Radioactive Waste Management
NEA/RWM/R(2015)7
August 2015
www.oecd-nea.org

Analysis of a Questionnaire on Hazards Associated with Co-activities in Deep Geological Repositories 2013-2015

Integrated Group for the Safety Case (IGSC)
Expert Group on Operational Safety (EGOS)

OECD
BETTER POLICIES FOR BETTER LIVES

NEA
NUCLEAR ENERGY AGENCY

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

English - Or. English

NUCLEAR ENERGY AGENCY

NEA/RWM/R(2015)7
Unclassified

Radioactive Waste Management Committee

Integration Group for the Safety Case (IGSC)

EXPERT GROUP ON OPERATIONAL SAFETY (EGOS)

Analysis of a questionnaire on hazards associated with co-activities in deep geological repositories (2013-2015)

For any further information, please contact Dr. Gloria KWONG (gloria.kwong@oecd.org)

English - Or. English

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of 34 democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Chile, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission takes part in the work of the OECD.

OECD Publishing disseminates widely the results of the Organisation's statistics gathering and research on economic, social and environmental issues, as well as the conventions, guidelines and standards agreed by its members.

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1 February 1958. Current NEA membership consists of 31 countries: Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherlands, Norway, Poland, Portugal, Russia, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The European Commission also takes part in the work of the Agency.

The mission of the NEA is:

– to assist its member countries in maintaining and further developing, through international co-operation, the scientific, technological and legal bases required for a safe, environmentally friendly and economical use of nuclear energy for peaceful purposes;
– to provide authoritative assessments and to forge common understandings on key issues, as input to government decisions on nuclear energy policy and to broader OECD policy analyses in areas such as energy and sustainable development.

Specific areas of competence of the NEA include the safety and regulation of nuclear activities, radioactive waste management, radiological protection, nuclear science, economic and technical analyses of the nuclear fuel cycle, nuclear law and liability, and public information.

The NEA Data Bank provides nuclear data and computer program services for participating countries. In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has a Co-operation Agreement, as well as with other international organisations in the nuclear field.

Radioactive Waste Management

Expert Group on Operational Safety (EGOS)

Analysis of a questionnaire on hazards associated with co-activities in deep geological repositories

2013–2015

NUCLEAR ENERGY AGENCY
ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Foreword

In 2012, the Radioactive Waste Management Committee (RWMC) noted the needs of developing operational best practices and guidelines for geological repositories. Under the RWMC's mandate, the Integration Group for the Safety Case (IGSC) created an Expert Group on Operational Safety in 2013. The aim of the expert group is to identify, evaluate and help define international best practice in operating geological repositories for radioactive waste safely. One of its tasks, identified by the expert group in 2013-2015, is to evaluate the co-activity hazards.

Co-activity can be defined as the coexistence of simultaneous conventional and nuclear activities in a DGR. These include the handling and emplacement of waste packages while mining/construction activities are ongoing within the facility. The expert group noted that work conducted in the past tends to focus on post-closure safety, limited work has been undertaken internationally to develop a common view on the operational safety and even less on evaluating the hazards associated with co-activities within a geological repository. To further explore the potential hazards associated with co-activity in the operational processes, the EGOS conducted a questionnaire in 2014 to elicit background information for future work planning in this area.

Key findings of this questionnaire are summarised below:

1. Most countries develop their regulations for safe operation of disposal facilities based on a combination of nuclear safety regulations, mining regulations, and environmental protection regulations. With proper planning and repository design, it was noted that an expansion of the waste emplacement zones, a potential need of many national waste management programmes, may not compromise the operational and post-closure safety requirements of the geological repository. This survey cannot conclude whether the current regulatory processes are adequate in providing overall guidance in evaluating co-activity hazards (e.g. the responsibilities and expectations of implementers in demonstrating safety in co-activities);

2. In order to ensure safe repository operations and development, respondents to this survey indicated specific attention are required in the following activities:

    - Transfer and handling of materials/waste packages within the repository;
    - Operation of ventilation systems to ensure occupational health and safety;
    - Excavation and mining operations, their impacts on waste emplacement.

    Specifically, it is necessary to evaluate the impacts of some high-risk accidents on co-activities such as:

    - Fire incidents with various potential causes: ignition of combustibles, electrical fires, vehicle collisions;
    - Waste packages can be damaged by rock –falls, tunnel/excavation collapses, unexpected drops (of waste packages), failure of transport systems, etc.

3. Physical separations between conventional and nuclear activities can be achieved by technical measures such as segregation of construction and emplacement activities; use of distinct infrastructure/dedicated supporting systems. Separations can also be implemented via organisational means such as the implementation of procedures and work plans.

4. Ongoing R&D work will continue to improve the understanding of repository evolutions. Lastly, continual sharing and exchanging of newly gained knowledge among national programmes is beneficial to all programmes.

Table of Contents

1. Introduction and background

The NEA RWMC recognises the importance of operational safety in developing geological disposal facilities for radioactive waste. In revising their 2011 – 2016 Strategic Plan (NEA/RWM (2011)12), the RWMC formally covered both operational safety and long-term safety to be the focus of the Committee, indicating their readiness to support dedicated resources to work on this subject at an international level. In a relevant initiative, two (2) NEA groups - the Integration Group for the Safety Case (IGSC) and the Regulator's Forum (RF), jointly held a workshop on "Preparing for Construction and Operation of Geological Repositories – Challenges to the Regulator and the Implementer" in January 2012. This workshop further confirmed the usefulness of an international consensus on the best practices and guidelines for operating geological repositories.

1.1 NEA Expert Group on Operational Safety (EGOS)

In the 14th annual meeting of the IGSC in 2012, the IGSC endorsed the creation of an expert group on Operational Safety (EGOS). The primary objective of the EGOS is to identify and evaluate best international practices in safely operating geological repositories for radioactive waste. More background information and working group details, including their mandate, programme of work (PoW), project durations and mode of operation, are described in the NEA IGSC documents – NEA/RWM/IGSC(2013)1 and NEA/RWM/IGSC(2013)2. The NEA EGOS held its first meeting in June 2013 in which key work activities were discussed and planned for. With limited information sources, the working group has agreed to take into account experiences obtained from (i) existing surface nuclear facilities; (ii) conventional underground mines; and (iii) radioactive waste disposal facilities and/or other applicable industrial facilities.

Safety requirements for operating a geological repository include isolation of radioactive substances; protection of workers from irradiation during facility operations and underground emplacement activities; management of heat dissipation from the radioactive waste, etc. Geological disposal repositories rely on the multiple engineering barrier principle to achieve their long-term safety, i.e. individual barriers in the disposal system including the disposal container, the sealing materials used in the waste placement chambers/cells and, the surrounding host rock formation will ensure the long-term isolation of radionuclides from the environment. Risks are often managed in accordance with the principle of defence-in-depth (INSAG 10) and ALARA.

Among others international initiatives relevant to operational safety such as the IAEA's GEOSAF, GEOSAF-II projects, or the EC's IGDTP, and the FP7-SITEX projects; the EGOS has its own specificity. The EGOS focuses on technical and practical management solutions in handling plausible hazards during operation of a deep geological repository (DGR). Particularly in areas where experience had been gained from existing nuclear/applicable industrial facilities and underground mines, the EGOS provides a unique forum for facilitating repository implementers to openly exchange practical experiences. To avoid work duplication, both the IAEA and the EC are invited as observers in the EGOS group.

2. EGOS questionnaire on co-activity

Co-activity is defined as the coexistence of simultaneous conventional and nuclear activities in a DGR. These may include the handling and emplacement of waste packages while mining/construction activities are ongoing within the facility. It was noted that work conducted in the past tended to focus on post-closure safety, little work has been undertaken internationally to develop a common view on the operational safety and even less on evaluating the hazards associated with co-activities within a geological repository. To further explore the potential hazards associated with co-activity in the operational processes, the EGOS conducted a questionnaire in 2014 to elicit background information for future work planning in this area.

Five (5) questions were asked in this questionnaire, namely (i) are co-activity foreseeable or currently planned for in the national radioactive management programme; (ii) does a national regulatory framework associated with the management of co-activity currently exist; (iii) what types of co-activity hazards have been identified, how are they identified, how will they be assessed, lessons learnt and mitigation measures being considered and other relevant information; (iv) what are the challenging issues in managing co-activities during repository development; and (v) current and planned R&D work.

A total of 12 organisations responded (including 3 regulators) to the questionnaire, providing information relating to 7 national programmes, reflecting the viewpoints of implementers, authorised researchers and regulators. Responses received are, organised per question, gathered in Appendix A. The responding organisations and their roles are given in Table 1. This report focuses on the general trends reported in the questionnaire. Section 3 briefly discusses the survey results; including the types of co-activities identified in different programmes and their associated hazards. Overall trends observed from the results are also presented in this section. It is planned that all results gathered will be further discussed in the 2014 IGSC annual meeting, in which, paths forward to further explore co-activity hazards management will be planned for. The 2014 annual meeting is scheduled for October 7-9, 2014, in Paris.

Table 1: Roles and Nationalities of Responding Organisations

Organisation		Country	Role	Notes
AFCN/FANC	*Agence fédérale de contôle nucléaire/Federaal agentschap voor nucleaire controle* (Federal Agency for Nuclear Control)	Belgium	Regulator	
ONDRAF/NIRAS	*Organisme national des déchets radioactifs et des matières fissiles enrichies/Nationale instelling voor radioactief afval en verrijkte splijtstoffen* (National Agency for Radioactive Waste and Enriched Fissile Materials)	Belgium	Implementer	
NWMO	Nuclear Waste Management Organisation	Canada	Implementer	
ANDRA	*Agence nationale pour la gestion des déchets radioactifs* (National Radioactive Waste Management Agency)	France	Implementer	
BfS	*BundesamtfurStrahlenschultz* (Federal Office for Radiation Protection)	Germany	Implementer	Joint response with DBE Tech
DBE Tech	*Deutsche Gesellschaft zum Bau und Betrieb von Endlagern für Abfallstoffe mbH* (German Company for Construction and Operation of Waste Repositories)	Germany	Research Organisation	Joint response with BfS
GRS	*Gesellschaft für Anlagen- und Reaktorsicherheit, mbH* (Research and analysis organisation in the field of nuclear safety and radioactive waste management)	Germany	Research Organisation	
SKB	*Svensk Kärnbränslehantering AB* (Swedish Nuclear Fuel and Waste Management Company)	Sweden	Implementer	
ENSI	*Eidgenössisches Nukearsicherheitsinspektorat* (Swiss Federal Nuclear Safety Inspectorate)	Switzerland	Regulator	
Nagra	*Nationalen Genossenschaft für die Lagerung radioaktiver Abfälle* (National Cooperative for the Disposal of Radioactive Waste)	Switzerland	Implementer	
HSE	Health and Safety Executive	UK	Regulator	
NDA	Nuclear Decommissioning Authority	UK	Implementer	

3. Survey results

Please refer to Appendix A for more detailed responses.

3.1 Co-activities in national programmes

Q1) Do you have to manage co-activities in your facility? If yes, what type of non-nuclear (e.g. construction works…) and nuclear activities (emplacement, maintenance…) do you have to manage in parallel in your underground facility?	
Programme/Respondent	**Response**
Belgium, Ondraf/Niras	• Construction will be separated from the operation of the repository, i.e. limited co-activities. The only foreseeable co-activity will be to backfill / seal a filled gallery.
Canada, NWMO	• L&ILW DGR – no co-activities as the proposed DGR plans for complete construction of the facility prior to operation; • Used fuel (APM) DGR – design of the repository plans for co-activities although such conceptual design has not advanced sufficiently to evaluate co-activities in detail. The general layout including shafts and ventilation arrangement has been designed to allow one panel to be excavated while another panel is being filled.
France, Andra	Potential co-activities include: • Galleries/cell construction, i.e. excavation, drilling, vault setting; • Waste package transfer and emplacement; • Monitoring (e.g. of filled emplacement cells) and facility (operational) maintenance.
Germany, BfS, DBE Tech, GRS	Potential co-activities include: • Simultaneous excavations of new emplacement drifts, emplacement chambers (non-nuclear) with (nuclear) waste emplacement; • Facility construction with facility maintenance; • In case of retrieval, potential simultaneous waste retrieval and mine stabilisation.
Sweden, SKB	Potential co-activities include: • Deposition of encapsulated spent nuclear fuel with excavation of new deposition tunnels; sealing filled tunnels with excavation of new tunnels/ construction of facility.
Switzerland, ENSI, Nagra	Potential co-activity: • Emplacement of SF / HLW in tunnels with excavation operations/ construction of new tunnels.
UK, HSE, NDA	Potential co-activity: • Repository construction and waste emplacement.

While many programmes may not have detailed evaluations of co-activities, most of the responded programmes (6 out of 7 programmes, except Belgium, Ondraf/Niras. Note: the Proposed OPG's DGR for L&ILW of Canada also does not plan for co-activities, but the used fuel DGR conceptual design does) will have to manage excavation and waste emplacement activities simultaneously. Foreseeable co-activities include:

Conventional non-nuclear activities:

1. Construction of the underground facility, i.e. rock excavation, gallery and new emplacement cell drilling;
2. Backfilling and sealing of galleries (this activity will take place in nuclear zone where waste packages will be emplaced).

Nuclear activities:

1. Waste transferring and emplacement activities, i.e. transfer of packaged waste to the underground facility through galleries, and into the emplacement cells.
2. Monitoring and maintenance of the nuclear facility

3.2 Regulatory requirements and guidance

Q2) Do you have any national regulatory framework associated with the management of co-activity in your country?

Programme/Respondent	Response
Belgium, Ondraf/Niras	• No specific guidance on co-activity.
Canada, NWMO	• Canada's national regulatory framework is sufficient to cover the management of co-activity, but does not have specific guidance on co-activity.
France, Andra	• French decree 94-1159 of December 26th 1994" (only in French) and "decree 92-158 of February 20, 1992" (only available in French). The main purpose is to point out who is responsible for co-activity management, when construction works have to be realised in an industrial facility. It also indicates the specific documents needed in order to manage co-activity
Germany, BfS, DBE Tech, GRS - KONRAD	• no special regulatory framework dealing with the management of such co-activities although existing laws must be complied. These include: mining laws, laws related to water and water conservation, environmental safety laws, Federal emission control act, nuclear laws and directives, etc.
Sweden, SKB	• no regulatory framework that covers the co-activity • SSM to provide oversights;
Switzerland, ENSI, Nagra	• no national regulatory framework dedicated to the conventional/nuclear co-activities in Switzerland • existing framework includes NEA/NEO, RPA/RPO, ENSI guidelines;
UK, HSE, NDA	• existing legislation: HSWA, N1A65 and the Ionising Radiation Regulations 1999, RSA 93, GRA, etc.

According to the survey, many national regulatory frameworks associated with the management of conventional/nuclear co-activity do not have specific guidance (e.g. Canada, Germany, Sweden and UK). Existing mining laws are often seen to maintain its close tie to guide the development of underground repositories. Additional environmental safety, nuclear safety regulations, as well as regulatory requirements for radioactive waste management are also considered applicable in many countries. Some programmes have explicit requirements in addressing co-activity, for example, ENSI Guideline G03, 5.1.3.d states that "The design of the underground installations must ensure an appropriate spatial separation and separate ventilation of areas where radioactive waste is handled and areas where the disposal capacity is simultaneously being expanded. The expansion of the waste emplacement zones may not compromise the operational and post-closure safety of the geological repository." Also, in France, existing decrees (table above) identify the responsible personnel for managing co-activity during the construction phase of an industrial facility, specific documents for co-activity managements are also mandatory in the French regulatory framework.

Although none of the responses gave specific quantitative details about occupational health and safety protection, it is noted that many countries have given qualitative statements/requirements in their regulations specifically to protect workers in underground facilities and their potential exposure to radiological co-activity hazards.

3.3 Co-activity hazards

Q3) What type of hazards associated with co-activity have you identified? How are these hazards identified? What are the potential impacts on nuclear activities? How do you establish the basis in assessing the identified hazards? Are there lessons learnt from other nuclear facilities (e.g. expanding nuclear plants or nuclear surface facilities)? Can you explain what kind of prevention/monitoring/control/mitigation measures (technical and organisational) you have considered in managing risks related to co-activities? Could you give practical examples to illustrate your answer?

Programme/Respondent	Response
Belgium, Ondraf/Niras	• Foresee limited hazards due to separated construction and waste emplacement activities; • Main operational safety is associated with activities carried out in the vicinity of emplaced waste. Anticipated to manage such risks by limiting working time near waste and/or using shielding when feasible.
Canada, NWMO	• Potential hazards management of (i) minimising impact of mining on emplaced waste and (ii) minimising risk of contamination of the construction side. • Address in part by separating construction panels from waste filled panels; • Also by separating the flow of materials and air for excavation, from the flow of containers and air for emplacement, via layout of shafts and ventilation drifts.
France, Andra	• Andra considered (i) construction hazards and (ii) hazards associated with nuclear activities; • Hazards are identified by considering every single hazardous event of an activity (as well as its potential impact on other activities); • Potential impacts on nuclear activities e.g. fire or flood in operating areas, damaging supporting systems (power supply, air supply) or containment systems (e.g. waste packages, HEPA ventilation filter); • Hazards are assessed using the "MADS-MOSAR" assessment; • Lessons learnt from mining and nuclear activities have been considered in developing the design basis of CIGEO; • Prevention/control/mitigation measures include: (i) physical separation of activities; (ii) 2 independent supervision systems (with detectors if needed); (iii) mitigation by the provision of airlocks; fire-fighting / suppression equipment; emergency procedures; and refuge facilities.
Germany, BfS, DBE Tech, GRS - KONRAD	• Main hazards include fire, vehicle collision, rock fall, waste package drops; • Potential impacts on nuclear activities are the damage of waste packages with incidental release of radioactive substances and damage to/of the Repository site by co-activities; • The operation of disposal facilities is based on non-nuclear mining regulations (mining act is applied to DGR without restrictions), radiation safety regulations and environmental protection regulations. Based on the safety principles for nuclear engineering and the analogous adaption of existing rules and policies for nuclear facilities (Germanys *KerntechnischesRegelwerk*, KTA) to the specific licensing procedures for disposal sites to fulfil the regulatory demands, incident analyses have to be carried out; • Lessons learned: the requirement of the integrity of the isolating rock zone and the consideration of the complexity of the safety case. Also long-time operation of DGRs, can have impacts on the integrity of the site and on the isolating rock zone. • To prevent radionuclide releases, upcast ventilation is channelled via the same shaft where waste packages are transported. A separate shaft is provided for the transport of workers and non-nuclear materials.

	Airflow is also monitored for radioactive gases and aerosols.
Sweden, SKB	Potential hazards include: • Potential hazards: storing and handling explosives • Assessment by deterministic safety assessment – an iterative approach, i.e. more knowledge becomes available in each iteration, SA is enhanced; • Repository design eliminates some hazards e.g. bouldering / cave-in, flooding, fire, etc. • SR-Site assessed the impact of blasting, tunneling operations on barrier properties.
Switzerland, ENSI, Nagra	• Mitigation/prevention/control: a physical separation between emplacement zone and excavation (conforms with guideline ENSI-G03). Also planned to assess distance of separate access routes for rescue / evacuation; ventilation systems, etc.
UK, HSE, NDA	• Potential hazards include blasting may cause vibration, overpressure and affect emplacement; • Mitigation/prevention/control: use of airlocks, segregated roadways, access drifts/shafts to separate construction and emplacement. Airlocks will also be used for emergency passage. To address vibration/over pressure issues in strong rocks, vault construction sequence will be followed: one vault under construction, one vault undergoes fit-out and commissioning, one vault under operation. Non-operational vault and surrounding rocks act as a separation buffer. Less of an issue in sedimentary rocks and evaporates.

A preliminary analysis of the responses, even with limited details indicated, showed that hazards identification inherently provides a thorough basis for identifying potential accident events and for assessing consequences of co-activity hazards. Such outcome subsequently allowed preventative and mitigation measures to be defined. Also noted in some responses is the fact that hazards identification may be based on regulations (e.g. Nagra), analysis and feedback of experience from various facilities types (e.g. Andra).

Two types of hazards identified in the responses:

1. Hazards from normal operational conditions:

   Among the different co-activity hazards identified under normal operating conditions, potential contamination and/or subsequent radionuclide escape is one of the major concerns, in which the ventilation system, both in the construction (non-nuclear) and the waste deposition zones (nuclear), is repeatedly identified as a key component in ensuring operational safety and security (see Appendix A for detailed responses). Another hazard in concern under normal operating condition is the potential impact of vibrations from explosions, mechanical drilling and construction work on key nuclear system components including the waste packages.

2. Hazards from accidental situations:

   More significant radionuclide releases may occur in accidents resulted with damaged waste packages. These may range from rock-falls, tunnel collapses, fire in the repository, system failures (waste transfer lifts, vehicles), drops of waste packages, just to name a few. The 2014 WIPP incidents also illustrated how waste package damages may result from potential chemical reaction(s) within the waste packages, in which case, full conformance to the waste acceptance criteria plays an important role in ensuring safety.

Various assessment/evaluation methods are utilised in different countries. In spite of the variances, these methods aim at the same objective which is to identify hazards systematically in order to identify the initiating events which need protective, preventative or mitigating controls. Typically, as in the case of existing nuclear facilities, both radiological and non-radiological consequences of the potential events are evaluated under the conditions where no preventative / mitigation measures are in place. Safety margins as well as uncertainties are often taken into account in evaluating hazards. Such consequence analysis then allows the preventative, mitigation controls to be defined. It is perhaps worth noting that in a separate IGSC questionnaire (questionnaire for scenarios development), some countries indicated the usage of a risk based approach to rank the hazards. Hazards that pose the greatest risk or those with an unacceptable risk will be provided with appropriate preventative/mitigation features. The goal of these preventative/mitigation features is to either reduce the frequency of hazard occurrence (exclude its occurrence in case of preventative controls) or to limit the effects of the consequences.

Essentially, physically separating construction and operation activities is an effective means in preventing mitigating potential operational hazards. Respondents described the various engineered features (i.e. structures, systems and components) used as preventative measures, e.g. airlocks, separate roadways used in the UK, ventilation operating procedure to control airflow in Germany. Not explicitly stated in the survey but more from the experience gained from relevant facilities, other means to effectively manage operational safety include administrative controls (e.g. procedures, policies), and/or individual features that operate based on laws of physics, chemical properties. In reviewing the responses, it was noted the methodology used in identifying and assessing the hazards plays an important role in managing co-activities.

3.4 Challenging issues

Q4) What challenging issues have you identified regarding co-activities in line with the stage of the development of your project (generic study, industrial design, towards licensing…)?	
Programme/Respondent	**Response**
Belgium, Ondraf/Niras	• No challenges identified due to limited co-activities expected.
Canada, NWMO	• Not yet identified.
France, Andra	• The comprehensiveness of co-activity hazards; • The step-by-step facility building with mobile barriers between the 2 areas – potential impacts on various project aspects and equipment;
Germany, BfS, DBE Tech, GRS - KONRAD	• Activities associated with waste retrieval – mining related requirements, ventilation requirements (particularly with heat generating waste and/or long distance between shafts and emplacement chambers).
Sweden, SKB	• Keeping co-activities separate is a challenge. SKB uses two barriers between the nuclear and construction parts – one for security and 2nd for protection.
Switzerland, ENSI, Nagra	• Expect more details on challenges to be indicated from the risk analysis.
UK, HSE, NDA	• Safeguards were identified (instead of challenges) which include good working practices (i.e. emergency response, training, etc.), suitable working environment, and health surveillance.

Relatively limited information was revealed in this question – e.g. both Switzerland and Canada indicated more details of challenges may become available as their projects continue to evolve. In Sweden, simply keeping co-activities physical separated is a challenge while Germany considers waste retrieval and its consequent activities a potential difficulty. Other responses mentioned the comprehensiveness of co-activity hazards (France) and the in parallel construction/emplacement activities may have potential impacts on various project aspects including equipment and system availability. Rather than reporting their anticipating challenges, the UK programme named the safeguards being considered for managing their foreseeable challenges.

Although not explicitly mentioned in the responses, one can envisage that simultaneous construction and repository operations create a continuously changing environment. The ever changing environment incubates variations of hazards which may subsequently impact the safety case which in principle shall reflect the actual state of the repository. Such continuously evolution of the repository, particularly during the operational phase, must be accounted for as much as possible at the onset of the repository development project, in order to anticipate unexpected situations/incidents and thus guidance be developed to handle unexpected scenarios if necessary.

Despite of the limited responses, an important viewpoint was nevertheless noted in the French response – the completeness of co-activity hazard identifications and evaluations. This importance of sharing and exchanging experience gained from hazards evaluations and analyses is also noted.

3.5 R&D programme

Q5) Do you have any R&D programme concerning the management of co-activity risk? If yes, could you please provide some information about it?	
Programme/Respondent	**Response**
Belgium, Ondraf/Niras	• Study on defining a suitable backfill composition for backfilling and sealing of disposal galleries.
Canada, NWMO	• Currently no R&D on co-activity management.
France, Andra	• Currently rely on industrial experience. Future R&D is possible.
Germany, BfS, DBE Tech, GRS - KONRAD	• Currently no R&D on co-activity management. Potential R&D on repositories for heat generating waste.
Sweden, SKB	• Currently no R&D on co-activity management, assessment of co-activity risks is covered in safety assessment.
Switzerland, ENSI, Nagra	• ENSI: Co-activity risks are covered in an on-going R&D programme on the design of a DGR (including monitoring and design of a pilot facility). • Nagra: no ongoing R&D on co-activity.
UK, HSE, NDA	• No current R&D on co-activities.

While none of the respondents has R&D activities currently on-going to specifically address co-activity hazards, R&D work to improve the understanding of the repository performance continued in some programmes (e.g. ENSI conducts R&D on the DGR design, the design of the pilot facility and the DGR monitoring requirements) in which co-activity hazards are being investigated in these R&D studies, e.g. SKB continues to gather operational experience from the Äspö Laboratory continues their studies, etc. Other programmes have also indicated further R&D activities will be considered should they deem useful in the future.

3.6 Observations

The EGOS survey, with inputs from seven (7) radioactive waste management programmes, revealed the following observations:

1. Geological disposal repositories for radioactive waste are developed over long time spans. For efficient utilisation of resources, most national radioactive waste programmes are designed for in-parallel repository construction and operation activities. It may be concluded that co-activities can arise even in repositories that are planned to have separated construction/waste emplacement periods since it is a good practice to enhance passive safety by isolating and sealing placement zones once they are filled. The following are some typical co-activities identified in the questionnaire:

Conventional (non-nuclear) activities:

- Construction of the underground facility, i.e. rock excavation, gallery and new emplacement cell drilling;
- Backfilling and sealing of galleries (a conventional activity to take place in nuclear zones)

Nuclear activities:

- Waste emplacement operations, i.e. transfer of packaged waste to the underground facility, and into the emplacement cells;
- Monitoring and maintenance of the nuclear facility.

2. Regulations for safe operation of disposal facilities are in general based on a combination of nuclear safety regulations, mining regulations, and environmental protection regulations. A notable exception is the case of Switzerland, where an applicable guideline specifically addresses the issue of co-activity: "The design of the underground facility must ensure an appropriate spatial and physical separation of the ventilation systems for the area where radioactive waste is handled and areas where the disposal capacity is simultaneously being expanded. The expansion of the waste emplacement zones may not compromise the operational and post-closure safety requirements of the geological repository." This survey cannot conclude whether the current regulatory processes (in the responded countries) are adequate in providing overall guidance in evaluating co-activity hazards (e.g. the responsibilities and expectations of implementers in demonstrating safety in co-activities);

3. The objectives of co-activity management, under both normal operating conditions and accidental situations, are to ensure:

   a) safe placement and disposal of waste packages, i.e. minimise impact of mining on already emplaced waste packages, and

   b) prevent contamination between the nuclear/non-nuclear zones, i.e. minimise potential radionuclide escape from the repository to the environment.

   The simultaneously occurring activities, i.e. repository construction and waste placement, have different operational needs; the following activities thus require specific attention in order to ensure safe repository operations and development:

   - Transfer and handling of materials/waste packages within the repository;
   - Operation of ventilation systems to ensure occupational health and safety;
   - Excavation and mining operations, their impacts on waste emplacement.

   In analysing the collected responses, the Task Group also identified the need to evaluate the impacts of some high-risk accidents on co-activities such as

   - Fire incidents with various potential causes: ignition of combustibles, electrical fires, vehicle collisions;
   - Waste packages can be damaged by rock –falls, tunnel/excavation collapses, unexpected drops (of waste packages), failure of transport systems, etc.

4. Different practical solutions are planned for among various national programmes

   Where temporal separation is impossible, many programmes are considering providing physical space to separate conventional and nuclear activities. Such physical separation may be achieved via technical and organisational measures as follow:

   - Technical options: Several countries plan for physical segregation of construction and emplacement operations, with distinct infrastructure and dedicated supporting systems. For instance, the construction and waste emplacement working zones may be physically isolated by air locks, construction and emplacement operations may be serviced by segregated road/railways and access ways (drift and shafts), completely separate ventilation systems in order to minimise any unplanned interactions between the activities. Other programmes have considered imposing a minimal distance between working zones so as to ensure vibration/mechanical impacts from blasting/construction operations will not adversely affect the emplacement operations

- Organisational measures: while not thoroughly addressed in the questionnaire, there are control measures and procedures which can effectively segregate co-activities, e.g. assign separate routes for material transfers; segregate vehicle movements and personal flows. In addition to physical separated construction and emplacement operations, the use of airlocks may also be considered particularly for emergency passage from one area to another.

5. None of the responded organisation currently performs R&D work to specifically address co-activities hazard management. However, there are R&D activities ongoing to improve the understanding of repository evolutions. For example, backfilling and sealing of disposal galleries is the subject of several studies. Results of these activities are expected to be useful in addressing co-activities. More specific R&D programmes will also be considered should they deem required in the future.

6. Lastly, this exercise recognises the effectiveness of continual knowledge and experience sharing among national programmes.

Appendix A – Answers from EGOS members to the questionnaire on co-activity

1. Co-activities

1)	Do you have to manage co-activities in your facility? If yes, what type of non-nuclear (e.g. construction works…) and nuclear activities (emplacement, maintenance…) do you have to manage in parallel in your underground facility?

Belgium, ONDRAF/NIRAS

The repository will first be constructed and then operated. There is thus a complete separation in time between the construction and operation phase. Co-activity between construction works, or conventional civil works, and waste disposal is therefore limited. The only form of co-activity concerns the repository closure phase when galleries filled with waste will be backfilled and sealed.

Canada, NWMO

The design for OPG's proposed L&ILW DGR calls for complete construction of the facility prior to operation. Therefore, there will be no co-activities and associated hazards.

The APM DGR will have co-activity. The general layout, including shafts and ventilation arrangement, has been designed to allow one panel to be excavated while another panel is being filled. However, the APM DGR's conceptual design has not advanced sufficiently to evaluate in detail the co-activities.

France, Andra

During its 100th year of Cigeo's operation, the disposal zones will be modular in design to allow waste disposal tunnels to be built according to a step by step planning over time. Construction and equipment works for a new operating phase shall be achieved concurrently with nuclear operating activity. Andra will have thus to manage in parallel construction and operation areas (non-nuclear and nuclear activities) as such:

- Galleries and cell construction
  - Excavation activities;
  - Gallery and cell drilling;
  - Vault final setting (final networks and non-active tests);
  - Ventilation of galleries for workers into construction zone;
  - Grouting materials output.
- Waste package transfer and disposal
  - Transfer from the surface to the underground facility Transfer toward the cell;
  - Emplacement into the cell;
  - Ventilation (nuclear and non-nuclear) into nuclear zone!;
- Monitoring and maintenance activities

Germany, BfS and DBE Tech

Preface: In Germany, a new law on the site selecting process for a repository for heat-generating radioactive waste was issued in July 2013. Accordingly, it is an open question what type of site-specific repository concept will have to be adjusted to the selected host rock. Thus, the questionnaire was completed based on the licensed Konrad repository designed to host all radioactive waste with negligible heat generation in Germany.

1) During the operation of the licensed Konrad repository, it will be necessary to excavate new emplacement drifts parallel to the emplacement of waste packages.

Germany, GRS

Non-nuclear co-activities:

- excavation and backfill of mine tracks, galleries and emplacement chambers
- construction works, maintenance
- In case of the retrieving the nuclear waste in the Asse DGR non-nuclear co activities are related to the stabilisation of the mine (backfilling, digging, construction of new shaft and mine infrastructure)

Sweden, SKB

Yes, we have several co-activities we must manage at the same time, in different parts of the underground facility:

- Deposition of encapsulated spent nuclear fuel:
  - Preparations before deposition;
  - Deposition;
  - Back-filling of deposition tunnels;
  - Sealing of filled deposition tunnels.
- Excavation of new deposit tunnels

Switzerland, ENSI

Switzerland's DGR project is currently in a site-finding process, the so called Sectoral Plan. Nagra as the implementer is in charge of the operation layout for both the surface and underground facilities. The operation concept developed by Nagra within the scope of the safety case in 2002 (NTB 02-02) allows for simultaneous waste emplacement and excavation operations. ENSI assessed the safety case in 2005 (HSK 35/99) as being adequate for a generic safety case. At present, ENSI does not question parallel nuclear/non-nuclear operations in a DGR assuming appropriate spatial separation as well as separate ventilation systems to ensure radiological safety. Whether co-activities are necessary and to what extent, will be assessed in more detail in the subsequent steps of the licensing process for a DGR.

Switzerland, Nagra

Yes – in the HLW repository we will have to manage concurrent emplacement of spent fuel/HLW canisters in completed emplacement tunnels and construction of new emplacement tunnels.

UK, HSE

There are no current underground facilities in the UK – hence at present there is no need to manage co-activities from a regulatory point of view.

UK, NDA

The initial construction phase of the GDF would take place over a period of some 10 years, during which time three/four shafts and drift tunnel (depending on disposal concept and detailed design) would be constructed as well as the first UILW and SILW /LLW vaults. Therefore we are planning on the basis that, construction and emplacement work will be occurring simultaneously.

The UK does not yet have a site for the proposed GDF and is working with concept examples suitable for three generic environmental settings as shown in the Table below.

	Geology		
	Higher Strength Rock	Lower Strength Sedimentary Rock	Evaporite Rock
Construction Sequencing	• Construction to take place in parallel with disposal	• Construction to take place in parallel with disposal	• Construction would take place as required due to the creep properties of the host rock
	• By the time of first waste disposal there will be one UILW vault constructed and operating, one SILW/LLW vault undergoing fit-out and one SILW/LLW vault constructed and operating	• By the time of first waste disposal there will be one UILW vault constructed and operating, one UILW vault undergoing fit-out, one UILW vault under construction. • The same would be applied to the construction and operation of the SILW/LLW vaults so as to segregate the construction activities from disposal operations	• ILW disposal vaults have been split into 100m long disposal tunnels in banks of eight therefore two or three tunnels could be under construction and fit out at any one time

2. Regulatory framework on co-activity.

2)	Do you have any national regulatory framework associated with the management of co-activity in your country?

Belgium, ONDRAF/NIRAS

No.

Canada, NWMO

Canada national regulatory framework is sufficient to cover the management of co-activity, but does not have specific guidance on co-activity.

France, Andra

In France, national regulatory texts exist on the management of co-activities: "*décret 94-1159 du 26 décembre 1994*" (only in French) and "*décret 92-158 du 20 février 1992*" (only available in French). The main purpose is to point out who is responsible for coactivity management, when construction works have to be realised in an industrial facility. It also indicates the specifics documents needed in order to manage coactivity.

Germany, BfS and DBE Tech

In Germany, there is no special regulatory framework dealing with the management of such co-activities. But the stipulations and requirements of existing laws and ordinances (e.g. atomic energy act, radiation protection ordinance, mining law etc.) have to be met.

Germany, GRS

National regulatory framework associated with the management of co-activity in Germany is e.g.:

- Mining law;
- Laws relating to water and water conservation;
- Law and directives relating to environmental safety;
- Federal Immission Control Act;
- Nuclear law and directives (analogously);
- Safety Requirements Governing the Final Disposal of Heat-Generating Radioactive Waste.

Regarding their requirements the conventional laws and directives have strong influence on the operating license or combined operating license.

Sweden, SKB

We have different authorities for mining operations and for nuclear operations. There is no regulatory framework that covers the co-activity, only the separate parts. However, since the mining operation will take place in a nuclear facility, the Swedish Radiation Safety Authority (SSM) will have oversight also of the mining activities. This oversight will, however, focus on ensuring that the mining operations i) would not endanger the safety of the already built and deposited parts of the repository and ii) ensure that the excavation work with its quality control will result in deposition tunnels and deposition holes in conformity with the requirements set on these with respect to their impact on the repository safety. These aspects of the mining activities will also be presented as part of the Safety Analysis Report (SAR)

Switzerland, ENSI

At present, there is no national regulatory framework dedicated to the conventional/nuclear co-activities in Switzerland. Nuclear safety of a DGR is based on the actual legal framework (Nuclear Energy Act (NEA) and Ordinance (NEO), Radiological Protection Act (RPA) and Ordinance (RPO) as well as by guidelines (ENSI-G03/e; ENSI-G15). However, the existing operational concepts are not yet detailed enough to evaluate specific operational issues. Depending on the spatial configuration and Nagra’s underground ventilation concept (with individual lines for the nuclear and the conventional parts of the DGR), it might result that nuclear/non-nuclear co-activities are unobjectionable from a radiation protection point of view.

Switzerland, Nagra

The applicable ENSI Guideline G03 contains a paragraph (5.1.3.d) specifically addressing the type of co-activity described in our answer to question 1. It says: "The design of the underground installations must ensure an appropriate spatial separation and separate ventilation of areas where radioactive waste is handled and areas where the disposal capacity is simultaneously being expanded. The expansion of the waste emplacement zones may not compromise the operational and long-term safety of the geological repository."

UK, HSE

Both nuclear and conventional safety is covered by the same legal framework. The Health and Safety at Work, etc. Act 1974 places a general duty on employers to ensure, so far as is reasonably practicable, the health, safety and welfare at work [whatever type of work] of all his employees. For a geological disposal facility the same regulator, the Office for Nuclear Regulation will regulate both conventional and nuclear safety.

UK, NDA

In the United Kingdom, the main legislation governing the safety of nuclear installations is the Health and Safety at Work Act 1974 (HSWA) and the associated relevant statutory provisions of the Nuclear Installations Act 1965 (NIA65) and the Ionising Radiation Regulations (1999). The Office for Nuclear Regulation (ONR) is responsible for enforcing the Act and a number of other Acts and Statutory Instruments relevant to the working environment.

Any site upon which it is intended to develop a geological disposal facility is envisaged to require a Nuclear Site Licence, for which ONR is the licensing authority. In addition to the requirements of the nuclear site licence, there are regulations governing the release of radioactivity to the environment which are set down in the Radioactive Substances Act 1993 (RSA 93), which in England and Wales is enforced by the Environment Agency (EA). The EA's expectations with regard to environmental permitting for a GDF are set out in its Guidance for Requirements for Authorisation (GRA).

The Construction (Design & Management) Regulations (CDM) (2007) addresses the issue of responsibility for securing better provisions for design and management of construction projects. They have been developed to improve planning and management of construction projects from the outset, and to ensure that clients, designers and contractors have clearer responsibilities. The primary aim of the CDM Regulations is for health and safety considerations to be treated as an essential but normal part of a project's development and to clarify responsibilities for all the key players in a construction project.

3. Types of hazard

3) What type of hazards associated with co-activity have you identified? How are these hazards identified? What are the potential impacts on nuclear activities? How do you establish the basis in assessing the identified hazards? Are there lessons learnt from other nuclear facilities (e.g. expanding nuclear plants or nuclear surface facilities)? Can you explain what kind of prevention/monitoring/control/mitigation measures (technical and organisational) you have considered in managing risks related to co-activities? Could you give practical examples to illustrate your answer?

Belgium, ONDRAF/NIRAS

Co-activity in ONDRAF/NIRAS' design for geological disposal results from backfilling and sealing disposal galleries containing waste. As the wastes are contained in disposal packages and already in place during these operations, the hazards during backfilling are limited (no risk of a drop or collision of the disposal package). The main operational safety risks concern the execution of some operations in the proximity of the waste. These risks can be managed by limiting the working time close to the disposal packages and by the use of shielding materials where possible.

The hazards related to gallery sealing are very limited as this is done when the backfill material is already in place.

The identification and management of possible hazards makes part of a recently launched study (cf. question 5).

Canada, NWMO

See reply to Question 1). With respect to the APM DGR, the hazards identified and addressed in the conceptual design are to (1) minimise impact of mining on already emplaced containers, and (2) minimise risk of contamination of the construction side. These are addressed by (1) separating construction into panels, which are physically separate from filled panels; and (2) separating as much as practical the flow of materials and air for excavation from the flow of containers and air for emplacement through layout of the shafts and the ventilation drifts.

France, Andra

a) *What type of hazards associated with co-activity have you identified?*

Internal hazards may be associated to co-activity (in the Andra facilities configuration). More precisely, hazards strongly linked to works and nuclear activities need to be assessed.

At the stage of the Andra project, some typical events, for both activities, can be mentioned:

Construction events:

- vehicle shock or collision;
- flammable product leak on a motorised vehicle;
- motorised vehicle fire;
- water network leak or break (drinkable, industrial);
- dust production linked to digging.

Nuclear potential events:

- Radiological exposure;
- Vehicle collision with release of contaminated substances;
- Fire in nuclear zone.

b) *How are these hazards identified?*

Co-activity related hazards are identified by considering every single hazard event of one activity as potentially harmful for the other activity.

c) *What are the potential impacts on nuclear activities?*

The potential impacts of works activities may be on nuclear activities, for example:

- Fire or flooding spread from building area to operation area;
- Damage on a nuclear-support network (power supply, airing…);
- Damage on containment systems (waste package, HE –filters).

d) *How do you establish the basis in assessing the identified hazards?*

The assessment of the identified hazards is based on a classical French analysis namely "MADS-MOSAR" that is generally utilised for both non-nuclear and nuclear risk assessments.

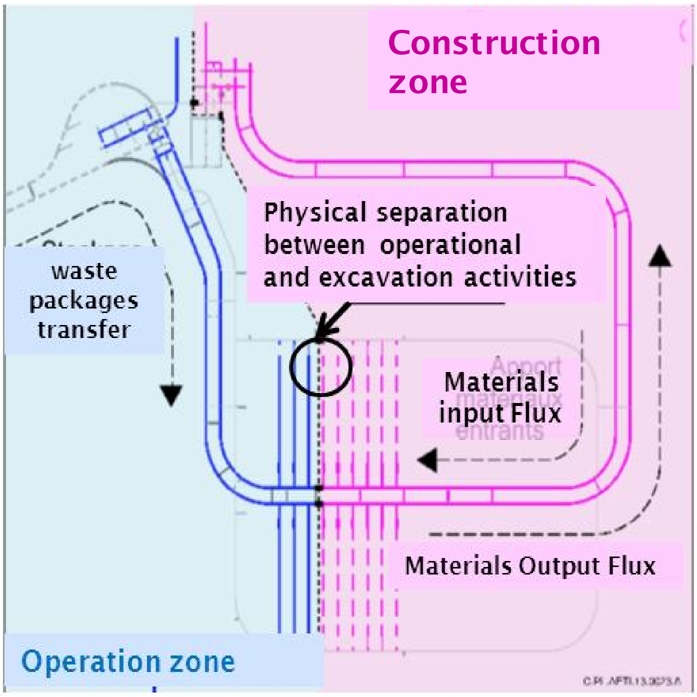
e) *Are there lessons learnt from other nuclear facilities (e.g. expanding nuclear plants or nuclear surface facilities)?*

Lessons learnt from other nuclear facilities are indeed taken into consideration when assessing the co-activity risks and mainly when looking for technical measures. For the management of co-activity in the underground facility, design basis takes into account the lessons learnt from mining and nuclear activities.

f) *Can you explain what kind of prevention/monitoring/control/mitigation measures (technical and organisational) you have considered in managing risks related to co-activities?*

In order to deal with the risks associated to co-activity, it has been chosen to maintain and guarantee a physical independence of both activities. Therefore the main measures to manage co-activity related risks are:

- Physical separation of activities:
  - Separated accesses (i.e. one "nuclear" ramp for waste package transfer and one ramp for building activity);
  - Different networks (ventilation, electricity supply, water collect, materials flows…);
  - If necessary, additional technical measures may also be used such as airlock.



Supervision measures:

Two independent fixed supervision systems completed if necessary by mobile detectors).

Mitigation measures:

- Airlocks designed to withstand internal and external aggressions;
- Stationary and semi-mobile fire-fighting measures;
- Enhanced firefighting measures on the nearest junction from the digging front;
- Emergency path identified, signalised, and kept clear;
- Mobile or semi-mobile air self-sufficient shelter near the digging front.

Germany, BfS and DBE Tech

Prior to deciding on the type of repository operation, an incident analysis was carried out. All transport and handling processes as well as the equipment necessary to transport and handle waste packages and to transport personnel and materials were considered. In accordance with the risks identified concerning operational disturbances or incidents, appropriate technical or organisational measures were defined. One example of these measures is the decision to empty the tube used to transport diesel to the underground in shaft Konrad 2 prior to a shaft transport of waste packages. Another example is an underground traffic control system that uses traffic lights with appropriate priority circuit for the waste transport unit.

Germany, GRS

As the main hazards associated with co-activities have been:

- Fire;
- Collision of vehicles;
- Rockfall;
- Dropping of waste packages.

a) *What are the potential impacts on nuclear activities?*

Potential impacts on nuclear activities are the damage of waste packages with incidental release of radioactive substances and damage to/of the Repository site by co-activities.

How do you establish the basis in assessing the identified hazards?

The basis in assessing these hazards is given in the application of the aforementioned regulatory framework. The operation of disposal facilities is based on non-nuclear mining regulations (mining act is applied to DGR without restrictions), radiation safety regulations and environmental protection regulations. Based on the safety principles for nuclear engineering and the analogous adaption of existing rules and policies for nuclear facilities (Germanys *KerntechnischesRegelwerk*, KTA) to the specific licensing procedures for disposal sites to fulfil the regulatory demands, incident analyses have to be carried out.

b) *Are there lessons learnt from other nuclear facilities (e.g. expanding nuclear plants or nuclear surface facilities)?*

Lessons learned from Germany's existing DGRs (Asse and Morsleben repository sites in salt) are e. g. the requirement of the integrity of the isolating rock zone and the consideration of the complexity of the safety case. Using for example chambers and galleries of pre-existing mines, which left open for long time periods (>100 a) implicates integrity and stability problems for the whole mine which can be avoided using underground repositories solely built for the disposal of radioactive waste.

Also long-time operation of DGRs, especially after completion of the disposal activities (as has been in the Asse site) can have impacts on the integrity of the site and on the isolating rock zone.

c) *Can you explain what kind of prevention/monitoring/control/mitigation measures (technical and organisational) you have considered in managing risks related to co-activities? Could you give practical examples to illustrate your answer?*

To manage risks related to co-activities the operation of DGRs is accompanied by the regulating authorities, e. g. mining authority, repository surveillance, etc.

Incidents with radiologic effects, based on incident analyses, have been assigned to two classes:

Class 1: incidents whose radiological effects are limited by the design of the plant and/or waste packages

Class 2: incidents which are precluded by the design of the plant and/or waste packages

For each individual case it must be decided to which class the respective incident is to be assigned and if appropriate precautions can be taken by design measures inside the DGR or on the waste packages.

E.g.: For the Konrad repository a radiological incident analysis has been performed regarding a transport vehicle fire during transport of waste packages in a transport gallery (belowground). Aim of this analysis was to demonstrate, based on radiological calculations that the incident dose limits imposed by the authorities are complied with. Flanking this it has also been shown that the requirements of the Federal Immission Control Act are complied with.

Another example is the organisational separation between transport of waste packages and excavation and closure of mine tracks (backfilling) and emplacement chambers, construction works or maintenance works underground. “Conventional” activities, including operation of underground storage tanks, in the DGR are not allowed during disposal operations.

To prevent hazards relating to a potential release of radioactive substances within the DGR where the radioactive substances are transported with the airflow, upcast ventilation is channelled via the same shaft the waste packages are transported belowground. Conventional transport of workers and non-nuclear material are operated within an additional shaft, strictly separated from the shaft where nuclear material is transported.

Based on incident analyses the radioactive inventory of the waste packages is limited to specific levels. Even if a hazardous release occurs the radiological effects are therefore limited to the dose limits imposed by the authorities.

Also the airflow is constantly monitored for radioactive gases and aerosols.

Sweden, SKB

Logistics: We have a different approach to excavation than the mining industry: Linear excavation, which means that new deposition tunnels are excavated when there is a demand of new depositing positions. In other words, the depositing rate regulates the excavation rate.

Storing and handling explosives needed for the excavation, in a nuclear facility with high security requirements.

Hazards are identified in the deterministic safety assessment for the operational phase (which is currently being revised). The deterministic safety assessment is an iterative process in the licensing stages, more knowledge about the facility is available every time it is performed and thus the safety assessment is constantly enhanced.

The facility is designed to eliminate certain hazards that theoretically could have their origin in one part of the facility and then spread to other parts, for example bouldering / cave-ins, flooding, fire.

Operating experience is collected both from the nuclear industry and the mining industry. But there is not much operating experience to be found when it comes to co-activities.

The impact of blasting and other tunnelling operations on the barrier properties of the already completed and deposited parts of the repository has also been assessed and are reported as part of the post-closure safety assessment SR-Site (SKB TR-11-01, section 10.2) being part of the license application for the repository. Among other things these assessments justify the allowed minimum distances between blasting operations and already completed, backfilled and plugged deposition tunnels.

Switzerland, ENSI

The present-day status of the stepwise approach in the Sectoral Plan does not yet include detailed considerations concerning the operational layout and the associated operational risks (hazards) of the future DGR. In its assessment (HSK 35/99) to the safety case of the Nagra (NTB 02-02), ENSI pointed out that the operation of the surface installations of a DGR is comparable in many ways to the routine operation of a surface interim storage facility. Hence, standard monitoring/control concepts will apply (e.g. radiological monitoring of the ventilation, of sewage water etc.). Whether these concepts have to be adapted to the particular needs of a DGR’s surface installation, will be answered at a later point of the siting/licencing process.

Switzerland, Nagra

A risk analysis related to construction of the two repository types (HLW repository, L/ILW repository) foreseen in Switzerland is currently under way (planned completion in 2014). A physical separation between the area where spent fuel / HLW canisters are being emplaced and the area where new emplacement tunnels are being excavated ensures that the requirement of ENSI Guideline G03 related to co-activity (see answer to question 2) is met. This includes separate access routes to the two areas. However, it will be evaluated in how far either of the separate access routes might be used for rescue & evacuation operations from any single one of the two separate areas in an emergency. Furthermore, it will be evaluated whether synergies can be used between the ventilation systems for the two areas.

UK, HSE

From a regulatory point of view we are in the early stages of considering the issue of co-activities.

UK, NDA

A preliminary review has been performed by RWMD and contractors of the potential hazards and required safeguards associated with the construction of the different areas of a GDF. These are identified and summarised in a Construction and Commissioning Fault Schedule. The fault schedule and results will be made available to the eventual construction contractor to assist in the production of their construction risk assessment.

The current plan is that construction and emplacement operations would be physically segregated with air locks between the two working areas, and their own dedicated services and infrastructure. Construction and emplacement would be serviced by separate and segregated roadways and access ways (drift and shafts). Therefore, although construction and emplacement activities will be occurring at the same time, they will be serviced by completely separate ventilation systems and services to minimise the potential for unplanned interactions between the activities. Two potential “interactions” have been identified:

- Whilst construction and emplacement operations are segregated it is planned that the airlocks which physically separate the two operations, could be utilised for emergency passage from area to the other.
- Construction blasting operations could potentially result in vibration which could have a negative consequence for emplacement operations.

The latter point has been considered in a study which has considered the vibration and air overpressure effects from blasting operations in strong rock. The study assessed the vibration and air pressures in vaults at distances of 50m and 100m from blast operations; which correspond to the distances for vaults undergoing fit-out and emplacement operations adopted in the higher strength rock illustrative design. This segregation, by solid pillars of rock, coupled with the design of blast patterns, where required, would be sufficient to ensure that blast vibration would not affect the waste emplacement operations.

This understanding of vibration and air pressure attenuation has led the definition of a vault construction, fit-out and operation sequence, which would see consecutive vaults as follows: one vault under construction, one vault undergoing fit-out and commissioning and one vault operating. The non-operational vault and its associated surrounding solid rock pillars would act as a separation “buffer” between areas undergoing excavation and those containing waste packages or undergoing waste package emplacement.

In lower strength sedimentary and evaporite environments it is envisaged that the majority of excavation would be carried out mechanically using tunnelling machines which would exert much reduced challenge in terms of vibration and overpressure.

The blasting study concludes that by application of controlled blasting (such as electronic delay detonation) and implementation of a vibration control and monitoring strategy, blasting operations could safely be carried out whilst safeguarding vaults undergoing fit-out, waste emplacement operations and previously emplaced vaults.

4. Challenging issues

4)	What challenging issues have you identified regarding co-activities in line with the stage of the development of your project (generic study, industrial design, towards licensing…)?

Belgium, ONDRAF/NIRAS

As co-activity is limited in our design and as our design is only developed at a conceptual stage, no challenging issues related to co-activity have been identified yet.

Canada, NWMO

See reply to Question 1). Challenging issues associated with co-activities have not been identified.

France, Andra

The main challenging issues are:

- The comprehensiveness of the hazards due to the co-activity;
- The step-by-step building of facility that impose to manage the mobile barrier between the two areas;
- These particularities require specific care during the whole development project because of the impact on many aspect and equipment (network plugging, security management including fire, emergency paths and emergency procedure, airing management…).

Towards the licensing, technical arguments will be presented to prove the efficiency of the physical measures and that impact of risk due to the co-activity complies with Andra protection objectives.

Germany, BfS and DBE Tech

In the course of the plan approval procedure for the Konrad repository, a disposal and ventilation system with the following characteristics was developed:

(1) spatial separation of waste package and debris transports and

(2) parallel ventilation of emplacement and drift excavation areas

In line with this concept, new emplacement drifts are excavated outside the controlled area, man hoisting and waste emplacement take place via separate shafts, and there are no workplaces in the exhaust air stream of the emplacement fields.

Germany, GRS

Challenging issues regarding co-activities are especially found regarding to the retrieval of radioactive waste. E.g. the mining related requirements, ventilation issues, esp. regarding heat developing waste, ventilation using two-shaft systems and long distances between shafts and emplacement chambers.

Sweden, SKB

In the industrial design: Ensuring that the co-activities are kept separate. We have two barriers between the nuclear part and the excavation part: One for security purposes and one for fire protection.

The nuclear parts of the facility are mainly autonomous, and the excavation parts correspond to civil works.

Switzerland, ENSI

Available and verified operational concepts derive from the safety case of a HLW/ILW repository in 2002 (HSK 35/99; NTB 02-02) and from the LLW safety case in 1985 (HSK 23/28; NGB 85-03), and may be seen as generic study. Consequently, the spectrum of 'challenging issues' from the regulators point of view is quite manageable. ENSI (then named *Hauptabteilung für die Sicherheit der Kernanlagen HSK*) classified the operational risks as comparable to nuclear power plants or interim surface storages facilities, respectively. Detailed operational hazards will be reviewed in the scope of later licencing steps. Guideline ENSI-G03 requires that operation activities (whether organised as co-activities or not) must not have any significant influence on the long-term safety of the installation.

Switzerland, Nagra

We expect first indications from the results of the on-going risk analysis related to construction mentioned in the answer to question 3.

UK, HSE

Our work on this is at too early a stage to have anything worth sharing.

UK, NDA

Potential safeguards were identified for managing the hazards whilst constructing a GDF in parallel to emplacement operations. It should be emphasised that along with risk assessment and applying the principles of the hierarchy of control (elimination, reduction, isolation, control, PPE) across all hazards, the following general operational safeguards were found to be applicable:

- Good working practices e.g. Appropriate and timely training on tasks and procedures (including emergency plans/procedures, correct lifting postures) resulting in high levels of personnel competency;
- Health surveillance;
- Appropriate environmental conditions (wherever possible), e.g. reasonable levels for lighting, temperature, humidity etc.

5. R&D programme

5)	Do you have any R&D programme concerning the management of co-activity risk? If yes could you please provide some information about it?

Belgium, ONDRAF/NIRAS

The backfilling and sealing of disposal galleries is the subject of a recently launched study (done by DBE). The study mainly focuses on the technological challenge of backfilling (i.e. defining a suitable backfill composition) and sealing, but also operational safety aspects will be examined. The study is expected to be finalised in 2014.

Canada, NWMO

NWMO does not presently have any R&D programme concerning the management of co-activity risk.

France, Andra

At this stage, we plan to use as much as possible best available practices from other industries to feed our design. In case of specific needs, we may develop specific tests/programme in order to demonstrate the reach of the efficiency.

Germany, BfS and DBE Tech

Since the Konrad repository was already licensed in 2002, there are currently no R&D programmes dealing with the management of co-activity risks. However, there will be R&D activities in the context of the development of a repository system for heat generating radioactive waste.

Germany, GRS

Within the GRS there a currently no R&D programme concerning the management of co-activity risks.

Sweden, SKB

There is no R&D programme that is exclusively dedicated to study the management of co-activity risk. However, full-scale tests are performed at the Äspö Hard Rock Laboratory, and operating experience (and potentially newly identified hazards) are collected from those tests and integrated in the safety assessment. Assessment of the potential co-activity risks, both with regards to nuclear operational hazards and to potential impacts on nuclear safety after closure of the repository is also part of the safety assessments.

Switzerland, ENSI

The Swiss Federal Workgroup for Nuclear Waste Disposal (Agneb) has issued an R&D programme which includes projects dedicated to the design of a deep geological repository, the design and inventory of the pilot facility, and to the monitoring concept and setups. The issue of co-activity risks has been discussed within these projects in a very broad sense. No regulatory requirements have been considered necessary to either support or suppress co-activities due to the associated risks.

Agneb project «Design of a deep geological repository » (Lagerauslegung)

This project focuses on the principles and main features of the DGR's design. The main goal is to identify possible needs to adapt existing regulation concerning the design principles of a DGR. First results are expected by the end of 2013. External experts contribute with their expertise to the following aspects:

- Superior demands and surrounding conditions and the resulting specifications of a DGR;
- Arrangement of the disposal tunnels and galleries and their optimal design regarding the local geological and tectonic setting;
- Engineering specifications of access tunnels/shafts and safeguards regarding the operational and long-term safety;
- Engineering specifications of the sealing structures.

Agneb project «Design and inventory of the pilot facility» (Auslegung und Inventar des Pilotlagers)

This project investigates the essential specifications of the pilot facility regarding its location within the DGR, its waste inventory and the most important parameters to be monitored. In addition to this, the project targets the issue of reliability of conclusions concerning the main repository and identification of unexpected system behavior. The project is scheduled from July 2010 to the end of 2013.

Agneb project «Monitoring concept and setups» (Monitoringkonzept und -einrichtungen)

This project deals with all aspects of the monitoring programme of a DGR, covering environmental reference measurements ahead of any construction works up to long-term monitoring after the final closure of the DGR. Aim of the project is to compile a comprehensive overview of potential monitoring concepts and setups. Furthermore, it should provide regulation principles for future monitoring guidelines and will closely follow the R&D programme of the European Union «Monitoring Developments for Safe Repository Operation and Staged Closure» (MoDeRn). The project will be finalised by end of 2013.

Switzerland, Nagra

No – this is not considered necessary at the current stage of the Swiss programme (site selection). We note that in Switzerland waste emplacement in the HLW repository will not start before about 2050.

UK, HSE

As regulators we do not have any R&D programme but we aim to actively engage with other regulators to learn on this topic.

UK, NDA

It is too early in the generic phase to identify a direct R&D programme for the management of co-activity risks. We believe that the principles of segregation will serve to minimise the unplanned interactions that could occur between the construction and the emplacement activities.