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MODERN
Monitoring Developments for Safe Repository Operation and Staged Closure
Motivation

Monitoring of HLW Repositories

2009
Missing: Common international framework or guideline for repository monitoring

Monitoring Developments for safe Repository operation and staged closure

Aim: providing a reference framework for development and implementation of monitoring activities
18 partners - 12 countries

Social Sciences:
- University of Antwerpen,
- University of Gothenburg,
- University of East Anglia

Underground Laboratories:
- Grimsel (Switzerland)
- Mol (Belgium)
- Bure (France)

EU Countries:
- France (Andra),
- Spain (Enresa and Aitemin),
- Germany (DBETEC),
- Belgium (Euridice, UA),
- United-Kingdom (NDA, UEA, GSL),
- Netherlands (NRG),
- Finland (Posiva),
- Czech Republic (RAWRA),
- Sweden (SKB, UGOT)

Non-EU Countries:
- Japan (RWMC),
- USA (Sandia),
- Switzerland (Nagra, ETH Zurich)

MODERN

2009 - 2013
MODERN proposed a *Monitoring Reference Framework* as a **structural approach** for development, implementation and operation of a monitoring program covering the topics of:

- How monitoring **objectives** may be developed and their role in the disposal process understood

- How monitoring **systems** may be designed and what **strategies** may help in attaining the monitoring objectives

- What can be achieved with monitoring; what are the **possibilities and limitations**

- How monitoring might contribute to **stakeholder confidence**
The **Modern Monitoring workflow** illustrates this **structural approach** and provides an overview of key steps to consider when developing a monitoring programme which are:

1. Analysis of objectives and relating these to processes and parameters to be monitored.
2. Analysis of requirements and available monitoring technology to design a monitoring programme.
3. Conducting a monitoring program and using the results as basic information for decision making.
MODERN (Case Studies)

Monitoring systems for the generic **German salt concept** are assumed to be implemented by applying the following principles:

**Principles**

- No cables running through geotechnical barriers
- No cables running along access drifts backfilled with compacting crushed salt
- No cable connection from the repository to the surface

→ **Wireless data transmission** is indispensable
MODERN

**WDT (short distance):** A high-frequency wireless node that allows measurement of several parameters (e.g. pore pressure, total pressure and water content), and transmission of the measured data over distances of **a few meters** has been designed, developed and tested. This potentially provides a method for wireless transmission of monitoring data through an EBS.

*Aitemin, Spain*
WDT (long distance): A low-frequency data transmission system, capable of transmitting data through **225 m** of an electrically highly-conductive geological medium, at frequencies up to 1.7 kHz has been designed, developed and tested at the HADES URL. This potentially provides a method for wireless transmission of monitoring data from a repository to the surface following repository closure.

NRG, The Netherlands
MODERN Reports

Level 1 Report - Public
(Target audience has a good understanding of geological disposal)

Project Synthesis Report
Deliverable D6.1.1

Level 2 Reports
(Target audience has a good understanding of safety case)

Monitoring Reference Framework Report
Setting out a Process for monitoring
Deliverable D1.2.1

Technology Summary Report
Summarising Technical Studies

Level 3 Reports
(Target audience has a good understanding of monitoring)

Case Studies Report
Examples for 3 rock types
Deliverable D4.1

Proceedings of International Conference & Workshop
Deliverable D5.4.1

Stakeholders
D1.3.1: Monitoring the Safe Disposal of Radioactive Waste: A combined Technical & Socio-Political Activity
D1.4.1: National Engagement Research Report
D5.3.1: Expert Stakeholders Workshop

WP2 Reports
Research & Development: Monitoring Technology
D2.1.1: Technical Requirements Report
D2.2.1: Monitoring Technologies Workshop Report
D2.2.2: State-of-the-Art Report
D2.3.1: Development Report of Monitoring RTD

WP3 Reports
In situ Testing and Demonstration of Monitoring Techniques
D3.1.1: Site Plans and Monitoring Programme Report
D3.2.1: Seismic Tomography at Grimsel Test Site
D3.3.1: Wireless Sensor Network Demonstrator Report
D3.4.1: HADES Monitoring Demonstrator Results and Analysis Report
D3.4.2: Wireless Data Transmission Experiments at HADES URL
D3.5.1: Disposal Cell Monitoring System Installation & Testing Demonstrator in Bure URL

Download:
www.dbe-technology.de
/Media/F&E-Berichte

2154-01-NDA
Development and Demonstration of monitoring strategies and technologies for geological disposal
The ambition of Modern2020 is to address the key challenges and to advance the state-of-the-art associated with:

➢ **Strategy**: Identify methods to link a monitoring program design to real-world safety cases and repository implementation programs

➢ **Technology**: Address key technology gaps existing with (wireless) data transmission, power supply, (new) sensing systems, reliability and qualification

➢ **Demonstration and Practical Implementation**: Illustrate how monitoring systems can be designed to the requirements identified by the strategy work and to use the technologies developed

➢ **Societal concerns and Stakeholder Involvement**: Evaluate the active engagement of public stakeholders in monitoring research and monitoring program specification

➢ **Dissemination**: Develop ways of establishing a common understanding on monitoring requirements and approaches.
**Consortium:** 28 Partners out of 12 countries  
**Coordinator:** Andra  
**2015 - 2019**  
**Total budget:** 8.6 Mill €  
**EC funding:** 6.0 Mill €

<table>
<thead>
<tr>
<th>Category</th>
<th>Partners</th>
</tr>
</thead>
</table>
| 8 radioactive waste management organisations | ![Logos](image1.png)  
| 5 organisations undertaking research on radioactive waste management in their respective country | ![Logos](image2.png)  
| 1 technical support organisation | ![Logo](image3.png)  
| 4 organisations with specialist technical monitoring expertise | ![Logos](image4.png)  
| 8 academic research units | ![Logos](image5.png)  
| 2 specialist consultants | ![Logos](image6.png)  

*This project receives funding from the Euratom research & training program 2014-2018 under GA n°662177*
MODERN2020 (Strategy)

➢ Compare and evaluate existing monitoring strategies
➢ Identify decisions requiring support from monitoring and what kind of monitoring data is required
➢ Identify and update approaches that could be used to compile and screen parameter lists
➢ Involve Stakeholders to explore how their early involvement in developing monitoring plans could be addressed appropriately

Special issue: Development of monitoring concepts for EBS. performed during the operational safety related to long-term safety (safety case) responding to the reversibility principle (France)
State-of-the-art Technology: Update the MODERN state-of-the-art on monitoring technology status and highlighting gaps that still need to be bridged

- Technology Readiness Levels (TRL) -

Wireless Data Transmission (WDT): Further develop systems for (short + long range) WDT. The required progress is related to the enhanced propagation of radio waves across the different repository materials and components

Sustainable Power Supply: Investigate power supply sources capable of extending the expected lifetime of the WDT

Thermoelectric-Generator (TEG), NRG
Radioisotope Thermoelectric Generator (RTG), AREVA, Andra, RWMC

Sensor System Improvements: Further develop and adapt available (or new) technology to monitor e.g. H2, Temperature, strain, radiation, pH, displacement (new FOS) to improve geophysical methods (SWFI, ERT/IPT)

Qualification: Develop a common multi-stage qualification methodology applicable to each component of a monitoring system
MODERN2020 (Demonstration and Implementation)

**ONKALO (Finland)**

Improving the existing wireless system for data transfer through rock, soil, and water
- 125 kHz system

Key further improvements pursued
- Increased transmission range
- More reliable and robust data transfer
- Longer sensor lifetime

Evaluation of the use of combination of different wireless solutions
Organisation of a monitoring training school (1 week)

... for early-career scientists/engineers in the field of geological disposal monitoring (advanced PhD candidates, Postdoctoral scientists and engineers affiliated to European research institutions)

➢ Training sessions will comprise a series of key lectures given by international experts and discussions alongside practical exercises.
➢ Visit of an Underground Research Laboratory

➢ Topics:
➢ Main regulation texts (e.g. Directive 2011/70 EURATOM)
➢ Explain monitoring challenges for geological disposal (e.g. long term monitoring)
➢ Main technologies used in such environment
➢ Methodology to elaborate a suitable monitoring system
➢ Monitoring data (results) and decision making
➢ Address data archive management
➢ Stakeholders’ involvement
Development of **monitoring concepts** for EBS

- Development of “synthetic” monitoring results in and around the EBS for different scenarios

- Identification of how “bad” monitoring results must be to indicate a risk for the safety of a repository by sensitivity analysis of barrier (component) performance

- Develop “trigger values” or “trigger evolutions” for EBS monitoring concepts

- Identify specific **requirements for sensing system**

- Development of **response plans** for scenarios exceeding specific trigger values
The development of a monitoring concept for a HLW repository has been started
Open Issues

➢ **Strategy:** EBS monitoring concepts

➢ **Technology:** WDT, power supply, improvement of sensing systems, qualification

➢ **Demonstration:** Illustrate how monitoring systems can be designed to the requirements identified

➢ **Stakeholder Involvement:** explore their early involvement
Stakeholder Involvement in:

MODERN
Montoring Developments for Safe Repository Operation and Staged Closure

MODERN 2020
Development and Demonstration of monitoring strategies and technologies for geological disposal
Monitoring is not only a technical topic

*Monitoring is limited through a number of societal factors*

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**Figure 2** The Belgian participants’ collective view on monitoring objectives
‘Experts’ vs. ‘Lay’?

**Conclusion**: experts (NWMOs) and citizens have different perspectives on monitoring

**Experts**:
- Aim of monitoring = ‘performance confirmation’, Reassurance, Confirmation
- Monitoring supports decision making processes

**Lay**:
- Citizens are more careful: „Check whether the disposal is safe“
Aim of the research

The development and implementation of an effective and efficient operational monitoring program for geological disposal for high level radioactive waste (B&C) and spent nuclear fuel

→ respectively of the national context (eg. Host rock, legislation)
→ involvement of different stakeholders (citizens)
WP5: Societal concerns and stakeholder involvement
Task of UAntwerpen (together with University of Gothenburg):

Stakeholder-Involvement in R&D activities on monitoring on two levels:

a) Involvement of representatives from local partnerships within internal Moden2020 project workshops
   At the project level

b) Creating‘ at home engagement sessions in (potentially) concerned communities
   At home

Belgium Finland Sweden
The role of local stakeholders
The role of local stakeholders

Analytical basis for public participation

➢ Geological disposal is not only a question of technical know-how

➢ Dividing between ‘experts’ and ‘lay’ is a faulty perspective

STS-perspective: “Lay knowledge is qualitatively different, but neither wrong nor useless!” (Bucchi & Neresini, 2008, Handbook of STS)

➢ What is the citizens‘ local knowledge? (Wynne, 1989)

➢ How to create a socially robust monitoring system? (Nowotny, 2003)

➢ Try Upstream Engagement in practice (Wilsdon and Willis, 2004)

➢ Establishing a dialogue basis, out of which mutual trust can be achieved

➢ More general research question: How can successful participation look like?
1. Dialogue workshop in Belgium (May 2016, Dessel)

- ca. 15 citizens from the communities of Mol and Dessel (partnerships Mona & Stora),
- 2 Niras-Ondraf / Euridice representatives
- WP3 leader
- UAntwerpen
- 2 presentations (held by UA and Niras-Ondraf)
- Open discussion round, facilitated by questions and moderation by the UA
1. Research results

Guiding Questions:

➢ How do citizens frame successful participation in Modern2020?
➢ What do citizens know on the topic already?

→ Great interest and curiosity in monitoring, follow-up of the current research
→ Citizens consider themselves as experts: long experience with the topic nuclear waste (CatA project)
→ Middlemen between waste managers, politics and society at large:
   (‘Monitoring is too specific topic to be discussed with society‘ at large)
= help to build up a societal support basis
→ Watchdog over the waste manager (=Niras-Ondraf)

Problems: → Topic Monitoring is quite abstract ! Technic/System not sharp enough defined
          → Mere ,ruperstamping‘ of solutions made within Modern2020 explictly denied!

→ When is the correct/best suitable point in time to involve citizens in such a complex research?
Research outlook 2016/2017


Development of a document (handbook) explaining monitoring technologies and strategies

➢ **Aim**: Monitoring als Technologie erklären, Transparenz schaffen, Offenheit gegenüber der verschiedenen Monitoringansätze in den verschiedenen Ländern (v.a. Frankreich, Schweden, Finnland), Diskussionspunkte darstellen, Dialog statt Kommunikation

➢ **Audience**: Citizens, local communities, policymaker, other interested groups

➢ **Standard**: IPCC Policy documents

➢ **Workshop**: End November to concretize shape of document
Many Thanks!

More information is available on the MODERN2020 website

www.modern2020.eu

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