D&D at CEA: Strategy and Lessons Learnt

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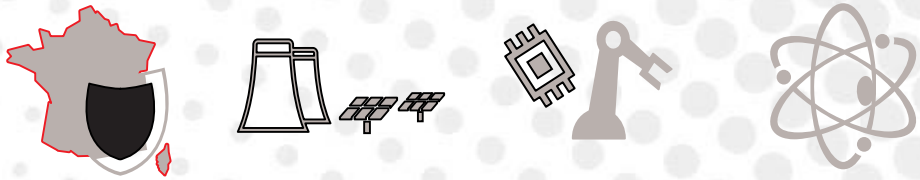
Fanny FERT
D&D Project Directorate
fanny.fert@cea.fr

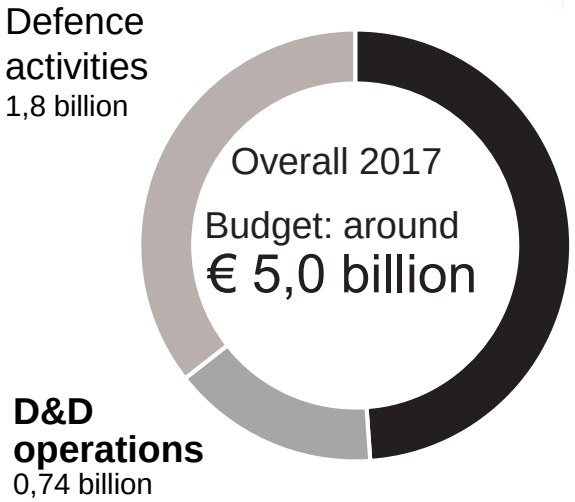
CEA: A UNIQUE PUBLIC RESEARCH ORGANISATION

- **With strategic missions in:**
  - Defence and security
  - Nuclear and renewable energy
  - Technology research for industry
  - Fundamental research



19 730 employees

1400 doctoral students and post-docs



9 centres

CEA DECOMMISSIONING PROGRAMS - KEY FIGURES

CEA employees working for D&D

+ 1100

740 M€

Budget per year

Industrial partners, 2500 employess from outside companies

+ 30

23 Bls€

Long term expenses

Installations under D&D

36

+ 100

D&D projects

Waste conditioning, investments, R&D, packaging for transport, waste management…

Civilian sites concerned at CEA: FAR, Saclay, Grenoble, Marcoule and Cadarache (+ Orano Pierrelatte)

5

From 5 to 50 y

Average duration of D&D works

Cost of a decommissioned site

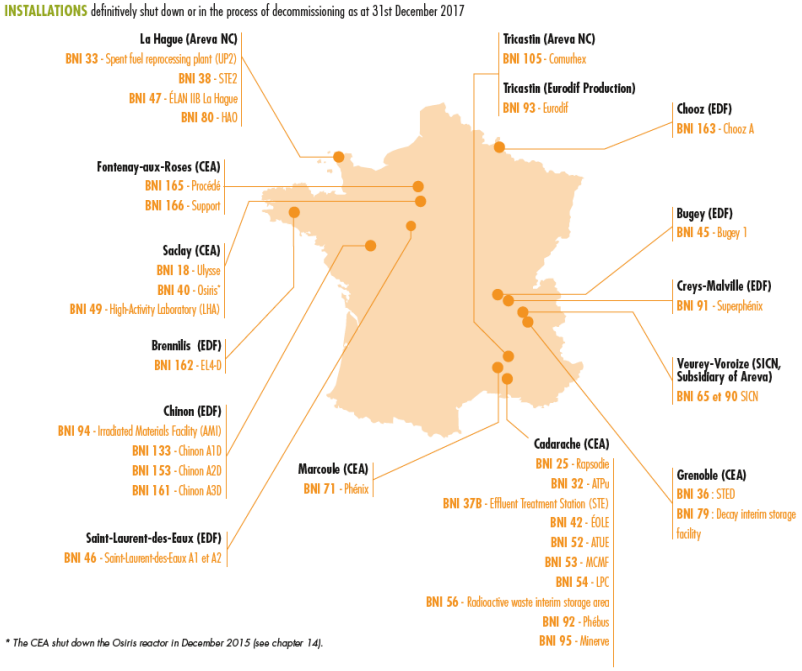
From 350 M€ to several Bls

25 000 m^3

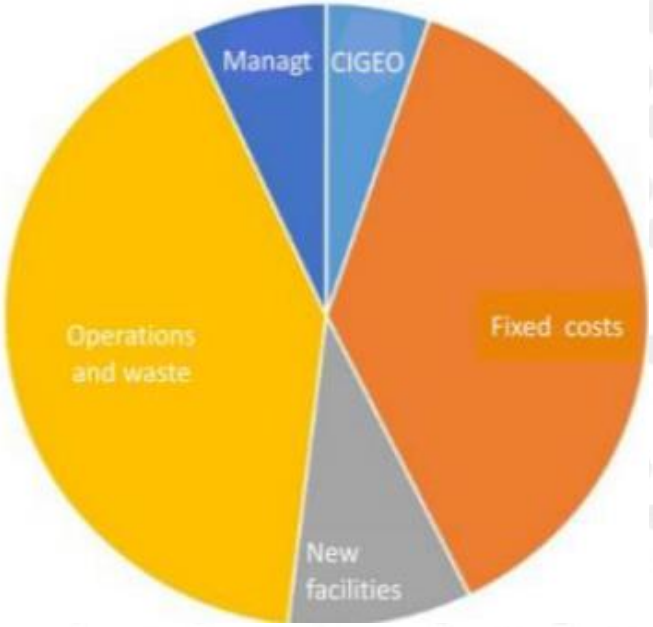
Conditioned waste per year

In France:

- French nuclear fleet = more than120 installations
- Would cost 34 billions euros (87 Billions euros including the waste and spent fuel management)



At CEA:



Cost allocation

CEA DECOMMISSIONING PROGRAMS

1 hot lab, 2 reactors,
2 service units,
1 RCD project

2 hot labs,
1 service unit,
1 RCD project

Fontenay-aux-Roses

Saclay

1 enrichment plant,
1 hot lab

Grenoble

Decommissioned:
1 hot lab, 3 reactors, 1 service unit
In decommissioning :
1 service unit

Pierrelatte

Marcoule

1 pilot workshop, 1 hot lab, 6 reactors, 1 reprocessing plant, 3 RCD projects, 2 service units

Cadarache

2 hot labs, 3 reactors, 2 service unit, 2 storage facilities, 1 RCD project, 3 critical mock-ups

SPECIFICITIES OF D&D AT CEA

- **Wide variety of complex facilities**
  - Reactors, pools, fast-neutron etc.
  - Accelerators and irradiators
  - Labs, workshops and plants
  - Waste treatment and storage facilities

- **Little to no scale effect**

- **Various sizes**
  - Reactors: Ulysse INSTN -> Phénix
  - LAMA -> bat 18 FAR -> APM -> UP1

- **R&D facilities**
  - Traceability of changes, history
  - Wide variety of waste

- **Chemical treatment of irradiated fuel**
  Level of contamination (and irradiation) can be important (FAR, Marcoule APM and UP1, ...)

- **Legacy sites and installations**

STRATEGY OF DISMANTLING: VARIOUS POSSIBILITIES

- **Immediate dismantling :** Enshrined in the French law and preferred by the French safety authority
- **Deferred dismantling :** Aims to wait for the decrease in radioactivity before starting dismantling or to wait for the availability of an industrial waste stream
- **Entombment :** It consists in pouring concrete over the nuclear installation. This way of management had been applied in the United States for some military nuclear installations

- **Dismantling in several steps :** Intermediate way of dismantling between immediate and deferred dismantling
- **The choice of strategy depends on:**
  - Techno-economic criteria : final cost of dismantling-decommissioning, monitoring cost of installations, cost of maintenance, availability of disposal for waste
  - Social and political criteria : public acceptance, major issues for the nuclear industry…

This leads to the choice of the dismantling scenario

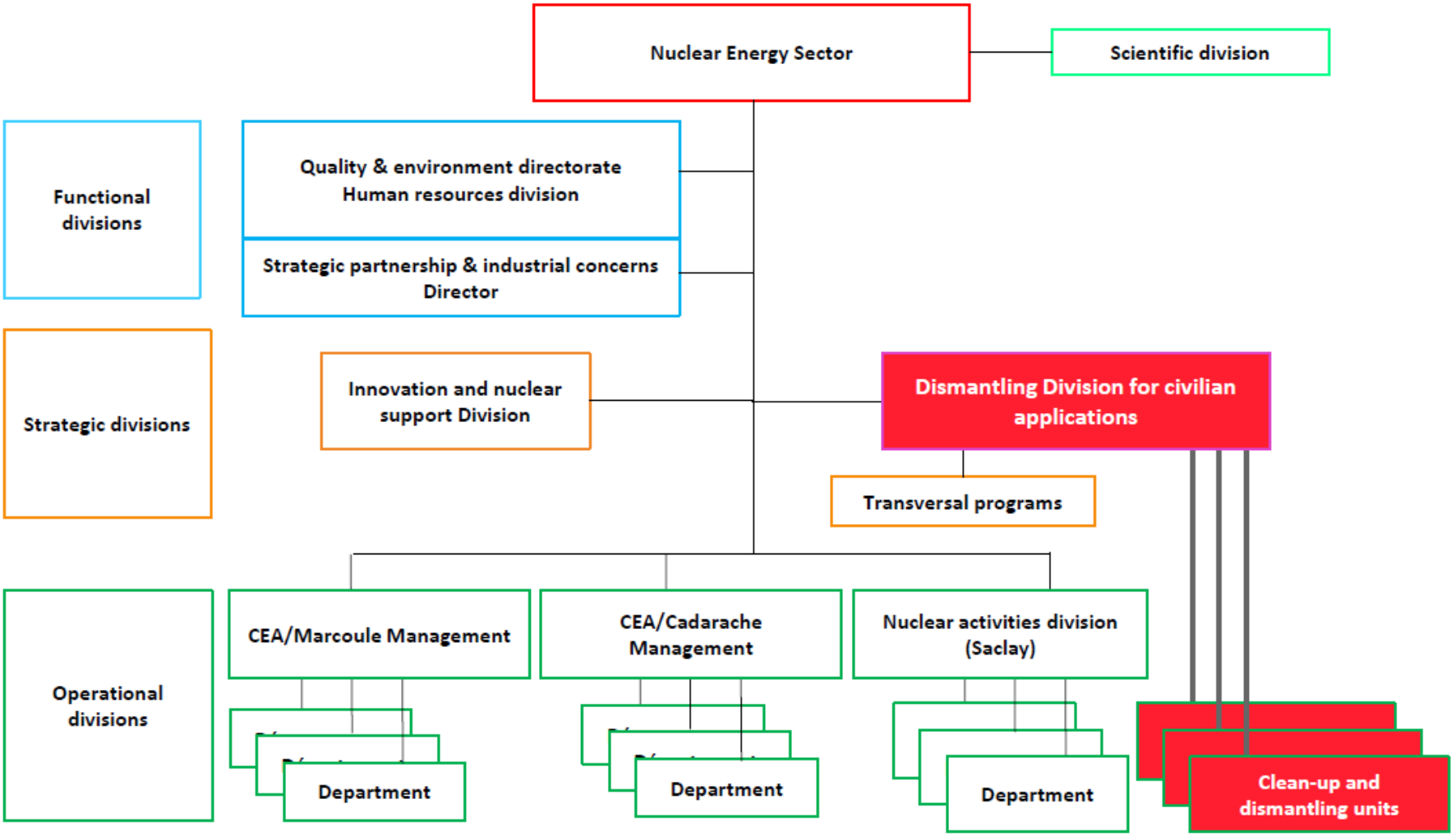
STRATEGY FOR D&D

- **A consolidated file was submitted to the safety authority at the end of 2016, covering:**
  - The strategy and scenario of each D&D project, with a **macroscopic risk analysis**, as well as the strategy for materials and waste management
  - The **prioritization** process: priority to reduce the source term
  - A presentation of the **new associated internal organization**
  - Problem of **financial resources**: reduction of fixed costs to conduct more operations
- **After a two-years discussion, it led to :**
  - The **prioritization of D&D projects over the next 15 years**, with credible safety milestones
  - Consolidation of safety commitments discussed with the safety authority

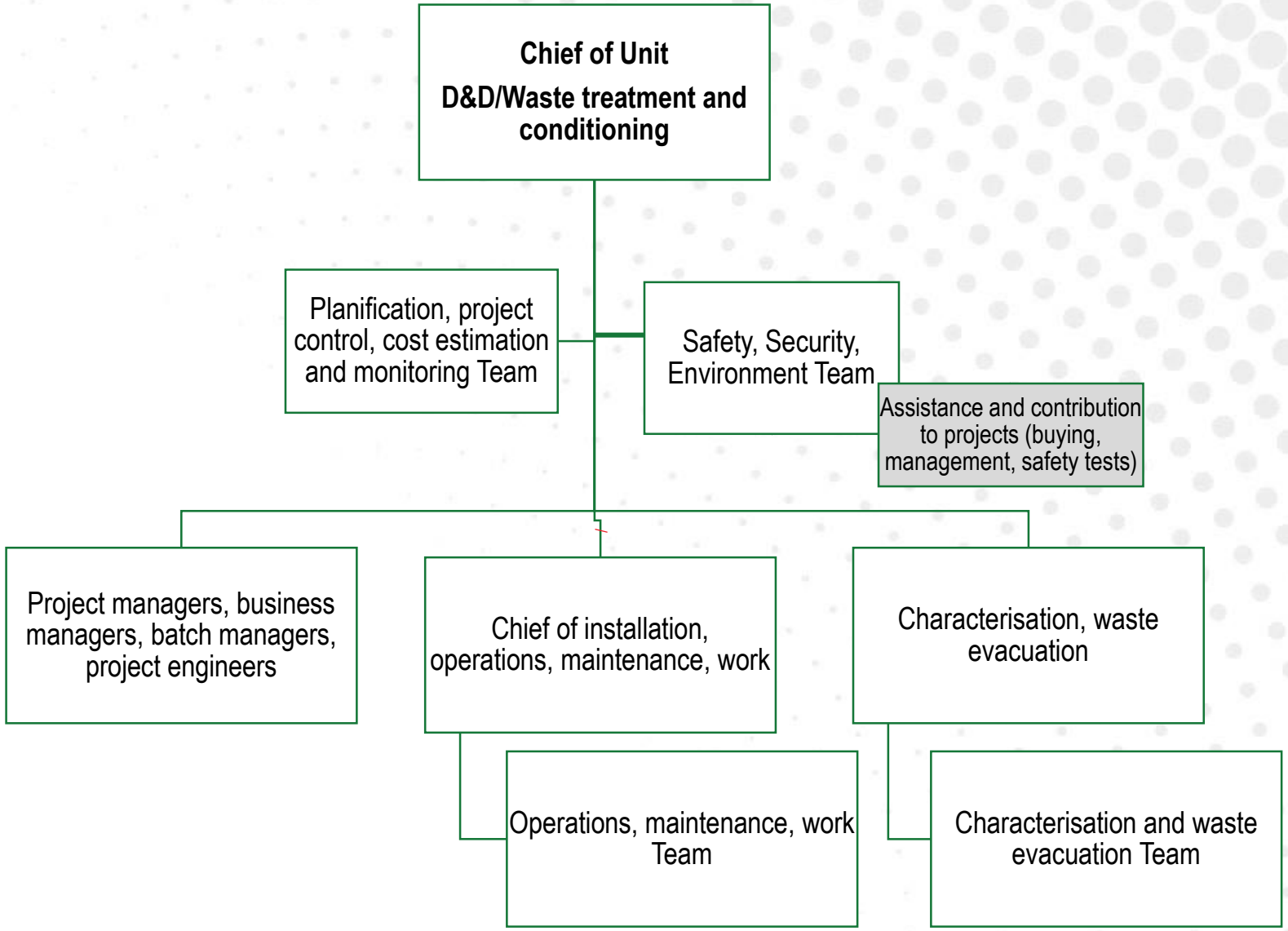
Objective of the CEA: to carry out the D&D programs in complete safety and in the strict respect of costs and deadlines

A NEW ORGANISATION FOR D&D

Enhancement of the clean-up & dismantling project jobs



CREATION OF D&D UNITS



STRATEGY FOR D&D

- Necessary compliance with the CEA's budget framework of €740 million per year ➔ priorities (Many installations shutdown simultaneously but the annual budget is unchangeable)
- Priority = projects which contribute to removing as much radioactivity as possible as quickly as possible from "less safe" to “safer” locations (RCD operations, related investments, ...)
- Final clean-up and, possibly, demolition of buildings is not a priority for CEA
- Therefore, for these final remediation operations, investigations and characterizations remain a priority to better acknowledge initial state and clean-up emergency
- Some non safety priorities have been proposed by the CEA for economic reasons (reduction of fixed costs), emblematic (denuclearization of CEA sites), pilot operations, regulation (compliance with decrees)
- R&D has a special role in support of these programs, helping:
  - Safety & security improvements and radioactive dose reduction
  - Cost & schedule reduction
  - Optimized waste management

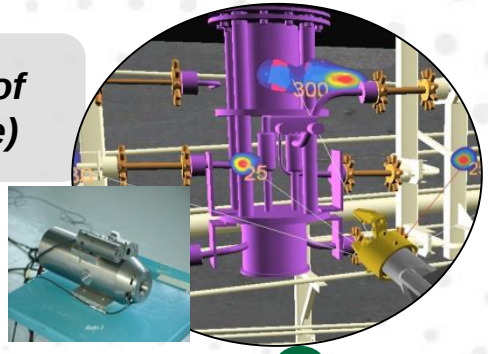
This strategy often leads to dismantling in 2 steps: immediate waste retrieval and equipment dismantling; deferred decommissioning and deconstruction.

OPERATIONAL STAKES

- **Knowledge of the initial stage**
  - Old installations, traceability and different practices today: improved characterization together with simulation and virtual reality to define decommissioning scenarios
- **Suggest changes to the regulatory framework**
  - Evolution of CEA internal circulars, exchanges with the safety authorities on final states, search for innovative solutions for waste
- **Have a guaranteed multi-year funding**
  - Triennial agreement signed with the Government: but capping at € 740 million, which requires the need to smooth programs for each new action
- **Handle waste management** (sorting, conditioning, packaging, transportation, storage)
  - About 30% of the project cost
  - Imperative need for stabilized specifications, whether for existing disposal or for future disposal
- **Manage the transition between operations and D&D**
  - Needs in project skills; offer training possibilities and promote these jobs

TECHNOLOGICAL STAKES

In-situ characterization of installations (initial state)



Tools and methods to well characterize waste and dispose them in the just needed stream)

Processing and conditionning of effluents and solid waste

Operations in hostile environments

Decontamination of structures and soils

R&D is essential to conduct dismantling operations, whatever the stage

ECONOMIC STAKES

- **For CEA, necessity to decrease operations / investment costs in order to accelerate projects and decrease total project costs**
- **From the industry's standpoint, D&D is far from the promised Eldorado**
  - Very low margins in dismantling engineering and operations:
    - No serial effect, changes in regulations and technology ➔ Significant risks on initial and final state
    - Great difficulty in estimating costs
    - Harsh competition on prices
    - Controlled margins in the operation and maintenance markets
    - Only high-margin sector: high-technology used in D&D

This leads to a strong interest to build cooperation with scientific and industrial partners, and with international counterparts

INTERNATIONAL COOPERATION

Cooperation agreements on D&D and R&D for D&D

GERMANY
BELGIUM
CANADA
CHINA
SOUTH KOREA
USA
FINLAND
HUNGARY
ISRAËL
JAPAN
LITHUANIA
UK
RUSSIA

IAEA
EUROPEAN COMMISSION
OECD - NEA

D&D : THREE TYPES OF PROJECTS

Marcoule gathers most of the priority works with 6 priority projects running in parallel

- **Dismantling Projects:**
  - Example of UNGG reactors

- **Legacy waste retrieval projects:**
  - Example of bitumen waste or magnesium claddings

- **Projects to build new facilities to answer to the needs of the two previous ones:**
  - Example of a new facility for waste disposal (DIADEM)

DISMANTLING IN SEVERAL STEPS

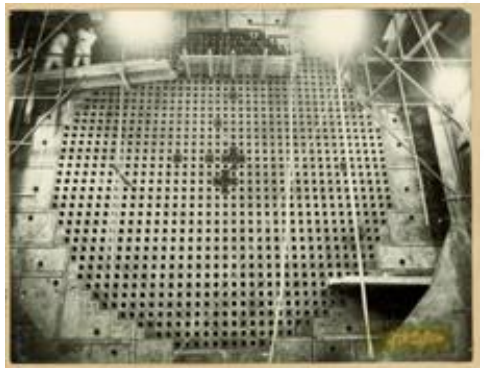
- **The first step of dismantling is the characterization of the source term to better know the initial state**
- **The second step is to reduce the source term and dismantle the facility :**
  - Adapt the dismantling techniques to the constraints of the facility with specific challenges regarding safety, environmental impacts, hostile environment, radiological protection stakes and costs
  - Manage the waste : treatment, conditioning and store the waste in order to dispose them and respect the acceptance criteria of repository
- **The last step is reached after cleaning up the walls and soil remediation depending on the dose target which is a function of the future use (nuclear or conventional)**
  - Characterization of the final state of the facility
  - Monitoring of the facility waiting for its demolition if it is decided

FRENCH UNGG REACTORS IN MARCOULE

- **G1 reactor**: Stopped in 1968
  - First French reactor built in 1954-55 to produce plutonium (industrial scale)
  - Cooled by air with atmospheric pressure

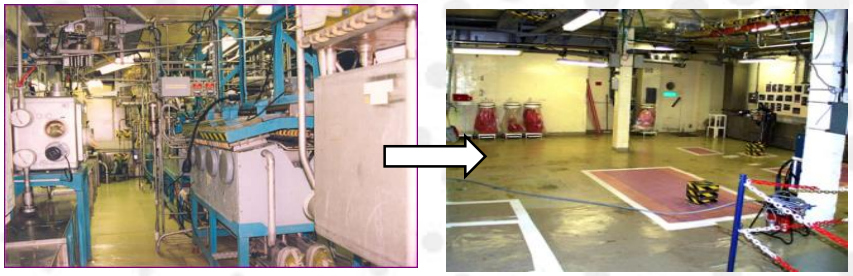
- **G2/G3 reactors**: Operated 1958 -1980/84
  - Mainly military purposes and then electricity generator as a demonstrator for next UNGG French reactors (EDF)
  - Natural uranium - Graphite moderator - CO2-cooled P= 15 bar

- **The primary and secondary circuits have been removed. Only the reactor blocks remain and we are working on dismantling scenarios. No storage for graphites yet, while a project of low activity long life disposal is under development at ANDRA**



MARCOULE FACTORY

- **Irradiated fuel reprocessing plant (1958 to 1997)**
  - **3** units : Medium activity (MA 100), high activity (HA 100), dissolution unit (MAR 200)
  - **20 000** m^2 including **9 000** m^2 in restricted area
  - **5** dissolvers, **17** extraction units, **9** evaporators, **105** tanks, **150** glove boxes



Dismantling of glove boxes

Dismantling of bitumen tanks

GRENOBLE: FIRST BIG D&D INDUSTRIAL OPERATION COMPLETED

- **Project « PASSAGE » launched in 2002:**
  - End of dismantling in **2012** (initially foreseen in 2015)
  - **3** Reactors and **1** lab decommissioned
  - June 2018 : The last requests of decommissioning for 2 BNI (STED) are under review
- **Total budget**
  - ~ **350** M€ (including 50 M€ linked to additional requests from the safety authority)



LESSONS LEARNT FROM D&D PROJECTS AT CEA

- **Lessons learnt**
  - Maintain **skills**, **capitalize** on them
  - **Promote** these activities
  - **Develop R&D** in the areas of D&D and value it
  - Importance of **safety aspects and relationships** with the safety authorities
  - **Regular local information**: staff, media etc.
  - **Optimize waste and effluent management**: minimize, optimize categorization

- **Many contengency inherent to this activity**
  - **Evaluation of the initial state, evolution during work**
  - **Evolution of the regulatory framework**
  - Large quantities of waste to be managed in connection with ANDRA *(the French national agency responsible for identifying, implementing and guaranteeing safe management solutions for all French radioactive waste)*
  - **Evolution of ANDRA specifications**
  - Significant fixed costs
  - Availability of disposal and means of transport
  - **Constantly taking into account new requests (under the same budget)**

Any extension of the deadline leads to additional cost, linked to the smoothing of operations and the increase in the duration of surveillance, maintenance and exploitation

CONCLUSION

- Need to comply with annual subsidy but also need to accelerate projects and reduce investment costs in order to decrease total project costs
- Strong interest to build cooperation with scientific and industrial partners, and with international counterparts
- Research has a special role to play:
  - To reduce cost, schedule , doses and optimize waste management
  - To improve safety and security
- Opportunities for continued collaboration within the decommissioning community:
  - Bilateral collaboration
  - NEA, IAEA
  - EU (Insider, Theramin, Micado EURAD, SHARE, etc.)

Thank you for your attention!