innovative technologies



## The SCK•CEN a pioneer also in Decommissioning

- BR3 = first PWR in Europe (and outside US), first to be dismantled
- Selected in 1989 as European pilot decommissioning project (with 3 other projects in Europe)

| Name of installation | Type of Installation     | Place Country            |
|----------------------|--------------------------|--------------------------|
| AT1                  | Pilot reprocessing plant | La Hague<br>France       |
| BR3                  | PWR plant                | Mol<br>Belgium           |
| KRB                  | BWR plant                | Gundremmingen<br>Germany |
| WAGR                 | AGR plant                | Windscale<br>U.K.        |



## A few years later a fifth project was added

- The only VVER plant on the territory of the E.U. at that time!

| Name of installation | Type of Installation             | Place Country            |
|----------------------|----------------------------------|--------------------------|
| AT1                  | Pilot reprocessing plant         | La Hague<br>France       |
| BR3                  | PWR plant                        | Mol<br>Belgium           |
| KRB                  | BWR plant                        | Gundremmingen<br>Germany |
| WAGR                 | AGR plant                        | Windscale<br>U.K.        |
| EWN                  | VVER plant<br>(several reactors) | Greifswald<br>Germany    |



# All **strongly radiating** components have been removed

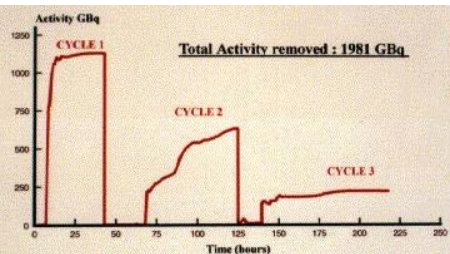


- 1991 full system decontamination primary loop
- 1994-1995 removal & cutting reactor internals
- 1998-2000 cutting reactor pressure vessel (RPV)
- 2002 removal BR3 fuel
- 2002-2003 decontamination SG and the PR
- 2005 cutting SG and PR
- 2007 cutting neutron shield tank
- 2008 demolition ventilation stack
- 2010 W&V building dismantling & concrete clean-up

*SG = Steam Generator / PR = Pressurizer*

**A long standing experience in the D&D !**

# Some outstanding experience and developments



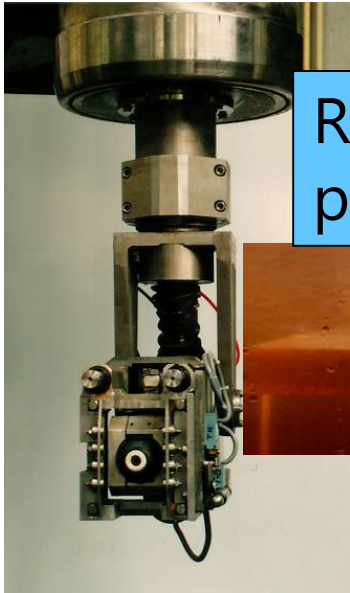
- Full system decontamination (using the CORD® process) leading to several man-Sv dose reduction;
- First (successful) use of an underwater bandsaw, fully remote controlled;
- First removal of a Reactor Pressure vessel from a PWR in Europe (and probably worldwide);
- First complete remote dismantling of a PWR RPV in the E.U.;
- Set up of a complete system of material management allowing the free release of more than 80% of dismantled material
- Use of various remote underwater cutting on highly active pieces (internals, RPV, NST,...)

## Some outstanding experience and developments (2)



- Development of a hard chemical decontamination process (MEDOC®) allowing to free release > 93 % of the contaminated metallic material;
- Cutting of heavy concrete (contaminated and activated), heavily reinforced;
- Use of underwater remotely controlled robot with HP water jet cutting;
- Set up of various software for the management of materials, radwaste and nuclear materials;
- Radioprotection ALARA optimization using the developed VISIPLAN® software;
- Etc...

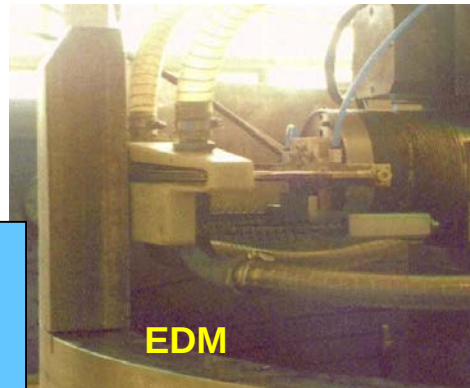
# Various underwater (remote) techniques were tested on **real** components



Remote underwater plasma cutting



Remote under water bandsawing



EDM

Electric Discharge Machining



SCK-CEN

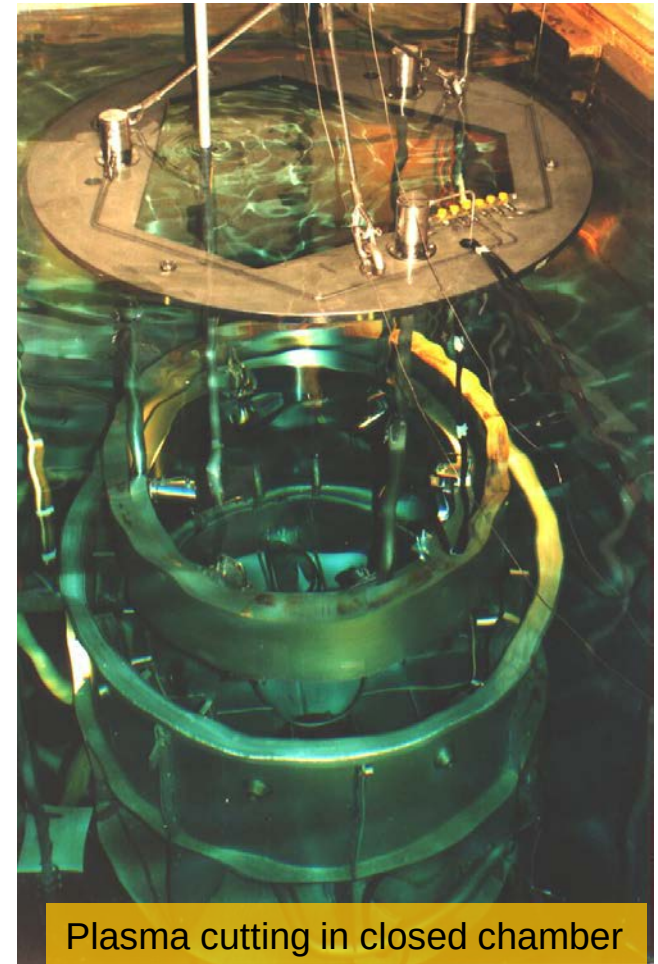
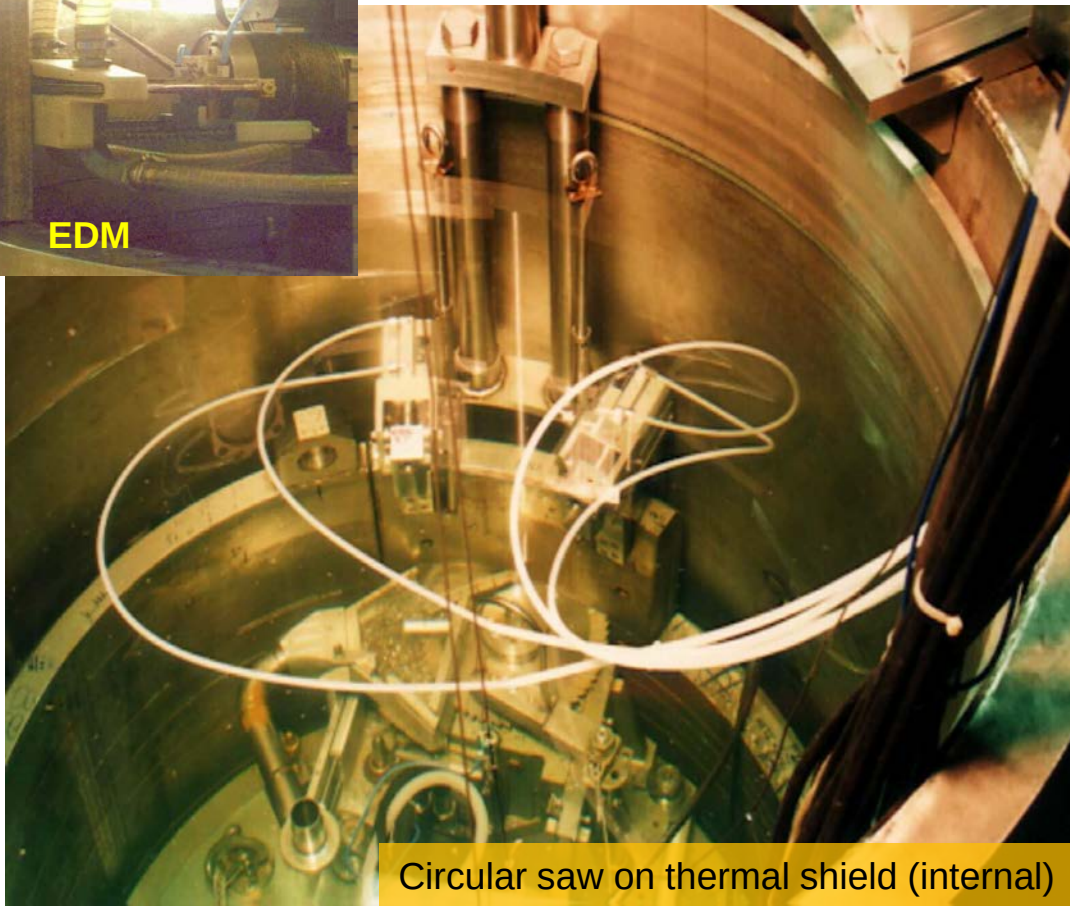
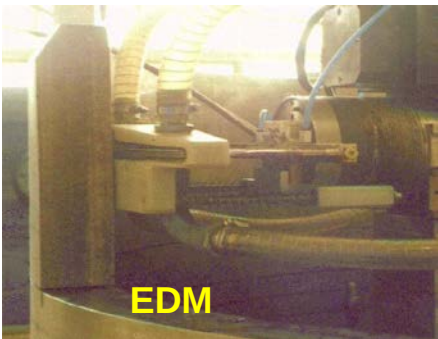
# Cutting of active components and bundles: the use of **robotics** as deployment system.

High pressure water jet cutting  
Deployment by telerobotic arm



3

# Cutting of highly active components: **comparison** of techniques on the **SAME** internal piece !



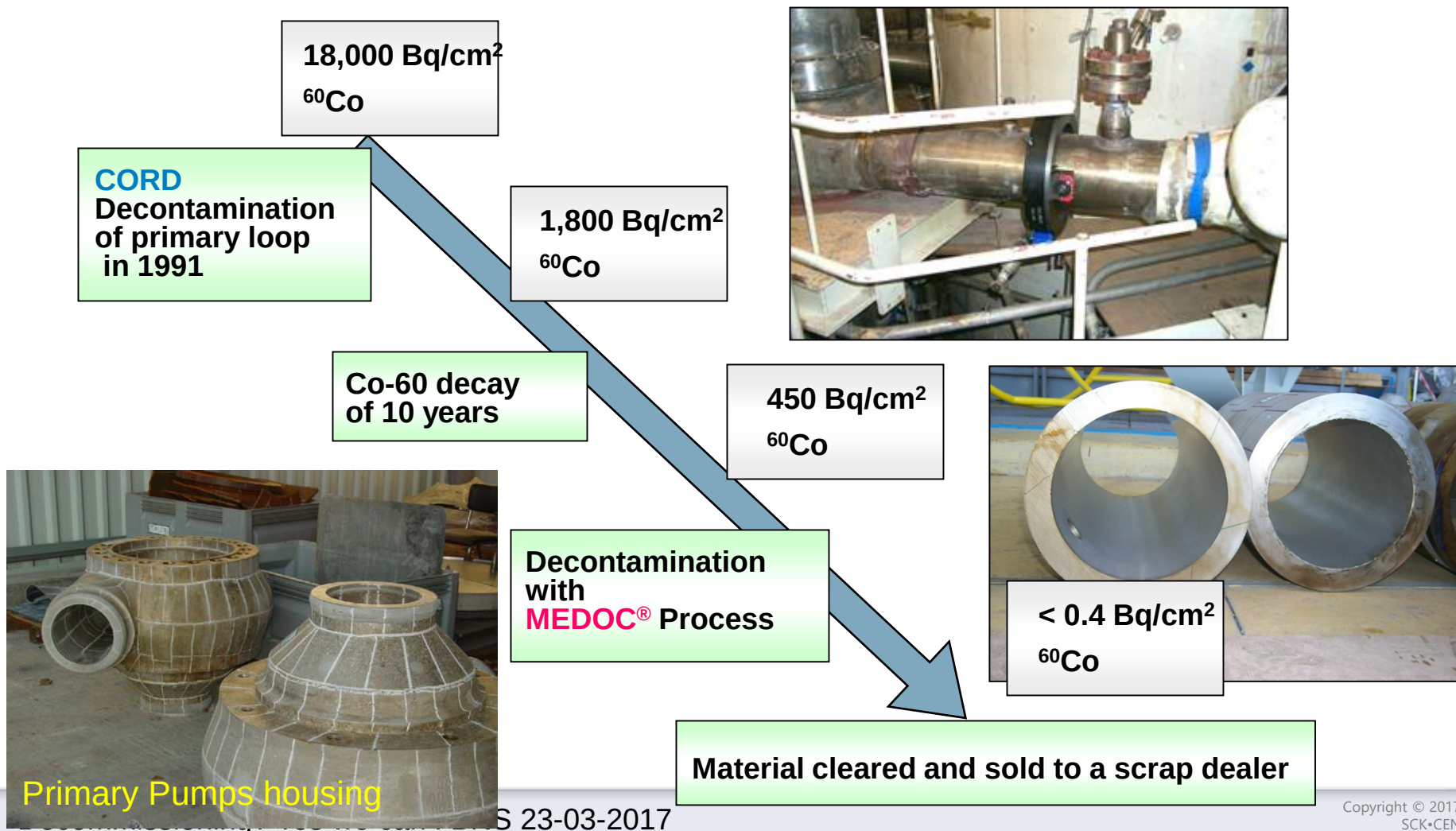
Remote cutting of high active pieces

# Decontamination of metal: ...up to free release level



Thorough chemical  
Decontamination  
**MEDOC®**

# Example: Clearance of the BR3 Primary Pipes



# Concrete cutting by diamond wire: important management of dust and sludge



Decommissioning? Yes we can ! BNS 23-03-2017

# Various methods for **concrete** dismantling were tested



Up to the test with explosives



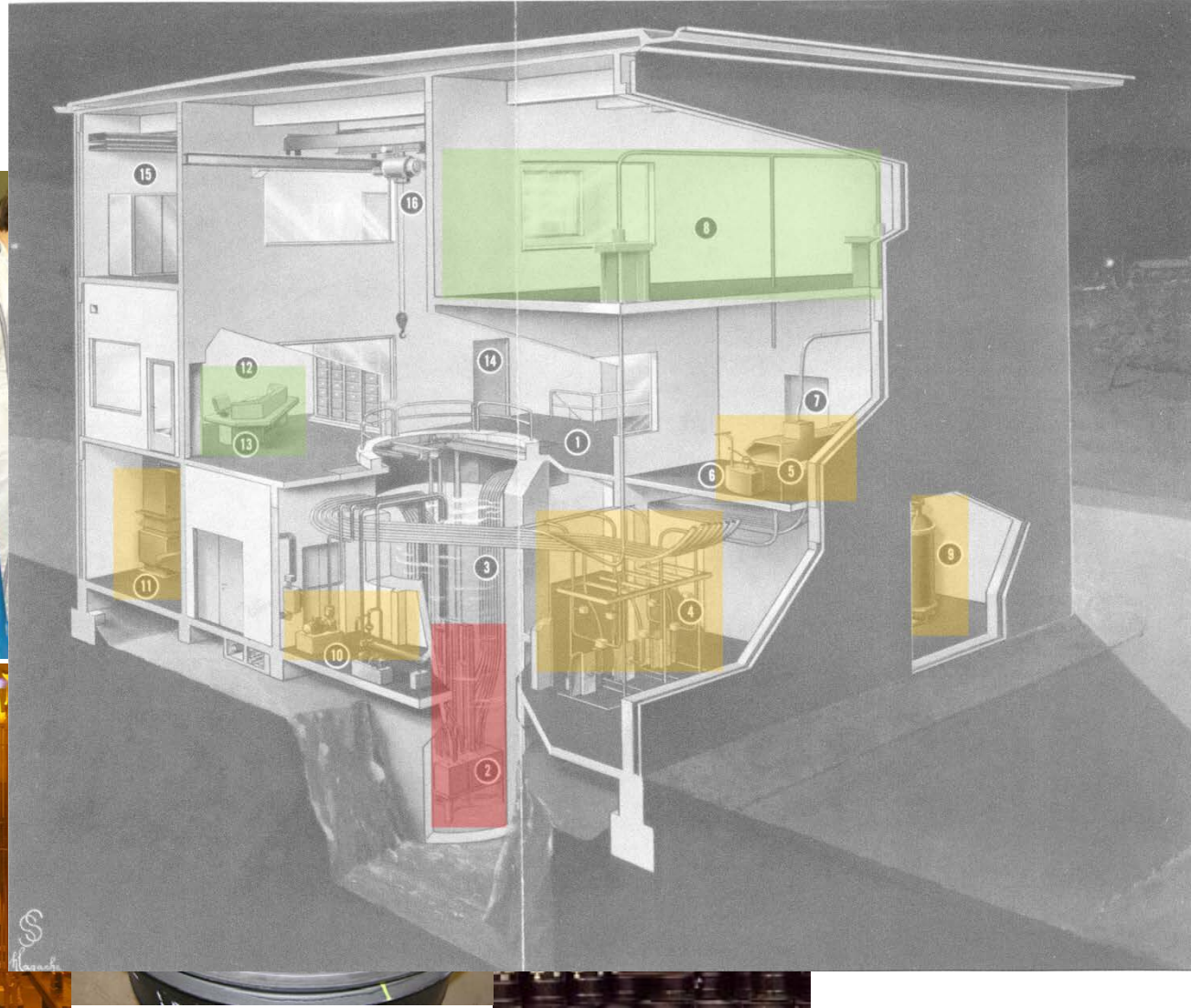
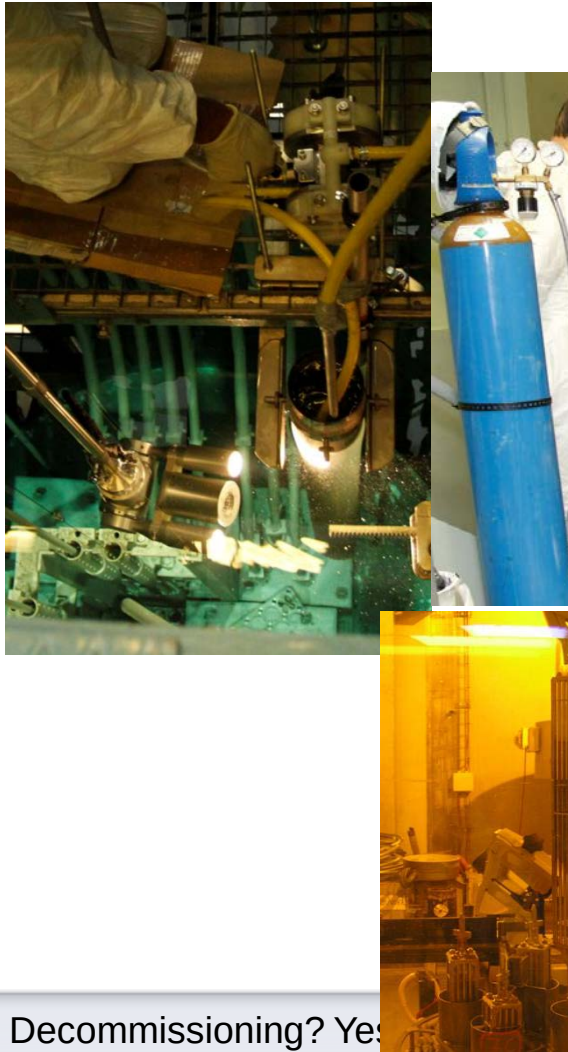
# Dismantling= management of a **lot** of materials (various forms and components)

Importance  
of sorting  
and follow up

Made at  
SCK•CEN  
under QA

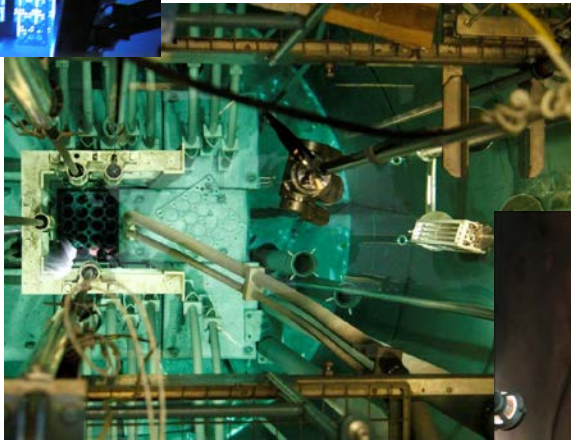
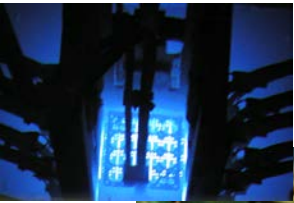


# The developped skills were used e.g. in: Thetis University reactor dismantling



# Thetis University reactor dismantling

- Spent fuel handling, evacuation and management
- Dismantling of the reactor



# Thetis University reactor dismantling

- Spent fuel handling, evacuation and management
- Dismantling of the reactor
- Decontamination of the pool
- Waste management, ALARA & radioprotection, safety, etc,



# The other skills and competences...

- Eurochemic reprocessing plant...



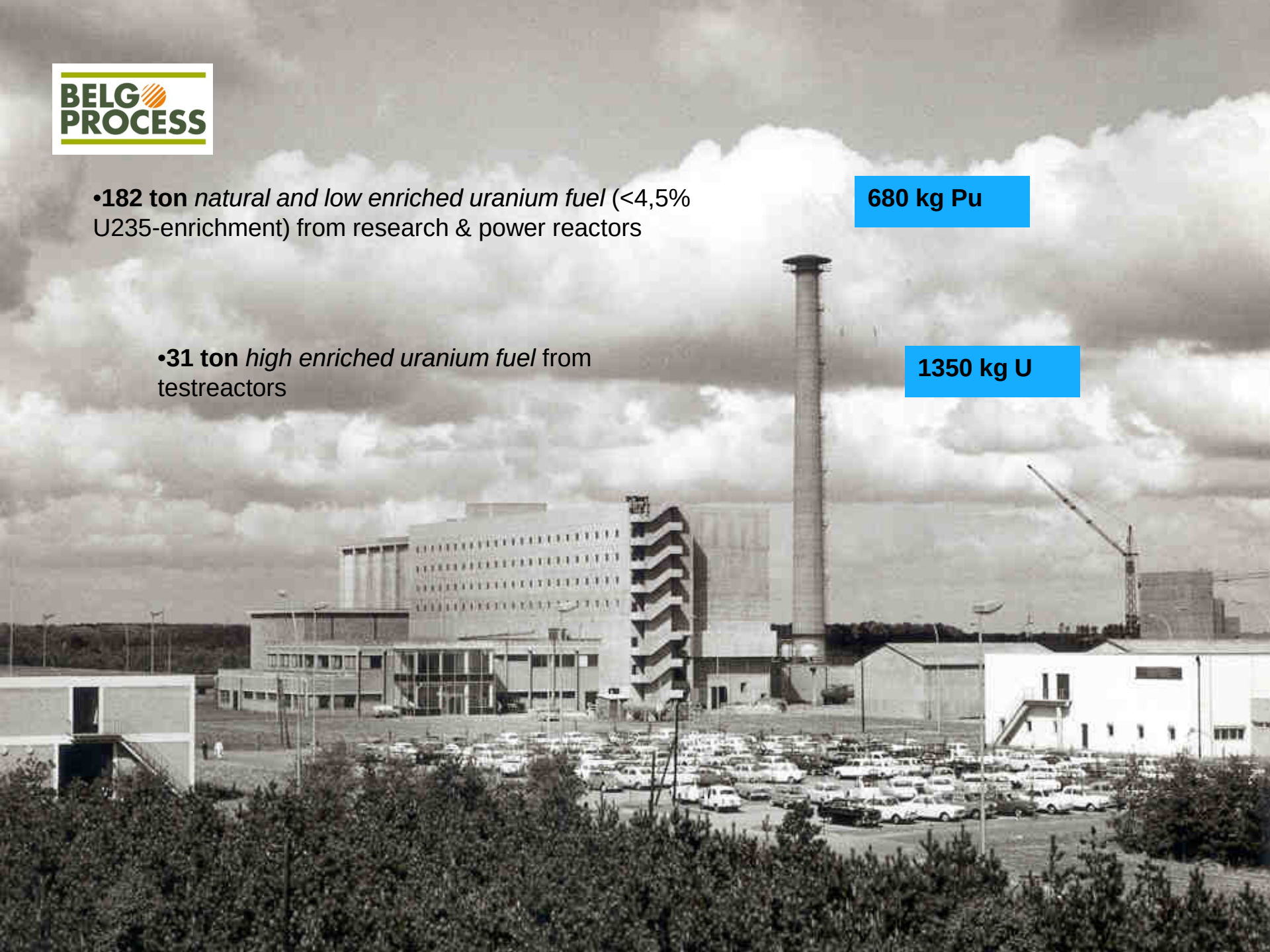
Decommissioning? Yes we can ! BNS 23-03-2017

• **182 ton** *natural and low enriched uranium fuel* (<4,5% U235-enrichment) from research & power reactors

**680 kg Pu**

• **31 ton** *high enriched uranium fuel* from testreactors

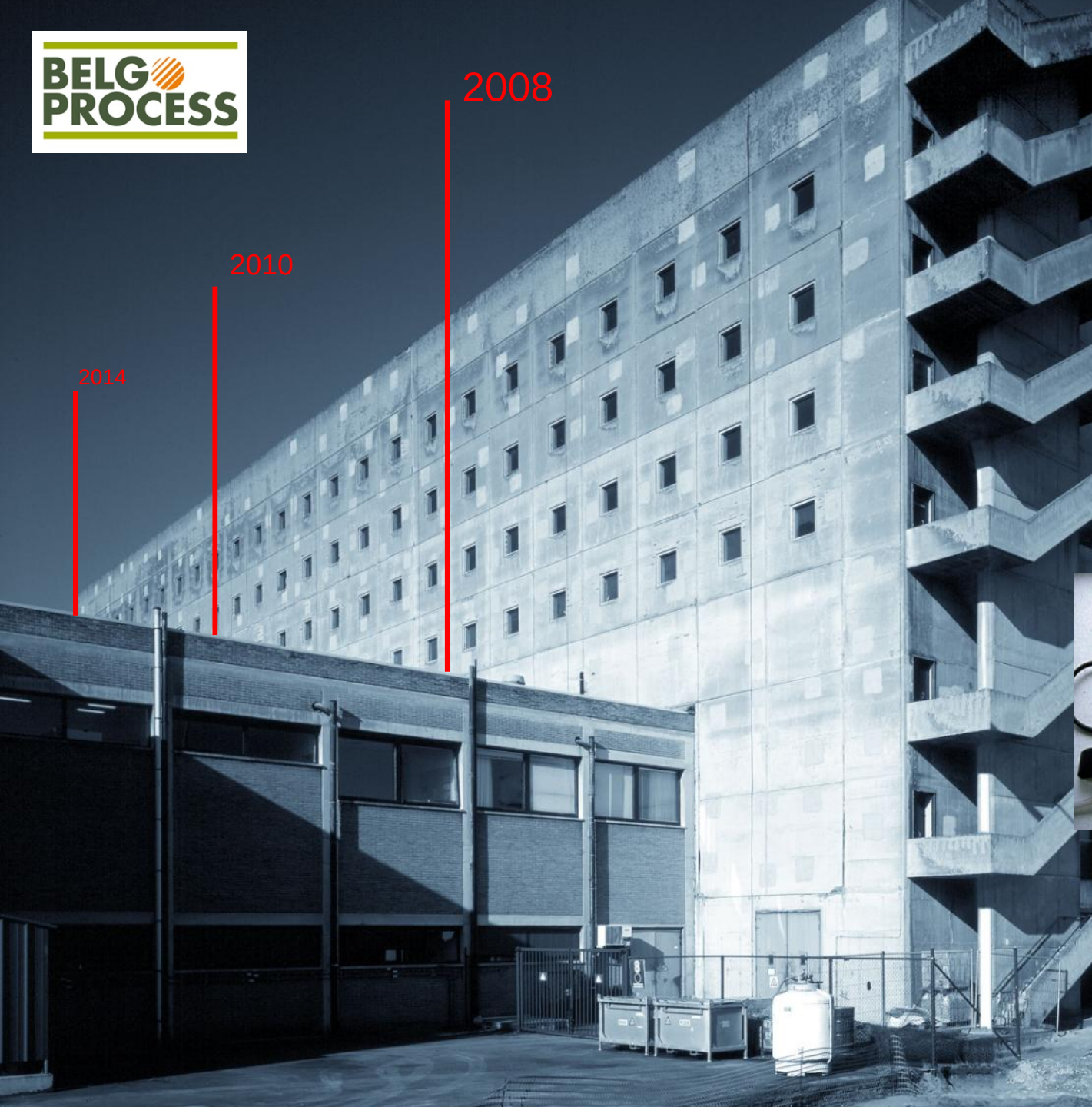
**1350 kg U**



2008

2010

2014





# A common project: The BN MOX Fuel fabrication plant



- **SCK•CEN, Belgoprocess** and **Tecnubel** were contractors for the dismantling of the BN MOX fuel fabrication facility in Dessel.
- The work is nearly finished and was realized successfully by this team of companies and institutions.

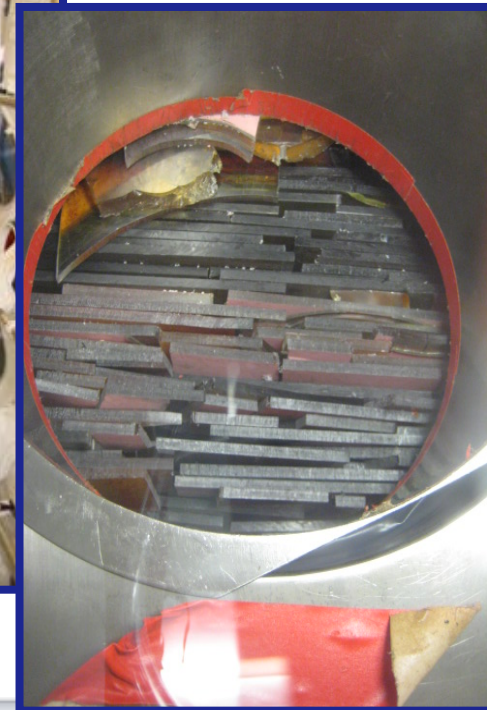
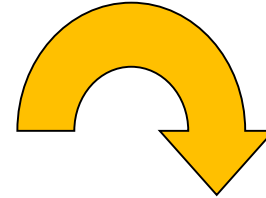


# Description of the plant

- Location: Dessel (north Belgium)
- Two single-floor process buildings (~5000 m<sup>2</sup>)
- Some figures
  - 170 gloves boxes
  - 1.200 tons infrastructure
- Shutdown
  - Last commercial reload: 2006
  - Surplus fissile material into rods and shipped back to customers: 2007
- Activities related to Decommissioning
  - License granted as Royal Decree in 2008
  - Signature contracts and start of decommissioning works in March 2009



From glove box to drum...



## Status January 31<sup>st</sup> 2017 (1)

- Integration and qualification of the contractors achieved by end of 2009
- Safety Records of Decommissioning
  - Labour accidents in Controlled Area: None
  - Incidents with nuclear impact: None
  - Max. individual dose of 8mSv per 12 months
- Turnover of personnel : < 10%
- Progress
  - 100% of GBs and of their internals are decommissioned
  - More than 95% of infrastructure treated of which half been sent to melting facility as metal scraps
  - Waste drum filling level according to previsions

 ***Decommissioning project is proceeding smoothly***

## Status on January, 31 2017 (2)

The first nuclear building has been free released in December 2014 and demolished in spring 2015



# And tomorrow ?

---

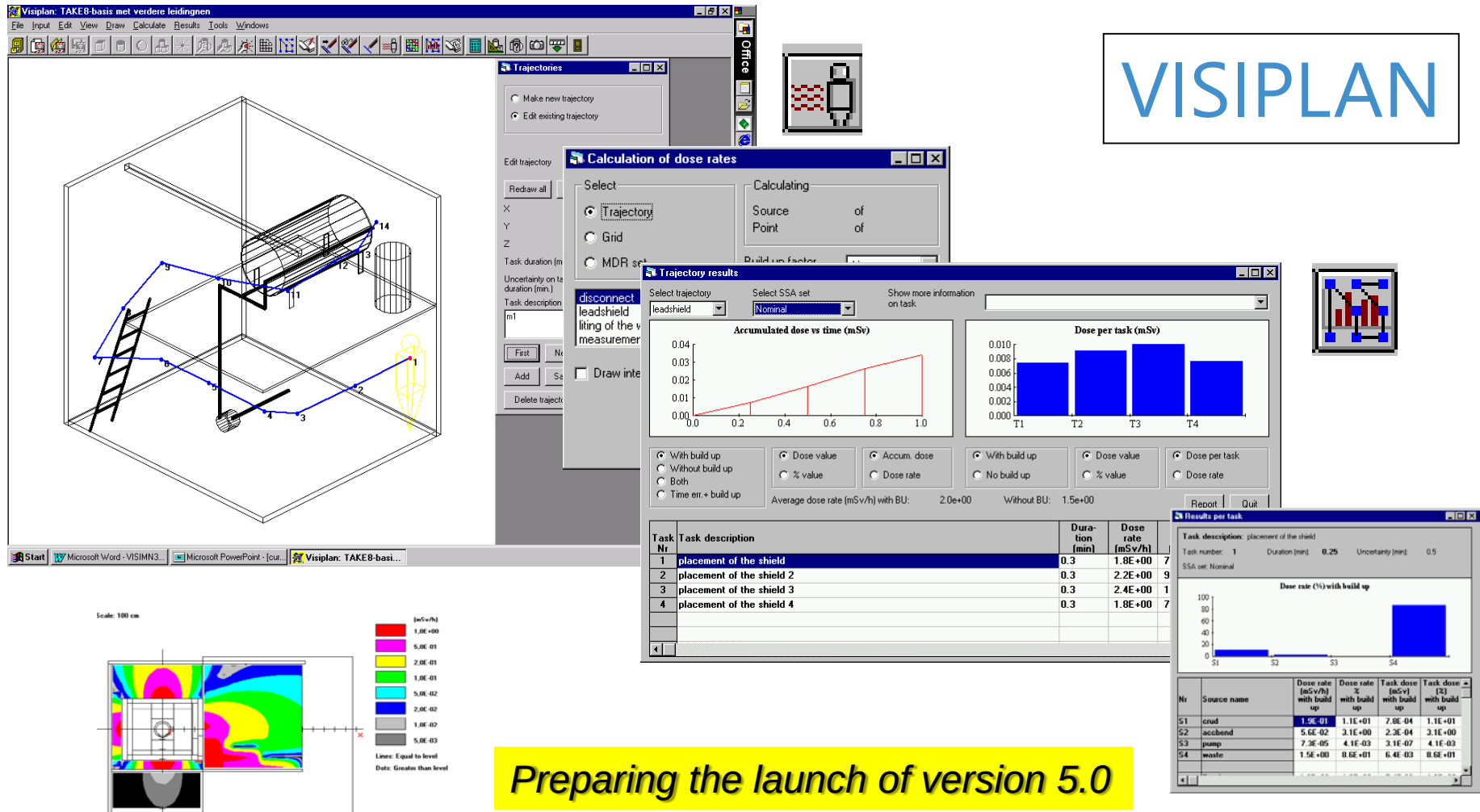


# How to decrease and control the costs and improve the safety and efficiency?

- New developments allow to reduce and control the costs and/or improve the safety and efficiency; like e.g.:
  - 3D Software for planning the job and optimizing the radioprotection;
  - Software for the management of materials, waste, organization etc...
  - New decontamination techniques (chemical, laser based, etc...)
  - Telerobotic deployment of tools and measurement systems
  - Radiation hardened electronics and components
  - Simple dose measuring systems
  - Characterization tools (the "triple secret" of D&D)
- We have developed some of these innovative systems
- But the main aspect is also the skills and competence of the executing teams (dismantling is not a simple job !)



# Radioprotection: Development and Use of a software tool: ALARA planning tool **VISIPLAN**



# The experience led to several developments and skills

## Skills

### Management of decommissioning program and waste

- Decommissioning plans
- Characterization survey
- Strategy optimization
- Costs estimates

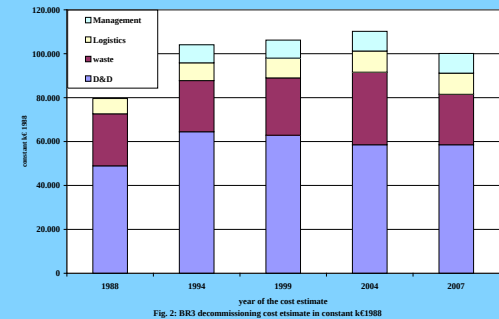
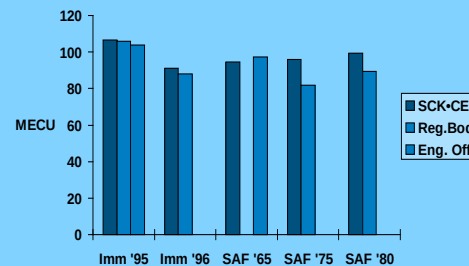
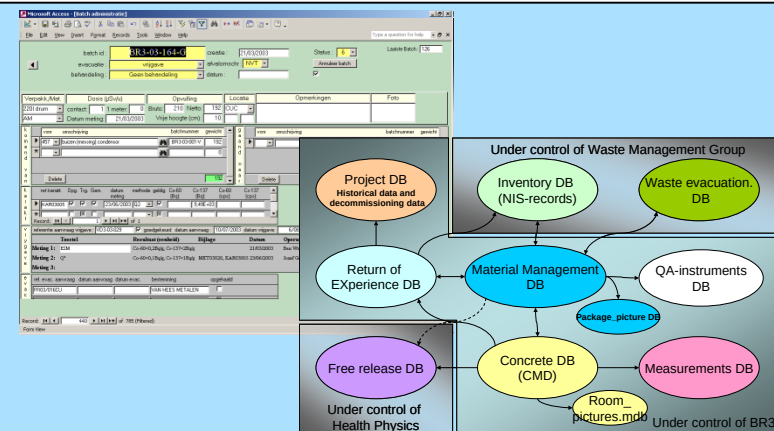


Fig. 2: BR3 decommissioning cost estimate in constant M€1988

## Software available

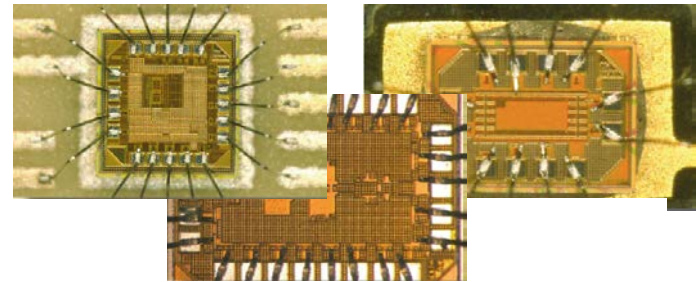
### Integrated network of databases

- NIS: Nuclear Inventory System
- MBS: Material Management Software
- DRAB: Waste Management database
- NMA: Nuclear Material Accountancy
- CMD: Concrete Management Database



# The development of rad-hard components and dose measurement system

- Creation of a spin-off ('MAGICS') for the development and production of rad hard micro-electronics and sensors...



## REMOTE HANDLING

in nuclear  
environments



## SENSOR NETWORKS

in hazardous  
environments



## INSPECTION

In high radiation  
environments

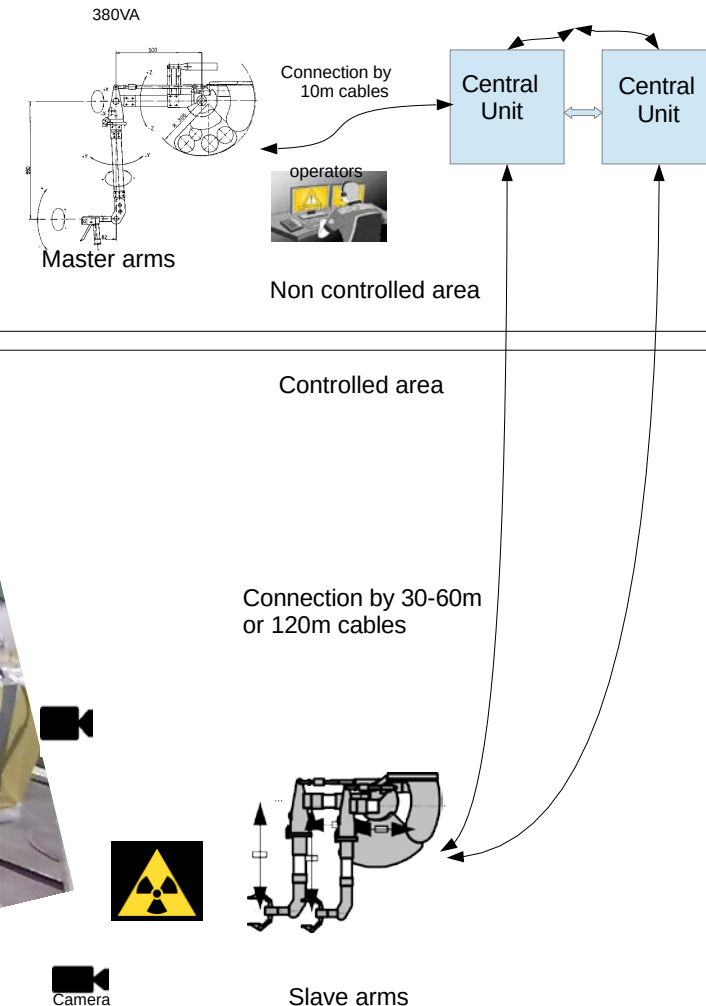
# Developing skills and competence in remote handling and robotics

- Involvement in different projects abroad:
  - KTE (WAK) – Karlsruhe (D)
    - Dismantling of activated Biological shield KNK Reactor
    - Dismantling of Hot Cells – irradiated fuel examination
    - 8 Remote Handling experts assist in modifying, testing and implementation of remote controlled equipment
  - ITU JRC – Karlsruhe (D)
    - Maintenance of MasterSlave remote handling equipment Hot Cells
  - Remote Handling Experts at KHG
    - “Nuclear Fire Brigade”
    - Training and Maintenance
    - Recurrent



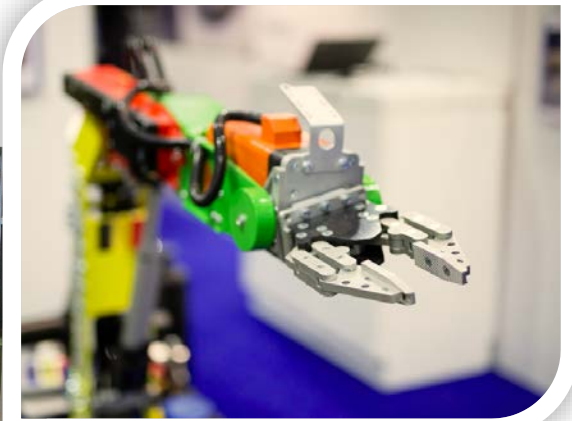
# Application in Belgium (CNT)

- Remote compacting & sorting RAW at Tihange NPP
- Application of Master/Slave manipulators



## Acquisition of ANSA / Siempelkamp – April 2015

- Key Experts & Equipment (Robots and Master-Slave manipulators)
- Develop Business
  - Focus on Germany ('cause of market, track record, contacts)



## Summary: Belgian companies & institutions have an Important **Return of Experience** (REX) to share

---

- Long standing experience in decommissioning
- As pioneers, tests (and comparison) of various D&D technologies on real components (for dismantling, decontamination, characterization and material management)
- Combined experience in Belgium on reactors, reprocessing plant, hot labs and MOX fabrication plant decommissioning, thus covering almost all kind of nuclear facilities.
- Various specific developments done for these projects (e.g. Visiplan, automated shaving system, underwater bandsaw, MEDOC hard decontamination process, material management software, robotics, rad-hard electronics, etc)

All these skills and processes are ready to be used on other projects...

# Acknowledgments

---



- Thanks to :
  - Wim Van Laer and the team of **Belgoproces**
  - Guido Mullier and Peter Berben and the team of **Tecnubel**
  - The **SCK-CEN** decommissioning team



Thanks for your attention !

