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Summary of the IAEA URF Workshop on the "Need for and Use of Generic and Site-Specific Underground Research Laboratories to Support Siting, Design and Safety Assessment Developments"

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IAEA International Atomic Energy Agency

Sandia National Laboratories

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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Outline

- Workshop Goals
- Outcomes of Workshop
- Agenda
- Focus Areas
- Workshop Guidelines

Goals

Better understanding of the role of URLs to support the phased development of the safety case for a geological disposal facility for HLW/SNF

Better understanding of the link between R&D conducted in URLs and the overall science and technology programme

Better understanding of how existing and new information from closed and operating generic and site-specific URLs can support program R&D needs

Better understanding of how to develop a plan for incorporating a URL and/or URL studies into a disposal program

Better understanding of the role a generic Salt URL would play in international disposal programmes and its potential benefits

Approach

- To achieve these overall goals, presentations and workshop discussions first reviewed the role of the safety case as a management and communication framework for integrating siting, design and safety assessment

- The workshop then proceeded through a succession of existing URL case studies (next slide) from various national programs in different phases of development to elicit the potential scientific and engineering contributions
    - These case studies included the role of URLs in advancing the technical knowledge base, in validating conceptual and numerical models of repository behavior, and in building confidence with stakeholders

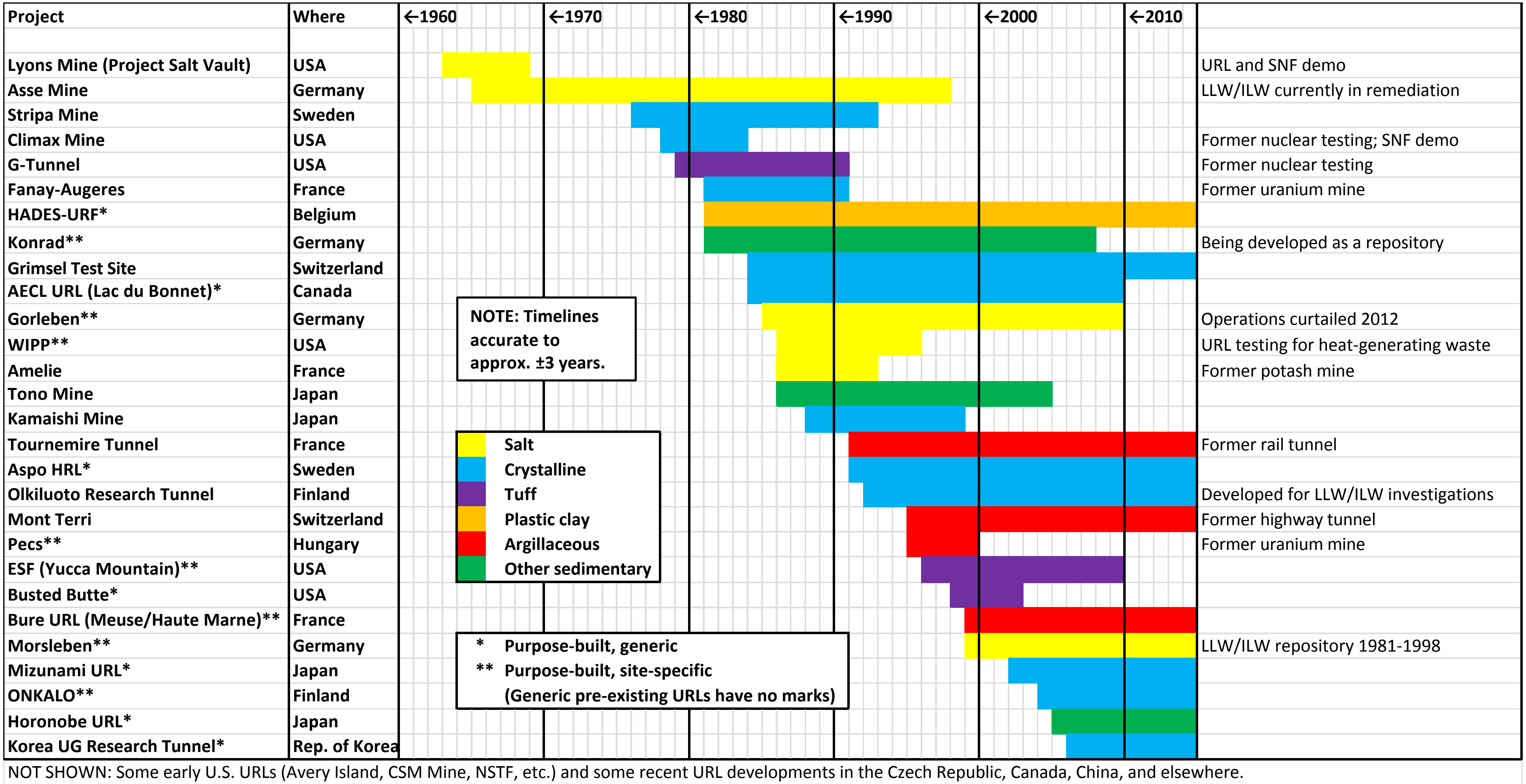
- Given the associated cost, design and operational considerations for a URL, group discussions further addressed the place and role of a generic or site-specific URL compared to other types of research, development, and demonstration (RD&D) activities

- Finally, these considerations were revisited for the specific case of a URL sited in a salt host rock, to elicit the need and urgency, if any, to establish such a facility, as there is currently not one in operation around the world

Workshop Presentations

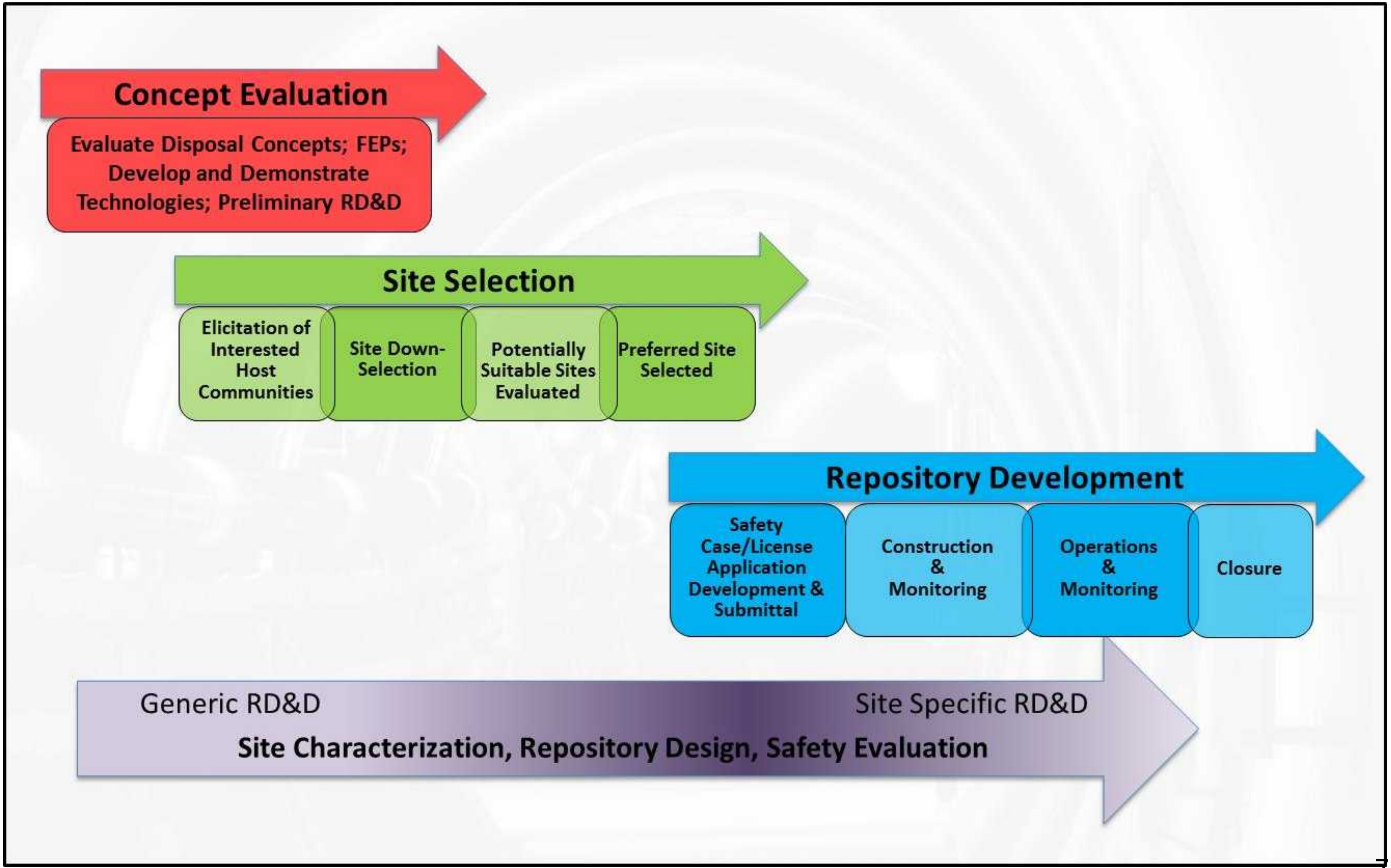
Presentation Title	Presenter	Affiliation
Introductions, Workshop Objectives, Structure, and Approach	Mr. Robert MacKinnon	SNL
Overview of International URLs	Mr. Stefan Mayer	IAEA
Role of URLs in Support of the Safety Case	Mr. S. David Sevougian	SNL
Importance of URLs in Safety Assessment with Focus on Licensing Processes in Canada	Ms. Karina Lange	CNSC
Overview of the U.S. DOE's International Collaborations in Disposal R&D	Mr. Peter Swift	SNL
Case Study: The Grimsel Test Site	Mr. Stratis Vomvoris	NAGRA
Case Study: The Mont Terri Rock Laboratory	Mr. Paul Bossart	swisstopo
Case Studies: Currently Operating Generic URLs in Crystalline and Sedimentary Host Rocks (Mizunami and Horonobe)	Mr. Naotaka Shigeta	JAEA
Case Study: ONKALO Underground Rock Characterization Facility	Mr. Kimmo Kemppainen	Posiva
Extension of the KURT and its Role for the Geological Disposal Programme in Korea	Mr. Geon Young Kim	KAERI
URL Cost and Design Considerations	Mr. Ernest Hardin	SNL
Lessons Learned from Canada's Underground Research Laboratory	Mr. Paul Thompson	AECL
Preliminary Plans for In-DEBS Experiment in KURT	Ms. InYoung Kim	KAERI
Plans for a URF to Support Czech Republic's National Disposal Program	Mr. Lukas Vondrovic	SURAO (RAWRA)
An Underground Laboratory in the Context of Salt Disposal RD&D	Mr. Frank Hansen	SNL
TSDE Thermal Test: Post-test Evaluation of Instrumentation and Considerations for Future Test	Mr. Gerald-Hans Nieder-Westermann	DBE-TEC
Results from the Preliminary Safety Analysis of Gorleben	Mr. Klaus Wieczorek	GRS
State of RD&D, Design & Site Characterization in Salt Host Rock	Mr. Kris Kuhlman	SNL

Worldwide URL Summary - Timelines



From Hardin, URL Cost and Design Considerations – SAND2014-17981 PE

Timeline for a repository development program and associated RD&D



Goal #1: Develop a better understanding of the role of URLs to support the phased development of the safety case for a geological disposal facility for HLW/SNF.

This goal applies to all phases of the repository development/RD&D timeline

- A very long-term (decades) perspective should be adopted for the uses of both generic and site-specific URLs
- A comprehensive knowledge retention program is important on both a national and an international basis
- Stakeholder input and involvement is important for both URL siting and operation. Stakeholders include the general public, the regulator, and technical advisors (such as universities)
- Outreach centers built at URLs (whether generic or site-specific) increase transparency, confidence, and national participation in solving the nuclear waste disposal problem

Goal #2: Develop a better understanding of the link between R&D conducted in URLs and the overall science and technology programme

This goal is again important to all phases of a repository program and requires an understanding of the economics involved in constructing and operating both generic and site-specific URLs

- Figure on the next slide identifies in situ R&D activities supported by URLs in the context of R&D for the overall science and technology program supporting the safety case
- Several URL programs, e.g., AECL's Whiteshell (Thompson 2014) and Nagra's Grimsel (Vomvoris 2014), have found that laboratory measurements of certain parameters and processes may result in parameter values that are not representative of repository conditions
- Retrievability, which is a licensing requirement in most national programs (e.g., Ouzounian et al. 2014), is an issue that still remains to be demonstrated

Key elements of a repository safety case (grayed-out elements are those not as strongly supported by *in situ* RD&D in URLs)

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1. Introduction, Purpose, and Context

2. Safety Strategy

2.1 Management Strategy
- Organizational/mgmt. structure
- Safety culture & QA
- Planning and Work Control
- Knowledge management
- Oversight groups

2.2 Siting & Design Strategy
- National laws
- Site selection basis & robustness
- Design requirements
- Disposal concepts
- Intergenerational equity

2.3 Assessment Strategy
- Regulations and rules
- Performance goals/safety criteria
- Safety functions/multiple barriers
- Uncertainty characterization
- RD&D prioritization guidance

3. Technical Bases

3.1 Site Selection
- Consent-based siting methodology
- Repository concept selection
- FEPs Identification
- Technology development
- Transportation considerations
- Integration with storage facilities

3.2 Pre-closure Basis
- Repository design & layout
- Waste package design
- Construction requirements & schedule
- Operations & surface facility
- Waste acceptance criteria

3.3 Post-closure Basis (FEPs)

3.3.1 Waste & Engineered Barriers Technical Basis
- Inventory characterization
- WP technical basis
- Buffer/backfill technical basis
- Shafts/seals technical basis

3.3.2 Geosphere/ Natural Barriers Technical Basis
- Site characterization
- Host rock/DRZ technical basis
- Aquifer/other geologic units technical basis

3.3.3 Biosphere Technical Basis
- Biosphere & surface environment:
  - Surface environment
  - Flora & fauna
  - Human behavior

4. Disposal System Safety Evaluation

4.1 Pre-closure Safety Analysis
- Surface facilities and packaging
- Mining and drilling
- Underground transfer and handling
- Emplacement operations
- Design basis event formulation
- Pre-closure model/software validation

4.2 Post-closure Safety Assessment
- FEPs analysis/screening
- Scenario construction/screening
- PA model/software validation
- Barrier/safety function analyses and subsystem analyses
- Uncertainty characterization and analysis
- Sensitivity analyses

4.3 Confidence Enhancement
- R&D prioritization
- Natural/anthropogenic analogues
- URL & large-scale demonstrations
- Monitoring and performance confirmation
- International collaboration & peer review
- Verification, validation, transparency
- Qualitative and robustness arguments

5. Synthesis & Conclusions
- Key findings and statement(s) of confidence
- Discussion/disposition of remaining uncertainties
- Path forward

Goal #3: Develop a better understanding of how existing and new information from closed and operating generic and site-specific URLs can support program R&D needs

Can a program's R&D needs be satisfied with information from URLs in other countries?

- Answer is strongly related to the stage of the repository program, which requires more site-specific information as it progresses towards a license for construction.
- Transferability of information (Mazurek et al. 2008) is the key concept here and some metric(s) should be proposed to help determine the degree of transferability from generic or site-specific URLs in one repository program to other repository programs.

Goal #4: Gain a better understanding of how to develop a plan for incorporating a URL and/or URL studies into a disposal program

The first step in developing a plan for incorporating a URL into a program would be to develop an overall program schedule, identify specific near-term and long-term objectives to be achieved, and include milestones in the schedule that correspond to achieving these objectives

- Cost estimates for completing the different milestones would also need to be made to have an understanding of potential future costs and to adjust expectations if needed
- A generic or site-specific URL can serve as both a research and an operational "playground" (Bossart 2014) that produces important lessons for repository construction and operation
- When planning for a site-specific URL, an important consideration is whether it might eventually become part of the same underground tunnel system as the eventual waste repository (i.e., co-location)
- Hidden benefits of a URL are sometimes not considered in the planning and budget profile

Goal #5: Gain a better understanding of the role a generic salt URL would play in international disposal programmes and its potential benefits

- There are definable benefits for establishing a generic salt URL, including (1) investigating heat dissipation for large waste packages (those containing a significant heat load, such as DPCs in the US program), (2) retrievability of waste packages in salt, including the issue of vertical movement (which appears to not follow currently available constitutive laws), (3) how neutron absorption is improved by salt (i.e., criticality control), (4) the effect of brine movement in the EDZ and its potential impact on gas generation, (5) hoisting and handling of large waste containers, (6) full-scale demonstrations of shaft sealing technology, and (7) maintaining long-term technical competence in salt repository research and operations
- Likely not needed until a national program specifically decides to site its repository in salt.

Key Conclusions

- The long history of RD&D in worldwide URLs (> 40 years) can be argued to be the primary reason that nuclear waste disposal systems are currently at a high level of maturity
  - Of particular interest is the relationship between technology maturity, as measured by technology readiness level (TRL), and the stages or milestones in the repository development timeline (see next slide)
- An international, easily accessible knowledge base should soon be established to avoid the loss of important experiences and information obtained from existing and closed URLs

General Definitions of Technical Readiness Levels

Relative Level of Technology Development	Technology Readiness Level	TRL Definition	Abbreviated Description
System Operations	**TRL 9**	Actual system operated over the full range of expected conditions.	The technology is in its final form and operated under the full range of operating conditions.
System Commissioning	**TRL 8**	Actual system completed and qualified through test and demonstration.	The technology has been proven to work in its final form andunder expected conditions.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in relevant environment	This represents a major step up from TRL 6, requiring demonstration of an actual system prototype in a relevant environment.
Technology Demonstration	**TRL 6**	Engineering/pilot-scale, similar (prototypical) system validation in relevant environment	Engineering-scale models or prototypes are tested in a relevant environment.
Technology Development	**TRL 5**	Laboratory scale, similar system validation in relevant environment	The basic technological components are integrated so that the system configuration is similar to (matches) the final application in almost all respects.
	TRL 4	Component and/or system validation in laboratory environment	The basic technological components are integrated to establish that the pieces will work together.
Research to Prove Feasibility	**TRL 3**	Analytical and experimental critical function and/or characteristic proof of concept	Active research and development (R&D) is initiated.
Basic Technology Research	**TRL 2**	Technology concept and/or application formulated	Once basic principles are observed, practical applications can be invented. Applications are speculative, and there may be no proof or detailed analysis to support the assumptions. Examples are still limited to analytic studies.
	TRL 1	Basic principles observed and reported	This is the lowest level of technology readiness. Scientific research begins to be translated into applied R&D.

Adapted from “U.S. Department of Energy Technology Assessment Readiness Guide,” DOE G 413.3-4, 10-12-09