

Implementing Geological Disposal of Radioactive Waste Technology Platform From the Strategic Research Agenda to its Deployment – 12015

Gérald Ouzounian*, P. Marjatta Palmu** and Torsten Eng***

* ANDRA, Chatenay-Malabry, France

** Posiva Oy, Eurajoki, Finland

*** SKB, Stockholm, Sweden

ABSTRACT

Several European waste management organizations (WMOs) have initiated a technology platform for accelerating the implementation of deep geological disposal of radioactive waste in Europe. The most advanced waste management programmes in Europe (i.e. Finland, Sweden, and France) have already started or are prepared to start the licensing process of deep geological disposal facilities within the next decade.

A technology platform called Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP) was launched in November 2009. A shared vision report for the platform was published stating that:

"Our vision is that by 2025, the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste will be operating safely in Europe."

In 2011, the IGD-TP had eleven WMO members and about 70 participants from academia, research, and the industry committed to its vision. The IGD-TP has started to become a tool for reducing overlapping work, to produce savings in total costs of research and implementation and to make better use of existing competence and research infrastructures. The main contributor to this is the deployment of the IGD-TP's newly published Strategic Research Agenda (SRA). The work undertaken for the SRA defined the pending research, development and demonstration (RD&D) issues and needs. The SRA document describing the identified issues that could be worked on collaboratively was published in July 2011. It is available on the project's public website (www.igdtp.eu). The SRA was organized around 7 Key Topics covering the Safety Case, Waste forms and their behaviour, Technical feasibility and long-term performance of repository components, Development strategy of the repository, Safety of construction and operations, Monitoring, and Governance and stakeholder involvement. Individual Topics were prioritized within the Key Topics. Cross-cutting activities like Education & Training or Knowledge Management as well as activities remaining specific for the WMOs were as well identified in the document. For example, each WMO has to develop their own waste acceptance rules, and plan for the economics and the funding of their waste management programmes.

The challenge at hand for the IGD-TP is to deploy the SRA. This is carried out by agreeing on a Deployment Plan (DP) that guides organizing the concrete joint activities between the WMOs and the other participants of the IGD-TP. The first DP points out the coordinated RD&D projects and other activities that need to be launched to produce these results over the next four to five years (by the end of 2016). The DP also describes general principles for how the joint work can be organised and funded.

INTRODUCTION

In the field of radioactive waste management, the closest great challenge is the implementation of geological repositories to dispose of spent fuel, high-level and other long-lived wastes. As a joint effort, the waste management organisations of several European countries launched in November 2009, with the support of the European Commission, a technology platform called Implementing Geological Disposal of Radioactive Waste Technology Platform (IGD-TP). The following common vision of this technology platform was described in the Vision report, which is the founding document of the IGD-TP [1, 2]:

"Our vision is that by 2025, the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste will be operating safely in Europe."

A shared Vision among ten European radioactive waste disposal implementers was a key issue to further identify and analyse the remaining research, development and demonstration (RD&D) needs for the future geological disposal projects. One of the main objectives of the IGD-TP is to produce savings in total costs of research and implementation by constituting a tool for reducing overlapping work, and to make better use of existing competence and research infrastructures. The three countries closest to licensing, i.e. Finland, France and Sweden, plan to commission their respective geological repository by 2025. Other countries with repository programmes further from licensing will benefit from the experience gained by these three programmes and will contribute to further developments and thus get prepared for the work needed in their own programme by accumulating shared experiences and knowledge from the IGD-TP's joint activities.

The SRA identified and prioritized the RD&D issues that could be worked together in Europe to achieve the IGD-TP's vision. The SRA was published in July 2011 and is also available from the IGD-TP website (www.igdtp.eu) [3, 4].

THE CONTENT OF THE STRATEGIC RESEARCH AGENDA

A thorough review of existing information was performed by the implementers. Each of them has identified its main RD&D needs to fulfil the 2025 Vision. The remaining needs were then organized through Key Topics, including more detailed Topics related to them. For each of the Key Topics, the SRA includes their specific definitions, objectives and the rationale and benefits from addressing the Key Topic. The strategy for the joint RD&D interest was organized in seven Key Topics:

- Key Topic 1: Safety case.
- Key Topic 2: Waste forms and their behaviour.
- Key Topic 3: Technical feasibility and long-term performance of repository components.
- Key Topic 4: Development strategy of the repository.
- Key Topic 5: Safety of construction and operations.
- Key Topic 6: Monitoring.
- Key Topic 7: Governance and stakeholder involvement.

The Key Topics comprise 37 individual Topics, with the majority of the Topics concentrating on the "Technical feasibility and long-term performance of repository components" reflecting the maturity of the repository development in the waste management programmes closest to licensing. Sixteen Topics were identified as being of high priority and urgency for future deployment of the SRA within the Key Topics. In addition, four areas for Cross-cutting Activities were identified, including Dialogue with the regulators; Competence maintenance, education and training; Knowledge management; and Communication.

In addition to the identification of the major areas of strategic RD&D needed to achieve the IGD-TP's vision, the SRA document describes the background of the SRA work, the framework and methodology for developing the SRA and the way forward to deploy the SRA.

THE DEPLOYMENT PLAN'S IDENTIFIED TYPES OF JOINT ACTIVITIES FOR IMPLEMENTING THE SRA

The goal of the deployment of the IGD-TP's SRA is to assist the IGD-TP Executive Group members and participants in achieving the vision and the desired results by joint RD&D activities during the next years. The IGD-TP's vision report states that the main objectives of the IGD-TP are to initiate and carry out European strategic initiatives to facilitate the stepwise implementation of safe, deep geological disposal of spent fuel, high-level waste, and other long-lived radioactive waste by solving the scientific, technological

and social challenges, and to support the waste management programmes in the Member States. The platform intends to constitute means to further build confidence in the solutions, to reduce overlapping work, to produce savings in total costs of research and implementation, and to make better use of existing competence and research infrastructures. This is done e.g. by pooling critical resources and preparing co-ordination of future projects, and also by pooling resources for other types of joint activities.

The following five different generic types of joint activities that could be implemented for the deployment of the SRA Topics were identified by the Deployment Plan Working Group:

1. **Information Exchange Platform (IEP):** this type of activity would provide for organized forums of exchange between the IGD-TP members and the other participants. It allows for discussion on programmatic choices made and on technical options to discuss and highlight differences. The organization of an IEP is based on a simple form of agreement or terms of reference on a non-commercial basis. The work could include e.g. common databases and the contribution of the participants would consist of in-kind work. In all cases each party to the platform covers their own costs of participation and offers to organize the platform meetings in turns.
2. **Organizational Working Group (ORWG):** this is a working group coming together for the specific purpose of organizing a Topic. Its work focuses on either the strategic or practical organizational approaches around the respective SRA Topic (e.g. organizing peer reviews or benchmarking) more than on detailing the technical matters related to a technical or scientific Topic itself. This type of working group aims to have more a task and time specific focus compared with an Information Exchange Platform, which can address several Topics during its lifetime. The outcomes of an ORWG can also provide for more permanent infrastructures e.g. in the case of organizing expert pools for peer reviews or improvements in organizational efficiency at the participant organizations via benchmarking practices. The cost contributions for this type of work could be similar to the technical working groups or to technological transfer (e.g. for peer review cases). The group does not engage directly in scientific or technical work; it has a specific task and time specific focus (limited lifetime of the group).
3. **Technical/Scientific Working Group (TSWG):** this is a working group with the specific purpose of development of a scientific or technical topic, i.e. preparatory work is conducted on a Topic to generate a possible Technical Project. Within this activity sufficient level detail for preparing a project plan and launching a joint project is made. This type of work may include e.g. a more detailed scoping and framing of a scientific or technical issue or the preparation of state-of-the-art subject-matter reports for a focused identification of needs prior to the development of a technical project plan. The outcome of the work can be the establishment of a technical project or transmitting the Topic e.g. for further exchange to an Information Exchange Platform. The lifetime of this activity is limited according to its defined task. In this type of activity, each party engaged in the work of the group covers their own costs of participation and offers to organize the group meetings on a rotating basis. This type of working group activities have long existed among the IGD-TP members and have also involved the organization of dissemination workshops to introduce the results. For a topic of a narrower scope, organizing a joint workshop of experts may also address the topic sufficiently.
4. **Technical Project (TEP):** this activity covers technical or scientific work on a specific SRA Topic. A TEP can either be immediately launched or needs very minor clarification before a detailed project plan and project agreement between the project parties can be produced and/or before launching the technical or scientific project. The focus of this activity is on the technical and scientific information needed to formulate a technical project. The sharing of the costs of this type of activity can consist of shared (direct) payments by the partners either via the project leader or to potential subcontractors. The cost division for the project implementation and various rights to the project results need to be agreed upon in advance between the engaged parties according to the IGD-TP's governance guidelines.
5. **Technology Transfer (TT):** this takes place between the actors by having a more balanced contribution from the engaged parties compared with the IEP. For example, it can be based on agreements of transfer of previously acquired results or knowledge on a commercial basis, in-

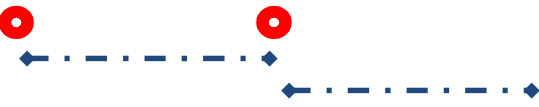




kind contributions or on less formal pooling of expertise on a non-commercial basis. The scope of the transfer in alignment with the IGD-TP vision should address the transfer of results that contribute to the licensing needs or the stages of repository development to be addressed to provide a license application of the recipient organization or organizations. The sharing of the costs of this type of activity can consist of direct payments of the associated costs either via the project leader or to potential subcontractors. The cost division for the project implementation and various rights to the project results need to be agreed upon in advance between the engaged parties according to the IGD-TP's governance guidelines.

DEFINING THE DEPLOYMENT TIMELINE

Together with the first analysis that was performed to group each of the Topics according to the potential types of joint activities suitable for their deployment, an overall timeline of the deployment of the Key Topics and their contents was then established for the activities needed to be implemented during 2011-2016. The first master schedule is presented in Table I. A green bullet on the master schedule means that a decision to go ahead was taken by the Executive Group of the IGD-TP, a red bullet shows the time at which a decision on go-ahead needs to be taken. A solid green line indicates a TEP and a dashed green line indicates the implementation time of a potential new TEP. And finally, a dashed blue line indicates joint work to be carried out in a working group.

Table I: Timeline of the deployment of the IGD-TP activities

| SRA Topics and their deployment activities | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|------|------|------|------|------|------|
| Waste forms and behaviour: TEP launched in 2011 (Topics 2.1, 2.4, 2.5) | | | | | | |
| Plugging & Sealing: TSWG launched in 2011 (Topics 3.6, 3.10, decision of the June 2011 EG) | | | | | | |
| Waste forms and their behaviour: TSWG on C14 (topic 2.2, Releases from ILW and their detailed characterization) | | | | | | |
| Monitoring the Environmental reference state: TSWG (Topic 6.3) | | | | | | |
| Safety of construction and operation: ORWG (Topics 5.1 and 5.2) | | | | | | |
| Materials interactions: ORWG (Topics 1.1, 3.12, 3.15, 3.17) especially cement and clay based interactions | | | | | | |
| Monitoring programme: ORWG (Topics 6.1, 6.2, 6.4) | | | | | | |
| Safety Case: ORWG on process model benchmarking (Topic 1.3) | | | | | | |
| Safety Case Peer review: ORWG (Topic 1.2) | | | | | | |
| Long-term stability of bentonite in | | | | | | |

| SRA Topics and their deployment activities | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 |
|---|--|------|------|------|------|------|
| crystalline environments: Activity type to be decided at the November 2011 (Topic 3.9) | | | | | | |
| Various topics (Topics 7.1, 3.1, 3.2, 3.3, 3.4, 3.5, and 3.16) Topics concern the governance of the decision making and various topics related to technical feasibility of repository components |  | | | | | |
| ORWG on Adaptation and optimisation of the repository (topic 4.1) |  | | | | | |
| ORWG on Communicating result from RD&D (topic 7.2 and CC4) |  | | | | | |
| Competence Maintenance, Education and Training: ORWG CMET (CC 2) |  | | | | | |
| Nuclear Knowledge Management: ORWG NKM (CC3) |  | | | | | |

The following text envisages ideas on what type of activities could be started for the period 2011-2016 besides the joint activities that are already on-going or that have been given a go-ahead based on the master schedule shown in Table I.

On-going and Potential Preparation of Technical Projects

Two TEPs were launched jointly in 2010 and 2011; first the LUCOEX¹ project on THM in-situ demonstration experiments, and second the First-Nuclide project² on waste forms and their behaviour, especially to study high burn-up effects in the context of the geological disposal.

The Plugging and sealing project is likely to become one of the most important joint activities for the programmes closest to licensing. It requires also significant investments to carry out the full scale experiments and demonstrations. A working group has started the work to prepare a TEP that requires at least four years to be completed. Topics including the full scale demonstration and the description of the materials behaviour are included in the scope of the working group planning for the Technical project.

The waste forms and their behaviour project covers also several other waste areas beside the First-Nuclide. A working group focussing on work related to C-14 has been launched and a decision to launch a TEP is foreseen to be taken in 2013.

Monitoring the environmental state has a main task of defining a shared vision on the reference (baseline) state of the environment before beginning construction works and operation of a geological repository. This topic aims at having a coherent approach among countries and having a similar level of characterization. A working group was launched in November 2011 to explore this project and to prepare

¹ Large Underground Concept Experiments (LUCOEX) EURATOM FP7 project <http://www.lucoex.eu>

² First/ Instant Release of Safety Relevant Radionuclides from Spent Nuclear Fuel (First-Nuclide) EURATOM FP7 project

a roadmap. A potential TEP could be organized to start work at the end of 2014. Since the MoDeRn³ cooperative project is already working on monitoring, further developments will be built from its expected results. A new project, more oriented on technologies would be developed after 2015.

The question of long-term performance of bentonite in crystalline environments is crucial to some of the national programmes. Some areas of this Topic are already addressed in the FP7 project BELBaR⁴.

Other potential joint activities

Safety of construction and operations increases in importance the closer to the commissioning of the disposal facility a programme is. Launching a working group to agree on a shared approach to the safety of construction and operations was decided in November 2011 to prepare a TEP or a TSWG to work from 2014. The same rationale is applied for materials interactions, beginning with a review of existing information before launching a new TEP or TSWG. The main idea is to feed a benchmark of material interaction models from 2014. In the field of modelling in support of the safety case, benchmarking is envisaged from 2015. This will be organized through working groups, first to organize, and then to do the benchmarking work. For the peer reviews on studies to support the Safety Case, a working group was launched at the November 2011 Exchange Forum. Its mandate is to define and propose modalities to organize peer reviews on limited extent subjects and in a very simple way.

An Information Exchange Platform would be suitable to address a series of questions involving governance and similar questions.

Even though the first license applications are submitted or intended to be submitted to the national authorities during 2010-2015, the disposal operations are at least another ten years away and a lot of new developments and innovations may be available during the operating time of a disposal facility. The optimization and improvements derived from the developments require the capabilities to adapt and optimize these into the existing repositories. A working group for adaptation and optimization is potentially needed to produce a roadmap outlining how to take account of and manage innovation and optimization.

A TEP on low-pH cements is foreseen to be launched in 2016.

Communicating results from RD&D to lay people remains a challenge for most of the waste management programmes. A working group to deal with communicating the results is foreseen for 2016.

Finally, the competence maintenance, training and education (CMET) working group was launched in early 2012.

For all specific topics to the waste management organizations, an Information Exchange Platform was decided to facilitate direct exchange on specific topics.

ENGAGING THE IGD-TP MEMBERS AND PARTICIPANTS IN THE DEPLOYMENT

The following steps are planned for engaging the IGD-TP's members and participants into the foreseen joint activities and their deployment:

- Following the listing of the joint activities for 2011-2016 according to their respective timeline, a more detailed technical description of the Topic is produced to complement the SRA description.

³ Monitoring Developments for safe repository operation and staged closure (MoDeRn) EURATOM FP7 project <http://www.modern-fp7.eu>

⁴ Bentonite Erosion: effects on the Long term performance of the engineered Barrier and Radionuclide Transport (BELBaR) EURATOM FP7 project

This work is done by the interested members of the Executive Group (EG) of the IGD-TP with the assistance of the IGD-TP Secretariat.

- The listing and the descriptions are presented to the IGD-TP Executive Group (EG) during a regular EG meeting for a go-ahead decision.
- The EG members decide on their willingness to participate in the joint activity subjected to go-ahead decision making. They also decide on who leads the activity and then carries out the scoping of the activity in a form that can be communicated to others to call for volunteers from the IGD-TP members and participants. The type of joint activity foreseen for the Topic's deployment already gives an indication of the type of funding and governance structure required for the new joint activity.
- After the joint activity participants are gathered, detailed discussions on the funding agreements, on the more specific activity planning and on the overall schedule take place among the activity participants under the leader of the activity.
- A given activity's schedule is then included into the IGD-TP's deployment master schedule and the progress of the activity is monitored. This is done by the activity leader together with the activity team for each activity and coordinated together by the EG and the Secretariat into the master deployment schedule. The governance and project management models that were developed in the SecIGD⁵ project are used to assist in the deployment and they will be further developed and refined by the IGD-TP's Secretariat in cooperation with the EG as experience on joint activity deployment is gained.

SUMMARY AND CONCLUSIONS

The goal for IGD-TP is to reach the Vision that that by 2025, the first geological disposal facilities for spent fuel, high-level waste, and other long-lived radioactive waste will be operating safely in Europe.

The first edition of the SRA was prepared and published in July 2011 to support that vision. It is important to note that the SRA production was based on a thorough review of the requirements expressed by the geological repository implementers and on the current state-of-the-art of their RD&D. They organisations began by compiling the results of RD&D performed since the early 80s in several of the waste management programmes. They then identified the remaining research and development areas derived from the continuous assessment of performance and safety of the respective geological repository programmes. Where identified, additional RD&D aim at improving designs and their robustness, safety, or reducing remaining uncertainties. The goal of the DP is to organize the Topics identified in the SRA in such a way that all are addressed timely in relation to the committed vision. From the work reported in this paper it can be seen that all joint activities to deploy the Topics can be launched successively so that the results are available in due time.

From the organizational viewpoint, the different types of joint activities for deployment were defined. In the framework of the European technological platforms it is important to define first forums where the exchange can take place. The IEP was defined as a place to share and exchange information among the IGD-TP participants. The IEP plays an important role as a vehicle for fostering discussion, information and further cooperation. The IEP will also play a key role at the joint work between the programmes closest to licensing and with the programmes further from licensing, since knowledge gaps can be closed faster and this can save time and money by avoiding duplications of work.

⁵ SecIGD project - Secretariat of the Implementing Geological Disposal Technology Platform. Euratom FP7 support action 2010-2012.

Where a Topic still needs to be worked in more detail before the start of specific research, development or demonstration work, a TSWG is considered as a tool to prepare a detailed roadmap and the project scoping. Then the Topic is launched through a Technical Project (TEP). In the case of common database needs, development of methodologies or organizing peer reviews, an ORWG can be set up. A Topic can successively move from a type of a joint activity to another, depending on the outcomes of the joint activity after the activity has been carried out. Last, a TT is defined as a joint activity that is most suited for the direct transfer of valuable or proprietary knowledge, service or product exchange, including on a commercial basis for the exchange.

The DP is an operational tool. Whereas the first SRA was developed over cover the full timescale to reach the Vision until 2025, the first DP's timeline was limited to a 5 year term. Its deployment master plan as presented in Table I needs to be followed up regularly and needs to be updated continuously either with minor updates or with additional topics to be considered. At the same time, it can also take account of evolutions in the SRA needs, which are updated less frequently as a result of major new RD&D findings or new needs.

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