Safety case: what is it about? (**PART III**)

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Outline of this lecture

PART I
- **Type of radioactive waste**
- **Why a geological disposal**
- **The passive safety and the concept of safety functions**

PART II
- **Description of the system**
- **Long-term safety assessment**
- **Scenarios in long-term safety assessment**
- **Scenarios development**
- **Key message and the big picture**

PART III
- **The long evolution of a geological program**
- **Safety case: What is about in the end ?**
- **QA procedures**
- **The Ondraf/Niras structure of a safety case**

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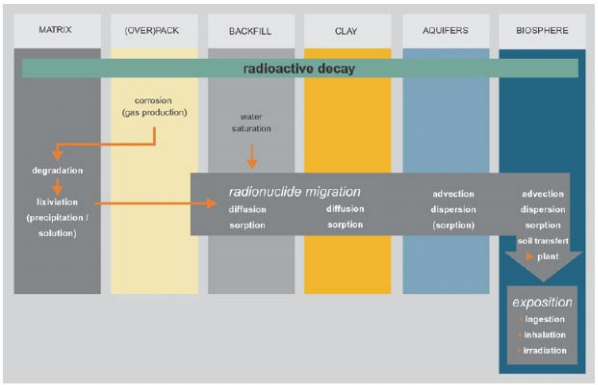
The long, long, long evolution of a geological program

decades

Generic program

- Generic safety concept based on the inventory and potential suitable host rock
- Safety asses
  international
- Hypothesis a
- Understandir
  limited and n
  model



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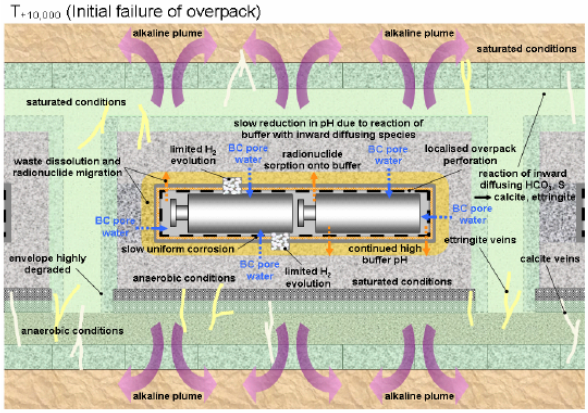
The long, long, long evolution of a geological program

$T_{+10,000}$ (Initial failure of overpack)



HLW Glass

Host roc

- Firm
  host
- R&D
- Interr
  checl
- Safet
  possi
- Incre
  repository evolution supporting the inherent conservatism of the safety assessment calculations.
- Traceability of the information

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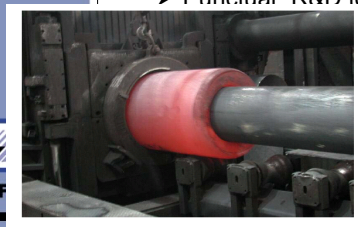
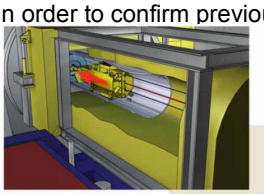
The long, long, long evolution of a geological program

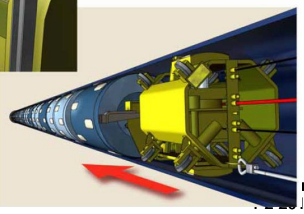
decades

Site characterisation towards implementation program

- Growing interactions with stakeholders
- Dual approach of the R&D:
  - ➢On-going research in order to confirm previous hypothesis. (Performance confirm
  - ➢"Punctual" R&D to s





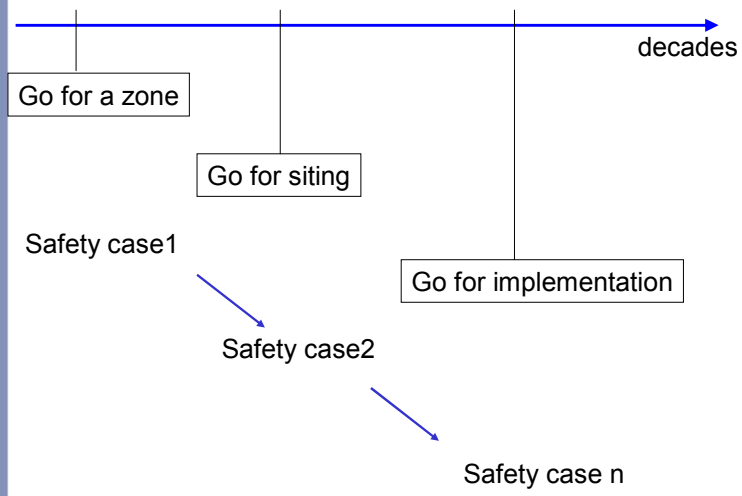


Starting point:
The post-closure safety case for a geological repository (NEA 2004)

The *safety strategy* is the high-level approach adopted for achieving safe disposal, and includes a management strategy, a siting and design strategy, and an assessment strategy

1. Management strategies include maintaining sufficient flexibility within a step-wise planning and implementation process to cope with unexpected site features or technical difficulties and uncertainties that may be encountered, as well as to take advantage of advances in scientific understanding and engineering techniques
2. The siting and design strategy is generally based on principles that favour robustness and minimise uncertainty, including the use of the multi-barrier concept
3. The assessment strategy must ensure that safety assessments capture, describe and analyse uncertainties that are relevant to safety, and investigate their effects

The long, long, long evolution of a geological program



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Post-closure safety case ?

- Report (or a series of reports) prepared to obtain a license for construction, operation or closure of a repository
- A safety case is the synthesis of evidence, analyses and arguments that quantify and substantiate a claim that the repository will be safe after closure and beyond the time when active control of the facility can be relied on. The safety case becomes more comprehensive and rigorous as a programme progresses, and is a key input to decision making at several steps in the repository planning and implementation process.(NEA Safety Case Brochure 2004)

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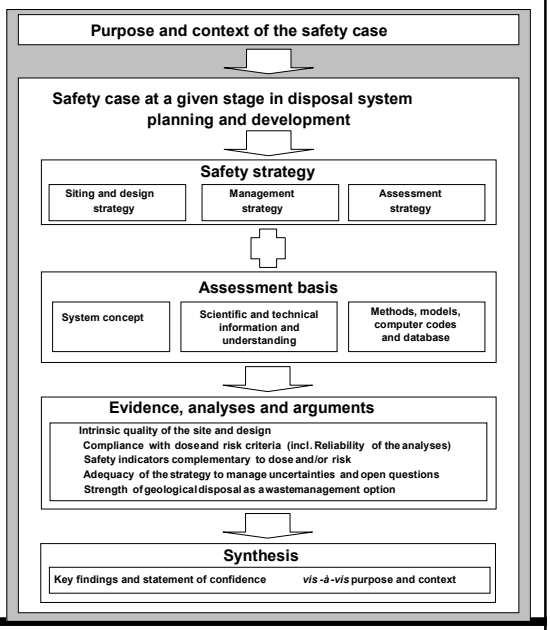
Relationships between the different elements of a safety case

The flowchart presented in the NEA Safety Case Brochure 2004



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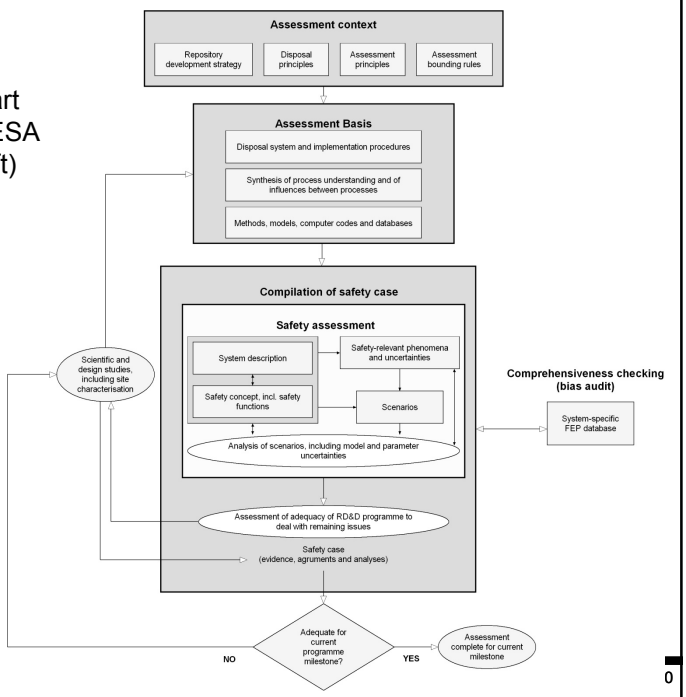
Safety case flowchart proposed by the MESA working group (Draft)



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Requirements for the development of the geological disposal (IAEA WS-R-4 + DS 334)

- Legal and organizational framework
- Safety approach
- Safety design principles
- Requirements for the development, operation and closure of geological disposal facilities
- Safety case and safety assessments
- Steps in the development, operation and closure of geological disposal facilities
- Assurance of safety and nuclear safeguards

Safety approach

- Post-closure is ensured by passive means
- Adequate understanding of the features and processes that provide for safety and might be detrimental to safety
- Safety must be provided by robust features
- Early in the development of the concept, the data and the level of understanding gained should provide the confidence necessary to commit the resources for further investigations.

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Safety design principles (1/2)

- Safety shall be provided by means of multiple safety functions provided by means of a physical or chemical property or process that contributes to safety, such as: impermeability, limited corrosion, dissolution…
- The overall performance shall not be unduly dependent on a single barrier or function.
- Containment has to be provided during the period when the waste produces heat energy and when the radioactive decay has not significantly reduced the hazard posed by the waste.
- Containment insures that any migration of radionuclides occurs only after the heat produced by radioactive decay has substantially decreased and a more stable physical and chemical environment has developed.
- Attention is also given to the durability of the waste form and to emplacing the most highly concentrated waste in containers that are designed to remain intact for a long enough period of time for most of the shorter lived radionuclides to decay and for the associated heat generation to decrease substantially.

Safety design principles (2/2)

- Isolation means retaining the waste away from the biosphere in a disposal environment that provides substantial physical separation from the biosphere, making human access to the waste difficult.
- The facility shall be sited in a geological formation and at depth that provide isolation of the waste form the bisophere and from humans over the long term, for at least several thousand years, with account taken of both the natural evolution of the geological disposal system and events that could disturb the facility
- Location in a stable geological formation providing protection against geomorphological processes.
- Location away from known areas of mineral resources.

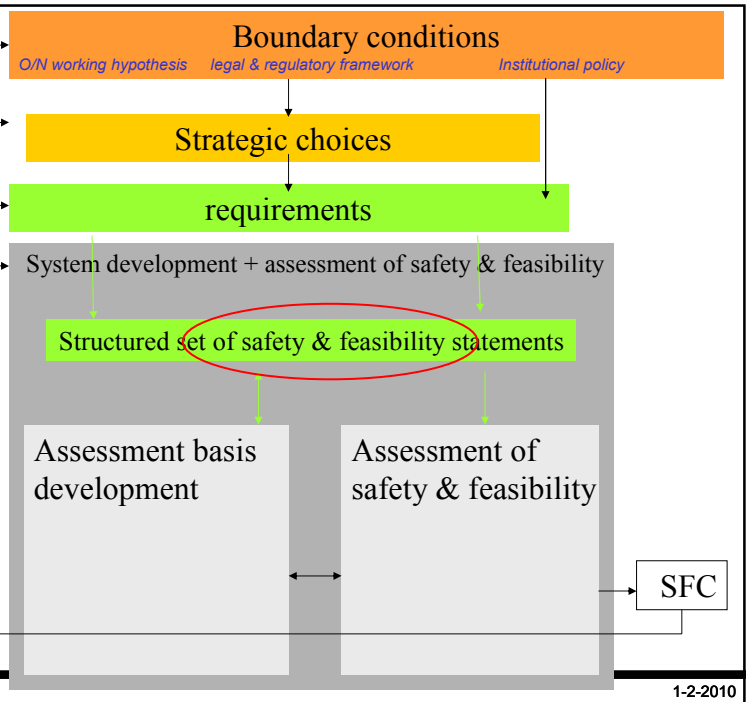
Safety Case & safety assessment (1/2)

- A Safety case includes the output of safety assessment, together with supporting evidence and reasoning on the robustness and reliability of the facility, its design and the quality of safety assessment. Any unresolved issues at any step will be acknowledged in the safety case and guidance for work to resolve these issues will be provided
- A safety case is prepared early in the development of a facility to provide a basis for licensing decisions, and to guide research and development, siting and design.
- The level of detail of a safety case depend on the stage of development of the project and the decision in hand.
- The safety case addresses both operational and post-closure safety.

Safety Case & safety assessment (2/2)

- Safety assessment is the process of systematically analyzing the hazards associated with the facility to provide for the safety functions and to meet technical requirements. It identifies the safety relevant key processes.
- It includes the quantification of the overall level of performance.
- Safety assessment analyses the performance of the geological disposal system under the expected and less likely evolutions and events, which can be outside the designed performance range of the geological disposal facility.
- Sensitivity analysis, uncertainty analysis will be undertaken to obtain an understanding of the performance of the system.

The Ondraf/ Niras safety strategy



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Boundary conditions

- *Legal & regulatory (inter)national framework & policy*
- *Other stakeholder conditions*

Some strategic choices made by O/N

- Boom Clay are reference host rock & ypresian clay as alternative
- Waste types shall be devided into groups to be emplaced in separate sections of the repository.
- There are preferences for permanent shielding of the waste and for minimisation of operations in the underground.

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Boundary conditions

The strategic choices made by O/N

	The long-term safety functions			SA		QA procedures
Requirements to fulfil SFC1 obkective	Isolation	Containment	Retardation	Methodolo-gy	Indicators	
	Reduce the likelihood of HI	*Containment at least through the thermal phase*	*Low hydraulic Conductivity*	*Reference (expected evolution) Scenario*	*Safety indicators*	FEP Completeness check
	Stable geological conditions	*Buffer selected to favour overpack longevitiy without perturbing undully the safety functions*	*Low hydraulic gradient*	*Altered Scenarios*	*Performance indicators*	Verification, qualification, validation
			High fixation capacity			
			Buffered physico-chemical environment			

Performance and safety indicators (review from PAMINA project)

Table 7.1 Performance indicators based on inventories or concentrations

Performance indicator	Unit
Activity in compartments	Bq
Activity outside compartments	Bq
Radiotoxicity in compartments	Sv
Radiotoxicity outside compartments	Sv
Activity concentration in compartment water	Bq/m^3
Radiotoxicity concentration in compartment water	Sv/m^3
Concentration in biosphere water / waste package water	-

Table 7.2 Performance indicators based on fluxes

Performance indicator	Unit
Activity flux from compartments	Bq/a
Radiotoxicity flux from compartments	Sv/a

	ENRESA	SCK·CEN	NRG	NRI	GRS
Effective dose rate (mSv/a)	0.1-0.3 [a]	0.3 [a]	0.3 [e]	0.25 [a]	0.1 [d]
Radiotoxicity concentration in biosphere water (Sv/m^3)	$2 \cdot 10^{-5}$ [b]	$2 \cdot 10^{-5}$ [b]	$2 \cdot 10^{-5}$ [b]	$4 \cdot 10^{-6}$ [c]	$2 \cdot 10^{-6}$ [d]
Radiotoxicity flux from the geosphere (Sv/a)	60 [b]	10 [c]	60 [c]	8 [c]	0.1 [d]
Power density in biosphere water ($MeV/s \cdot m^3$)	80 [c]	-	80 [c]	-	25 [c]

[a] Legal limits

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QA procedures

- To provide traceability and transparency of the work flow within the organisations
- To ensure traceability and transparency of the data, models and documentation

  A hierarchical database that will be developed over many decades
- To ensure completeness of the knowledge used in a safety case (peer review, FEP checks with Int. lists)
- To ensure that the models used are fit for purpose (qualification, verification, validation)

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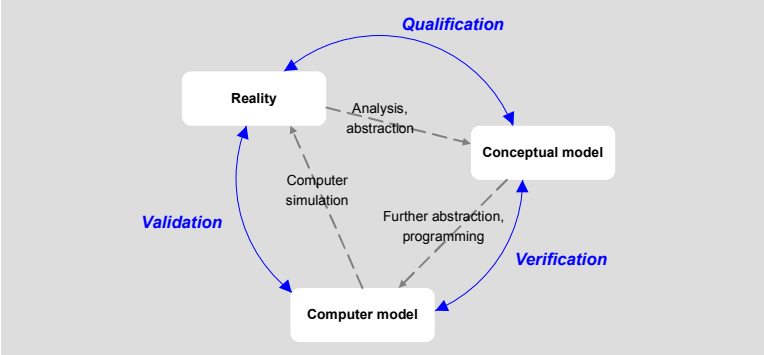
The models qualification, verification and validation of models



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Boundary conditions

The strategic choices made by O/N

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The safety statements as a structuring tool of the safety case:

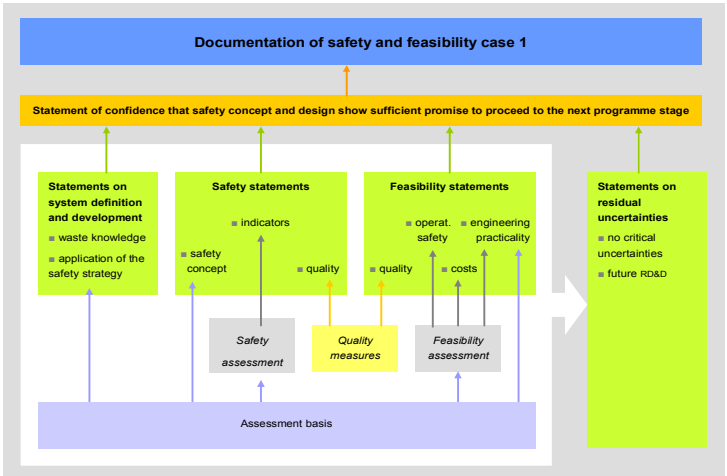

Figure 1 – Tentative organisation of the statements around which SFC1 will be structured.

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