The Underground Research Facilities (URF) Network - Illustrating the IAEA's Concept and Use of Professional Networks – 15382

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ABSTRACT

Since 2001, the IAEA has championed the concept and use of professional networks (Communities of Practice) to advance best practices and to provide a platform for cooperation in radioactive waste management, decommissioning and environmental remediation across the globe. The Underground Research Facilities (URF) Network was the first in a series of networks implemented under the auspices of the IAEA to share experiences, elicit best practices, and transfer knowledge on topics relevant to the development and implementation of geological disposal of long lived and high level radioactive waste – i.e. intermediate level waste (ILW), high-level waste (HLW) and/or spent nuclear fuel (SNF). Special emphasis is placed on the role and use of URFs to support such geological disposal developments. In addition to the direct benefits provided to Member States through its programme of work, the URF Network also delivers less tangible, yet equally valuable benefits through the informal exchange of information, the development of peer-to-peer professional networks, and seeding of multi-lateral cooperation between Member States.

Network members represent a range of nuclear programme sizes and advancements in their respective repository programmes. After a decade of fruitful cooperation, delivering more than 30 training courses on topics relevant to geological disposal, the URF Network is gradually reassessing its mode of operation and focus of work. Emphasizing selected strategic goals – focused in part on more systematic training of URF Network members human resources and in part on select key technical issues – would benefit all network members, while remaining cautious in the commitment of scarce resources.

INTRODUCTION

The IAEA is the world's centre for cooperation in the nuclear field. It was set up as the world's "Atoms for Peace" organization in 1957 within the United Nations family [1]. The Agency works with its Member States and multiple partners worldwide to promote the safe, secure and peaceful use of nuclear technologies. As part of its Functions stated in its Statutes [1], the Agency is authorized, among others:

- To foster the exchange of scientific and technical information on peaceful uses of atomic energy;
- To encourage the exchange of training of scientists and experts in the field of peaceful uses of atomic energy;

The role and use of Underground Research Facilities to contribute to the scientific and technical basis for geologic disposal of ILW, HLW and/or SNF, as well as to contribute to public confidence, is discussed in IAEA TECDOC 1243 (2001) [3], and considered as "clearly acknowledged by outside expert forums". Chapter 8 of this report specifically discussed the use of Underground Research Laboratories (URLs) for

building confidence and fostering international co-operation, and offered among its concluding remarks that:

> ”…confidence building and international co-operation are closely linked. Joint demonstration projects can therefore be further promoted by facilitating international co-operation, e.g. under the IAEA’s aegis. Collaborative R&D and demonstration projects on technologies for the disposal of high level and long lived radioactive waste could contribute to:
>
> - Helping Member States achieve strategic objectives and make progress in implementing state-of-the-art technologies in their waste management programmes;
> - Advancing knowledge on radioactive waste disposal and integrate worldwide expertise in a cost-effective way;
> - Enhancing public acceptance for waste disposal and building international consensus.
>
> International co-operation efforts should further contribute to making the transfer of knowledge and technology for geological disposal easier to Member States not having direct access to URLs. Good identification and integration of key areas for this co-operation will make the Agency's guidance more effective.”

A Technical Committee Meeting held at IAEA in Vienna on October 8th to 10th, 2001, recognized the benefits that could be gained from continued exchange of information between Member States as well as provision of training on topics relevant to geologic disposal of radioactive waste. This Technical Meeting recommended that a *Network of Centres of Excellence* for training in and development of waste disposal technologies be implemented without delay. It was intended both (i) to support Member States lacking the resources needed to build an Underground Research Facility or participate significantly in the work needed to establish a high level of confidence in geologic disposal, and (ii) to further encourage existing interactions between Member States with well-developed disposal programmes.

As a focal point to the intended exchange of information and training under the auspices of the IAEA, the network was to consist of nationally developed URFs and associated research institutions relevant to the development of geologic disposal. The associated co-operative programme was to share in the experience gained from operating such facilities and through the associated experimentation and demonstration programmes. It was also to offer the opportunity of access and use of these facilities, institutions and resulting technical and scientific basis for geologic disposal to Member States lacking the resources to develop their own comprehensive programme.

As a consequence of this recommendation, the Underground Research Facilities (URF) Network was established in 2001. It provides a platform for worldwide sharing and transfer of experience and knowledge leading to safe, technically reliable, cost effective and timely solutions for ILW, HLW and/or SNF disposal. Its programme of work is guided by the needs of the Member States, as presented and discussed during the network's annual meetings. At these meetings, the future activities of the URF Network are decided.

Since its creation, the URF nNetwork comprises a variety of Member States ranging in size of the nuclear programme and advancement in their respective repository programmes. While network membership has grown continuously, the fundamental challenge has remained unchanged: To create a useful programme which benefits Member States with advanced development of URF infrastructure, Member States with a current siting plan for an initial infrastructure development, and Member States with no current siting plan and limited URF infrastructure. The current and future activities of this network will help ensure improved information exchange and retention, and developing a road map for the optimization of the use

of URFs in the successful implementation of radioactive waste disposal.

ORIGINAL MOTIVATION, OBJECTIVES and ORGANIZATION

Recognizing that waste isolation programmes in Member States are in various stages of development, and that plans to begin construction for a geologic repository is not contemplated for at least one, two, or more decades (estimate from 2001), network needs and activities should be assessed and tailored to corresponding Member State's needs. Most importantly, these time frames allowed the URF Network to initiate and provide robust training and cooperation to ensure the efficient development of safe waste isolation systems.

The original, major objectives of the URF Network were identified as:

- To encourage the preservation and transfer of knowledge and technologies in geologic disposal;
- To supplement national efforts and promote public confidence in waste disposal schemes;
- To contribute to the resolution of key technical issues.

It has been recognized since Network inception that while direct participation in URF activities is a primary interest to some Member States, numerous other member state needs are also focused on other aspects of geologic disposal studies, such as understanding the relative merits of various host media, associated generic design considerations, site selection criteria, approaches to conduct site characterization, or developing overall system safety assessments.

Furthermore, the importance of both technical and non-technical factors for successful development and implementation of disposal programmes was recognized. One aspect of this is sharing in the experience gained by the IAEA and by the network's Member States, of presenting various aspects of disposal development, of the scientific and technical basis for safe disposal, and indeed of the basis for experts' confidence in disposal feasibility and safety to non-specialist audiences.

Finally, the original URF Network Terms of Reference [3] identified a few key technical issues that would benefit from further cooperation, for example:

- A reversibility/retrievability demonstration test in salt medium,
- A comprehensive R&D project on the long-term monitoring of geologic repositories,
- R&D studies and demonstration on the application of safeguards standards during the operational phase and partial closure of a geologic repository in clay.

These topics remain timely, were and remain ambitious and their realization is only possible with substantial human and financial resources committed by network members to address these issues.

These objectives were maintained for well over a decade, and the particular role that URFs play in the development of geologic disposal was recognized from the networks creation, and at a later stage further recognized as a fourth major objective:

- To work on solutions for Member States currently without URFs.

REVIEW OF URF ACTIVITIES 2001 – 2013

After the initial Technical Committee meeting of October 2001, a proposal for an IAEA Interregional Technical Cooperation project was developed, approved as project INT/9/173, and managed through the IAEA Technical Cooperation Department. The IAEA technical cooperation (TC) programme is the main

mechanism through which the IAEA delivers services to its Member States [5]. Through the programme, the IAEA helps Member States to build, strengthen and maintain capacities in the safe, peaceful and secure use of nuclear technology in support of sustainable socioeconomic development. TC projects provide expertise in fields where nuclear techniques offer advantages over other approaches, or where nuclear techniques can usefully supplement conventional means. All Member States are eligible for support, although in practice technical cooperation activities tend to focus on the needs and priorities of less developed Member States.

This project INT/9/173 provided 2008 management and financial support to fund a series of 16 training courses and workshops delivered between 2003 and 2008 to representatives of 23 Member States. Further to the organizational and financial support received through this project, some of the Network Members agreed to provide significant, in kind contributions to the network activities for the benefit of the entire network. To recognize this and their pro-active role in further network developments, they formed a core group known as the Network Partners. As owners and managers of facilities and laboratories, they offered access to their knowledge and/or infrastructure, provided experts that contributed to training, and agreed to host training and demonstration activities relating to the disposal of ILW, HLW and/or SNF.

This cooperation provided substantial benefits to Member States, in particular to exchange and train on fundamental topics of interest when establishing a geologic disposal project. The specific topics, host organizations and external experts and/or facilitators are discussed and agreed during the networks annual meeting. The 16 training courses were hosted, in turn, by Canada, the USA, Belgium, the Czech Republic, Hungary, Switzerland, the UK, Sweden, and Germany – with some organizations offering a training course venue repeatedly. As part of the training programme, technical visits to URFs or other facilities of the host organization were also organized.

These training courses aimed at developing basic understanding of topics relevant to the development of a geologic disposal programme, and included training courses on:

- Fundamentals of geologic disposal;
- General methodologies for geologic disposal;
- Decision-making and stakeholder involvement;
- The role of siting;
- Focused technical/scientific topics – disposal in sedimentary formations, transport and retardation in fractured rocks, and use of cement and cementitious materials;
- Design, construction and operation; and
- The role and use of numerical simulation.

Upon closure of the interregional project INT/9/173 in 2008, the annual network meeting and in particular, the Member States whose national geologic disposal developments were still at an early stage, reported on the positive impact of the network activities in their national programmes. They highly recommended a follow-up project for capacity building by training in both fundamentals and specific aspects of geological disposal technologies. As more than half of the recipient Member States and almost all underground research facilities are in Europe, it was considered that further Technical Cooperation support should be provided under a European regional project while maintaining the option for other Member States to participate through their specific national or regional Technical Cooperation projects.

Such a project was proposed and approved for the period 2009-2013, as project RER/9/103, providing support to 12 European Member States, and open to participation from other Member States around the world. The projects' overall aim, consistent with the URF Network's objectives, was focused on

transferring knowledge and technology from Member States with advanced research and development programmes in URFs to Member States with less developed repository implementation programmes and/or no direct access to URFs. It funded workshops and training courses to support knowledge and technology transfer to Member States with less developed geological disposal implementation programmes and/or no direct access to URFs. Overall, 17 training courses, three workshops on timely topics, a group scientific visit and a report were delivered under this cooperation project, making use of the URF Network for its implementation, and thus providing cumulative training and information to more than 300 participants.

Table I below provides an indication of the extent of this continuous effort and support, with an overview of event topics, hosts, venues, and participating Member States.

Another main conclusion of the 2003-2008 Technical Cooperation project was that, while Member States mostly interested in training opportunities were provided with a continuous support matching their needs, the URF Network partners and national organizations representing advanced geologic disposal programmes did not find the opportunity to exchange information on more advanced technical issues. Therefore, the 2009-2013 project also provided for the organization of three workshops, to address timely topics of interest to URF Network members representing advanced programmes. An overview of these is provided in Table II.

Overall, this decade of sustained cooperation and management of the URF Network provided substantial amounts of information and training to waste management professionals from Member States at various degrees of progress in establishing and implementing a geologic disposal programme – ranging from uncertain overall plans and absence of national policy to the most advanced programmes at or near licensing. Consistent with this, benefits range from maintaining a fundamental understanding of what is needed for safe disposal of ILW, HLW and/or SNF, over offering an opportunity for training to young professionals in advanced programmes.

Equally as important, the consistent management and secretariat provided by IAEA to this URF Network established an international community of professionals dedicated and focused on preserving and sharing knowledge and information relevant to the implementation of geologic disposal, including representatives of virtually all the URFs presently and recently in operation worldwide.

TABLE I. Overview of Training Courses delivered through the URF Network within the RER9103, 2009-2013 Technical Cooperation project:

Date	Host - Location	Title	Objectives	Participants
15-19 June 2009	IRSN Tournemire (France)	Underground testing in hard clays as a geological formation for radioactive waste disposal	To expose participants to a broad background on several characterization methods of hard clays, examining a range of pertinent subjects from geology, hydrogeology, geochemistry, geomechanics to numerical modelling. The course focused on the development of the French programme, IRSN's position as technical support organisation to the French regulator and its tools such as the Tournemire experimental platform. It included both classroom training and group visits inside the platform in order to gain an appreciation of applications of the course work and the scientific work that has been carried out by IRSN and its partners.	13 from: ARG, ARM, CRO, CZR, GFR, HUN, KAZ, MEX, ROM, SLO, SLR, UKR
15-24 Sept. 2009	RAWRA, NRI & NAGRA Puhonice (CZR) & Meiringen (SWI)	Surface-Based and Underground Site Characterization for Geological Repositories in Sediments and Hard Rocks	To (a) take participants through the steps of planning, carrying out and evaluating surface-based investigations at prospective geological repository site (Czech Republic); and (b) to look at the important transition to underground characterization work at sites selected for detailed evaluation through examining techniques for underground rock characterization and considering the planning of activities in deep rock characterization facilities (Switzerland).	13 from: ARG, CRO, CZR, MEX, PAK, PHI, POL, ROK, SLO, SLR, UKR
26 Oct. – 4 Nov. 2009	DBE Technology Peine (GFR)	Fundamentals of Geological Disposal in Sedimentary Environments	Present the main scientific and engineering aspects that need to be considered in the development of repositories in clay and salt formations. Also consider some societal issues involved in repository development, such as communication with stakeholders. Visits to the underground facilities at Konrad and Gorleben illustrated how the developing understanding of pathways for radionuclide migration has led to the definition of repository design and execution at these sites.	15 from: ARG, CRO, CZR, GFR, HUN, MEX, ROM, RUS, SAF, SLR
18-25 June 2010	Sandia National Laboratories Albuquerque (USA)	Advanced Conceptual and Numerical Methods for Modelling Subsurface Processes Regarding Nuclear Waste Repository Systems	Develop competencies in the skills required to develop natural systems understanding and its representation through the use of models, which may include simulations of the migration of radionuclides and the effects of human activities. Elucidate the use of modelling for the interpretation of natural systems and its critical link to support repository design studies and safety assessment.	14 from :BUL, CPR, CZR, HUN, KAZ, MEX, PHI, POL, ROK, SLR, UKR

Date	Host - Location	Title	Objectives	Participants
8-17 Sept. 2010	JAEA Horonobe & Tokai (Japan)	Fundamentals of geologic disposal	To inform and update participants' present knowledge of the technologies and methods used in the development of geologic repository programmes for HLW/SF and other long-lived waste.	14 from: ARG, BUL, CPR, CZR, PAK, POL, ROK, ROM, RUS, SAF, SLR, UKR
18-22 Oct. 2010	SCK/CEN Mol (Belgium)	Geological Disposal: From R&D to Safety Case Development	To inform and train participants about methods and technologies used in the development of geological repositories for HLW/SF and other long-lived waste, particularly in clay environments.	11 from: ARG, CRO, CPR, KAZ, POL, ROM, RUS, SAF, UKR
30 Nov. – 10 Dec. 2010	Nagra, ITC, Swisstopo & PSI Wuerenlingen & Meiringen (SWI)	Transport and Retention of Radionuclides in Argillaceous and Fractured Media	To inform participants about methods and technologies used in site characterization and the development of geological repositories for HLW/SF and other long-lived waste, particularly regarding radionuclide migration and retardation. The data acquisition and interpretation methods to be described and the approaches to inform safety case development have application in both sedimentary and hard rock disposal environments. Provide technical visits to ZWILAG, Beznau NPP, Mont Terri URL & Grimsel Test Site URL	11 from: ARG, BUL, CRO, KAZ, MEX, PAK, POL, ROM, RUS, SLR
16-20 May 2011	Andra Meuse/Haute-Marne Centre, Bure (France)	Evaluating and Describing Site Conditions for Geological Disposal based on the ANDRA Programme of Site Characterisation and Underground Experiments in France	To inform participants about methods and technologies used in the development of geological deep disposal facilities for HLW/SF and other long-lived waste. The examples to be demonstrated are based on the extensive research programme adopted in France by ANDRA for a clay environment. However, many of the data acquisition and interpretation methods to be described and the strategy adopted to define experiments to address outstanding uncertainties have applications in other potential disposal environments. Provide technical visits to the Bure URF and to the Disposal Technology Exhibit Centre.	15 from: ARG, BRA, CZR, GHA, INS, KAZ, LIT, ROM, RUS, SLO, SLR, THA, UKR
14-23 June 2011	Czech Technical University Prague & Josef underground	Fundamentals of geological disposal	To inform and update participants with knowledge about the methods and technologies used in the development of geological repositories for high-level waste/spent fuel and other long-lived waste.	14 from: BUL, CPR, CZR, HUN, KAZ, MEX, PHI,

Date	Host - Location	Title	Objectives	Participants
	facility (CZR)			POL, ROK, SLR, UKR
7-11 Nov. 2011	DBE Technology Peine (GFR)	Practical Aspects of Repository Engineering for Disposal of HLW/Spent Fuel in Sedimentary Environments	To inform and update participants with knowledge about the methods and technologies used in the development of geological repositories for high-level waste/spent fuel and other long-lived waste and specifically concerning the engineering aspects of repository operations. The course is to examine a range of technologies from the handling of the wastes to be disposed right through all the stages to geological disposal. Provide technical visits to Konrad and Gorleben.	14 from: BRA, CRO, HUN, INS, LIT, MAL, POL, ROM, RUS, SLO, THA, UKR
18-22 June 2012	ITN Lisbon (POR)	Identifying and Managing Uncertainty for Post-Closure Safety Assessments in Support of Repository Development Programmes	To provide participants involved in radioactive waste management with a good understanding of uncertainty in the context of safety assessments for radioactive waste repositories: What it means, the various types of uncertainty that may be encountered, how to classify it, how to analyse uncertainties and how to manage them. Main messages are equally relevant for near-surface disposal programmes as well as for geological disposal programmes.	21 from: BRA, CZR, GHA, HUN, INS, LIT, MAL, PAK, POL, POR, ROK, ROM, RUS, SLO, SLR, UKR
10-14 Sept. 2012	IRSN Tournemire (France)	Characterizing Hard Clay Environments for Radioactive Waste Disposal - Highlights from IRSN Safety Research Performed at Tournemire to Support Regulatory Review	To help Member States at all stages of programme development to make decisions leading to the selection of sites for underground facilities in order to inform decision makers on major choices for national bodies, institutions and organisations.	12 from: BUL, HUN, INS, LIT, MAL, MEX, PAK, POL, ROM, SLR, UKR, VIE
15-19 Oct. 2012	Nagra & Swisstopo St Ursanne & Meiringen (SWI)	Monitoring in Argillaceous and Chrystalline Rocks in the Context of Repository Development	To inform participants about methods and technologies used at different scales for site characterisation and to provide an insight into monitoring requirements at different stages of repository implementation to support the development of geological repositories for high-level waste, spent fuel and other long-lived waste.	13 from: BRA, CPR, CRO, GHA, HUN, PAK, POL, ROM, RUS, UKR, VIE
19-23 Nov	PAA Warsaw (POL)	Lessons Learnt in the Area of Stakeholder	To engage participants involved in radioactive waste management to: (i) understand why stakeholder dialogue is important; (ii) identify	34 from: BUL, CRO, GHA,

Date	Host - Location	Title	Objectives	Participants
2012		Dialogue to Strengthen National Competencies for Radioactive Waste Disposal	what the key challenges are when involving stakeholders in disposal programmes; and (iii) to be aware of how stakeholder interactions can constructively support the successful implementation of repository programmes through all phases of development.	HUN, JOR, LIT, MAL, PHI, POL, ROM, THA, UAE, UKR, VIE
1-5 July 2013	IAEA (Delivered by Sandia experts) Vienna (Austria)	Identification, Analysis and Presentation of Spatial Variability in Site Investigations for Radioactive Waste Repositories	To (i) summarise and communicate, by way of lectures, examples and idealised exercises, how natural site heterogeneity can be represented in site investigation studies for radioactive waste disposal programmes; To (ii) provide participants with the tools and understanding necessary for them to sample, analyse, manage and present spatial variability in safety assessments; and To (iii) suggest communication strategies about how uncertainty and spatial variability should be treated more widely in a safety case, in order to engage more effectively with.	14 from: ARG, BRA, BUL, HUN, JOR, LIT, MAL, PAK, POL, ROM, RUS, SLO, UK, UKR
2-13 Sept. 2013	Czech Technical University & Cardiff University JOSEF-Educational Research Facility, Czech Technical University (CZR) and the Geoenvironmental Research Centre, Cardiff University (UK)	Obtaining site data and developing numerical simulations to characterize and assess processes relevant to Bentonite Barriers and Near-field interactions	To (i) summarise and communicate the role of engineered barrier systems in containing high activity radioactive waste in geological repositories and to particularly describe the work that has been carried out to date on the characteristics and use of bentonite; To (ii) provide participants with hands-on experience of how to design and operate in situ experiments and collect field data concerning bentonite barriers and near-field properties; and To (iii) learn how to develop and assess conceptual models of the near-field and to set-up, populate and run coupled Thermal-Hydro-Mechanical numerical models that are intended to inform on bentonite barrier processes.	15 from: ARM, BUL, CZR, GHA, HUN, INS, LIT, MAL, PAK, POL, ROM, UK, UKR, VIE
11-15 Nov. 2013	JAEA Mizunami (Japan)	Fundamentals of geological disposal	To inform and update participants' present general knowledge of the technologies of the development of geological repositories for high-level waste, spent nuclear fuel and other long-lived waste.	16 from: BUL, CPR, GHA, HUN, INS, LIT, MAL, POL, RUS, UKR

TABLE II. Workshops delivered through the URF Network within the RER9103, 2009-2013 Technical Cooperation project:

Date	Host - Location	Title	Objectives	Participants
6-10 Dec. 2010	Sandia National Laboratories Las Vegas (USA)	Strengthening National Competencies in The Area of Stakeholder Engagement for Radioactive Waste Disposal	To enhance the human resource capabilities of Member States and their capacity to manage repository development programmes by providing an understanding of stakeholder concerns around radioactive waste disposal and how these concerns might be addressed, both at the level of national Policy and Strategy and also in terms of operational planning for stakeholder involvement.	13 from: ARG, BRA, CRO, GHA, LAT, MEX, POL, ROM, SAF, SLO, THA, UKR, VIE
28 Nov – 2 Dec 2011	British Geological Survey Keyworth, Nottingham (UK)	Enhancing Confidence in Geological Disposal of Radioactive Waste: Role of Natural Analogues and Safety Indicators	To demonstrate in the use of natural analogues and safety indicators to enhance confidence in the development of a safety case for the geological disposal of radioactive wastes. To visit natural analogue sites in England.	12 from: BRA, BUL, CRO, LIT, PAK, POL, ROM, SAF, SLO, SLR, UKR
23-27 Sept. 2013	DBE Technology Peine (GFR)	Engineering for Safe Geological Repository Construction and Operation	To strengthen the understanding and potential for making sound decisions on engineering developments needed to implement a geological disposal through exposure to relevant engineering considerations, recent examples of successful developments and information on those aspects of engineering design which have proven to be challenging. To conduct a technical visit to the Konrad geologic disposal, and discuss ongoing refurbishment construction.	18 from: ARM, BUL, CZR, GHA, HUN, INS, LIT, MAL, PAK, POL, ROM, UK, UKR

RECENT EVOLUTIONS AND FUTURE PLANS

The 2013 URF Network annual meeting provided an opportunity to review and discuss this first decade of network activities and its strong emphasis on providing training to young professionals and to programmes that are less advanced. Upon revisiting its overall initial motivations, a transition from a dominantly communication and information exchange forum to a programme of work focused on addressing strategic topics was initiated. Network members would propose and assess topics of shared interest, and discuss options to pursue these through the network. Issues surrounding the use of the URF Network to support national repository programme development will remain central to this.

As a first step, the 2013 URF Network annual meeting decided to assess the current use, and/or understanding of network members of the potential use of generic URFs to support national programme developments. Two questionnaires were developed to inquire on Member States use of their generic or site-specific URFs to support their national programme, and Member States expectations for potential cooperation in other URFs to support their early national disposal programme. Results being analyzed are expected to provide a reference to assist Member States in making their own strategic decision on when and where to develop and site a national URF.

To date questionnaire feedback from Brazil, Khazakhstan, India, Lithuania, Poland and the United Kingdom has been reported and analyzed by the URF Network. These Member States range from large nuclear programmes to small programmes in the decommissioning phase. All Member States do not have a current repository site and are interested in a variety of repository options in several geologic media. The primary drivers for developing a URF for each country were: characterization of the specific physical processes and technology testing, demonstration of safety and facilitating public acceptance. All Member States desired to utilize data from existing URFs, especially those sited in a comparable geology, to help develop initial designs and safety case arguments. In addition, most Member States considered it important to develop their own site-specific URF for characterization and testing of a particular media and disposal design as a milestone in repository development. However, significant hurdles were identified for developing URFs including financing, public acceptance, decision making and scheduling.

Given the significant hurdles associated with the development of URFs, the degree of transferability and applicability of existing data from generic or site-specific URFs to other sites is a key question. Over the past 40 years a significant number of generic and site-specific URFs have been operated (Figure 1). The OECD/NEAs Radioactive Waste Management Committee (RWMC) published a report in 2001 describing the role of URFs in nuclear waste disposal programmes [6], and in the same year the IAEA provided a review on how URFs contribute to the scientific and technical basis for geologic disposal of long lived and high level radioactive waste, as well as to public confidence in geological disposal. More recently (2013), the OECD/NEA RWMC reviewed and published the strategic outlook of NEA Member States on URFs [7].

The recognition that significant data exists which can be leveraged to build confidence in a safety case leads to questions about the need and timing of site-specific URFs for individual Member States, and the need for additional generic URFs in geological media which are not covered by the existing network (Figure 1). Given the financial, societal and logistical barriers for URL/URF development, there is a significant need to optimize the development and utilization of URFs at the international level in order to facilitate individual Member States successful implementation of geological disposal.

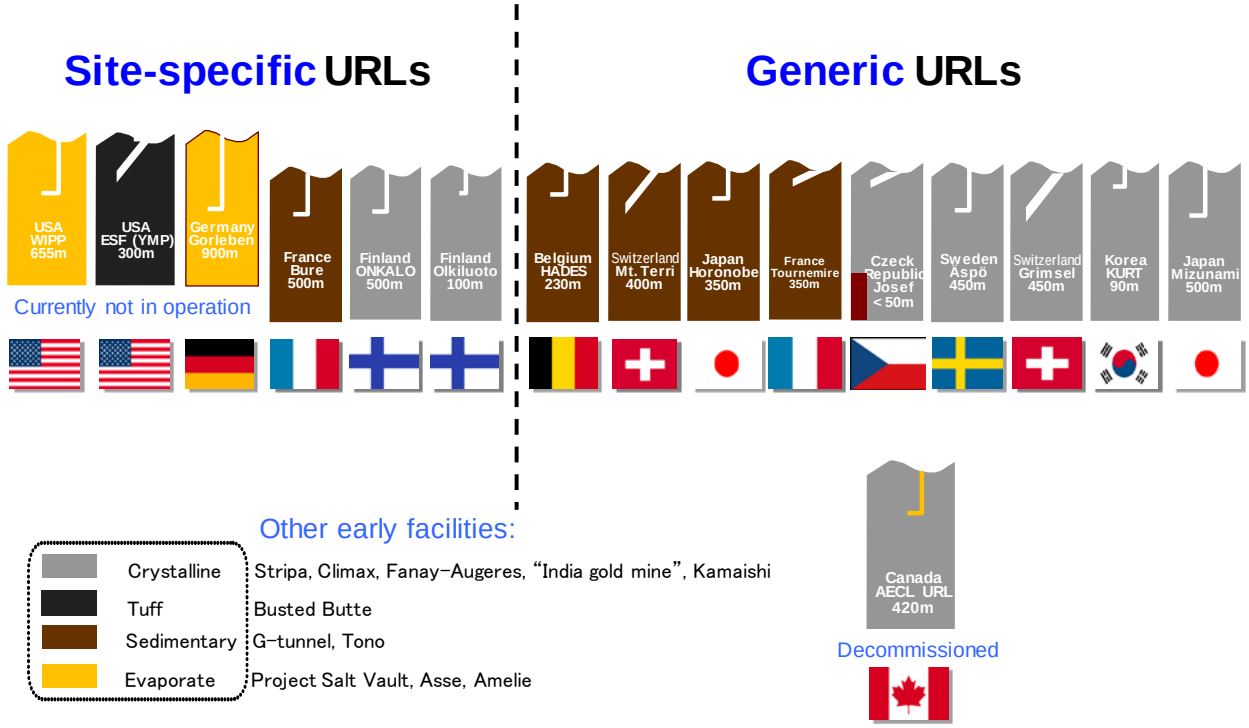

Figure 1 - Summary of URFs and their respective geological media around the world. Site-specific and generic URFs are separated by the dashed line. Shaft, and tunnel access is indicated by the shape of the access feature. Closed URFs are indicated by a yellow (backfilled) tunnel.

Systematic incorporation of international data from both site-specific and generic URF is a significant component of the safety case, but the implementation and use of experiments in a URF has been largely country specific. That is to say, results obtained through URF experiments were shared, compared and discussed. However, only a few programmes implemented experiments or demonstrators specifically for which a common interest to several national programmes was recognized from the start, and incorporated into the design of the URF activity. A more systematic international approach to leveraging URF data and infrastructure would help optimize these institutions and their role in the safe disposal of nuclear waste. Recognizing this, as well as the need to develop costly and time-consuming, large scale demonstrators, a significant step in that direction has already been taken. Several years ago, EURATOM established the IGD-TP platform, whose programme of work incorporates a suite of such large scale demonstrators under development by several national programmes, in cooperation with the participants to that platform.

In 2014 a URF Network workshop was held to specifically address the role of URF in the development of national programmes [10]. The meeting was designed to get member states input and develop an international consensus on:

- The role of URFs in the iterative development of a Safety Case;
- The link between URF R&D and the overall repository science programme;
- How to best utilize URFs to support individual programme needs.

These items were considered in general, and also assessed in the context of an evaporite host formation. Presently, no URF in salt remains accessible to conduct further generic research. It is acknowledged that

substantial earlier work has been performed to assess some of the fundamental properties of salt for waste isolation, and e.g. numerous thermal-mechanical experiments have been conducted. The question was thus raised whether it is necessary to construct a new URF in salt, to pursue generic studies on geologic disposal in such a host formation.

The results of this workshop as given in [10] indicate that:

- URFs are a primary reason that nuclear waste repository technology is at a high level of maturity.
- URFs should be recognized as a long-term process which can be used to improve the Safety Case and build public confidence throughout the entire repository development cycle.
- Data and knowledge utilization and preservation from existing and closed URFs should be systematic, and an easily accessible knowledge base should be established soon.
- The URF should be used as both a scientific and engineering facility to characterize and investigate physical processes, but also to test and optimize engineered technologies.
- A URF in salt would eventually be needed if a country had specific plans to site a repository in such a host formation.

These recent meetings have shown that the URF Network can function as an excellent platform of knowledge transfer and communication, and also play a larger strategic role in helping build an international consensus on how to optimize the use of URFs towards the final goal of successful implementation of radioactive waste disposal. Network members agree that a programme of work striving to develop selected strategic goals through agreed projects – focused in part on more systematic training of URF Network members human resources and in part on select key technical issues – would benefit all network members, while remaining cautious in the commitment of scarce resources. As a result of such recent assessment, current plans envision improving the efficiency of transfer of know-how, by considering a more systematic sequence of workshops that develop a specific topic from fundamentals to advanced levels. They will benefit from the recent launch of a comprehensive, IAEA web-based eLearning suite on radioactive waste disposal – ensuring that fundamental knowledge of radioactive waste disposal has been acquired prior to any workshop. The URF Network will also provide feedback on the content of these eLearning modules and thus be a forum to test eLearning delivery. In addition, fellowships and scientific visits from younger staff will help enhance their professional development as well as build peer-to-peer professional networks and foster cooperation between organizations.

Better utilization and preservation of internationaly-derived URF data and experience will be accomplished through new common platforms including the IAEA CONNECT [6] web platform, and its hosted Wiki site allowing member states to readily update the current state of knowledge in the field. The increased data exchange provided by these platforms will be leveraged by focused workshops to develop international consensus on how to best utilize existing and planned URFs to facilitate the national programme needs of individual Member States. The URF Network members will both benefit from the access to these platforms and be primary producers of the content on these platforms.

CONCLUSIONS

At the present time there are eleven Networks organized under the auspices of the IAEA in these and related areas [6]. Over ten years of URF Network operations illustrate how, under the auspices of the IAEA, such networks evolve into communities of professionals willing to share their experiences, developing options for cooperation and providing training to benefit young professionals in waste management organizations as well as the larger human resource developments in national programmes –

either because these are still in the early stages of development, or to plan for and ensure talent succession in mature programmes staffed with an aging workforce. They also illustrate that the networks programme of work and mode of operation requires constant assessment and adjustment to adapt to network members needs and preferences as well as to the resources available to carry out network activities.

As a result of such recent assessment, current plans envision improving the efficiency of transfer of know-how, by considering a more systematic sequence of workshops that develop a specific topic from fundamentals to advanced levels. They will benefit from the recent launch of a comprehensive, IAEA web-based eLearning suite on radioactive waste disposal – ensuring that fundamental knowledge of radioactive waste disposal has been acquired prior to any workshop. The network is also currently assessing whether developing a more thorough review of past experimental results obtained in URFs could be beneficial to the planning of future URF experimental and demonstrator programmes – and indeed whether such an ambition can be met through the combined input of all URF Network members.

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