Remediation of north fleet sub-marines bases

Remote Handling technologies for Hazardous Environments issues

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APPLIED RESEARCH ON HAZARDOUS ENVIRONMENT ISSUES

Innovation - Design - Proof of principle

Qualification Phase
Lesson learned
Operational Tentative
Operational Phase

APPLIED RESEARCH 300 People

AREVA
Nuclear Robotic Intervention for Accident

Implement, maintain and operate
A fleet of specific remote-controlled equipment, able to intervene in place of human beings, face an accident in one of its member’s nuclear site.
On call 24 hours a day, ready for operation on any French site within 24 hours

Typical missions:
• To make site inventories
• To supervise site equipment
• To carry out specific operations
• To carry out civil engineering

International relations with other nuclear robotics intervention companies
Russia : MINATOM | Germany : KHG

OVERVIEW
Aerial cartography HELINUC
Outdoor Robotics
Indoor Robotics
Logistics
Civils engineerings
**Nuclear Robotic Intervention for Accident**

### Indoor Robotics
- Cable length: 350 mètres
- Hardened electronics (integrated dose $10^4$ Gy - debit max 70 Gy/h)
- Autonomy: 7 h EROS - 4h EOLE
- Gamma goniometric sensor
- Generic control bay
- Clearing of door and stairs

**EROS**
- Length: 0.98 / 1.57 m
- Width: 0.44 m
- Height: 1.16 m
- Weight: 300 kg
- Arms: 6 dof - 5dN or 12.5 dN

**EOLE**
- Length: 1.00 / 1.60 m
- Width: 0.72 m
- Height: 1.13 m
- Weight: 376 kg
- Arms: 5 dof - 16 dN

### Outdoor Robotics
- Set up in non-hostile areas, they have nevertheless NBC ranked protection
- Driving desk shelters
- Central transmission shelters
- Armoured Mobile Command Post which attenuation factor 100 against gamma radiation
- 10 km
- 300 m
1 - Data recording in flight:

- Detectors: HP Ge, NaI (16 l)

2 - Data processing on the ground after the flight: a printer, a scanner, a PC.

<table>
<thead>
<tr>
<th>Performances</th>
<th>Contaminated zone (2000 m²)</th>
<th>Punctual Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>E &lt; 200 keV</td>
<td>≈ 15 kBq/m²</td>
<td>≈ 100 MBq</td>
</tr>
<tr>
<td>137Cs</td>
<td>≈ 2 kBq/m²</td>
<td>≈ 20 MBq</td>
</tr>
<tr>
<td>60Co</td>
<td>≈ 2 kBq/m²</td>
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</tr>
</tbody>
</table>

- Helicopter
  - Speed: 40 km/h
  - Altitude: 120 feet / 40 m

- Hélinuc
  - Operators: 3 which 1 or 2 aboard
  - Montage of equipments: < 2 h
  - Measure rate: ≈ 50 km²/days at least

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CEA – LIST Recent French R&D results in R. H. E.

Gremikha, Rationales

- Radiative layouts
- Reduced accessibility to the site
- Possible unexpected situation
- A 10 years duration project
- ...

Design of R.H.E.

- 30 Years of experience
- > 1000 PMY + 500 TMY involved

Remote Handling Equipment for in/out door works

- TELEEROBOTICS
- SENSORS - METROLOGY
- NUMERICAL MOCKUP
Telerobotics – Computer based architecture

TAO2000: A Computer-based teleoperation architecture

MAGRITTE Supervision System

ROC

Slave Manipulators

Master Arm

TAO2000 Controller

Controled Remote Handling

Computer

Telerobotics – Force Feedback

Camera

Fibre optique

Ethernet

Liaison

HOMME MACHINE

Slave Manipulators

Master Arm

TAO2000 Controller

Controled Remote Handling

Computer
Interactive Numerical Mock-up

- Training of Personal Intervention scenarios (Hands on, R.H., ALARA ...)
- Real time dose computation
- Site access simulation
- Design of Equipment
- Safety report issues
- Monitoring of operation (as Built => as Done)
- Operational feedback: Numerical record

Virtual Reality CAD Features in Hazardous environment issues

Telerobotics & Vision – 3D Reconstruction

- On site as built modelling.
- On site picture analysis
  - Edge detection
  - Cylindric shape detection
  - Elliptic shape detection
- 3D Estimation
  - View point calibration
  - Iterative re-built
  - Block reconstruction
- Automatic Model Matching
  - Points
  - Edges
  - Cylindric shapes
**Telerobotics – Nuclear Hardened Equipment**

- **Full responses for targeted systems**
  - In/Out-door mobile robots
  - In/Out-door cranes
  - Inspection tools
  - Electric or Hydraulic Manipulators

- **Validation to radiative environments**
  - Between 1 kGy to 100 kGy,
  - Fault-tolerant
  - On sites since 1992

- **Complement R&D developments**
  - Up-grading with recent electronic technology
  - Hardening to local environments
  - Adaptation to existing or new equipments (travelling cranes, cutting and soldering tools, ….)

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**Sensors & Metrology**

- **Inspection camera**
  - On site since 1996
  - Manufactured by LHESA électronique
  - Adaptable on all the remote-handling engines
  - Targeted applications
    - Preventive inside inspection of suspicious buildings
    - Up-grading of nominal plans for virtual decommissioning scenario
    - Outside control of waste storages, docks, pools, casks or submarines
  - R&D extensions
    - Up-grading with recent vision sensors technologies

- **Embedded autonomous microdosimeter**
  - At least 18 months self-supplied electronic module
  - On site since 01/2004 (EDF)
  - Manufacturing on the way (nuclear industry)
  - Targeted applications
    - Self acquisition and storage of radiative and thermal data, but also of « to define » data and sensors
    - Surveillance of critical parameters during unactives periods on yards
  - R&D extensions
    - Adaptation to targeted environment (temperature, supply autonomy, robustness)
Sensor & metrology

CARTOGAM: a portable gamma camera

- **Design features of the camera**
  - 15 kg (8cm of ext. diam.)
  - Energy Rays scale: 50 – 2000 kEv
  - Dose rate scale: 0.1 – 500 mGy/h

- **Manufactured by Canberra-Eurisys**

- **Targeted applications**
  - Simultaneous Radiative and normal vision to Localise Gamma Sources
  - On-line inspections of suspicious areas (buildings, storage tanks, docks, open-sky wastes storages, casks, …)
  - Global survey to prepare virtual remediation activities.

- **R&D extensions**
  - RF link to avoid umbilical problems
  - Increase environment perception by addition of extra sensors (dosimeter, range-meters)
  - Adding of a spectrometric probe
  - Up-grade of the collimation process

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Sensor & Metrology

ADONIS: a high throughput Gamma spectroscopy

- **Technical features**
  - Automatic calibration independent of the radiation environment
  - Support very high throughput of Gamma events ($10^6$ counts per second vs $10^5$ as currently)
  - Allow lower detection limits in very noisy Gamma environment

- **Developed with AREVA**

- **Targeted applications**
  - Identification of embedded multiple Gamma sources
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- **R&D extensions**
  - Up-grading of the spectrometric probe to avoid liquid Nitrogen cask
  - RF link to deport main electronic functions
Sensor & Metrology

IGA: an Actinide Spectrum Analysis software

- **Technical Features**
  - Globally and Automatically Analysing any X/γ spectrum (HPGe detectors)
  - Quantifying major and minor actinides, fission products and pollutants
- **Tested by IRSN and AREVA**
- **Targeted applications**
  - Identification of U/Pu sources embedded with other Gamma sources
  - On-line inspections of suspicious areas
  - Global survey to prepare virtual remediation activities
- **R&D extensions**
  - Analysis of spectra from CZT (or other) detectors
  - Used in combination with gamma-camera (equipped with a spectrometric probe)

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