Benefits from R&D for D&D Projects Preparation

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Wide variety of facilities with no series effect
- Reactors: pool-type, fast breeder, gas graphite…
- Accelerators and irradiators,
- Fuel cycle laboratories, workshops and plants
- Waste treatment and storage facilities

Different facility sizes
- Reactors: Ulysse (piloting training) -> Phénix (Industrial)
- Facilities: FAR or LAMA -> UP1

High contaminated areas
Waste diversity
History and traceability of Old nuclear facilities
WIDE RANGE AND LARGE AMOUNT OF HLW WASTE

Ex UP1: 75 types of legacy wastes, located in 18 different locations:
- ~ 3150 glass canisters
- ~ 1630 t of HLW Mg clads
- ~ 1300 t of powdery waste
- ~ 1300 drums of alpha-waste
- 60 000 drums of bituminized waste
- Active areas = 140 000 m3
- 26 000 t of waste from active areas

- Very different in their chemical and radionuclide composition
- Long-lived radionuclides
- Re-disposal required
R&D Program has two main purposes:
- Optimizing R&D activities in support of clean-up and dismantling programs:
  - to reduce the cost, the duration of the work, the doses incurred, the amount of waste produced
  - to improve the safety and security of dismantling worksites
- Developing and promoting R&D and expertise:
  - to share R&D developments
  - to provide expertise
  - to develop industrial partnerships

CEA leads R&D actions and develops expertise in 6 main axis:
- **Overall facility characterization**
- **Methods and IT tools**
- **Liquid and solid waste Treatment**
- **Structure and soil decontamination**
- **Waste characterization**
- **Work in hostile environment**
Synergy between R&D, expertise and experience from D&D workshops

- Orientation of R&D towards industrial needs
- Easy access to pilot workshops in order to give confidence to other users
- Opportunity for sharing with other contracting authorities the development of solutions on same challenges
EXPERTISE AND R&D FOR D&D

- Development of R&D programs,
- Research partnerships,
- Access to pilot job sites,
- Access to laboratories / technological platforms,
- Consulting,
- Technology transfer

SACLAY
- Waste behavior
- Characterization / Physical and Chemical analysis
- Laser cutting, Robotics
- Simulation
- Materials

FONTENAY
- Geostatistics
- Soil remediation

CADARACHE
- Waste characterization
- Nuclear measurement
- Fuel conditionning
- Corium behavior
- Tritium waste
- Sodium waste
- Impact studies

MARCOULE
- Structure and soil characterization
- Remote control, Simulation
- Cementation
- Vitrification
- Decontamination
IN SITU CHARACTERIZATION

NEEDS for:
- Better knowledge of radiological and physical states to control hazards management, cost and delay
- Reduction of doses integrated by operators
- Optimization of samplings

EARNINGS
Optimization of D&D scenarios, from the identification of characterization objectives through to the final physical and radiological inventory

IMPROVEMENTS
- to map facilities and soil,
- to localize hot spots,
- to identify radionuclides,
- to estimate radioactivity,

Geostatistics
Gamma camera
LIBS technology
Gamma spectrometry for concrete contamination
Autoradiography
Alpha camera
NEEDS for:
- Better knowledge of radiological and physical states with less uncertainties in the mesurements
- Transportable and multipurpose systems for different kind of waste

EARNINGS
- Waste minimization
- Good predictive data for storage facilities
- Optimization of characterization processes

IMPROVEMENTS
- Non destructive analysis:
  - γ et α imaging
  - γ spectrometry
  - Neutronic measurement
- Destructive analysis:
  - beta long live analysis

Modeling with pre- and post- measurement
Waste characterization in glove boxes
Active neutronic measurement of U and Pu
Passive neutronic measurement of Uranium
EARNINGS

- Identify and implement decontamination techniques for radioactive solids, structures and soils
- Waste optimisation

IMPROVEMENTS

- Technologies adaptable to many geometrical configurations, and to a wide range of materials and natures of contamination:
  - aspirable self-drying gels,
  - laser ablation,
  - viscous foams or active solutions,
  - float foams or supercritical fluid,
  - coating gels,

- Studies of chemical medium formulations with associated physico-chemical characterizations,
**DECONTAMINATION OF LIQUID WASTE**

**IMPROVEMENTS**
- Innovative decontamination process design
- Innovative Cs and Sr sorbents design
- Sorbent synthesis from laboratory scale up to industrial scale.

**EARNINGS**
- Increase decontamination efficiency
- Minimization of generated waste
- Compatibility with large flowrates
- Compatibility with existing waste treatment (cementation, vitrification)

**SORBMATECH® FOR Cs**

**NEW SORBENTS FOR Sr**

**Reactors design**

**Synthesis reactors**

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**Graph**

- [Sr]/[Sr]₀ vs t (min)
  - t: 0, 200, 400 min
  - [Sr]/[Sr]₀: 0, 0.2, 0.4, 0.6, 0.8, 1.0

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**Image**

- pictures of reactor design and synthesis reactor
**Earnings**

- Develop efficient treatments for complex radioactive wastes (mercurials, sodics, tritiates, Mg from decladding, powders, graphite, sludges, other legacy waste, ..)

**Improvements**

- design and carry out radioactive waste treatment processes from laboratory scale through to industrialization phases.

- Several thermal processes for the treatment of solid or liquid organic radioactive wastes:
  - incineration,
  - mineralization of organic liquids by hydrothermal oxidation or by plasma incineration
  - Vitrification (in-can melting)
  - Encapsulation with geopolymers (Mg, oils), Mercury, sodium, tritium waste, treatment, etc.
**EARNINGS**
- Validate intervention scenario feasibility
- Reduce the doses integrated by operators
- Minimize cost, delay, waste volume, cuttings
- Compare alternative scenarios
- Qualify remotely-controlled

**IMPROVEMENTS**
- Design, adaptation of fine-tuning innovative systems for computer-assisted tele-operation actions, as well as carriers: remote handling MAESTRO
- Development of laser cutting processes in air or under water to improve cutting yields while limiting the aerosols and waste generated.
- Development of 3D simulation software and virtual reality: Immersive Room for training
REMOTE DISMANTLING OF THE DISSOLVERS
The use of Virtual Reality to secure the project

RESULTS

- Optimization of cutting sequences
- Modification of video cameras positions
- Modification of tool rack design
- Assessment of Maestro arm introduction into dissolver “stack”
- Operators formation
- Simplification of the mock-up testing program

Simplification of the mock-up testing program
Several factory tools, have been studied, developed and qualified.

- Nibbler
- Gamma camera
- Alternating saw
- Hydraulic shears
- Disk grinder
- Screwdriver
- Drill
- Laser torch
- Offset screwdriver
- Video camera
- IF104 radiation probe
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DEFINITION OF SCENARIOS: A COMPLETE MODEL

- Characterization
- Simulation, virtual reality
- Remote technologies, robotics
Tools for estimation of overall costs (ETE – EVAL)

Tools for project management (DEM +, Saphir, etc.)

Tools for transportation management (SINTRA)

Tools for waste management (CARAÏB, INFLUVAL)

Key figures:
- **3000** technico-economic costing ratios,
- **+50** product headings,
- **225 000** packages recorded
- **+300** users.
CONCLUSION: MAIN CHALLENGES of D&D

- Preparation
- Strategic vision / prioritization
- Integrated organization and Synergy between technical trades, operators, project management teams and R&D teams
- Need for R&D to afford adequate technologies and processes with need to get involved since engineering studies.
- Need for international sharing of R&D and best practices

- Unique position of CEA both Operator and Research Organization
- Numerous facilities under decommissioning, with contamination levels sometimes very high, and a wide diversity from laboratory scale to industrial plants.
- CEA leads R&D actions and develops expertise in the 6 main axis of D&D
- R&D has a special role to help decrease costs, schedules and amounts of waste and to improve the safety of workshops.
- CEA is willing to work in partnership with other contracting authorities and industrialists in order to share R&D developments and to implement results.
Thank you for your attention