Monitoring Developments for safe Repository operation and staged Closure: The International MoDeRn Project

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Outline

- Introduction
- Objectives
- Results from the Modern project
  1. Reference framework
     - guidance on the development of repository monitoring programmes
  2. Illustrative Monitoring Programmes / Case study (German case Study Salt Host Rocks, French Case Study: Clay Host Rocks, KBS-3V Case Study: Crystalline Host Rocks
  3. Research and technical development (RTD)
     - State of art
  4. Stakeholder Involvement in Monitoring Programmes

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The MoDeRn Project *in a nutshell*

MoDeRn is a collaborative project co-funded by the European Commission under the 7th Framework Programme

EURATOM Programme	Call for propositions FP7-Fission-2008 « **Nuclear Fission and radiation protection** » Topic « **Strategies and technologies for repository monitoring** »
Duration:	1st of May 2009 – 31 October 2013 (4 1/2 years)

It aims at providing a **framework for the development and possible implementation of monitoring activities** and associated **stakeholder engagement** during relevant phases of the radioactive waste disposal process.

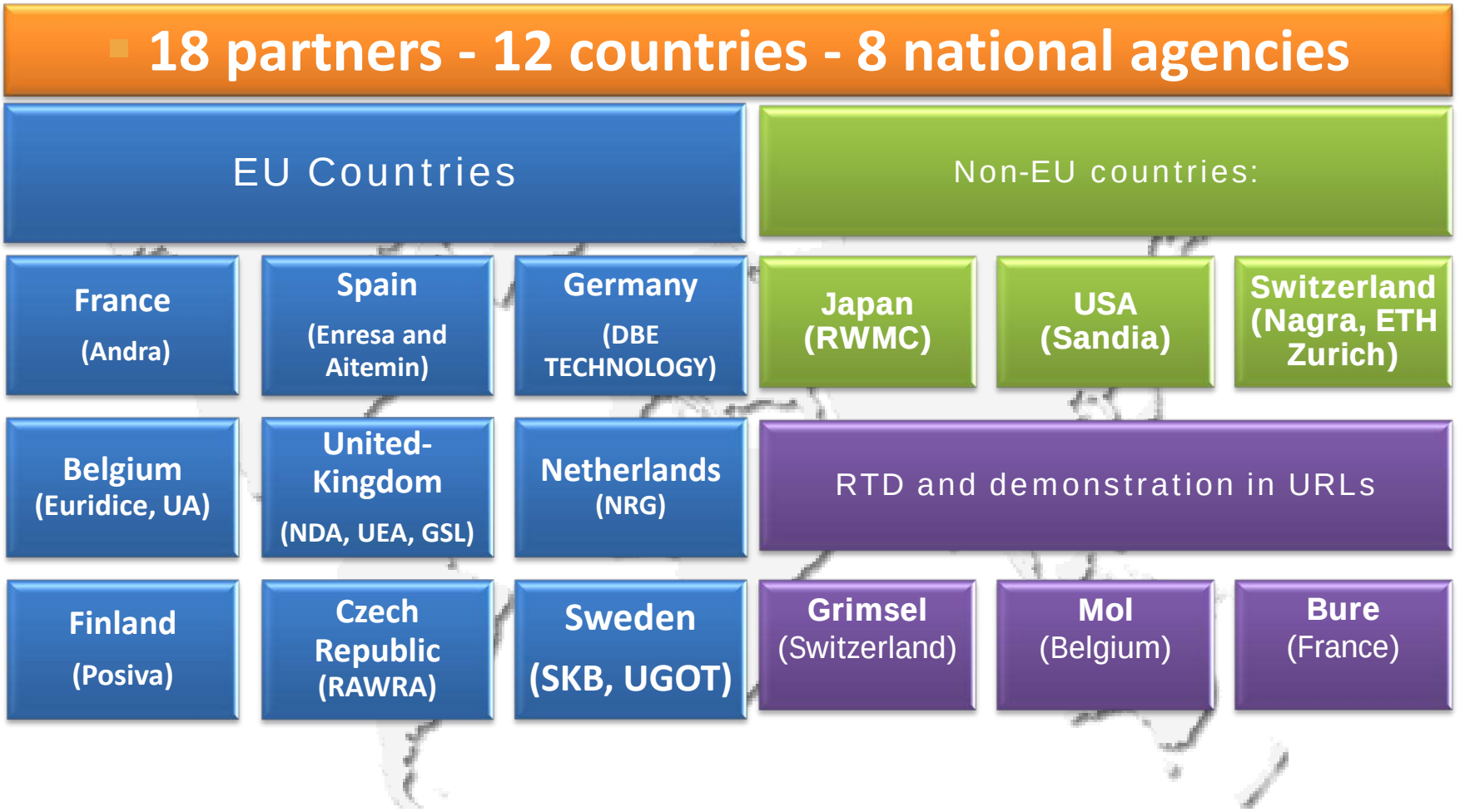
18 partners from 12 countries	Coordinator : Andra
Budget : 5 million €	EU contribution : 2.8 million €

Published project documents are available on:

www.modern-fp7.eu

Project Partners

18 partners - 12 countries - 8 national agencies



Pre-MoDeRn references

IAEA TECDOC 1208 (2001)	Monitoring of Geological Repositories for High Level Radioactive Waste
European Commission Project Report EUR 21025 (2004)	Thematic Network on the Role of Monitoring in a Phased Approach to Geological Disposal of Radioactive Waste
IAEA Safety Requirements WS-R-4 (2006)	Geological Disposal of Radioactive Waste – Requirements on monitoring programs
IAEA Safety Standards GSR Part 4 (2009)	Safety Assessments for Facilities and Activities – e.g. Maintenance of the safety assessment
IAEA Safety Standards – Draft Safety Guide DS357 (2011)	Monitoring and Surveillance of Radioactive Waste Disposal Facilities
All program specific developments (WMOs) and regulatory/safety guidelines	MoDeRn National Context Summary Report and Country Annexes Report

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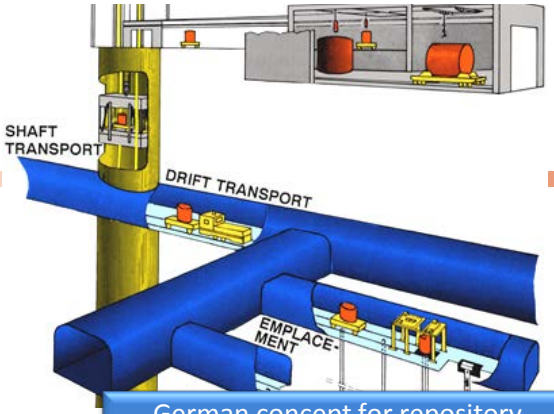
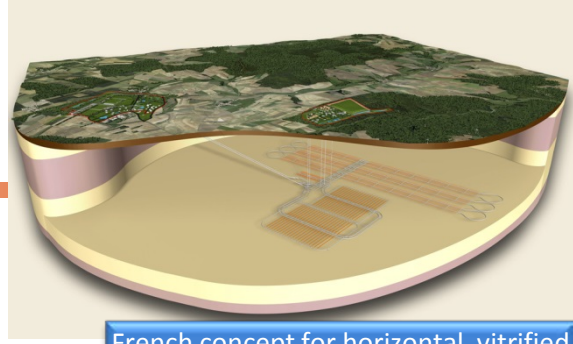
Repository layout in Finland
(Posiva - crystalline host rock)

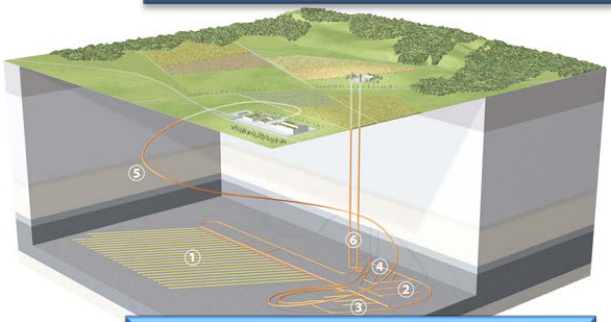


German concept for repository disposal boreholes DBE TEC - evaporite host rock)

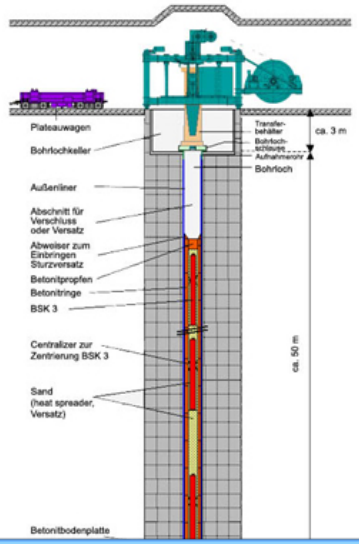


French concept for horizontal, vitrified waste disposal cells
(Andra – sedimentary host rock)

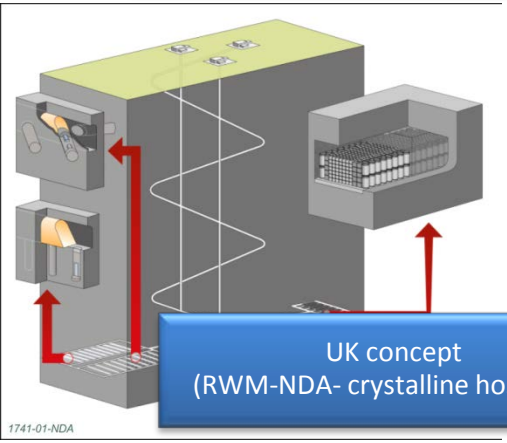
Repository layout in Sweden
(SKB- crystalline host rock)



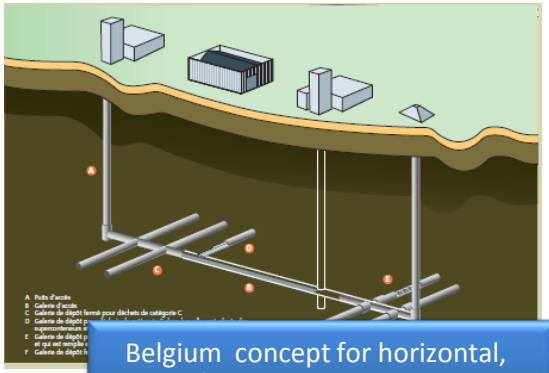
Swiss (Nagra – sedimentary host rock)



German concept for repository disposal boreholes DBE TEC - evaporite host rock)



UK concept
(RWM-NDA- crystalline host rock)



Belgium concept for horizontal, vitrified waste disposal cells
(Ondraf-Niras – sedimentary host rock)

Is there a “one size fits all” approach to monitoring?

MoDeRn Objectives

Develop a reference framework to guide development, implementation, use, and evolution of a monitoring program - within its national context

Develop:

- Provide recommendations on how to develop monitoring objectives
- Provide a knowledge base on national monitoring contexts

Implement

- Provide a state-of-the art of relevant monitoring technologies and discuss remaining technological obstacles and technologies to develop
- Provide demonstrations of the use of non-intrusive monitoring techniques and of implementing monitoring under construction conditions
- Discuss technical feasibility, limitations, and possible implementation strategies

Use

- Provide and discuss options for the potential use of monitoring results to assist decision making
- Provide recommendations on engagement with lay stakeholders on complex socio-technical issues such as repository monitoring

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Influence of National Contexts

Societal "boundary conditions"

Legal / regulatory requirements:

- A specific parameter (site piezometry...)
- Pre-closure management (retrievability...)
- A specific strategy (monitor pilot facility...)

Expert stakeholder requirements

Lay stakeholder requirements

Physical "boundary conditions"

Waste inventory

Host rock, local / regional hydrogeology, transport properties

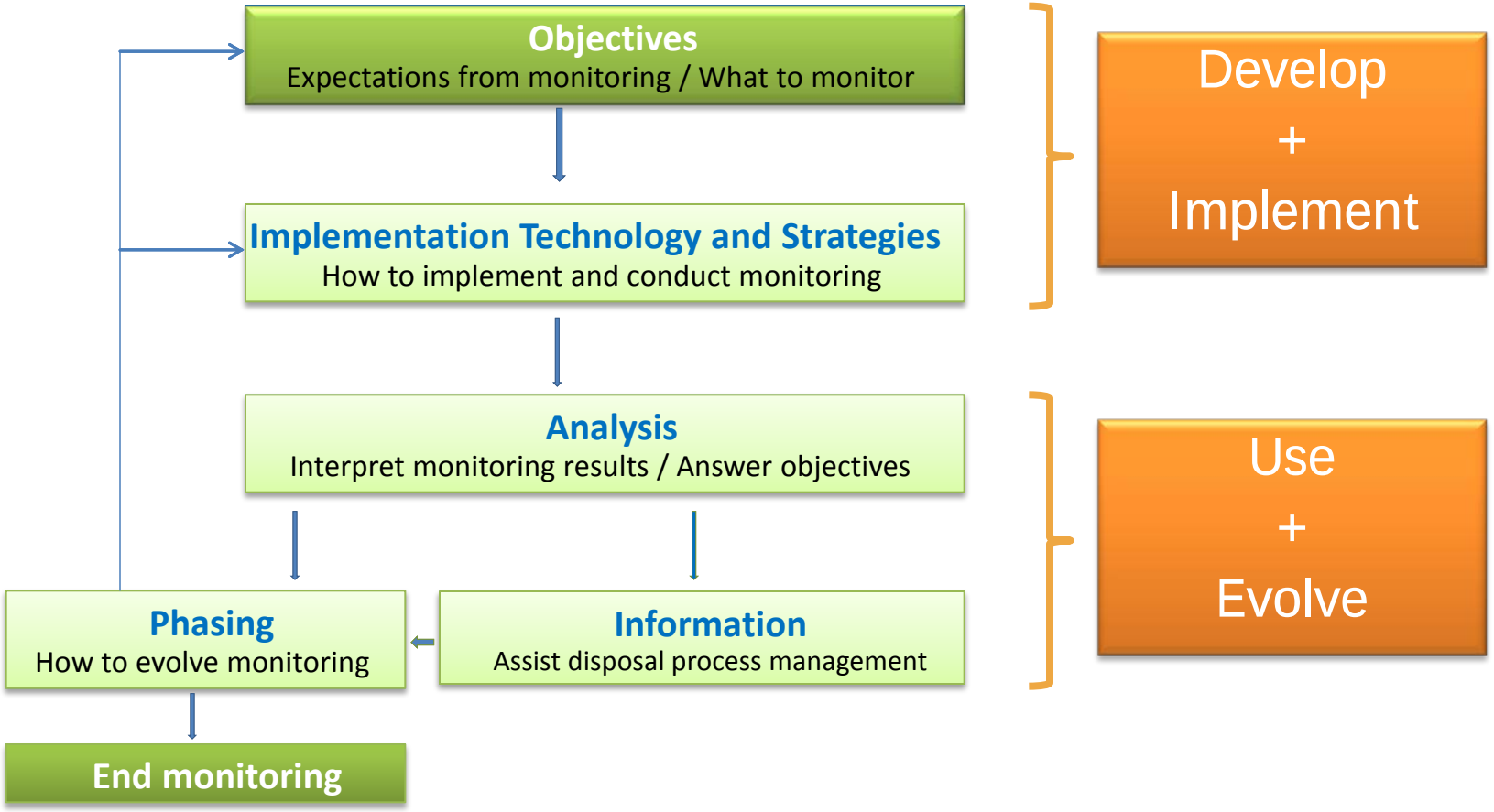
Repository layout and engineered barriers design

- Waste Disposal Package (concrete, steel, copper, special alloys...)
- Cavern, drift, borehole disposal
- Buffer (swelling clay...), backfill
- Rock support/liner (rock bolts, shotcrete, concrete, steel...)
- Seals (at disposal cell/drift, in access galleries, in surface to depth infrastructure)

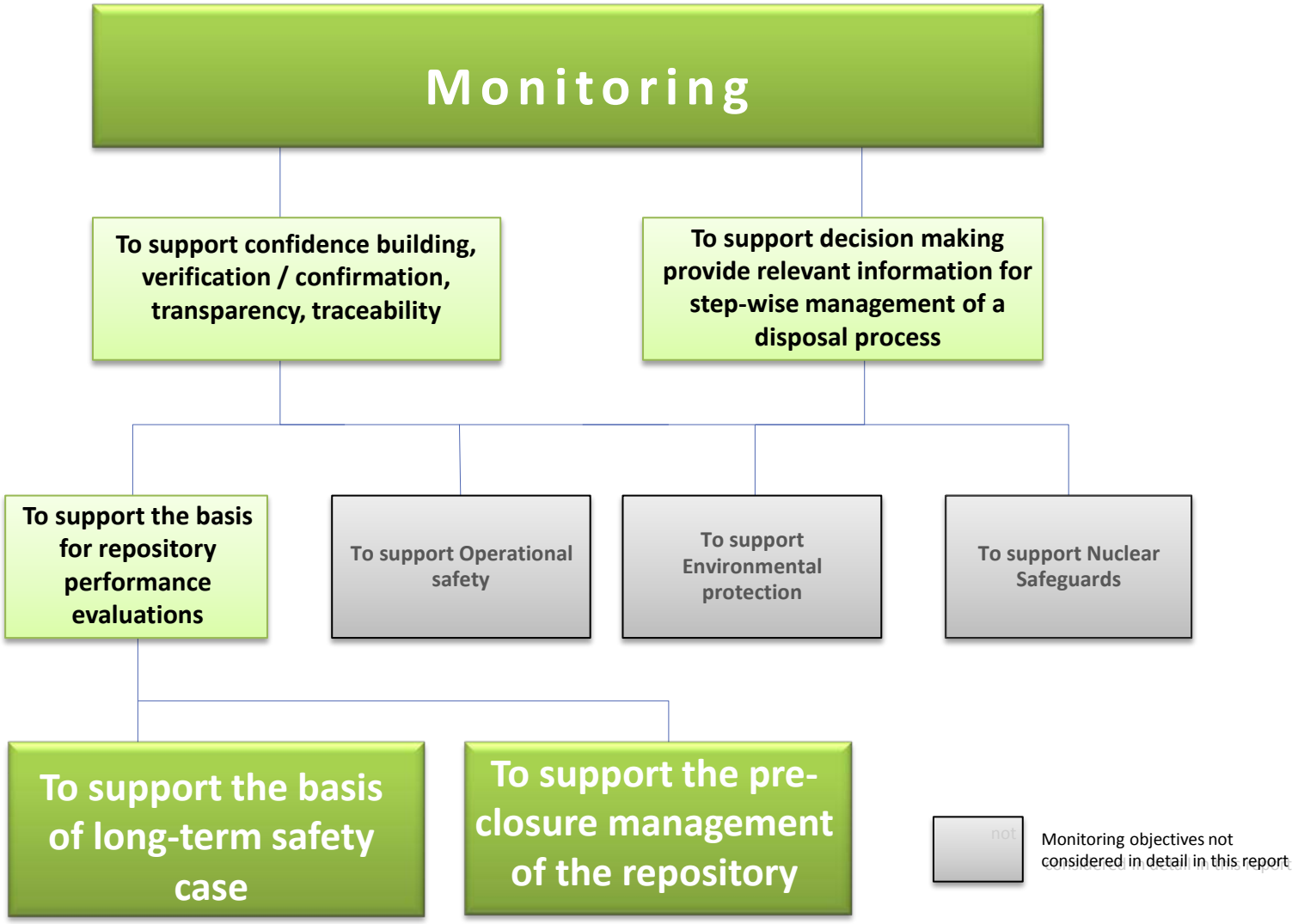
MoDeRn to develop a "reference framework", not a "reference program"

Reference Framework

Key steps to develop / implement / use / evolve a monitoring program



Why monitor


Monitoring
To support confidence building, verification / confirmation, transparency, traceability
To support decision making provide relevant information for step-wise management of a disposal process
To support the basis for repository performance evaluations
To support Operational safety
To support Environmental protection
To support Nuclear Safeguards
To support the basis of long-term safety case
To support the pre-closure management of the repository
Monitoring objectives not considered in detail in this report

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Cases

1
Salt

2
Clay

3
Granite

German Concept

Long vertical boreholes
No buffer

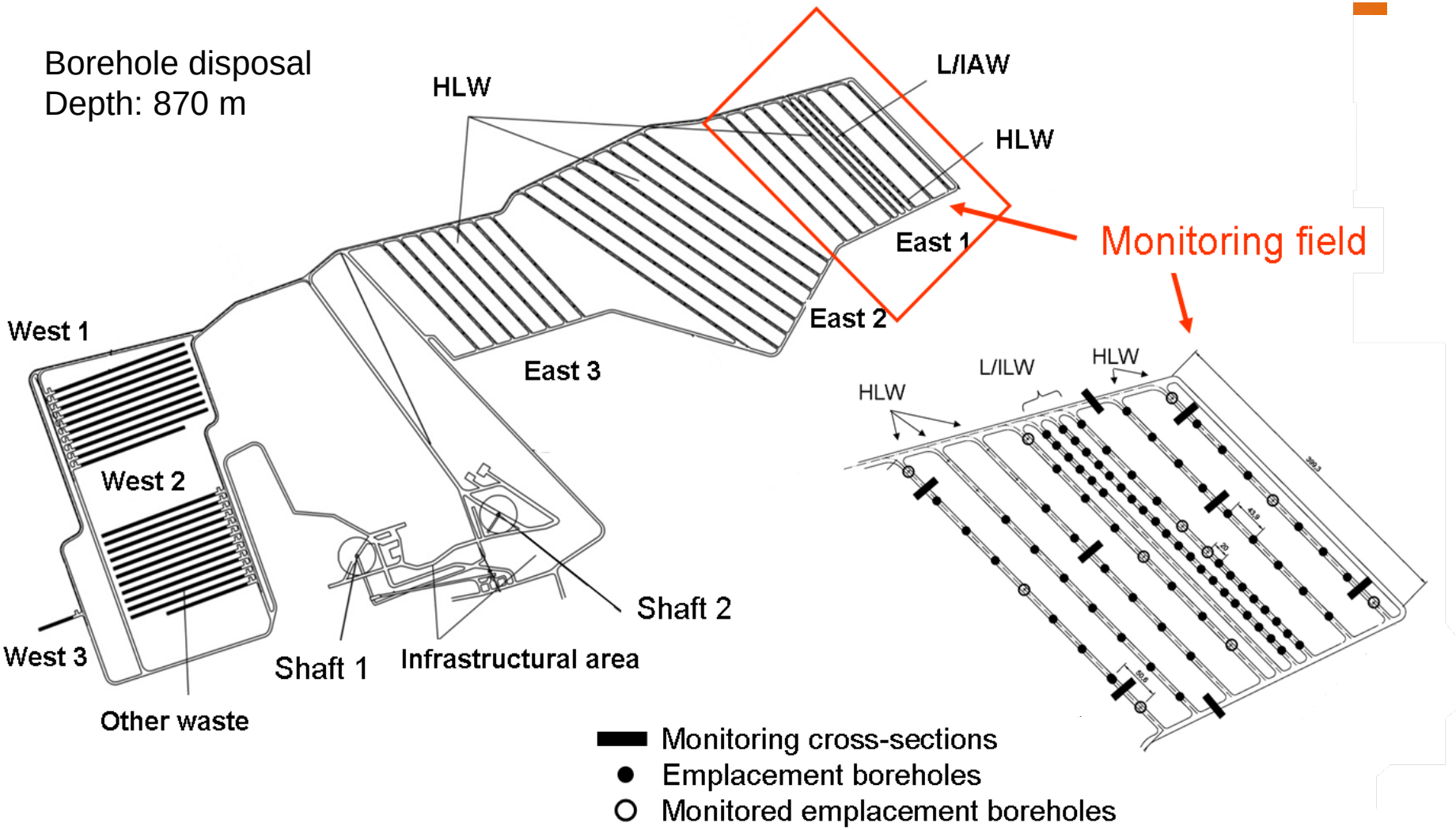
French Concept

Medium horiz. boreholes
Reversibility option

Swedish/Finnish Concept

Short vertical boreholes
Buffer

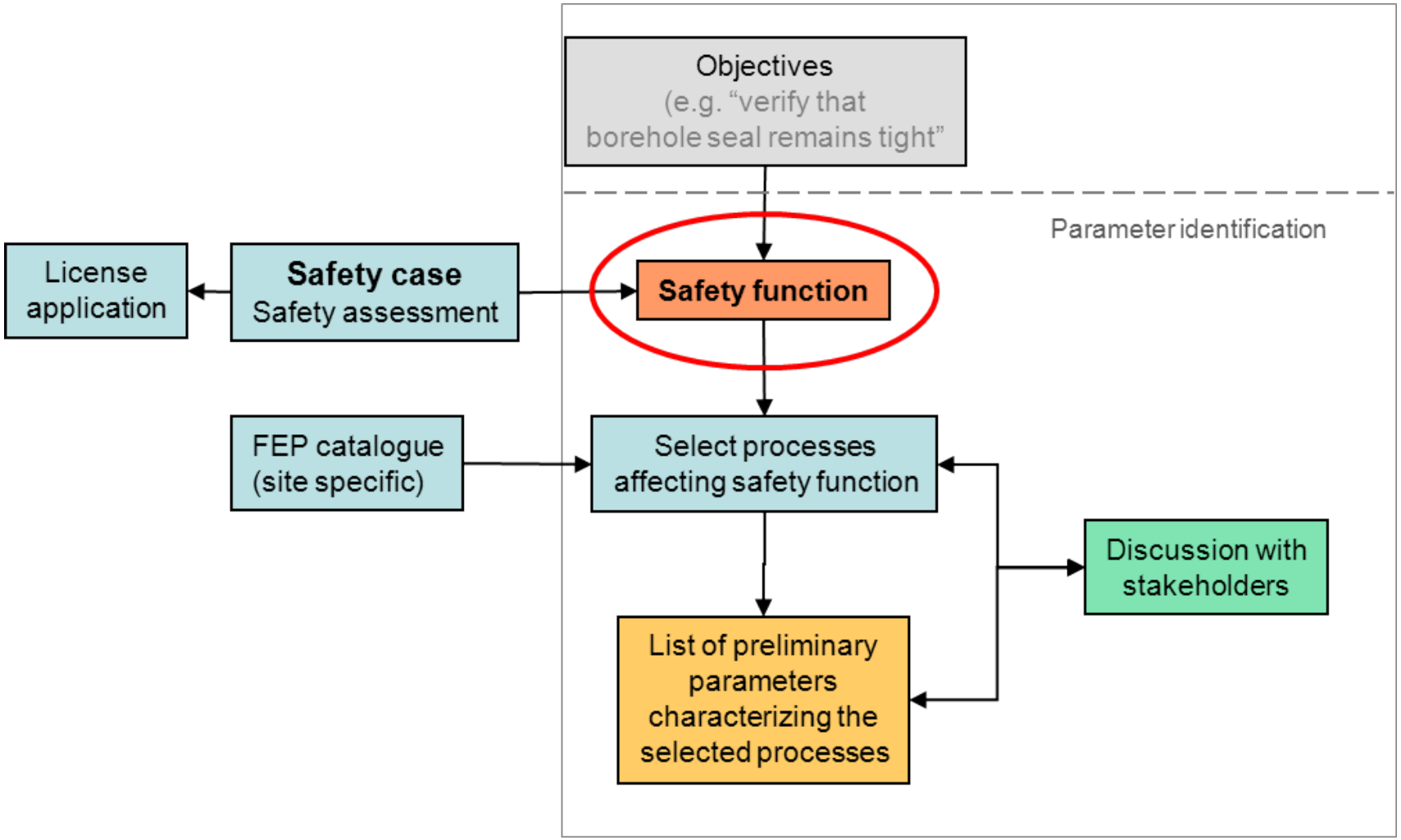
Where to monitor (case 1, German concept)



source: *Preliminary safety analysis of the Gorleben site*

Similar to “Pilot facility”

Parameter identification



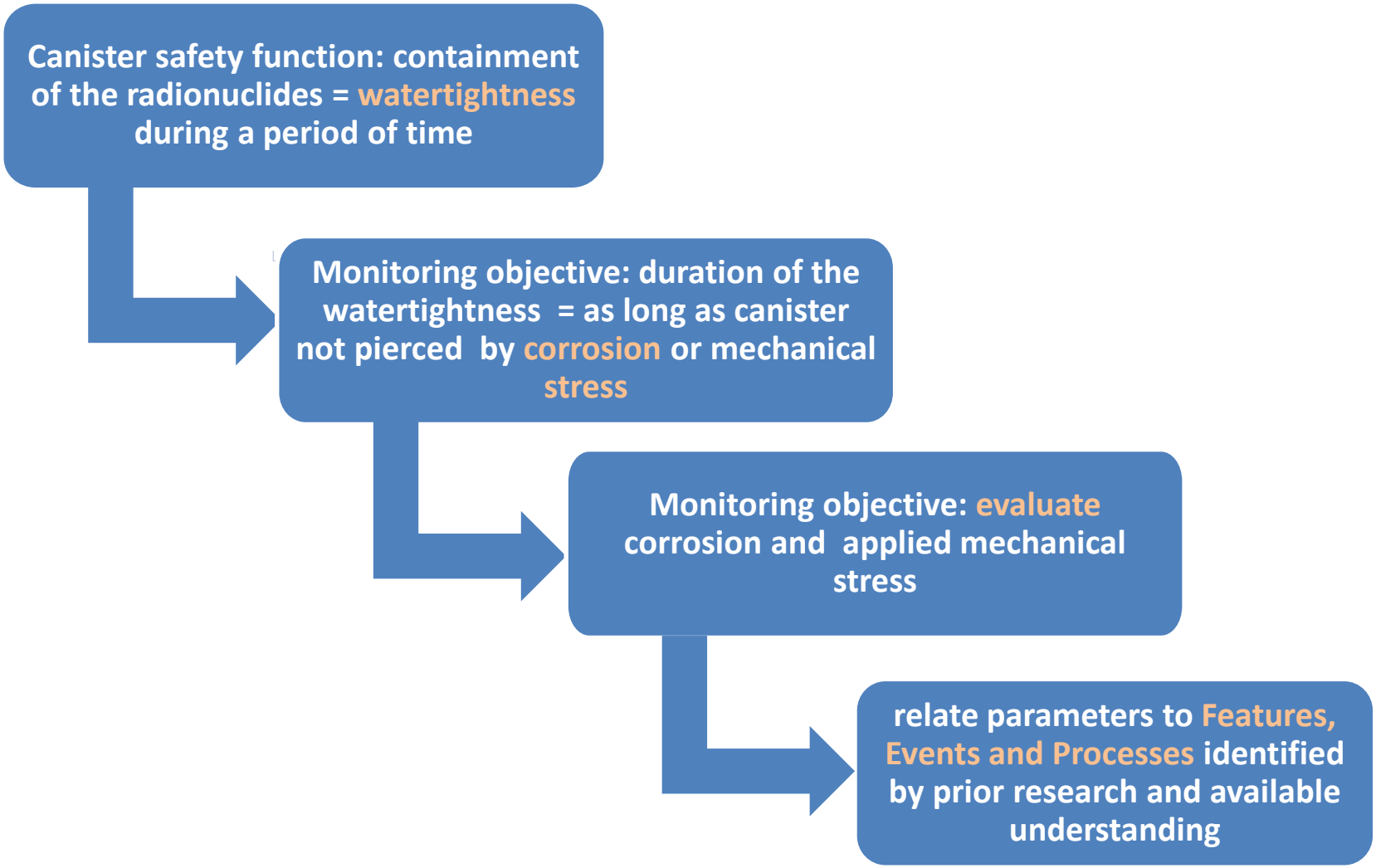
Monitoring objectives

Functional analysis demonstrate that specific safety functions can be related to specific components performance

A monitoring objective is to provide information needed to obtain support to evaluate an expected performance associated with a safety function

Overall monitoring objectives are to confirm that parameters and their evolution are as anticipated in the repository design and license

Example of defining a monitoring objective



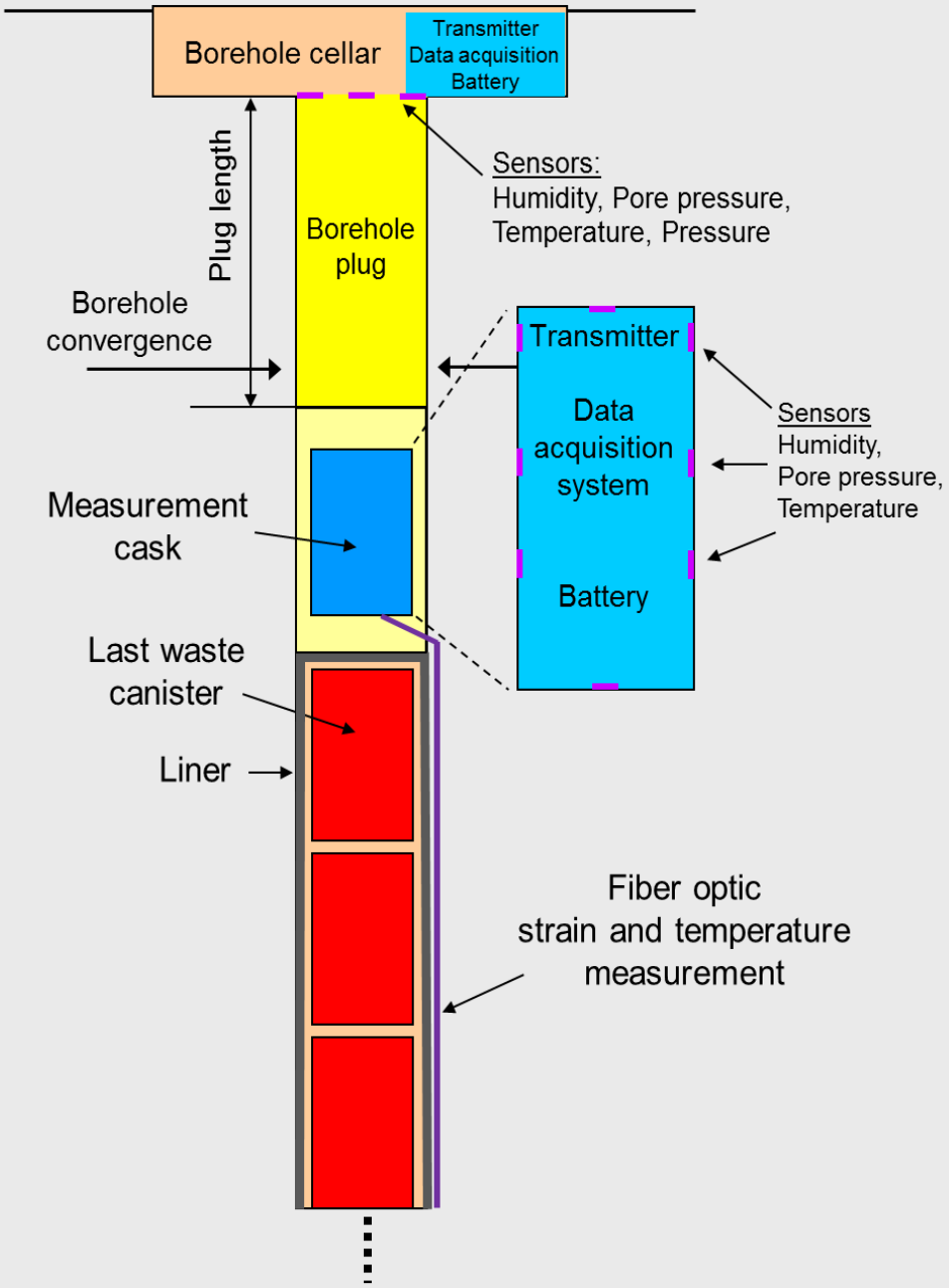
Monitoring representative emplacement boreholes

Relevant processes:

- borehole convergence
- gas pressure build-up (bottom of plug)
- brine pressure build-up (top of plug)
- temperature development
- liner deformation

Parameters:

- rock displacements (not feasible)
- borehole convergence (not feasible
- pore pressure, total pressure (feasible)
- humidity (feasible)
- temperature development (feasible)
- strain on the liner
- temperature on the liner



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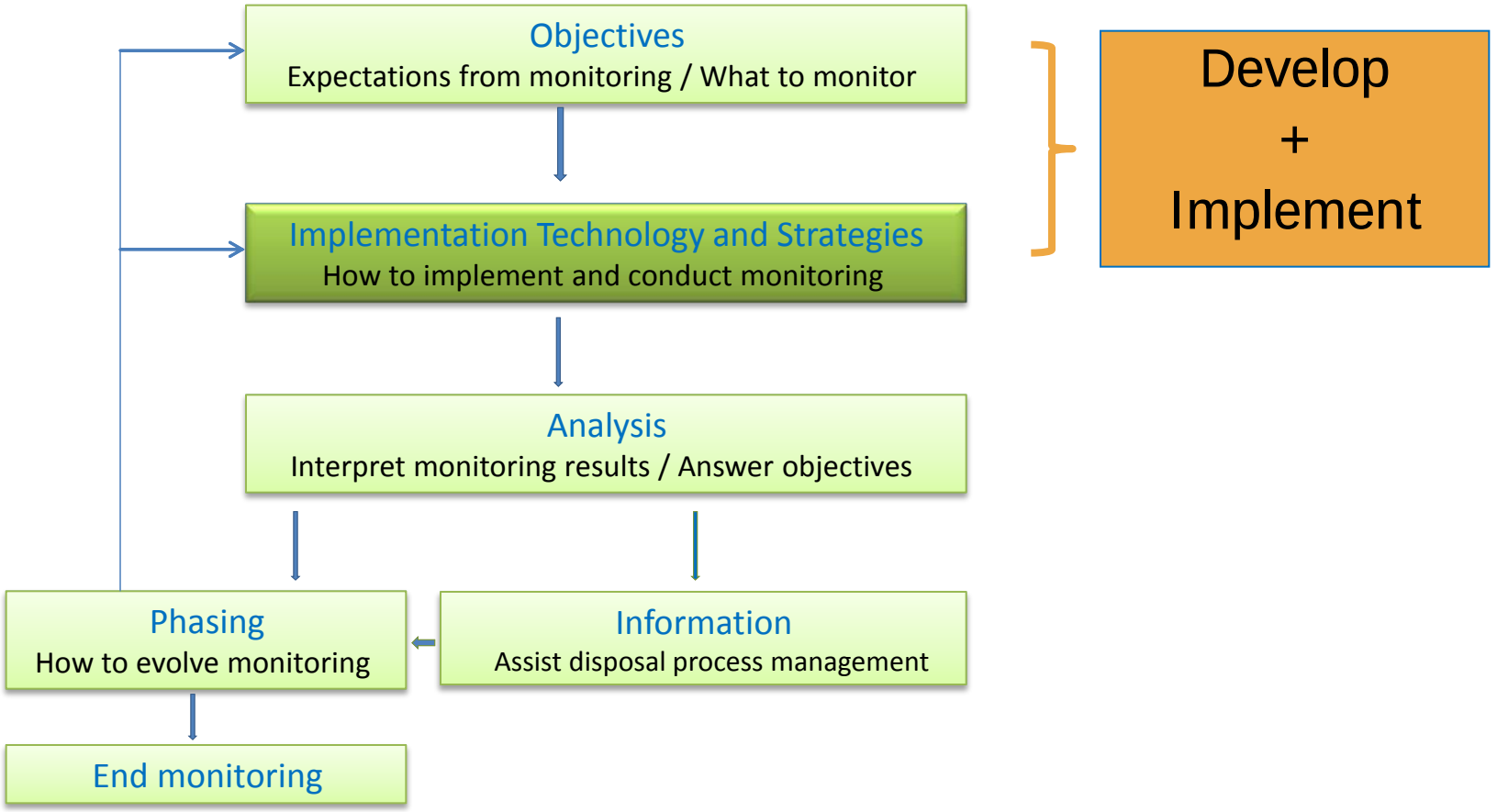
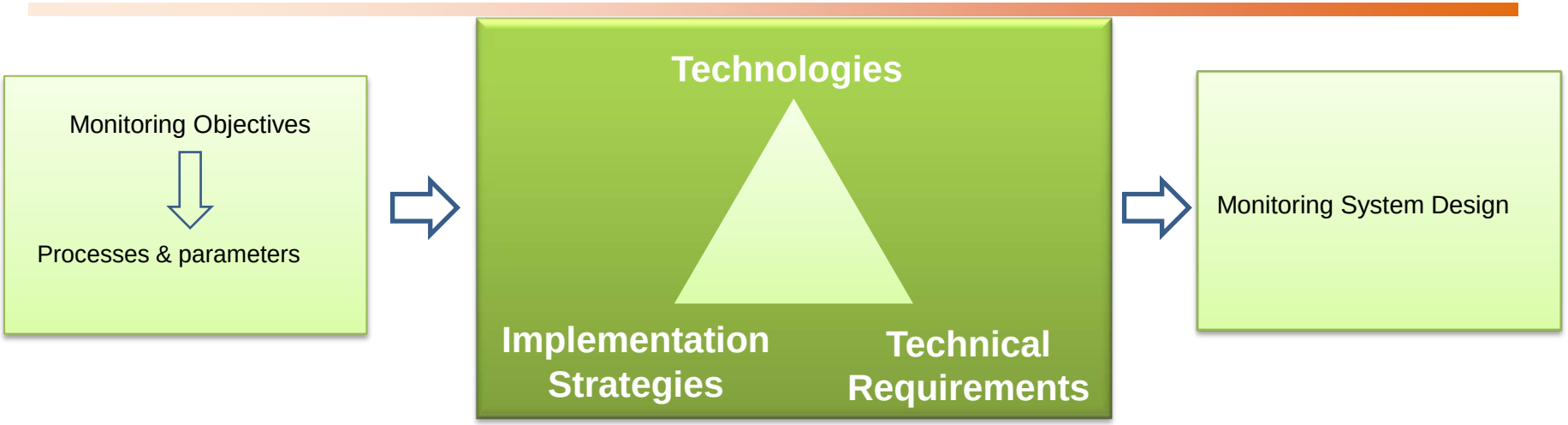
How to monitor



Implementation Strategies



Technology

- Understanding of available and relevant technologies and their limitations addressing the monitoring requirements

Implementation strategies

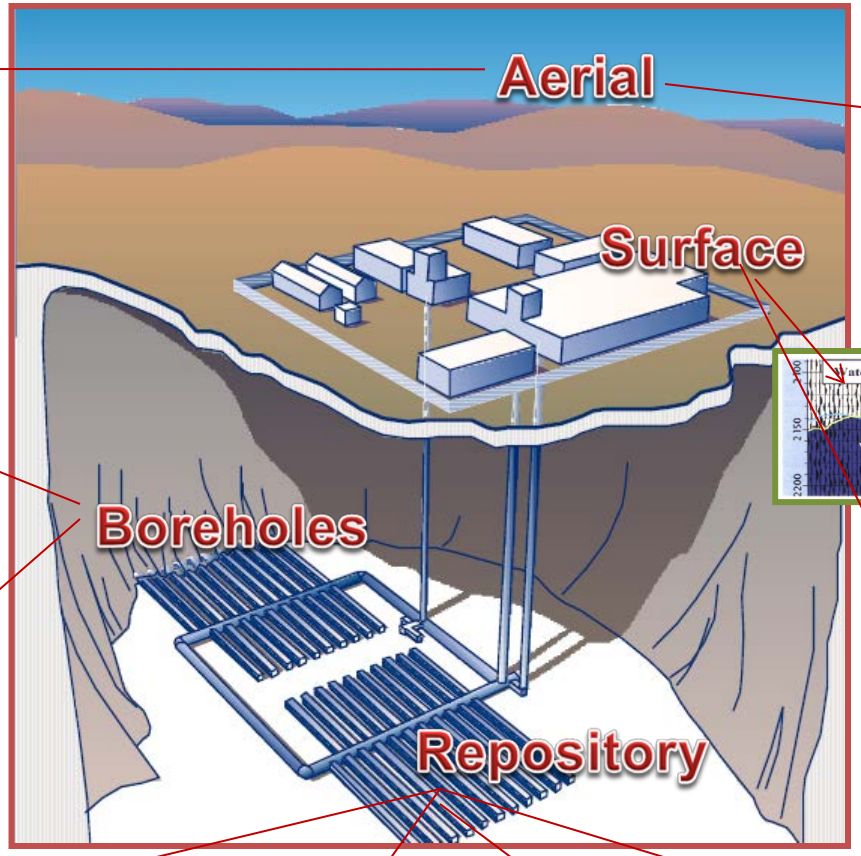
- Possible approaches to instrument the repository meeting the monitoring objectives

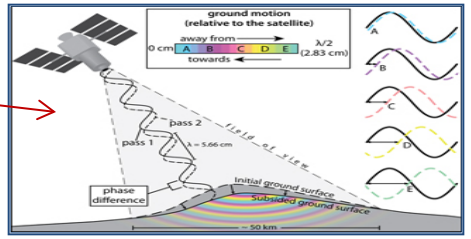
Technical requirements

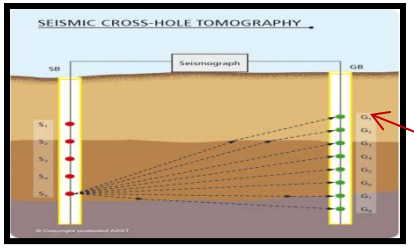
- Assessment of techniques that could be applied, with regards to environmental conditions: durability, reliability, resistance to environmental , and non-interference with barrier performance

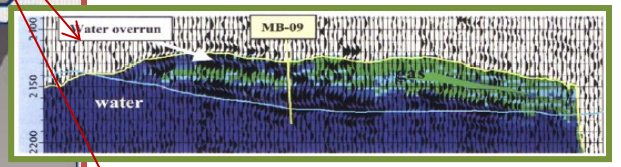
The state of art report

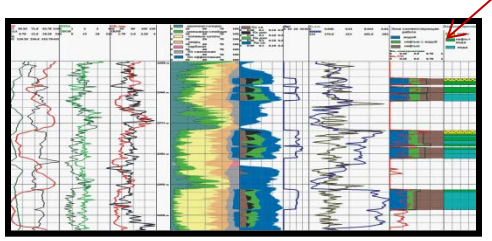
STRUCTURE

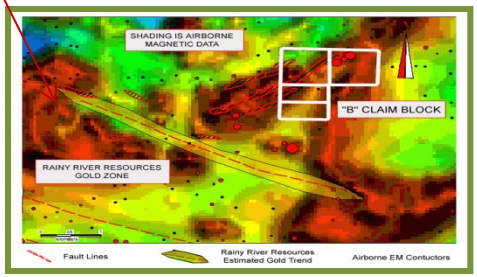


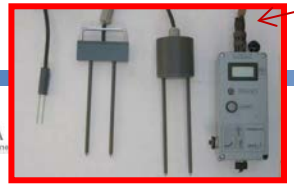


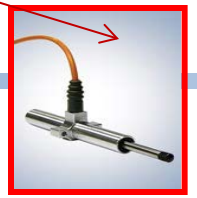












The state of art report

MONITORING TECHNOLOGIES

For each parameter a high-level summary of the monitoring technology is provided, covering all or most of the following points:

- A brief rationale: why measuring such parameter
- Available techniques and main characteristics
- Accuracy and range of application
- Long term performance and reliability
- Installation topics
- Particularities
- Data acquisition units
- Conclusions
- References to obtain more details if required

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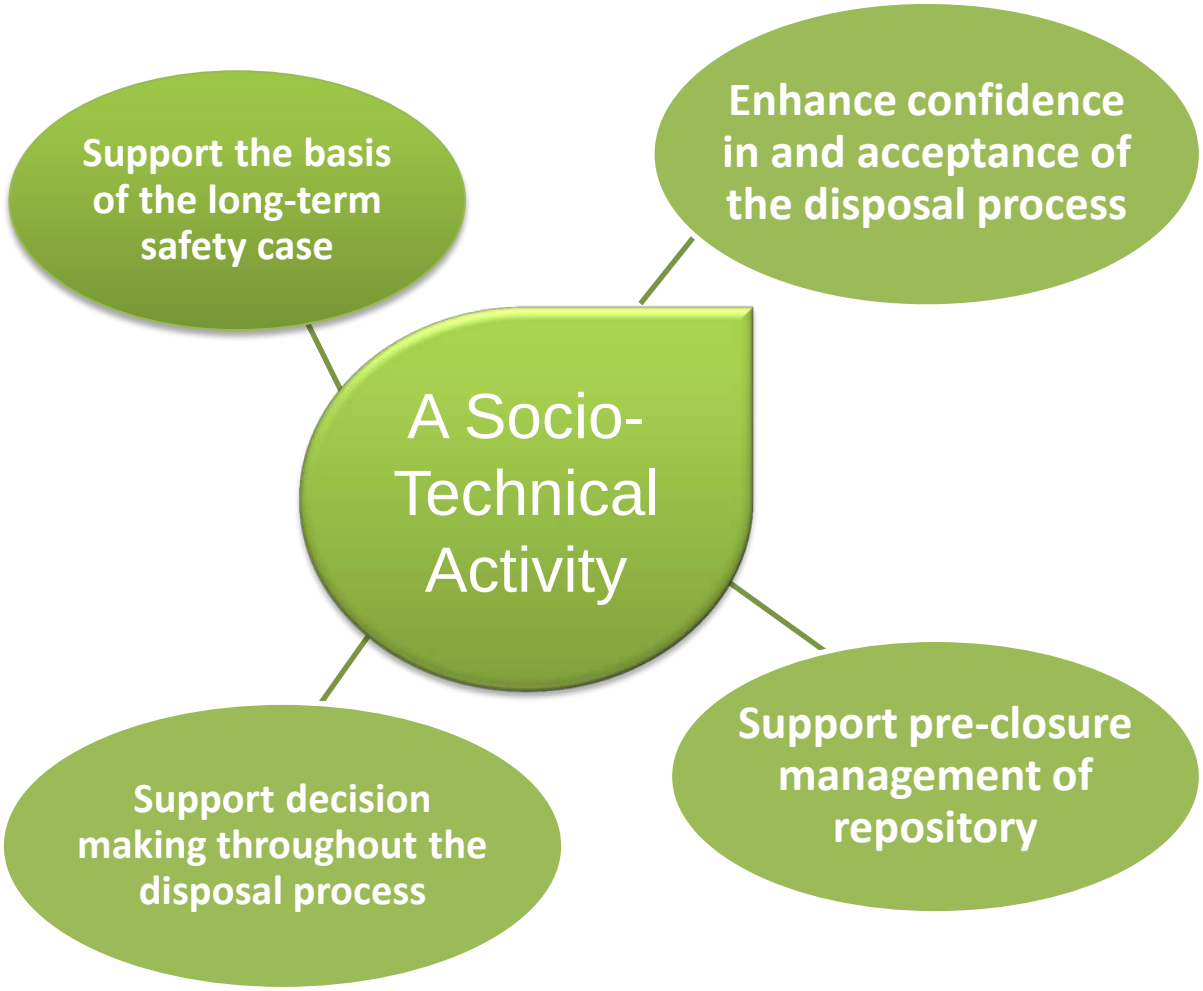
A Socio-Technical Activity



Important to include all stakeholders in the disposal process

Link between

* basis for safety,

* options for pre-closure management and

*What to monitor

needs to be justified and traceable

Link between confidence, acceptance and monitoring deserves close scrutiny

Expert stakeholders key recommendations

May 2011 workshop (Oxford, UK) - Some of the key recommendations

- Be clear about assumptions underlying the decision to monitor
- Acknowledge the benefits of independent scrutiny of monitoring
- Be clear about strategy on how to communicate monitoring results

- Be clear about link between monitoring program and safety case/design
- Define acceptable ranges for monitoring results
- Provide a response plan if results are outside of range

- Identify needs for monitoring technology R&D
- Provide a flexible, adaptable monitoring program
- Acknowledge benefit in considering post-closure monitoring

Stakeholder confidence – similar (or greater?) emphasis on process as on actual technical content

Implement Monitoring - Strategies

Examples of possible approaches

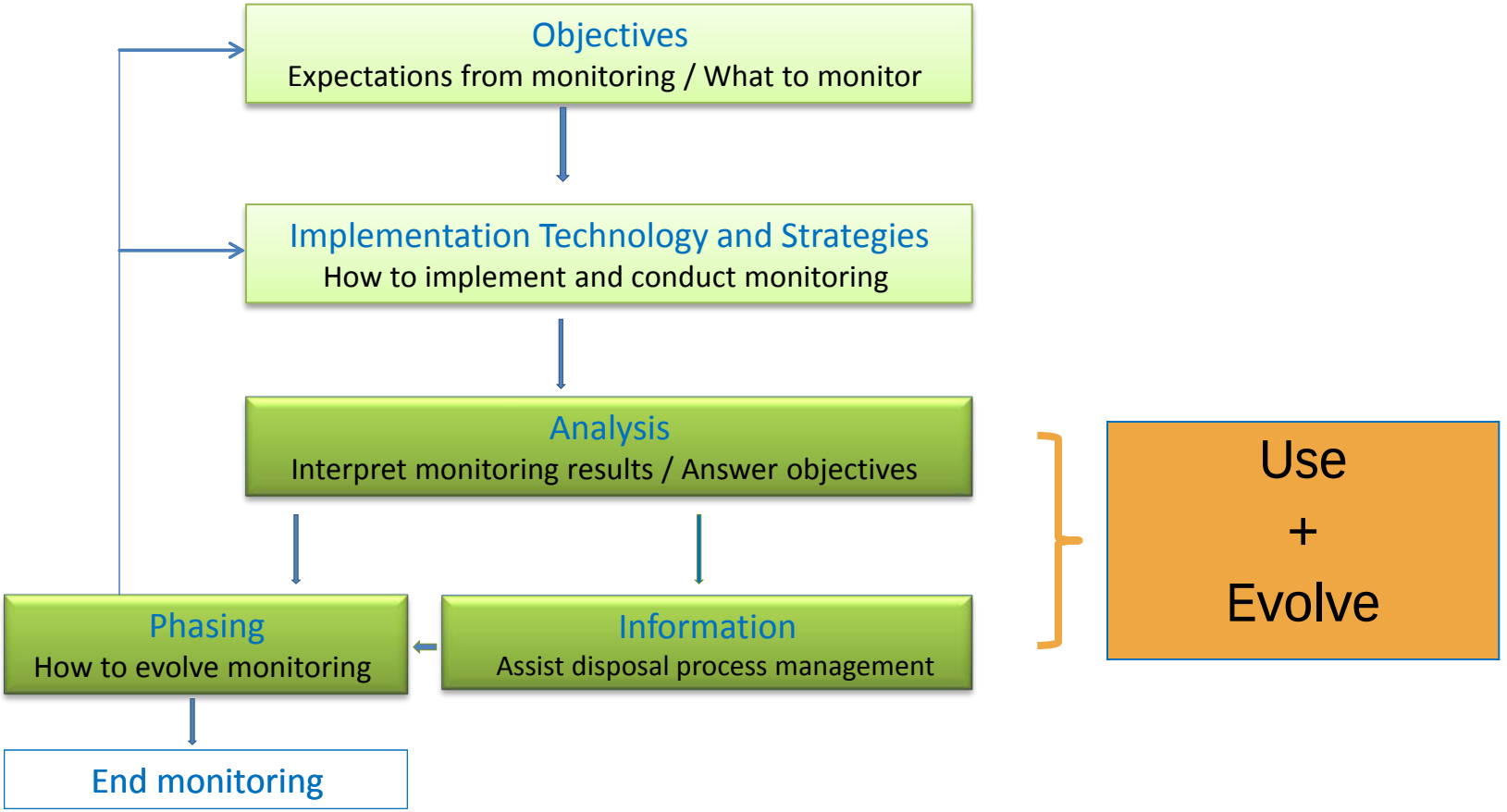
- Quality Control of Manufacture process (e.g. for Waste Disposal Packages)
- Long term experiment under representative conditions (e.g. WDP corrosion)
- Test facility, Pilot facility (easier access; maintenance possible)
- Representative structures inside main facility
- Combination of intrusive and non-intrusive techniques
- …

Risks and limitations

- Monitoring not performed exhaustively on the repository
- Costs, difficulty of operations
- Risks to degrade barriers effectiveness…
- Limited to select locations, specific components: need to be demonstrably representative (homogeneity, repeatability)
- Monitoring is not performed on the timescale of most processes affecting the repository components: century vs thousands of years
- Better than experiments but not enough to confirm some of the predicted processes
- Experiments with artificially accelerated transients

❿ Monitoring limited to detecting early initial evolutions

How to use monitoring results



Role of monitoring in decision making

IAEA statement

- The primary objective of monitoring is to provide information to assist in making decisions

Monitoring addresses technical/scientific and political concerns

- They are often related: decisions are often taken on mixed considerations

Decision points

- Decisions are taken at points defined on a calendar, related to operational or configuration changes or are unplanned, from unexpected technical or political input

Timescales

- From the granting of the license, monitoring plays a role in evaluating conditions and progress related to that license basis.
- Timescale is of the order of a century (construction, waste emplacement)

Stages and Decisions

IAEA Safety Requirements (2006)

Pre-operational, operational, and post-closure period

NEA Reversibility and Retrievability Project (2011) - Stages for Waste lifecycle

- Stage 1: Waste package in storage
- Stage 2: Waste package in disposal cell
- Stage 3: Waste package in sealed disposal cell
- Stage 4: Waste package in sealed disposal zone
- Stage 5: Waste package in closed repository
- Stage 6: Distant future evolution, progressive Waste package degradation

Major decision points (after licensing)

- Decide to emplace waste
- Decide to seal disposal cell
- Decide to seal disposal zone
- Decide to close repository
- Decide to end institutional control

Options for Decision making (NEA R&R)

- Follow reference path
- Continue on modified path
- Re-evaluate
- Go back

Using monitoring results

Using monitoring results require prior good understanding of how data relates to the safety assessment

Results are compared to expectations, as provided for the license basis

The base for decision making is not the result but its implication on the safety assessment, unless the parameter is a direct performance indicator, defined in the safety assessment with nominal values and deviations

Discrepancies or unexpected values should trigger a pre-prepared response plan, graduated with the associated evaluated risk.

Questioning the monitoring equipment, its reliability, accuracy, even the methodology are the fist risk management steps., If discrepancy with expected value remains, implications on the safety assessment are then required, with a re-evaluation of the technical baseline

Results may also reduce uncertainty , and contribute to enhance our understanding of processes, allowing a re-evaluation of the repository performance

Conclusions

The MoDeRn project developed a set of documents to support the design and implementation of monitoring programs:

A framework, presenting the workflow, with a systematic top-down approach to developing monitoring programs (established a collective understanding of repository monitoring approaches)

Case studies provide examples of monitoring programs in 3 host rocks

National Contexts

The State of the Art in technologies for monitoring, complemented by 5 programs of research and demonstration in URL

The basis for SH communication and National Engagement Reports

Information available on MoDeRn website

www.modern-fp7.eu

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Thank you.