

REVERSIBILITY, RETRIEVABILITY, RECOVERABILITY AND LONG-TERM GOVERNANCE

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Reversibility, retrievability, recoverability

These three terms—**reversibility**, **retrievability**, and **recoverability**—are core concepts used in systems engineering, data management, and hazardous waste disposal. They represent a progression of steps designed to fix mistakes, adapt to new information, or handle emergencies.

1. Reversibility (The Ability to Undo Decisions)

Reversibility is the capacity to reconsider, revise, or completely reverse an action or decision taken at an earlier stage.

Focus: Process-oriented and decision-making.

Purpose: It allows for a flexible, stepwise approach where previous choices can be adjusted or canceled before finalizing a project.

Example: In radioactive waste management, it allows future generations to re-assess whether a deep geological repository remains the best option before permanently sealing it.

2. Retrievability (The Ability to Extract)

Retrievability is a physical, planned capability to safely remove items, materials. It is often considered a specialized, practical component of reversibility.

Focus: Action and technology-oriented.

Purpose: It provides the physical means to reverse the emplacement step, though it usually requires significant technical effort.

Example: The option to extract waste packages from a geologic repository using specialized machinery

3. Recoverability (The Ability to Reclaim in Emergencies)

Recoverability refers to the capability to reclaim materials or data under unexpected, accidental, or emergency conditions.

Focus: Emergency and incident response.

Purpose: It is a contingency measure, implying that something has gone wrong and requires extraordinary, sometimes unplanned technical measures to salvage the materials.

Example: Deploying unplanned, highly specialized remote equipment to recover radioactive materials from a collapsed or compromised tunnel

Reversibility, retrievability, recoverability

These three concepts build on one another as a risk-management strategy:

Reversibility asks: *"Can we change our minds?"*

Retrievability asks: *"Do we have the physical tools and processes to safely pull it back out?"*

Recoverability asks: *"Can we save it even if everything goes wrong?"*

Reversibility, retrievability, recoverability – long-term governance

- Reversibility (*can we change our minds?*), retrievability (*do we have the physical tools and processes to safely pull it back out?*) and recoverability (*can we save it even if everything goes wrong?*) can mean different things during decision-making, during operation, during closure and post-closure.
- Long-term governance needs to have this figured out (defined uniformly?) in decision-making, during operation, for closure and post closure. Public needs to be involved and understand the differences (important with education).
- There is strong connection between the type of waste and the desire for reversability. High-level reprocessing waste, spent nuclear fuel (containing plutonium), long-lived intermediate radioactive waste, short-lived wastes. All countries will have spent fuel to dispose of as reprocessing will be stopped before the last reactors?
- Recoverability/retrievability after closure – how much should this be part of long-term governance? German law – 500 years.
- Should all waste disposal in the future be distributed or centralised (shared solutions, even global)? Big governance differences!
- How to deal with the idea that the waste is a resource, is this a reason for reversability/retrievability/recoverability? What is a resource – for energy, for material, for weapons?
- Does it matter if we are moving to a non-nuclear future or a long-term nuclear future? Meaning for governance?
- There needs to be a plan B (DBD?) that can be implemented if plan A (mined repository?) is to be reversible.
- Should there be no repository? Only long-term above-ground surveillance (Covra plan A - 100+ years? Greenpeace plan for pyramids)? Long-term governance is central!
- Do we transmute everything instead? Centralised globally? Accelerator-driven systems?