International Perspective on Decommissioning and Environmental Remediation - Technology and Safety Aspects

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Introduction

- The IAEA was invited to make a presentation that focuses on the nexus of safety and technology from an international perspective.
- The presentation is structured into two parts:
  - The overall framework for optimized decision making
  - Examples from practice
- The presentation does not provide any information on Agency activities.

Basis for Planning and Decision Making

- Activities like nuclear power generation, or radioisotope production or uranium production are justified because the benefits they offer outweigh any detriments.
- A nuclear power plant, radioisotope production facility or uranium production facility are financial assets that generate revenue and profits for their owners.
- However, the “other side of the coin” of such activities is they create liabilities as well.
- Decommissioning of facilities, remediation of contaminated areas and radioactive waste management are by their very nature purely liabilities (i.e., no potential for revenue generation).

Basis for Planning and Decision Making

To put liabilities to rest, safe and affordable solutions that are acceptable to society have to be found.

Hence, decommissioning, remediation and radioactive waste management are driven by the following fundamental factors:

1. Safety
2. Cost / affordability
3. Societal acceptance
4. Sustainability

The sustainability of any solution is defined by its ability ”to meet the needs of the present without compromising the ability of future generations to meet their own needs”, which is similar to Principle 7 of SF-1. Sustainability to some extent envelopes the first three factors.

What role does technology have?

In regard to decommissioning, remediation and radioactive waste management, ***the role of technology is that of being an enabler for optimization across these fundamental factors***.

An optimized solution ensures that each of the four factors is achieved to a satisfactory level (e.g., regulatory approval for decommissioning plan, public acceptance for proposed solution, etc).

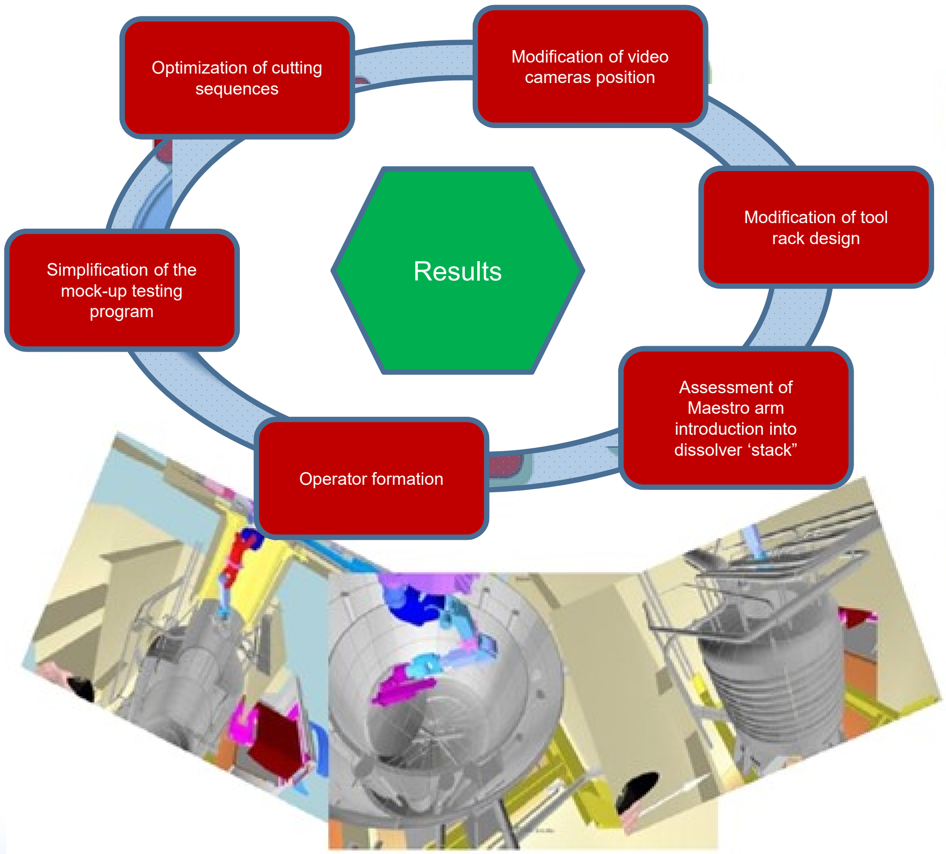
Examples:

- technologies for more precise radiological characterization
- IT technologies used during planning (visualization, 3D-modelling, simulations)
- technologies that minimize secondary waste generation
- technologies that more effectively decontaminate materials for re-use/recycle

all contribute to the process for achieving optimized solutions.

Virtual Reality (VR) and 3D simulations

support preparation and optimizations of decommissioning operations

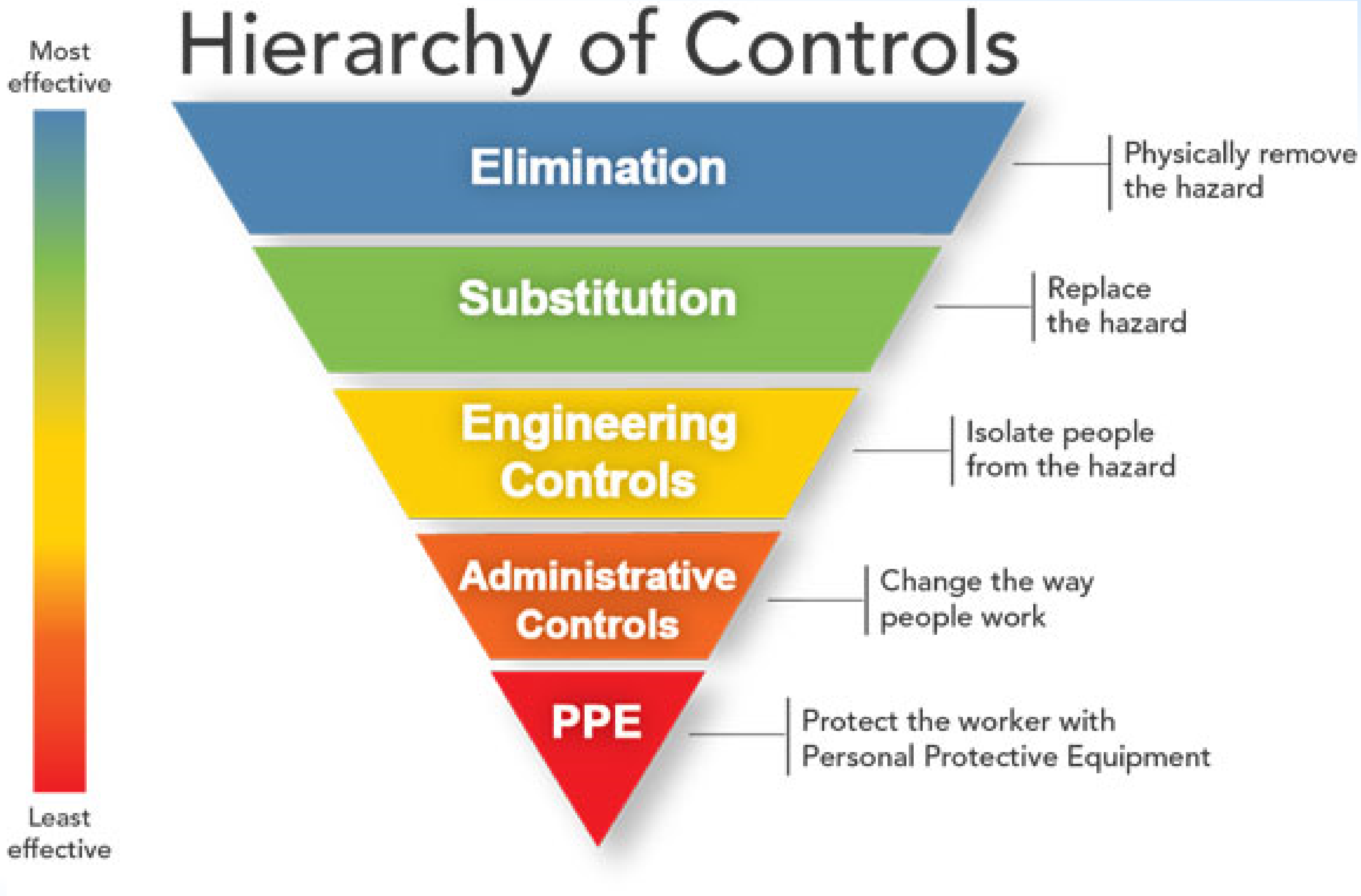


Example of complementarity of virtual and physical mock-ups to prepare for dismantling operations (CEA Marcoule, UP1 Dissolver workshop)

Strategy, safety criteria and administrative controls

- In addition to technology - strategy, safety criteria and administrative controls can have a decisive influence for achieving solutions that optimize across these fundamental factors.
- Example of a multi-unit NPP site, where a strategic decision is made to defer dismantling of the oldest shutdown unit until other units cease operation, in order to achieve more efficient decommissioning.
- Proper use of “reference levels” for remediation of contaminated lands can greatly influence the remediation process. Among other things, by returning land to re-use and reducing volumes of contaminated materials to be managed.
- Technology, strategy, safety criteria and administrative controls all come into play when optimizing safety of operations. This is illustrated in the “hierarchy of controls”.

Safety of operations



Technology is decisive at the top of the pyramid.

Examples

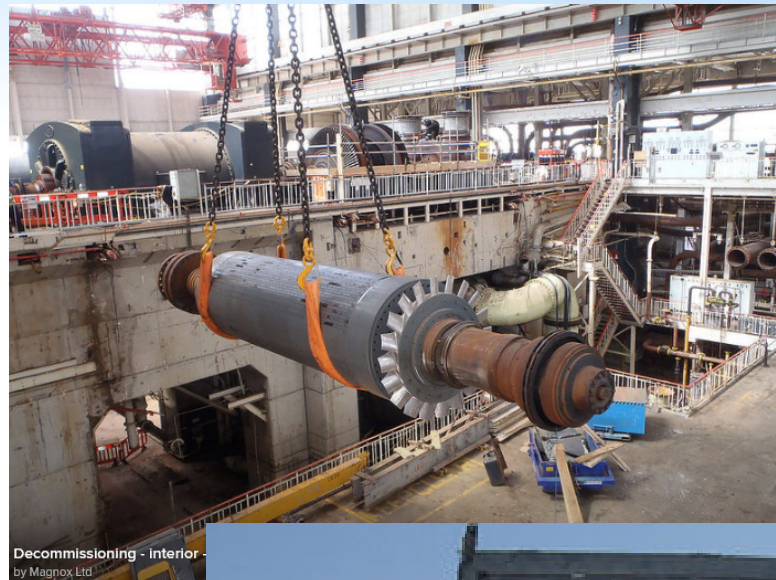
In what follows, a few examples from decommissioning and remediation are chosen to illustrate how technology can assist with finding solutions that optimize across the fundamental factors.

1. Selecting a decommissioning strategy
2. UK’s Magnox Decommissioning Programme – management of decommissioning waste
3. Decontaminate or not?
4. Removal of large components
5. Demolition of buildings
6. Site cleanup
7. Groundwater remediation
8. Decommissioning of damaged and legacy facilities

Example 1 - Selecting a decommissioning strategy

- Immediate vs. deferred dismantling of a facility?
- Technologies exist to conduct immediate dismantling of all types of facilities – access to technologies and their cost could be a challenge in some countries
- Some of the driving factors for strategy selection:
  – Proposed reuse of the site (sooner or later)
  – Availability of dismantling technologies
  – Availability of waste management infrastructure
  – Radiological status (benefits from radioactive decay)
  – Interdependencies with other facilities on-site
  – Socio-economical impact

Magnox Bradwell, Dungeness A & Hinkley Point A: Immediate dismantling of turbine halls, safe enclosure (deferred dismantling) of the reactors



Decommissioning - interior -
by Magnox Ltd

Hinkley Point A backfilling of the turbine hall basement
by Magnox Ltd

Example 2: UK's Magnox Decommissioning Programme – management of decommissioning waste

Technology, in combination with other factors, had an important role in managing the optimization of decommissioning wastes from the Magnox fleet through:

- Large volume reduction of ILW from fuel element debris (FED) through technologies selected for dissolution of FED and packaging of ILW residues.
- Better segregation of FED waste streams to separate LLW and ILW.
- A regulatory process that requires application of best available techniques (BAT).
- Establishment of disposal facilities for VLLW.

Example 3 - Decontaminate or not?

Benefits:

- Achieve clearance and reuse of materials that would otherwise be classified as radioactive waste.
- Transfer some radioactive waste to lower waste categories (e.g., LLW to VLLW).
- Less radioactive waste to be disposed of.

Disadvantages:

- May present additional exposures for workers.
- Usually generates secondary waste (liquids, organics, chemically aggressive).
- Time consuming.

Availability of high efficiency decontamination technologies is one of the driving factors for decision making

Decontamination technologies

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Example 4 - Removal of large components

- Removal of large components in one piece or segmentation on the site?
- Factors to be considered:
  - Exposures to workers
  - Waste packaging efficiency
  - Lifting devices
  - Space within the facility
  - Packaging requirements
  - Transport arrangements
- Availability of remotely controlled high speed cutting technology is desirable for segmentation of activated large components on site

Greifswald example: decay storage and central facility for size reductions.

Cutting of RPV, Greifswald NPP

Example 5 - Demolition of buildings

- Option 1: decontamination and clearance of standing building structures, followed by a conventional demolition
- Option 2: radiologically controlled demolition (under protective tent, with dust suppression, control of radioactivity in the air, respiratory protection), followed by clearance of building rubbles
- Option 2 is much more demanding due to safety measures needed for radiologically controlled demolition and due to the difficult segregation of contaminated and clean rubble.
- Efficient surface decontamination technology and rapid measurement techniques for surface contamination are needed for Option 1.

Cooling towers demolition at the Calder Hall, Sellafield

Example 6 – Site cleanup at end of decommissioning

- Option 1: extensive cleanup of soil, reaching derived activity concentrations for unrestricted release of the site.
- Option 2: decision to leave some contamination in place and to release the site with restrictions to the future use (institutional controls in place for a certain period of time, in situ decay).
- Factors to be considered:
  - Intended reuse of the site, its size and location (other facilities around?)
  - Nature of the residual contamination (radionuclides, activity, migration)
  - Possibility to arrange for continuous monitoring and control, nature of controls needed
- Option 1 could lead to generation of large amounts of low-activity waste

Release of sites after decommissioning

Niederaichbach
NPP, Germany

Yankee Rowe
NPP, USA

Example 7 - Groundwater remediation

Sites with contaminated groundwater often present few options:

- Option 1: source removal
- Option 2: “pump and treat” approach

Often Option 2 may be the only practical solution, as source removal is often impractical or impossible.

Disadvantages of Option 2:

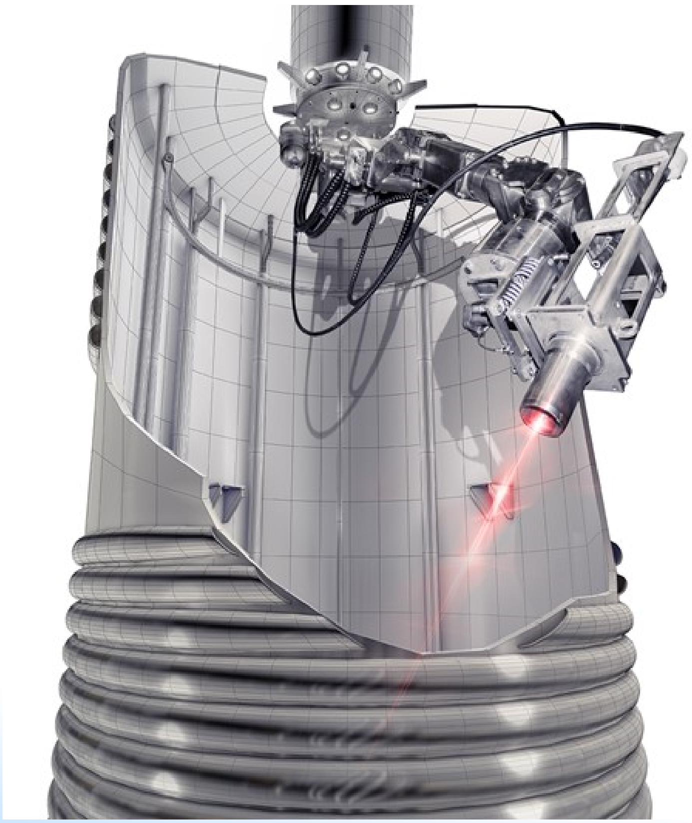
- Need for ongoing regulatory control
- Re-use of site is constrained
- Ongoing monitoring is needed
- Active control (i.e., pump-and-treat) presents an ongoing expense

Example 8 – Decommissioning of damaged or legacy facilities

- Damaged and legacy facilities (especially high hazard facilities) often present unique challenges that require unique technical solutions
- Fukushima Daiichi NPS
  - groundwater bypass and the sub-drain systems
  - frozen-soil wall
  - impermeable sea wall
  - complex water treatment systems
  - application of advanced visualization and characterization technologies
  - robotics and virtual reality tools (JAEA Naraha Center for Remote Control Technology Development)
- Chernobyl NPP Unit 4
  - New Safe Confinement with a number of active systems

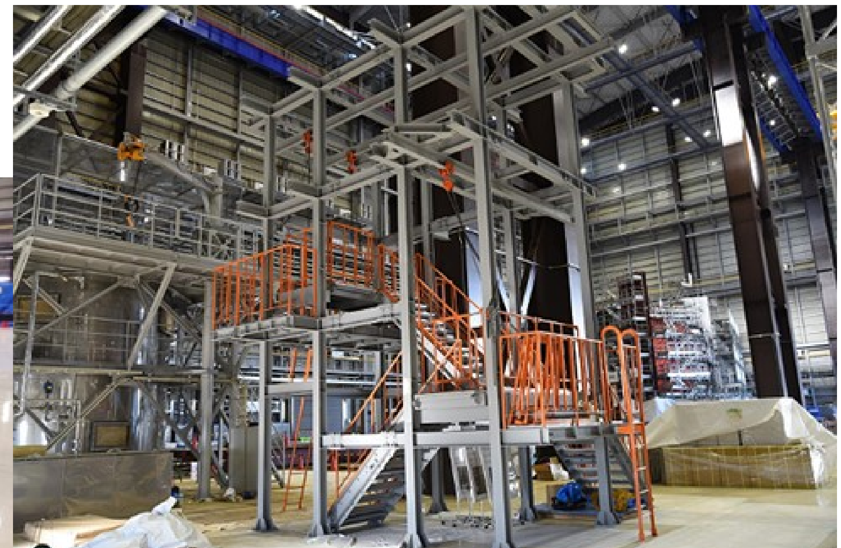
Robotics / remote handling technologies

- Couple of examples of recent development – laser cutting and robotic arm Maestro / remote carrier:



Special developments: Fukushima Daiichi

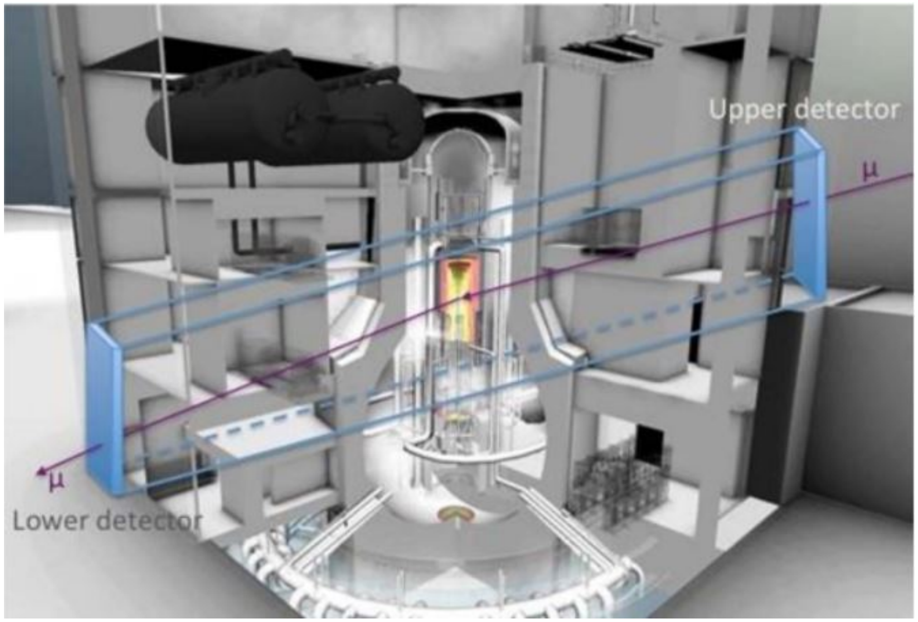
- Variety of robotics technologies are under development to support Fukushima Daiichi decommissioning
- JAEA's Naraha Center for Remote Control Technology Development



Robots, mock-up and training exercise in the JAEA's Naraha Center

Special developments: Fukushima Daiichi

- Advanced visualisation technique: use of cosmic ray muons measurements to identify the fuel debris location …



Pictures from SimplyInfo.org and TEPCO / IRID handouts

The New Safe Confinement in its final position over the reactor 4 at Chernobyl NPP, Ukraine

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Conclusions

- Optimized solutions for decommissioning, remediation and radioactive waste management are derived from analysis of the “interdependences” in the steps from design of a facility through to end-of-life decommissioning and disposition of materials (i.e. steps leading to materials being re-used, recycled or disposed of as radioactive waste).
- In “normal” situations, new technology tends to lead to incremental improvements for decommissioning and radioactive waste management.
- In dealing with “difficult” situations, such as decommissioning of accident-damaged and “legacy” facilities, the contribution of technical innovation is even more apparent. It can be essential for progress.
- For remediation of areas with radiological contamination (i.e., surface/ subsurface of land and water bodies), conventional technologies are applied in most situations. Technical innovation is not so apparent for remediation of areas with radiological contamination.
- Each country has its own unique set of constraints to deal with.

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Thank you!