Expected contribution of statistical methods to nuclear decommissioning of CEA facilities

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Workshop "Statistical methods for safety and decommissioning" CEA/DES

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Summary

D&D deployed for CEA nuclear facilities

Analysis in support to D&D

R&D applied to D&D

Expected contribution of statistical methods to D&D
D&D deployed for CEA nuclear facilities
Clean-up and dismantling nuclear facility process

1. Nuclear materials and waste removal
2. Nuclear facility cartography
3. Dismantling preparatory operations
4. Dismantling operations
5. Building cleanup
6. Final radiological controls

Waste disposal

► Authorization or executive order
► Dismantling report writing and public inquiry
► Application for decommissioning
Expected contribution of statistical methods to nuclear decommissioning of CEA facilities

C&D perimeter at CEA energy direction

1 labo chaud, 2 réacteurs, 2 installations de service, 1 projet de RCD

2 labos chauds, 1 installation de service, 1 projet de RCD

1 usine d’enrichissement, 1 labo chaud

1 atelier pilote, 1 labo chaud, 6 réacteurs, 1 usine de retraitement, 3 projets de RCD, 2 unités de service

Démantelés: 1 labo chaud, 3 réacteurs, 1 installation de service
En cours de démantèlement: 1 installation de service

2 labos chauds, 3 réacteurs, 2 installations de service, 2 installations d’entreposage, 1 projet de RCD, 3 maquettes critiques
Large diversity of nuclear facilities
- Reactors
- Accelerators and irradiators
- Laboratories, and nuclear plant
- Facilities for waste treatment and storage

No « series » effect

Various sizes
- Reactors: Ulysse → Phénix
- Laboratories to plant LAMA → bat 18 FAR → APM → UP1

R&D facilities
- Various liquid and solid wastes

Spent nuclear fuel treatment
- Contamination and irradiation level potentially high

Historical nuclear sites
PASSAGE Project

- Dismantling end: 2013
- 3 nuclear reactors and 1 laboratory decommissioned
- June 2018: Send of the application for decommissioning for nuclear facilities: **ultimate administrative step** of full Grenoble site decommissioning

First complete industrial C&D operation at site scale
Some operational issues and transversal safety priorities

- **Operational issues**
  - Initial state control of old facilities
    - Characterization improvement and coupling with virtual reality to contribute to dismantling scenario definition
  - Waste management control
    - Sorting, treatment, conditioning, transport, storage
  - Need of stabilized specifications for existing storage or for future storage to define both R&D and characterization actions

- **Transversal safety priorities**
  - Polluted Soils characterization and management
  - Construction of waste treatment and storage facilities associated with recovery operations
  - R&D needed in support for these operations
  - Analysis capacities, particularly radiochemical, sized to support dismantling projects
R&D applied to D&D
D&D activities have reached maturity, but technological/methodological developments are needed to improve:

- the operational performance of complex projects,
- dose uptake and to improve work safety & security on nuclear operator
- waste minimization
Short-term applied R&D (3-5 years)
► Contribute to the realization of the 10 priority D&D projects
► General & transversal studies required for at least two D&D projects of the CEA (and industrial partners)

Medium-long term prospective R&D (5-10 years): Technical and economic optimization, with equivalent level of safety
► Develop and qualify technological processes
► Evaluate the future treatment/packaging options for unpackaged waste
► Evaluate the technical feasibility of re-classifying packages/historical waste to the different storage

Breakthrough R&D (including dedicated theses)
► Identify new axis of research for topics in the coming years.
► Attract new recruits on future topics with real technical and scientific issues.
► Building an active network between researchers and A&D projects
Analysis in support to D&D
Analysis strategy and organization in support to D&D projects

► Analysis needs include all the C&D project phases whose:
  ✓ Initial knowledge of liquid and solid wastes
  ✓ Process controls
  ✓ Operation monitoring of the facilities
  ✓ Compliance Guaranty to outlet requirements

► Aim
  ✓ Rationalize analysis use of in terms of:
    • Quantity,
    • quality,
    • Rendering times
    • Economic optimum,
  ✓ Contribute to maintaining/developing the CEA team expertise

► Ensure the interface between projects and analysis laboratories
  ✓ Challenging project needs and laboratory offers,
  ✓ Translating needs and offers in understandable language

► Anticipate responses to future needs
  ✓ Identifying over 5-10 years,
  ✓ Support analytical developments in interaction with R&D for D&D

► Laboratory network use
Expected contribution of statistical methods to D&D

Expected contribution of statistical methods to D&D
Statistic methods applied to D&D and waste management

Innovation

→ 2 patents
→ 3 reviewed publications
→ CARTOSTAT platform

Projects

→ CEA Nuclear Reactors
→ C&D CEA facilities
→ WRC
→ C&D ORANO facilities
→ ...

Collaborations

→ C&D CEA facilities
→ WRC
→ C&D ORANO facilities

European projects

➢ Géovariances (FR)
➢ SCK-CEN (B)
➢ Brenk (D)
➢ ONET techno (F)
➢ ...

Un lead CEA reconnu en France et en Europe
Statistic methods applied to D&D and waste management

- Initial and final characterization (1/2)

Characterization

D&D Constraints (exploitation, financial, …)

Data Statistic analysis
Machine learning
**Initial and final characterization (2/2)**

- **Événements**
  - Chute, Incendie, Infiltrations - inondations
  - Risque H2
  - Dégradation conteneur
    (carbonatation, fissures, corrosion externe, ...)

**Confinement statique**

- Systèmes passifs + Règles de conception

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<th>4ème barrière</th>
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<tbody>
<tr>
<td>Colis (métal, ciment, verre, ...)</td>
<td>Conteneur béton ou acier</td>
<td>Alvéole</td>
<td>Matrice géologique argileuse</td>
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**Confinement dynamique**

- Ventilation naturelle et/ou forcée
- Filtres, arrêt extraction
- Récupération des eaux, ...

**Statistic methods applied to D&D and waste management**
Surface and object CARTOGRAPHY

CARTOSTAT: Characterization and cARTography of pollution with STAtistical Techniques

- **Patent 1**
  - CARTOSTAT0D: Local approach
  - Non spatial data
  - uncertainties LOD\(^1\)
  - spatial data

- **Patent 2**
  - CARTOSTAT1: Global approach
  - CARTOSTAT2: Local approach

\(^1\) LOD or LD: Limit of Detection
Statistical methods need to contribute to analysis process steps

- **Non destructive measurements**
  - Radiological cartographies
  - Background noise versus low radionuclide contamination

- **Sampling**
  - Where,
  - How much,
  - How many,
  - Sample representativeness?

- **Analysis**
  - Counting time versus number of measurements,
  - Uncertainty measurement determinations.

- **Data treatments**
  - With few analysis results (sampling in difficult and constraint conditions)
  - With dispersion of analysis result (sampling conditions, representativeness)
Thank you for your attention