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Technical Expertise network
SITEX-II
Radioactive Waste Disposal

SITEX-II

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SITEX-II Final Project Report

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SITEX-II OUTLINES

Sustainable network for Independent Technical EXpertise of Radioactive Waste Disposal – Interactions and Implementation (SITEX-II)

The SITEX-II Project (Coordination and Support Action) was initiated in 2015 within the EC's Horizon 2020 programme to further develop the Sustainable Independent Expertise Function Network in the field of deep geological disposal safety. This Network is expected to ensure a sustainable capability for developing and coordinating, at the international level, joint and harmonized activities, related to the Expertise Function. SITEX-II brings together representatives from 18 organisations including regulatory authorities, technical safety organisations, research organisations and specialists in risk governance and interaction with general public, including NGOs and an education institute. It is aimed at practical implementation of the activities defined by the former EURATOM FP7 SITEX project (2012–2013), using the interaction modes identified by that project. SITEX-II, coordinated by IRSN, is implemented through 6 Work Packages (WP).

WP1 - Programming R&D (lead by Bel V). The general objective of WP1 is to further define the Expertise Function's R&D programme necessary to ensure independent scientific and technical capabilities for reviewing a safety case for geological disposal. In this perspective WP1 will develop a Strategic Research Agenda (SRA) and define the Terms of Reference (ToR) for its implementation accounting for the preparatory work to be carried out in the framework of the JOPRAD project for construction of a Joint Programming of research for geological disposal.

WP2 - Developing a joint review framework (lead by FANC). The key objective of WP2 is to further develop and document in position papers and technical guides a common understanding of the interpretation and proper implementation of safety requirements in the safety case for the six phases of facility development (conceptualization, siting, reference design, construction, operational, post-closure).

WP3 - Training and tutoring for reviewing the safety case (lead by LEI). WP3 aims to provide a practical demonstration of training services that may be provided by the foreseen SITEX network. A pilot training module will focus on the development of training modules at a generalist level, with emphasis on the technical review of the safety case, based on national experiences, practices and prospective views. The training modules will integrate the outcomes from WP1, WP2 and WP4 and support harmonisation of the technical review processes across Europe.

WP4 - Interactions with Civil Society (lead by Mutadis). WP4 is devoted to the elaboration of the conditions and means for developing interactions with Civil Society (CS) in the framework of the foreseen SITEX network, in view of transparency of the decision-making process. The future SITEX network is expected to support development of these interactions at different levels of governance and at different steps of the decision-making process. Three thematic tasks, namely R&D, safety culture/review and governance will be addressed by institutional experts and representatives of CS within SITEX-II as well as externally through workshops with other CS organisations.

WP5 - Integration and dissemination of project results (lead by CV REZ). The overall objective of WP5 is to produce a synthesis of the results achieved within all the WPs of SITEX-II together with an Action Plan that will set out the content and practical modalities of the future Expertise Function network. WP5 will also foster the interactions of SITEX-II with external entities and projects, as well as the dissemination of SITEX-II results so as to allow possible considerations from outside the project in the process of developing the future SITEX network.

WP6 - Management and coordination (lead by IRSN).

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Further details on the SITEX-II project and its outcomes are available at **www.sitexproject.eu**

ABSTRACT

The coordination action SITEX-II was initiated in 2015 within the EC programme Horizon 2020, aiming at practical implementation of the activities defined by the EURATOM FP7 SITEX project (2012–2013), using the interaction modes identified by that project. The network is expected to ensure a sustainable capability for developing and coordinating, at the international level, joint and harmonized activities related to the independent technical expertise in the field of safety of deep geological disposal of radioactive waste. SITEX-II gathered different types of actors - Technical Safety Organisations (TSOs), National Regulatory Authorities (NRAs), Research Entities (REs) and Civil Society (CS) - involved in four types of tasks prefiguring the activities of the future network:

- **R&D** - defining the Strategic Research Agenda (SRA) based on the common R&D orientations defined by SITEX, defining the ToR for the implementation of specific topics from the SRA, and interacting with IGD-TP and other external entities mandated through the JOPRAD EU project to implement research on radioactive waste disposal regarding the potential setting up of an European Joint Programming on radioactive waste disposal;
- **Safety review** - producing guidance on the technical review of the safety case at its different phases of development, fostering a common understanding on the interpretation and proper implementation of safety requirements for developing, operating and closing a geological disposal and on the verification of compliance with these requirements; such activity was carried out in connection with other international entities or projects;
- **Training and tutoring** - developing a training module for generalist experts involved in the safety case review process, including the implementation of a pilot training session; this activity accounted for the existing training programs performed at national and international levels;
- **Interaction with CS** - developing interactions between institutional experts and CS, in the framework of R&D and review related tasks mentioned above, and more globally in the definition of governance patterns including CS in the framework of Radioactive Waste Management (RWM) including geological disposal.

In addition, SITEX-II prepared of the "administrative" framework for a sustainable network, by addressing the legal, organisational and management aspects for launching such an association.

This Final Project Report (D5.4) is the fourth deliverable prepared by the SITEX-II project group for Work Package 5 *Integration and dissemination of project results*. One of the objectives of Work Package 5 was to produce the synthesis of the results achieved within all the WPs of SITEX-II together with an Action Plan for establishing the SITEX network, which provides the contents and practical modalities of the future network for independent technical expertise of radioactive waste disposal. The present report sums up the SITEX-II project outcomes, achievements, findings and lessons learnt.

Regarding R&D programming, SITEX-II developed the SRA of the Expertise function, accounting for the concerns of the CS representatives. The R&D topics were ranked with regard to their level of interest and priority, leading to 7 "Main topics" associated to 35 specific issues. This SRA was an input to the European JOPRAD project aimed at assessing the feasibility of a Joint Programming (JP) in the field of RWM including geological disposal, involving Waste Management Organisations

(WMOs), TSOs and REs. All the SRA topics were acknowledged to be eligible for such a JP if the conditions identified by SITEX-II and documented in its SRA for preserving the independence of the organizations fulfilling an Expertise function are met. The JOPRAD Programme Document globally well considers the needs of the Expertise function identified in the SITEX-II SRA. Further SITEX-II has developed first Terms of Reference for its SRA implementation, considering three options for each topic: i) deploy activities through the first wave of European Joint Programing (EJP) in the field of RWM, ii) develop these activities through a future SITEX network or iii) consider the results of on-going European projects before deciding to start new activities.

For the safety case review activities, SITEX-II partners shared national experience and prospective views on the interpretation and implementation of safety requirements on four topics: optimization of protection, waste acceptance criteria, site characterization and operational issues with regard to post closure safety. Position papers were developed on each of these topics. Besides, SITEX-II partners continued developing the guidance on reviewing a safety case initiated during the former SITEX project, notably through the construction of grids for addressing the successive phases of a geological repository lifecycle.

Regarding training and tutoring, an overview of existing training and tutoring practices used by SITEX-II partners located in Europe and Canada was issued, as well as recommendations for competence building of independent technical experts (safety case reviewers). On this basis and thanks to the extensive practice of the involved SITEX-II partners and their effective collaboration, a training module at a generalist level with emphasis on the technical review of the safety case was developed and implemented in June 2017 in Lithuania, with 18 trainees from different SITEX related countries. The feedback provided by trainees and lecturers was thoroughly analysed and improvements were identified. This experience forms a valuable basis for further developing the training and tutoring services to be provided by a future SITEX network.

Interactions between institutional experts and representatives of CS within SITEX-II took place on three thematic tasks, namely R&D, safety culture/review and governance, internally with SITEX-II CS representatives and externally through workshops with other CS organisations, as well as through interviews of various representatives of non-institutional (NGOs) and institutional actors in Europe (NRAs, TSOs, REs). Regarding R&D, a concept of CS knowledge interaction in international research projects on RWM was developed that could be relevant in the JP on RWM under preparation. The main communalities and differences in the vision of safety culture were investigated as well as the expectations regarding the engagement of CS in the safety case review. Regarding intergenerational governance of geological disposal, recommendations were written out on the basis of a literature review and a questionnaire. An innovative multi-stakeholders approach of interactions was also developed, entitled Pathway Evaluation Process (PEP), presented as a serious game and conceptualized as an exercise of participative and comparative assessment of different parallel alternative scenarios on long-term management of radioactive waste.

This work, together with the Action Plan dealing with statutes and rules established by SITEX-II for a future SITEX network, provided all the provisions to make the SITEX initiative sustainable. The relevance of the SITEX initiative being widely recognized by its participants and beyond, this consequently led to the launching of the association SITEX_Network at the beginning of January 2018.

CONTENT

1 Context and objectives

The European Council Directive 2011/70/EURATOM of 19 July 2011 establishes a Community framework for the responsible and safe management of spent fuel and radioactive waste. This Directive reaffirms the principle of prime responsibility of the license holder with regards to safety and reinforces the role and independence of the competent regulatory authority. It also states that it is broadly accepted at the technical level that, at this time, deep geological disposal represents the safest and most sustainable option as the end point of the management of high-level waste and spent fuel considered as waste.

In line with this Directive and in consistency with international high level safety standards issued by IAEA and WENRA, and with international approaches developed within the NEA/RWMC activities, waste management organisations (WMOs) are developing a safety case for presenting the technical and organisational arguments that support the development of the national geological repository concept.

As safety cases develop, the safety case review by regulatory bodies in the framework of the decision making process develops as well. In that context, organisations in charge of reviewing the safety case must in particular evaluate whether the elements of safety, and in particular that supported by scientific and technological results, are sufficiently convincing to be accepted by the regulatory authority as a basis for proceeding with the decision making process. The assessment of the scientific and technical issues developed by the WMOs requires specific skills from the assessor in order to evaluate whether they allow compliance with the safety requirements issued by the regulatory authority.

In that context, there is a **need at the international level for developing and coordinating activities associated to the regulatory review process of deep geological disposal**. For that purpose, a number of initiatives, projects and groups of experts at international and European level have been launched as for example ENSREG, WENRA, NEA/RWMC/Regulator Forum, IAEA/GEOSAF and GEOSAF II. In 2012, the EURATOM FP7 **SITEX** coordination and support action was launched in order to complement the above mentioned initiatives with the view to characterize the Expertise function activities devoted to the scientific and technical review of the safety case with respect to the safety of the geological disposal. SITEX was a 24 months FP7 EURATOM coordinated action (2012-2013) bringing together 15 organisations representing Technical Safety Organisations (TSOs) and safety authorities, as well as Civil Society (CS) outreach specialists involved in the regulatory review process of the safety case of geological disposal.

The SITEX project (2012-2013) highlighted different **needs and missions of the national Expertise function along the decision making process,** in relation to safety case regulatory review, implementation of research in safety, training of experts in charge of regulatory review and interaction with CS. Regarding these different tasks, SITEX (2012-2013) identified the potential areas of cooperation, exchanges or sharing of resources that could be developed by a future SITEX network, as well as a set of organisational and technical opportunities that could be implemented in practice. Though the considerable preparatory work carried out within SITEX (2012-2013), some of its outcomes and key concepts for a future SITEX network required being further developed and/or tested in practice. Thus, a follow-up was proposed to the European Commission, the EURATOM Horizon2020 Coordination Action **SITEX-II** (2015-2017), aiming at practical

implementation of the activities defined by the former SITEX project using the interaction modes developed by that project, with a view to further developing the Expertise function network. This network is expected **to ensure a sustainable capability of developing and coordinating joint and harmonized activities related to the independent technical expertise in the field of safety of geological disposal of radioactive waste.** SITEX-II included the following main tasks:

- **Programming R&D** - to further define the Expertise Function's R&D programme necessary to ensure independent scientific and technical capabilities for reviewing a safety case for geological disposal, through the development of a Strategic Research Agenda (SRA) and definition of Terms of Reference (ToR) for its implementation;
- **Developing a joint review framework** - to further develop a common understanding of the interpretation and proper implementation of high-level safety requirements and regulatory expectations for the safety case at its different phases of development, issuing technical guidance and position papers;
- **Training and tutoring for reviewing the safety case** - to gather national feedbacks on existing practises and develop a training module for generalist experts involved in the safety case review process, including the implementation a pilot training session;
- **Interacting with Civil Society** - addressing the conditions and means for developing interactions with CS, with a particular focus on R&D, safety culture/review and governance patterns with CS in the framework of geological disposal.

In addition, SITEX-II prepared the "administrative" framework for a sustainable network, by addressing the legal, organisational and management aspects.

The present final project report first summarises SITEX-II bases issued by the former SITEX project and gives a brief description of the SITEX-II consortium. Then, achievements, findings and lessons learnt are described for each of the SITEX-II technical activities together with the action plan for the creation of the network.

2 The Expertise function and the SITEX initiative

Expertise function

SITEX (2012-2013) presented a common understanding (shared by the SITEX participants) of the function of expertise and its missions (see SITEX deliverable D6.1 [1]), as summarized hereafter. The "**Expertise function**" contributes in activities carried out in the context of the regulatory review of safety case in order to provide the technical and scientific basis of safety for:

- decisions by the national regulatory body,
- ensuring that regulatory expectations are clearly communicated to and interpreted by the implementer,
- improving the quality of the interactions with CS in the decision making process (DMP) in order to contribute to build a robust review of the Safety Case.

Depending on the national institutional framework, these activities can be assigned to the national safety Authority (included in or performed by subsidiaries), to TSOs, to Research Entities (REs) or

other external organizations like consultants specialized in safety. They include:

- conducting safety review and developing the capacities to understand and assess the Safety Case,
- contributing to inspections,
- implementing R&D in safety,
- interacting with CS along the review process and developing appropriate governance patterns to conduct this interaction.

Three key conditions are required in order to both ensure the required level of quality of the Expertise function and allow its independency:

- competence, experience and knowledge notably provided by resources and skills independent from implementers in order to avoid conflicts of interest,
- transparency and proximity to the public, involving public release of its assessments and exchanges with CS,
- impartiality when delivering a technical opinion mainly afforded by the above requirements.

The role and the interactions of the Expertise function with the other stakeholders involved in the DMP are represented in Figure 1.

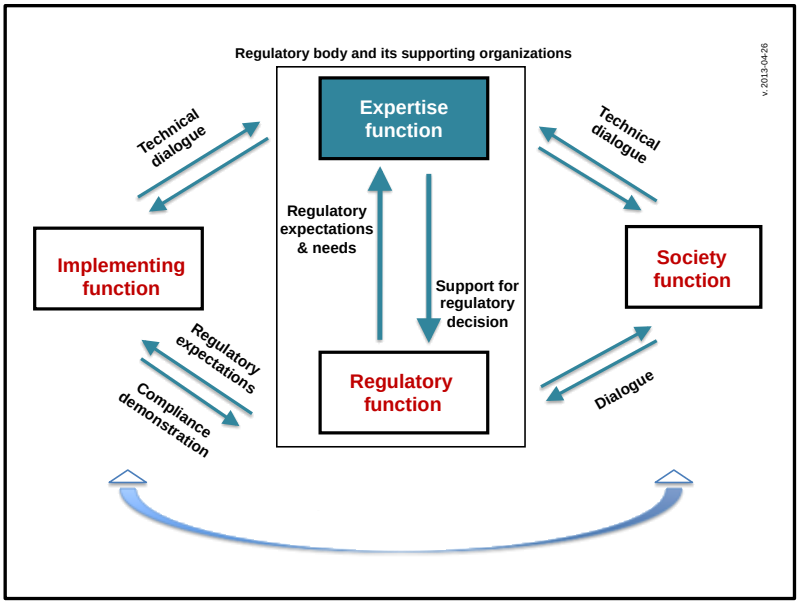

***Figure 1*: The Expertise function and its interactions (SITEX D6.1 [1])**

Interactions between the Expertise function and the "**Regulatory function**" contribute in:

- developing the safety requirements and conditions that have to be fulfilled in order to meet the general safety objective of protecting human and the environment against the hazards associated to ionizing radiations ("Regulatory expectations"),
- assessing the compliance with these requirements and conditions ("Compliance demonstration").

Assessing compliance with safety requirements requires strong technical support from the expertise function. This includes several activities such as independent R&D, reviewing of safety demonstration and inspections. In order to provide the regulatory function with an adequate decision support, the regulatory needs associated with the evaluation of conformity have to be clearly formulated and communicated to the expertise function.

The Expertise Function interacts with the "**Implementing Function**" (WMO) through technical dialogue, inside or outside the formal review of a safety case, e.g. on R&D issues, adequacy of the approaches followed to tackle safety issues and on risk assessment. The Expertise Function also interacts with the "**Society Function**" (CS), on the definition of the R&D programme carried out by expert's bodies and on safety case review with a specific emphasis on the assessment of the safety strategy and safety concept adopted by the implementer.

SITEX technical activities and mode of interaction

SITEX (2012-2013) (deliverable D6.2 [2]) proposed terms of reference for the technical activities of a SITEX network: four types of "technical activities" (previously called "functions" in SITEX; A, B, C, D in Figure 2) would be carried out in order to support, facilitate and strengthen national activities of expertise of its partners. These technical activities correspond to "R&D implementation", "Reviewing a safety case", "Training and Tutoring" and "Interaction with Civil Society".

For each of these technical activities, the SITEX network would provide the following three graded potential modes of interactions (1, 2, 3 in Figure 2) between partners:

- The first mode of interaction ("**Programming**") aims at identifying specific needs and developing diagnostic and specific programmes and products (training modules, safety guides, review guidance, SITEX SRA, strategy for interacting with CS) by **sharing national experiences, practices and prospective views** and by auditing appropriate stakeholders.
- The second mode of interaction ("**Implementing"**) aims at implementing in practice within the SITEX network the programmes and products identified in the first mode of interaction by **developing joint work and sharing resources** (human resources, tools, funding, etc.).
- The third mode of interaction **("Harmonizing, linking with external entities"**) aims, on the one hand, at promoting and diffusing the SITEX products as well as the collective opinions of the network **with the view to reach harmonization**, where appropriate. On the other hand, it aims at **developing interactions and partnerships** with external entities such as: European Institutions, international organisations (IAEA, NEA, ICRP), networks and platforms (ETSON, WENRA, IGD-TP), and civil society organisations (CSOs) and other partners (e.g. ENSTTI).

These three graded modes of interactions provide different types of operating opportunities related to each of the four SITEX technical activities (see green boxes in Figure 2 below). These operating opportunities are the different procedures and actions that the network could implement to fulfil needs for each SITEX technical activity.

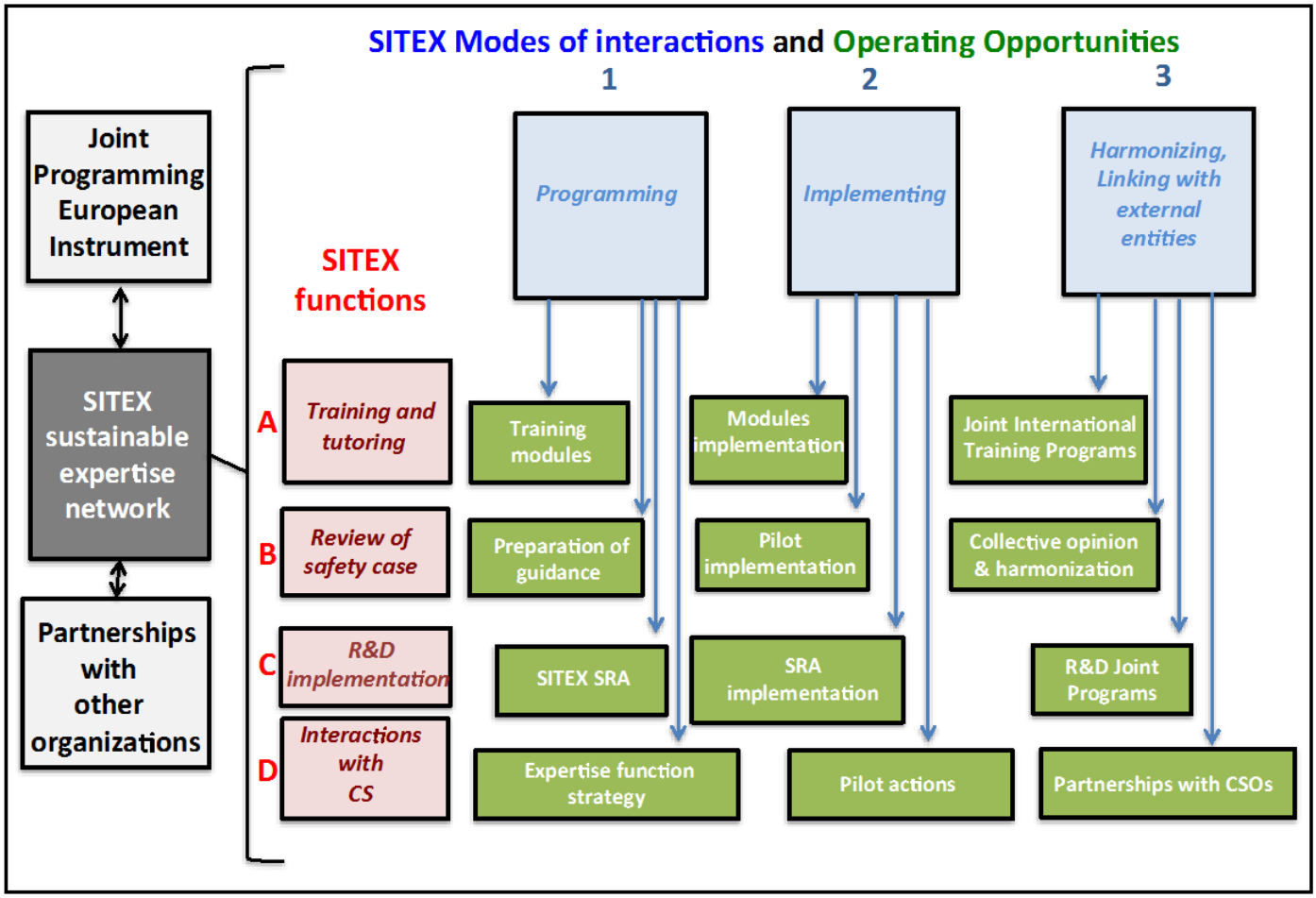

***Figure 2*: Framework of the technical activities in the SITEX network (SITEX D6.2 [2]).**

In red A, B, C, D: *"Functions" (carrying specific needs of expertise function at European level) of the SITEX network, called "**technical activities**" in the present report.* ***In blue 1, 2, 3****: Modes of interactions to be offered by the SITEX network.* ***In green A1, A2, A3, B1, B2, B3, C1, C2, C3, D1, D2, D3:*** *Operating opportunities (procedures to fulfil needs for each SITEX technical activity)*

3 SITEX-II consortium

SITEX-II brought together representatives from 18 organisations from 12 countries (see Appendix 1), involving regulatory authorities (FANC, ASN, CNSC), technical safety organisations (Bel V, CVREZ, DECOM, IRSN, NRG), research organisations (GI-BAS, GRS, LEI, PSI), specialists in risk governance and interaction with general public, including NGOs (ENERGIAKLUB, MKG, MUTADIS, REC, SYMLOG) and the education institute (ENSTTI), as illustrated in Figure 3.

In addition, an Associated Group (SSM, STUK, AE, ENSI, CLIS de Bure, SSTC NRS, SwRI, JAEA) was formed along the project with organisms which expressed their interest for SITEX-II and fed discussions in general meetings or in specific technical meeting, with enlarged know-how, experiences and point of view; members of the Associated Group were also required to review SITEX-II deliverables. Further, the SITEX-II CS partners interacted all along the project with a larger group of European CSOs and non-institutional experts engaged in following RWM activities at EU

or national level, gathering representatives of 35 organisations from 18 countries in Europe.

Besides, SITEX-II project was meant to provide an input to the JOPRAD (2015-2107) coordination action ("Towards a Joint Programming Project on Radioactive Waste Disposal"). Thus, a specific link to this project was designed notably through common participants to both SITEX-II and JOPRAD (IRSN, Bel V, CVREZ, Mutadis). The overall aims of the JOPRAD project was to assess the feasibility and, if appropriate, to generate a proposal for Joint Programming (JP) in the field of RWM, including geological disposal.

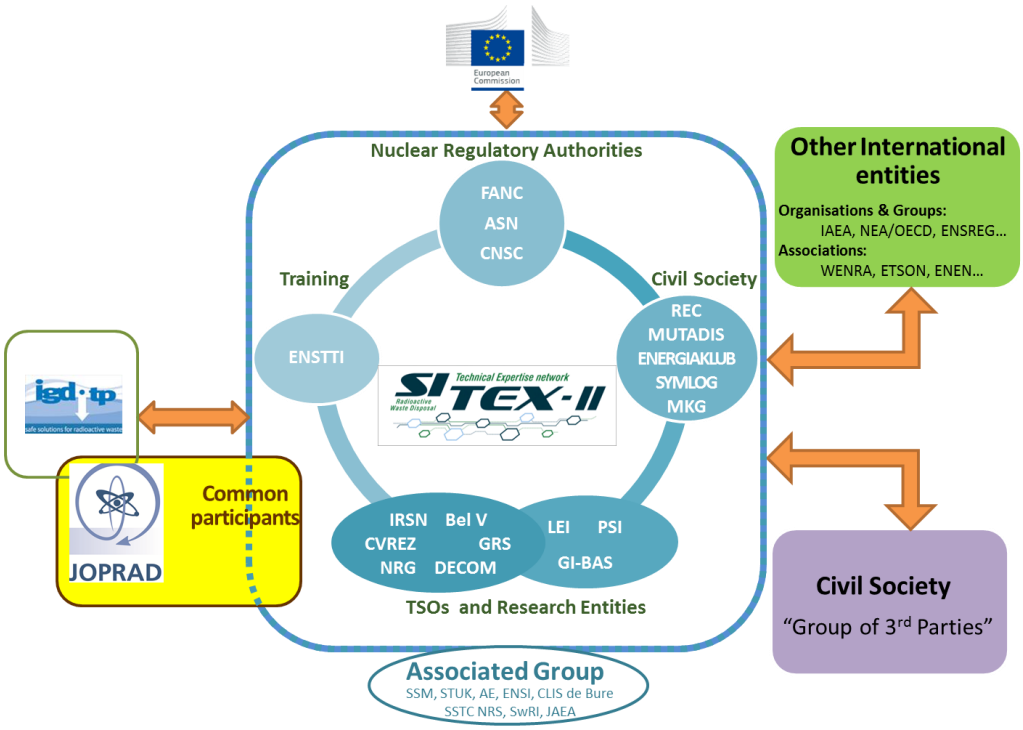

***Figure 3*: SITEX-II composition and interaction with external entities.**

4 Implementing R&D

The actions of SITEX-II work package 1 (WP1) partners (IRSN, LEI, FANC, Mutadis, CNSC, CVREZ, GRS, GI-BAS and PSI), led by Bel V (Belgium), were organized into two tasks: setting a Strategic Research Agenda (SRA) (Task 1.1) and setting the Terms of Reference (ToR) for the SRA implementation (Task 1.2). The findings of these tasks, described in the SITEX-II deliverables D1.1 [3] and D1.2 [4] respectively, are summarized below.

4.1 DEFINITION OF A STRATEGIC RESEARCH AGENDA OF THE EXPERTISE FUNCTION IN THE FIELD OF GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE

One of the major challenges of the SITEX-II project was to turn the R&D orientations for which future collaboration and sharing of resources would be potentially useful as defined in the SITEX project (2012-2013) into a SRA, defining and prioritizing R&D topics in line with these preliminary orientations (Task 1.1).

4.1.1 Objectives, scope and applied methodology

The objective of the SRA produced by SITEX-II is to identify and prioritise the needs for competence and skills development of the expertise function in the safety of RWM with a focus on geological disposal, at the international and in particular at the European level. These needs include research activities as well as horizontal activities such as exchanging on practices, establishing states of the art and transferring knowledge.

The commitments of the SITEX-II members for the development of the SRA are the following:

- The SRA is developed by applying a transparent methodology;
- The SRA addresses the needs associated with the different states of advancement of geological disposal programmes;
- The concerns of civil society are taken into consideration.

The scope of the SRA covers all the topics relevant to the expertise function to assess whether geological disposal facilities are developed and will be constructed, operated and closed in a safe manner. Therefore, topics related to pre and post-closure safety as well as to the technical feasibility of geological disposal are considered. The scope encompasses all topics relevant to any waste type and spent fuel for which geological disposal is envisaged as a solution for its long-term management. Actions dedicated to pre-treatment, treatment, conditioning, as well as transport and storage of radioactive waste having an impact on the safety of geological disposal facilities could also be considered in the SRA. Furthermore, activities related to management options other than geological disposal may be addressed by the SITEX network if relevant to several national programmes. However, this first version of the SRA is specifically focused on disposal in underground facilities.

The current SRA is not an exhaustive list of all the potential topics that could enter into the scope above. It covers topics for which a sufficient level of common interest has been expressed amongst the SITEX-II members (see below for the applied methodology).

This SRA was developed by the organizations of WP1 fulfilling an expertise function. It should answer to their variety of interests: indeed, countries of the participating organizations are in different stages of development of the geological disposal programme (see EPG report [5]): conceptualization for Belgium, Bulgaria, Lithuania as well as for the HLW and SNF disposal facility in Germany; siting for Czech Republic, Switzerland and for spent fuel disposal facility in Canada, reference design for France and for low and intermediate level waste in Canada, construction for KONRAD disposal facility in Germany, operation for ERAM disposal facility in Germany. The concepts (waste forms and containers, engineered barriers systems, host rocks, reversibility) are also slightly different from a country (or type of waste) to another.

The SRA was developed in three steps:

- identification of possible topics, following a preliminary list notably based on the deliverable D3.1 “R&D orientations for TSOs” of the former SITEX project [6];
- appraisal of the common level of interest for the possible topics; for each topic of the previous list, partners indicated the types of common activities in which they are interested (1- R&D; 2- sharing, exchanging or consolidating knowledge and expertise; 3- developing states of the art; 4- transferring knowledge) and ranked their level of interest

("H" for High, "M" for Medium or "N" for Not Interested);

- identification of the main topics (i.e., in which a high level of common interest could exist) and specific issues that will be included in the SRA.

The applied methodology allowed considering the concerns of the CS about the R&D needs of the expertise function. In particular, possible SRA topics built in step 1 of the SRA methodology were reviewed by WP4 (see chapter 7 of the present report), as well as the draft SRA established 6 months after the start of the project. Further, the SRA was reviewed by the Associated Group members of SITEX-II and by all the SITEX-II partners.

4.1.2 SRA Main topics and associated specific issues

Based on the methodology presented above, 7 main topics associated to 3 specific issues and activities of common interest for the expertise function were identified and included into the SRA. Theses main topics are:

1. Waste inventory and source term;
2. transient THMBC conditions in the near-field;
3. Evolution of EBS material properties;
4. Radionuclide behaviour in disturbed EBS and HR;
5. Safety-relevant operational aspects;
6. Managing uncertainties and the safety assessment;
7. Lifecycle of a disposal programme and its safety case.

In addition to R&D activities, the needs for knowledge transfer (e.g. training or tutoring), for developing state of the art and for exchanging on practices and developing common positions were also identified in the SRA. Figure 4 illustrates the associated issues and activities of common interest for Main Topic 1; Appendix 2 gives such a summary for the entire SRA.

SRA Main Topic and associated issues		Research activities (experiment and/or modeling works)	Horizontal activities		
			Exchange on practices, develop common positions	Develop states of the art	Transfer of knowledge (eg. training)
Main Topic 1: Waste inventory and source term					
#1.	Uncertainty about databases and methodologies used for defining waste inventories(including historical waste)				
#2.	Evolution of the waste inventory due to possible neutron activation				
#3.	Understanding of the release processes and speciation of the radionuclides for spent fuel, vitrified and cemented waste				
#4.	Waste acceptance criteria				

***Figure 4:* Associated issues and activities for Main Topic 1 of the Expertise function SRA.**

One particularly innovative development of the SRA relates to the introduction in the main topic 7 of several holistic (complex) topics, for which both technical and societal aspects need to be investigated in an integrated manner, using specific interdisciplinary methodologies and involving CS participation (e.g., safety culture, site selection process, license of disposal operation,

intergenerational governance of such phase, conditions for closure…). Also, regarding the other main topics, that are mainly technical, it came out essential to embed CS participation through the involvement of trained individuals, therefore offering the public the possibility to follow the development of this technical research, and to perform Knowledge Sharing and Interpretation (KSI) activities along the development of R&D results.

4.2 SETTING THE TERMS OF REFERENCES FOR THE STRATEGIC RESEARCH AGENDA IMPLEMENTATION

The task 1.2 of SITEX-II WP1 aimed at identifying plans for the deployment of actions covering the SITEX-II SRA issues.

In the frame of the European H2020 JOPRAD project [7], the TSO working group of JOPRAD has identified key RD&D aspects that the Expertise function could share with other actors and conditions for sharing, notably based on SRA of the Expertise function developed within SITEX-II. (see §4.1). The WMO and RE working groups of JOPRAD have performed a similar work. This led to set the conditions for developing the JOPRAD Programme Document (PD) [8]. A key conclusion of the SITEX-II WP1 and of the TSO working group of JOPRAD is that, if the conditions identified by SITEX and documented in its SRA [3] for preserving the independence of the organizations fulfilling an Expertise function are met, then all the activities and topics of the SITEX-II SRA could be implemented in the framework of a JP.

4.2.1 SITEX-II SRA issues associated to JOPRAD PD subdomains and their levels of common priority

In order to develop the Terms of References for implanting its SRA, SITEX WP1 has verified the SITEX-II SRA issues that are in the scope of the JOPRAD PD [8]. It resulted that:

- all SITEX-II SRA issues have corresponding subdomains in the JOPRAD PD;
- the vast majority of the SITEX-II SRA issues for which a common interest in RD&D activities was identified have a High or a Medium level of common interest in the JOPRAD PD;
- several SITEX-II SRA issues for which a common interest only in horizontal activities was identified have a High or a Medium level of common interest in the JOPRAD PD;
- the topics of the SITEX-II SRA for which technical aspects could be investigated in an integrated manner with social and citizen sciences aspects are of Medium or Low level of common interest or not covered by the JOPRAD PD.

Therefore, the JOPRAD PD globally well considers the needs of the Expertise function identified in the SITEX-II SRA. However, the following issues correspond to JOPRAD PD subdomains with a Low common priority and are thus not expected to be covered in the first phase of the EJP:

- Issues related to R&D activities
  - Main Topic 2 – Issue 1: Oxidative transient
  - Main Topic 5 – Issue 2: Assessment of the risk of fire and explosion
- Issues related only to horizontal activities
  - Main Topic 1 – Issue 2: Evolution of the waste inventory due to possible neutron activation
  - Main Topic 2 – Issue 4: Co-disposal of waste: interactions between different types of waste

- Main Topic 5 – Issue 3: Assessment of the risk of flooding
- Main Topic 7 – Issue 4: Organization of the pre-licensing phase
- Main Topic 7 – Issue 5: Reversibility and Retrievability
- Main Topic 8[1] – Issue 1.3: Determination in which circumstances a re-processing of the waste should be performed and what type of re-processing is appropriate

4.2.2 Plans for the deployment of actions covering the SITEX-II SRA issues

Considering the views of WMOs, TSOs and REs, the following possible EJP1 Work Packages were identified by the Core Group facilitating and coordinating the EJP1 proposal development in December 2017:

- RD&D activities:
  1. Modelling of process couplings and numerical tools applied to Performance Assessment
  2. Assessment of chemical evolution of ILW and HLW disposal cells
  3. Mechanistic understanding of gas migration (mainly in clay-based materials)
  4. Influence of temperature on clay-based material behaviour
  5. Cement-Organics-Radionuclide-Interactions
  6. Fundamental understanding of radionuclide mobility
  7. Spent Fuel characterization and evolution until disposal
- Networking activities:
  1. Waste management routes in Europe from cradle to grave
  2. Understanding of uncertainty, risk and safety by different actors

Based on this information, SITEX-II has developed a preliminary deployment plan for its SRA, considering, for each SITEX-II SRA issue, the following possible options for the deployment of future SITEX activities:

- Consider the results of an on-going European project before starting new activities. This option is selected for the SRA issues associated to the on-going European projects[2];
- Deploy activities through the EJP1. This option is selected for the SRA issues that currently enter in the scope of the envisaged EJP1 WPs;
- Deploy activities through the SITEX network. This option is considered for the SRA issues that currently do not enter, or partially enter, in the two previous options.

The resulting deployment plan is given in Appendix 2. SRA issues that are currently candidates for a deployment through the future SITEX network are summarized in Table 1 below, together with a short rationale. This deployment plan is still preliminary and needs to be refined in the future, notably considering the final EJP1 proposal that will be submitted in September 2018 to the EC, the future activities of existing IAEA or NEA projects and groups and on the resources of the future SITEX network.

[1] This Main Topic is not included in the SITEX-II SRA but was of common interest in the JOPRAD TSO Working Group

[2] CAST [9], CEBAMA [10], MIND [11], MODERN2020 [12], CHANCE [13], THERAMIN [14], DISCO [15], BEACON [16]

SITEX-II SRA Issues candidate for a deployment through the SITEX network			Explanation
Main topic	Issue	Description	
1	2	Evolution of the waste inventory due to possible neutron activation	Not covered by on-going EC projects and Low common priority in the JOPRAD PD.
2	1	Oxidative transient	This issue has a Low common priority in the JOPRAD PD but could be (at least partly) covered by the RD&D WP #2.
	4	Co-disposal of waste: interactions between different types of wastes	Not covered by on-going EC projects and Low common priority in the JOPRAD PD.
3	2	Behaviour of metallic components	This issue could be partly covered by the R&D WP #2 of EJP1. However, the following specific points mentioned in the SITEX-II SRA would not be covered: • Study of metal (e.g. steel, copper) corrosion in repository conditions or of canister design lifetime. • Exchanging on container design and manufacturing issues (e.g. modelling codes and standards and QA/QC programs and procedures for container design and manufacturing)
4	1	Competition between sorption of radionuclides and other elements from EBS/waste	Not covered by on-going EC projects and do not seem to be covered by RD&D WP #6 of EJP1.
5	2	Assessment of the risk of fire and explosion	Not covered by on-going EC projects and Low common priority in JOPRAD PD.
	3	Assessment of the risk of flooding	
5	4	Influence on long term safety of pre-closure disturbances	Not covered by on-going EC projects and by current Networking WP of EJP1.
6	3	General methodologies for the safety assessment	Not covered by on-going EC projects and not fully covered by the Networking WP #2 of EJP1 (only the aspects related to uncertainty management will enter the scope of this WP).
7	all	Lifecycle of a disposal programme and its safety case	Not covered by on-going EC projects and not fully covered by the Networking WP #2 of EJP1 (only the aspects related to uncertainty management will enter the scope of this WP).
8	all	Pre-disposal radioactive waste and spent fuel management	Not covered by on-going EC projects and not fully covered by the Networking WP #1 and #2 of EJP1 (in WP#2 only the aspects related to uncertainty management will be covered).

***Table 1*: SITEX-II SRA issue candidates for a deployment through the SITEX network**

5 Developing a joint review framework

As for all other nuclear facilities and activities, the overall goal of the regulatory review of a safety case for a geological disposal facility for radioactive waste is to confirm, with adequate confidence, that the geological disposal will not cause unacceptable adverse impact on safety, human health and on the environment, both now and in the future.

The activities of SITEX-II work package 2 (WP2) partners (IRSN, LEI, Bel V, Mutadis, Decom AS, CNSC, NRG, CVREZ, ASN and REC), led by FANC, were organized into two tasks: developing a

common understanding on the interpretation and implementation of safety requirements (Task 2.1) and developing guidance on reviewing the safety case (Task 2.2). The findings of these activities, described in the SITEX-II deliverables D2.1 [17] and D2.2 [18] respectively, are summarized below.

5.1 INTERPRETATION AND IMPLEMENTATION OF SAFETY REQUIREMENTS

The fulfilment of the safety requirements by WMOs (implementing function) requires not only a clear formulation of regulatory expectations but also technical guidance explaining how these requirements can be met in practice and how their fulfilment should be substantiated in the safety demonstration (i.e. safety case).

Within the SITEX-II project, the first Task of WP2 aimed at sharing national experience and prospective views on the interpretation and implementation of selected international safety requirements and recommendations (EC Directives, ICRP, IAEA, NEA, WENRA…), among Regulatory Authorities, TSOs and CS.

Among the topics identified according to the priorities set up in the former SITEX project, four topics have been discussed within the SITEX-II project:

- Optimisation of protection,
- Waste Acceptance Criteria,
- Operational issues in regard to post-closure safety,
- Programme for site characterization.

The discussions allowed developing a common understanding by regulators and TSOs on these topics and were summarised in position papers. However, the position papers do not cover the issues exhaustively; they only highlight topical issues SITEX-II participants feel they are worth to be raised. These position papers provide a reference to national regulatory bodies when they are developing their own technical guides and to WMOs when developing the safety case during the various phases. Interactions with IGSC (NEA), GEOSAF II (IAEA) and WENRA were also organised. Hereafter a focus is given on the key messages of each of the positions.

5.1.1 Position paper on optimisation of radiological protection applied to the development and implementation of a deep geological repository

There are various uses of the word “optimisation” throughout international and national guidances. For the regulatory body, it is important to focus on the optimisation of protection as defined by ICRP (103 & 122) including ALARA principle. There was therefore a need to discuss on the practical implementation of this principle as well as on the verification that this principle and associated requirements have been adequately implemented.

Following key messages are pointed out in the position paper:

1. The optimisation of radiological protection is a process which consists in the identification and use of safety criteria/attributes necessary to select the best protective technical options under the prevailing circumstances.
2. Prevailing circumstances, which refers notably to non-technical aspects (social issues,

resources, political context…) can bound the optimisation process to various extents, such as by limiting the available options and/or by defining additional conditions (e.g. retrievability). However, prevailing circumstances may not unacceptably impair safety.

3. Prior to the options comparison exercise starting, common understanding and commitment shall be reached among all concerned organisations, in particular between the implementer and the regulator, on which factors shall be taken into consideration in the optimisation process.
4. Optimisation approaches might be quantitative (whenever possible) or qualitative (whenever not).
5. The optimisation of protection process is stepwise and iterative, it shall be duly planned and adequate milestones identified upon inception.
6. Options are compared on the basis of safety criteria/attributes by assessing the effect on the performance and the robustness of the disposal system as a whole. The criteria/attributes selected must allow the safety benefits of the considered technical options to be assessed. Their selection and their weighting should be clearly allocated to problems being solved.
7. The "optimum" is considered to be reached once the benefit in protection has become small with regard to the resources needed.
8. Optimisation of protection does not mean "*minimisation*" of radiological impacts as the best option is not necessarily the one with the lowest dose.
9. Any decision "to go-back" (i.e. reconsidering previous decisions/choices) should be the result of optimisation in the sense that the benefits to go back should be balanced with harm (efforts to go-back, dose detriment….).
10. Optimisation of long term safety can be achieved in practice by incorporating in the stepwise evolution of the safety case an ongoing questioning on the performance and the robustness of the disposal system and its components. Both operational and long term protection have to be optimised from early phases and across the full lifecycle of the geological disposal, and balanced as a whole.
11. Application of Best Available Technologies (BAT) has been acknowledged as one of the items to be considered in the optimisation process; in other words, the optimisation process itself is not limited to only BAT application, it is broader.
12. The regulatory body shall verify that the optimisation principle and associated requirements have been adequately implemented throughout the disposal development.
13. The importance of protection against non-radioactive pollutants has been recognised; a balance should exist between protective measures against potential impacts of radioactive and non-radioactive species.

5.1.2 Position paper on Waste Acceptance Criteria for deep geological repository

The position paper intends to cover the lifecycle of Waste Acceptance Criteria (WAC), including preliminary WAC and updating of WAC. The preliminary WAC might not be able to take into account any requirements related to a specific disposal facility. However, it is important that the waste is conditioned in a passively safe way so that they are suitable for safe storage, while ensuring as far as possible that they are also suitable for disposal so as to reduce any future need for re-conditioning or repackaging the waste.

Following key messages are pointed out in the position paper:

1. Defining Waste Acceptance Criteria (WAC) is a stepwise iterative process, it shall be duly planned and adequate milestones identified prior it starts.
2. Roles and responsibilities have to be precisely defined throughout the continuous and iterative process of defining WAC, allowing for thorough understanding of the criteria and their use by each interested party.
3. Preliminary WAC should be available as soon as possible including the intention for minimizing the need for any future intervention. Their updating should be done through an iterative process carried out in parallel and in conjunction with the development of disposal facility design and safety assessment.
4. Elaboration of preliminary WAC needs to take into account all the interdependent steps identified or assumed for the management of these wastes until final disposal, and their interdependencies.
5. While defining limits and parameter values, particular attention should be paid how to check compliance of waste with these limits and values.
6. Traceability of departures from WAC and non-conformity treatment is important and the lessons learned are a key task within the objective of continuous quality and safety demonstration improvement.
7. WAC may include different parameters, eventually with different limit values to be checked at different steps in the management process of the waste.

5.1.3 Position paper on site characterisation program for deep geological repository

Site characterization essentially begins at the earliest stage of the investigation of a site and is expected to become more intensive as the siting process progresses through to confirmation of the site. Even after site confirmation, site characterization activities will be required in the initial licensing phases and are normally expected to continue into the site preparation, construction and operational phases, in order to contribute further to an adequate baseline for future monitoring and to contribute to the confirmation of assumptions made in earlier safety cases and reduce any residual uncertainties in the safety case.

Consequently, the regulatory body may have a role to play all along this siting process, from the very beginning of this process. The early involvement of the other stakeholders (including public) may also be included in the siting process.

Following key messages are pointed out in the position paper, which provides high-level views and experience to provide guidance on technical aspects that should be considered during the site characterization phase of the siting process for a deep geological repository (DGR) for radioactive waste:

1. Site characterizing activities could take place over several years to decades and the data gathered in the preliminary stages may be used to support the initial licence application, forming part of the safety case and future iterations. Therefore, site characteristic activities should be carried out under a robust management system.
2. Regular dialogue between the implementer and the regulator from the very beginning of

the process is strongly encouraged to ensure that regulatory expectations and licensing requirements are clearly understood. The extent of consultations between the regulatory body should be balanced so as to preserve the independence of the regulator while providing adequate guidance to the applicant.

3. The site characterization program should establish baseline conditions for the site and environment in its undisturbed condition; support the understanding of the normal evolution; identify any events and processes associated with the site that might disturb the normal evolution of the DGR system; support the understanding of the effect on safety of any features, events and processes associated with the DGR.
4. Baseline data gathered during site characterization program is used as a reference for the monitoring the DGR system.

5.1.4 Position paper on operational issues with regards to post closure safety

For the Expertise function, as underlined by the IAEA GEOSAF [26] and GEOSAF II projects, a challenge in the evaluation of DGR safety cases is to assess operational safety with regard to long term safety and *vice versa*. Discussions focused therefore on the main items related to this interrelationship which are of particular interest when evaluating the safety of a DGR during its operational phase.

Following key messages are pointed out in the position paper:

1. The *safety envelope* corresponds with the values below which, at the start of the post-closure phase, the safety functions must fall in order to deliver post-closure safety. It consists in the overall objective the operator and/or implementer should seek during the stepwise evolution of the safety case over the lifecycle of the DGR.
2. The challenge is to evaluate whether the safety case shows that (i) the safety envelope allow to reach the safety objective, (ii) arguments and evidences allows to give confidence in reaching the safety envelope, (iii) a sound operational safety strategy has been developed taking into account peculiarities of the operational phase, such as concurrent activities (construction, nuclear operation, maintenance, partial closure…) and the specifics given by the context of a DGR (facility size, underground risks, monitoring…) and (iv) a capacity for *resilience* exists during the DGR lifespan, whatever the incidents, accidents, design and waste acceptance criteria changes that will occur before the DGR is finally closed.
3. The performance of engineered barriers can be targeted to operational safety or to long term safety. However, the long term performance of engineered barriers will be affected by the way they will be built and managed during the operational phase. A key issue for the Expertise function is to verify that the implementer's arguments are derived from an optimization process considering both operational and long term safety.
4. Considering the timeframe of the operational phase of a DGR, changes may not but will inevitably occur during this period. For the Expertise function, this calls for the evaluation of a DGR's design and provisions that show a resiliency to change, i.e. a capacity to sustain evolutions of technology, context, society, regulation, waste forms and packages… without jeopardizing the safety envelope.

5. The operational aspects of the safety case should show the strategy the operator aims at developing for the final closure of the DGR. This strategy is deeply correlated with reversibility and flexibility where required.
6. The verification of the pertinence and comprehensiveness of scenarios with regards to normal, incidental and accidental situations during the operational phase calls for a specific assessment methodology (i) taking into account the peculiarities of a DGR (risks that may be different in underground spaces, e.g. fire), (ii) highlighting the risks and scenarios that may have an impact on long term safety and (iii) investigate whether different provisions may lessen such impacts.
7. Human factors should be integrated throughout the safety case, considering links between operational safety and long term safety. Beyond common understanding hat safety culture shall be promoted and sustained overtime, a decline in safety provisions and practices may occur for any reason (lack of funding, complacency, failure to hire qualified staff…). It is therefore important to ensure right from the design phase that the facility can provide compensating measures for such decline, i.e. a *resilient* design.
8. The assessment of the strategy for the management of ageing of equipment and structures should consider both operational and long term safety. In particular, it is of outmost importance to identify the components that need to be maintained (or replaced) with relevance to their role in the long term safety when assessing the relevance of a design.
9. Monitoring should allow checking continuously whether any event during operation may impact the facility and the safety envelope. Besides, a sound balance between provisions made for monitoring and DGR disturbance shall be found in the safety case.
10. QA and management systems should be overlooked with a particular scrutiny, especially when they deal with components that should reach a defined state at closure, identified in the safety envelope and thus play a role in long term safety. A knowledge management system appears to be essential in order to backtrack the justifications made earlier and make sure that new requirements in design and operation do not conflict with the achievement of the safety envelope.

5.2 TECHNICAL GUIDANCE ON THE REVIEW OF A SAFETY CASE

A guidance on reviewing the safety case was developed by the SITEX-II WP2 partners with specific emphasis on practices implemented to verify that safety requirements are effectively and properly implemented throughout the different phases of the development and implementation of a geological disposal. This guide describes the role of the regulatory body in the pre-licensing and in the licensing processes, identifies the needs for an efficient management system and for developing competences. It proposes also a tool for the regulatory body to analyse the safety cases through the different phases of the development of a geological disposal. The opportunities to involve the CS in the different steps of the review process were examined as well. The guide provides also an example of table of content for the review report to be performed by the regulatory body.

5.2.1 Regulatory body involvement within the pre-licensing process

As defined in several international guidances such as the EPG Report [5] and as considered within

the SITEX project (D2.2 [22]), the typical phases of a disposal programme during pre-licensing process should at least include the conceptualization, siting and reference design phases.

Early interactions with the regulatory body, prior to a formal licence being submitted, can provide valuable input in process to the prospective licence applicant, and other stakeholders such as government and the public. This is important as the prospective licensee is gathering information that may be used in the safety case as part of the future licence application and information may be used in future licensing stages.

A stepwise process with discrete and evaluated steps facilitates the traceability of decisions, accommodates stakeholder needs and promotes public and political confidence in the safety of long-term waste management arrangements.

From the earliest stages, the prospective licensee should develop roadmaps with clear milestones, considering for each key decision step, the remaining uncertainties to be reduced and to what extent the performance, the robustness and the feasibility of the geological disposal have to be confirmed. The roadmaps have to be a plan that matches the objectives to be reached for each key decision step. The identified actions have to provide good prospects of achieving a disposal system meeting the safety objective. Quality assurance programmes and a properly structured organization are needed to ensure appropriateness of these actions and of their deployment.

At each step, the regulatory body has to review the results achieved by the prospective licensee and to stipulate the conditions under which the next step may be allowed.

However, the regulatory body should be very careful to maintain regulatory independence by not contributing to developing the concept and the design of the facility. This implies ensuring an appropriate organization to ensure allocation of sufficient resources for the review, including identifying the need for its own independent research and development to be conducted in support of its expertise.

5.2.2 Regulatory body involvement within the licensing process

The licensing process includes the following phases: construction, operational, and post-closure phases. The safety cases, supporting the decisions, are expected to comply with the safety requirements specified in the national legal and regulatory framework as well as to provide assurance that the safety objective can be reached, notably:

- For the operational period, that workers, members of the public and the environment will be adequately protected against radiological and non-radiological hazards, under normal and accident situations;
- For the period after closure, that members of the public and the environment will be adequately protected against radiological and non-radiological hazards, under conditions of expected and less likely modes of evolution of the disposal system.

The regulatory body has a continuing role to review the safety case, which has to be regularly updated to remain an adequate basis for making decisions throughout the repository life cycle. At every step, the regulatory body will assure itself that the licensee is achieving an adequate level of quality on safety-related aspects of the project and its implementation. The regulatory body will thoroughly review each aspect in the light of up-to-date information in order to decide whether to allow the implementer to move to the next step. All the information necessary to demonstrate the

long-term safety fully and confidently may not be complete until a decision to close the facility is sought and it is subsequently confirmed that closure of the facility has been implemented appropriately.

5.2.3 Regulatory body management system and expertise capacity building

In order to fulfil its statutory obligations (functions, activities) and to achieve and maintain, at all time, a high level of quality performance in regulating the safety of nuclear facilities and activities, the regulatory body has to develop, establish, implement, continuously evaluate and improve an effective and efficient integrated management system, in accordance with international and national standards (IAEA Safety Fundamental, Safety Requirements and Safety Guides…, see SITEX-II deliverable D2.2 [18]). The integrated management system should rely on a sound governmental, legal and regulatory framework. An appropriately organized and staffed independent regulatory body with well-defined responsibilities and functions and access to adequate resources is a key element of such a framework.
The regulatory body integrated management system should have three main purposes:

- To foster and support a safety culture in the regulatory body through the development and reinforcement of leadership as well as good attitudes and behaviour in relation to safety on the part of individuals and teams;
- To provide the necessary guarantees for the integrated management of the organization, responsibilities, resources, processes and quality;
- To maintain and continuously improve the performance of the regulatory body by means of the planning, control and supervision of its safety related activities.

Regarding the technical capabilities of the regulatory body, their importance is underpinned in Article 8 of the EC Directive 2011/70/Euratom [21], stating that Member States shall ensure that the national framework require all parties to make arrangements for education and training for their staff, as well as research and development activities to cover the needs of the national programme for spent fuel and RWM in order to obtain, maintain and to further develop necessary expertise and skills. This requirement, when applied to the regulatory body, is indeed a prerequisite for ensuring effective independence of the regulatory body, as required by Article 6-2 of the same EC Directive. This should start early in the pre-licensing phase.

In order to ensure the quality and success of a regulatory review, the regulatory body should have personnel with expertise and hands-on experience in safety assessment of radioactive waste facilities and should have either in house expertise or should have access to specialists in all the necessary disciplines involved in such assessment. The team of experts in charge of a review includes a variety of profiles (see SITEX deliverable D4.2 [23] and Chapter 6 of the present report), notably a project manager responsible for overall coordination and for the verification that the safety case and its review process are consistent with regulations as well as senior specialists responsible for peer reviewing, integrating and synthesizing comments from other specialists.

Assessing compliance with safety requirements requires strong technical support from the Expertise function. This includes several activities such as the regulatory body's independent R&D programme and reviewing of safety demonstration. Such programme should answer to the main key technical issues that must be assessed by the regulators at the different stages of repository

development (see e.g. SITEX deliverable D2.2 [18]).

5.2.4 Review Grid to review geological disposal safety cases

The SITEX-I project has concluded to the lack of guidance on how to do the review of a safety case in practice and a preliminary review grid was developed for the review of a safety case related to site selection (see SITEX deliverable D4.2 [23]). One objective of Task2.2 in SITEX-II project was to further develop such a grid and to extent the exercise to the other phases of the lifecycle of a disposal facility.

The support tool has been developed in Excel. Since a lot of issues are common to several phases, it has been decided to establish a generic database including all issues (that have to be reviewed) in a database making the link with WENRA SRLs [20] and the corresponding phases during which they have to be reviewed. The review grid also accounts for the requirements, guides, recommendations or expectations mentioned in the former SITEX project, in the 2015 EPG Report [4], the IAEA Safety Standards Series (SSR-5 [19], SSG-23 [24], SSG-14 [38]), the IAEA international projects ASAM [25] and GEOSAF [26] as well as the ETSON Safety Assessment guide [27].

It is important to acknowledge that the SITEX-II partners do not claim to construct a complete checklist because "*it has to stay relevant for any safety case and let the experts follow its own feeling. Its aim is to stay a matrix to assist the reviewer, to the contrary of the developed NRC review plans*" [28]. Moreover, the database would have to be adapted for each country taking into account specificities of the national regulatory context.

The review grid (Figure 5) is divided into sections. Each relates to one specific component of the safety case as defined in the IAEA SSG-23 publication [24]: Safety Case context**,** Safety Strategy**,** System Description (Assessment Basis, AB), Safety Assessment, Assessment of the safety case as a whole, Integration of Safety Arguments and Evidence and Management System. In addition, the review grid includes specific sections related to Monitoring and Periodic Safety Review.

Within each section, columns are describing:

- The expected safety case content;
- The related safety areas and issues;
- The related verification(s) to be done by the regulatory body as a support of its review.

Other columns correspond to the six pre-licensing and licensing phases of the disposal mentioned above (see §5.2.1). For each line the review grid specifies the status of the content of the safety case at these different phases:

- Not asked for the related phase (<blank>);
- Preliminary status asked for the related phase (P);
- First formal status asked for the related phase (F);
- Updates asked for all the related phase(s) (U).

An additional column "Generic" is marked with a cross (X) when a status can be given for all phases. The tutorial for working with the tool is given in the SITEX-II deliverable D2.2 [18].

Key Aspects of the SC (review & content)	IdNum	WENRA DI#	WENRA §	WENRA TITLE	WENRA TXT	Related Safety Case Content	Verification	Generic	Conceptualization	Site Investigation & selection	Reference Design &
Monitoring	MO-12	**DI-049**	**2.2.4**	Disposal Facility Development • Information Gathering & Monitoring	**DI-49**: The licensee shall ensure that the monitoring program contributes to • Demonstrating adequate protection of people and the environment and demonstrating compliance with the regulatory requirements and licence conditions • Confirming that the disposal facility and system behaves and evolves as expected in the safety case • Building confidence in and refining the key assumptions and models made in the safety case • Enhancing understanding of the environmental conditions and of the functioning of the disposal system • Acquiring information for supporting decision-making and • Providing background information for any post-closure surveillance program.	Results of monitoring both within the disposal facility and in its environment	Verification that : • the regulatory requirements and licence conditions are fulfilled ; • the disposal facility and system behaves and evolves as expected in the safety case ; • deviations from the expected behavior of the disposal are identified ; • key assumptions and models are confirmed.	·	·	·	

Figure 5: One line example in the review grid

The review grid must be seen as an evolving tool. An objective should be to improve the tool gathering the experience and feedback of all members / users. At least, the review grid will be used to exchange experiences and feedbacks related to safety case reviews between the members of the future SITEX network.

6 Training and Tutoring

International safety standards for radioactive waste disposal require an understanding of the relevance and the implications for safety of the cases to be developed by operators throughout the process of designing, constructing and operating disposal facilities. They require such facilities to be developed in a step-by-step manner supported by safety demonstration and subject to regulatory approval. This means planning the process steps, setting the milestones, identifying the decision points and involves a number of licence applications and approvals. A safety case and supporting assessment must be prepared and updated by the operator as necessary at each step in the development of the facility that presents all the arguments and evidence supporting the safety of the facility. The regulatory authority must review and assess the safety case and the outcome of its review will form a basis for the decision on granting regulatory approval.

Experts with a wide range of competencies are required to review a safety case for geological disposal. During the former SITEX project, five types of experts were identified to be necessary for such technical review - **generalist experts, environmental experts, numerical modellers, risk experts, experts in long-term safety** - and the knowledge and skills required were compiled into "experts' profiles" [1, 2, 28, 23]. SITEX-II was initiated with a view to further developing an independent "Expertise function" network in the field of deep geological disposal safety. One of the missions of the network will be training and tutoring [1], thus the Work Package 3 (WP3) of SITEX-II was devoted to the **development of a training module for generalist experts** and its implementation in practice to test the viability of the network to fulfil this mission.

The activities of SITEX-II work package 3 (WP3) partners (Bel V, FANC, CNSC, CVREZ, Decom AS, IRSN, Mutadis, ENSTTI), were led by LEI and were organized into three tasks: Identification of the practices, experiences and prospective views on training and tutoring (Task 3.1); Development of a training module for generalist experts in geological disposal (Task 3.2); Implementation of a pilot training session for "common core module" (Task 3.3), respectively described in the SITEX-II deliverables D3.1 [29], D3.2 [30] and D3.3 [31]. The SITEX-II deliverable D3.4 [32] deals with the experience feedback of this pilot training session. The findings of these activities are summarized below.

6.1 STRATEGIES AND PRACTICES ON COMPETENCE BUILDING FOR REVIEWING A SAFETY CASE FOR GEOLOGICAL DISPOSAL

A questionnaire was developed to collect information from SITEX-II partners on their strategies and practices on competence building of technical experts. A thorough analysis of the answers led to the following key conclusions and recommendations to be considered while developing the training module for the pilot training session (Task 3.2) [29]:

- The importance and necessity of knowledge management and learning processes such as training, learning from experience and continual improvement is acknowledged. The strategy for knowledge management is more formalized and documented in the organisations having dedicated human resource or knowledge management departments or is incorporated into overall organisation's management systems;
- Different means of knowledge management and expert training are used: while some have dedicated departments, internal procedures or schools for expert training, others rely more on co-working of younger and senior experts, participation in research programmes on the national and international level. Usually, organizations have several parallel ways for knowledge management and training of experts in parallel;
- On-the-job training, participation in research projects and taking external courses were reported as the common ways for competence development. Considering this observation, the form of SITEX training could be recommended to be defined as a package of activities on a cycle of several years (lectures accompanied with practical exercises, visits, partial review of existing safety cases, etc.);
- To ensure effective competence building in the specialized areas for technical review of a safety case, a means to "equalize" the background of the participants needs to be considered.

It was also observed that the events organized and coordinated by the IAEA are highly acknowledged and attended most frequently. **In view of the absence of training schemes dedicated to the review of the safety case for geological disposal at an international level, the development of a sustainable scheme could expect international acknowledgment**. Existing IAEA eLearning material was acknowledged, and recommendations were given for trainees (newcomers) to access IAEA eLearning material prior coming to SITEX pilot training session.

6.2 DEVELOPMENT OF A TRAINING MODULE FOR GENERALIST EXPERTS IN GEOLOGICAL DISPOSAL

Development of training module has led to the development of training material and organisation of five-days training course aimed at generalist experts. The pilot training session was organized 12-16 June 2017 in Kaunas (Lithuania). The lecturers were the WP3 partners LEI, CV-REZ, IRSN, FANC, Bel V, MUTADIS and DECOM as well as the Associated Group members SSTC NRS and STUK. Eighteen trainees from SITEX-II partners' countries participated to the whole pilot training session.

The lectures (see [31]) are listed below:

- Day 1 – "Introduction to geological disposal and safety demonstration":
  - A0. "Introduction" – "Asta Narkūnienė", "LEI"
  - A1. "Overview of Lithuanian nuclear and waste management programs" – "Asta Narkūnienė", "LEI"
  - A2. "Overview of the Ukrainian national RW management program and recent developments" – "Oleksii Tokarevskyi", "SSTC NRS"
  - A3. "Geological disposal programs" – "Jitka Miksova, Lumir Nachmilner", "CV REZ"
  - A4. "Geological disposal concepts and challenges" – "Jitka Miksova, Lumir Nachmilner", "CV REZ"

- A5. “Overall regulatory process and technical and scientific expertise requirements” – “Phil Metcalf”, “IRSN”

- Day 2 – “Regulatory expectations of the Safety Case and safety assessment”:
  - B1 & B2. “Regulatory expectations of the Safety Case:” – “Frederic Bernier/Jean-Pierre Wouters”, “FANC”

- Day 3 – “Regulatory review and assessment of the Safety Case”:
  - C1. “Regulatory review and assessment process and its challenges” – “Michael Tichauer/Muriel Rocher”, “IRSN”
  - C2. “Regulatory review, moving from conceptualisation to implementation” – “Jean-Pierre Wouters/Frédéric Bernier”, “FANC with support of IRSN”

- Day 4 – “Interacting and supporting activities”:
  - D1. “Design and conduct of supporting research programmes” – “Valery Detilleux”, “Bel V”
  - D2. “Summary of current programmes and future Joint Programming” – “Valery Detilleux”, “Bel V”
  - D3. “Stakeholder engagement and introduction to Pathways Evaluation Process” – “Adela Mrskova “, “Decom”, “Julien Dewoghélaëre”, “Mutadis”
  - D5. “PEP exercise ” – “Adela Mrskova “, “Decom”, “Julien Dewoghélaëre”, “Mutadis”

- Day 5 – “Summary and evaluation”:
  - E1. “Recent experience with regulatory review of French Safety Case for radwaste disposal in clay formation” – “Muriel Rocher”, “IRSN”
  - E2. “Recent experiences and topical issues with regulatory review of the Finnish Safety Case for geological disposal” – “Jaakko Leino”, “STUK”
  - E3. “Test evaluation and roundtable” – “Phil Metcalf”, “ENSTTI”
  - E4. “Course evaluation and closure” – “Asta Narkūnienė”, “LEI”

6.3 LESSONS LEARNED FROM THE PILOT SESSION

Participants and lecturers were requested to undertake a formal evaluation of the pilot training session and training participants took an examination at the end of the training session.

The **key lessons** from the evaluation were:

- There is a great interest in training on regulatory review of the safety case for geological disposal and on a variety of related processes/activities necessary to support the regulatory review. The review process requires an adequate understanding of the geological disposal concept, overall requirements for implementation, safety case development and safety case review, managing of an independent R&D programme, interaction with various stakeholders, etc.

- The potential of the lecturers for future SITEX network training is high as the content and transfer of know-how received a positive evaluation by the majority of trainees.

- Based on the overall evaluation by trainees, the training session was highly rated (18.4 out

of 20).

- Summarizing the feedback provided by the lecturers it was concluded that the pilot training session was successful, attracted appropriate and active participants, confident and experienced lecturers and provided good feedback for further improvement.
- 70% of trainees received a rather high mark and exceeded the average mark.
- Despite high rating of the lectures and exercises there is still room for further improvements. Suggestions provided by the trainees were grouped as related to organisational aspects, related to the content of developed module and related to the content of future training.
- The feedback received indicated a number of topics where participants felt more detailed training would be of benefit specifically related to regulatory review and assessment.

6.4 TRAINING AND TUTORING IMPLEMENTATION IN THE FRAME OF A FUTURE SITEX NETWORK

Future SITEX training courses

The pilot training course was successfully implemented both technically and administratively and demonstrated that the necessary expertise is available within the SITEX member organisations to present such training events. Two options can be contemplated for future training activities (see Figure 6). One option is the training programme proposed involving participants committing to a series of training courses, scientific visits and a review project. The programme suggested would be integrated within the activities of the future SITEX network. The second option is a series of training courses over a defined period involving general courses similar to the pilot course and several specialist courses focussed on the topics previously identified by SITEX. The viability of either option depends on the numbers of participants anticipated to be interested and the funding model determined.

WP3 activities performed during the SITEX-II project correspond to the whole implementation of the first SITEX mode of interaction (“Programming”) and a first implementation of the second mode of interaction (“Implementing”) regarding the training of the “generalist experts”. For the other identified experts’ profiles as well as for the tutoring aspects, the SITEX-II project only experimented the conditions for programming such activities: national experiences, practices and prospective views were shared for both aspects and specific needs were preliminarily identified for the training of other experts’ profiles. Thus further development will be required whether one or the other options mentioned above.

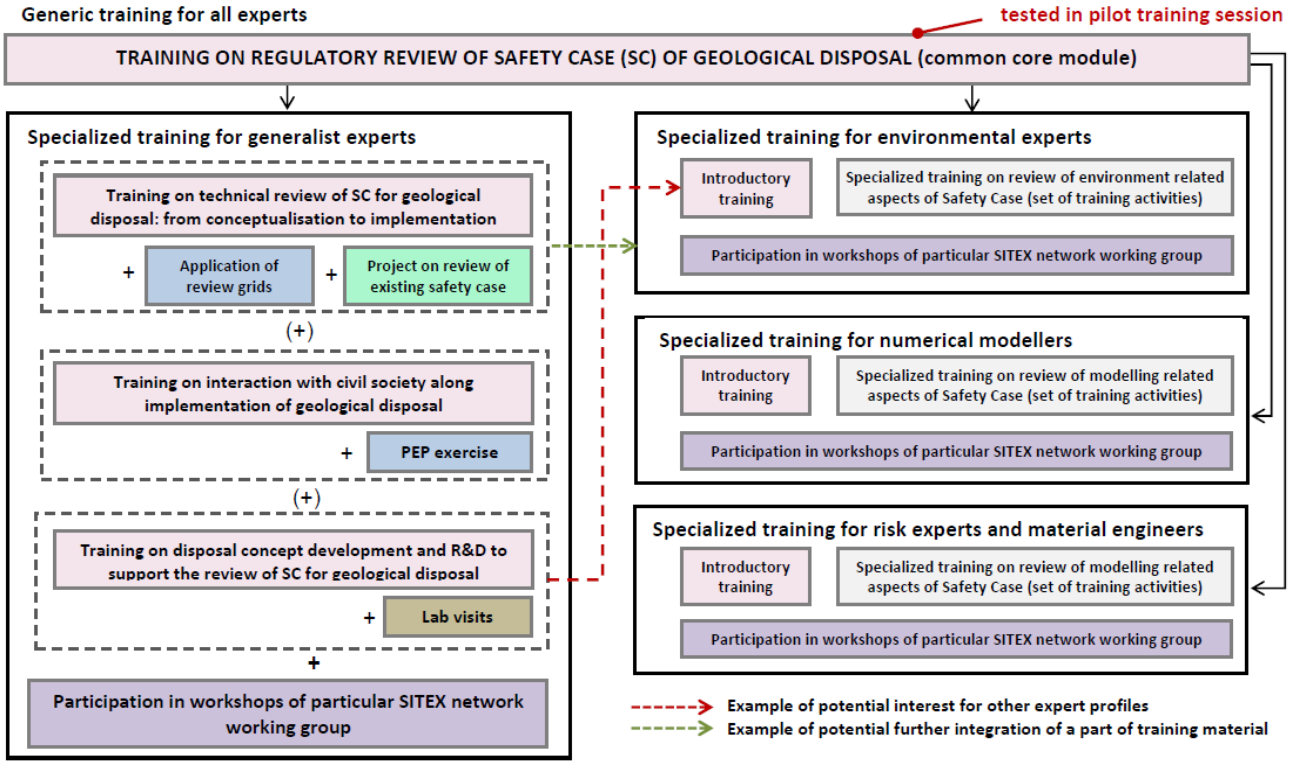

***Figure 6*: Example of modular SITEX training programme**

7 Interacting with Civil Society

The SITEX-II work package 4 (WP4) led by Mutadis, included the following partners: IRSN, LEI, Bel V, FANC, Decom, ENERGIAKLUB, NRG, CV REZ, MKG, ASN, REC and SYMLOG. WP4 was dedicated to the interactions between institutional experts and CS, through three tasks: CS interacting with R&D (Task 4.1), CS contribution to safety culture and safety case review (Task 4.2) and Intergenerational governance of Geological Disposal (Task 4.3). The findings of these activities, described in the SITEX-II deliverable D4.1 [34], are summarized below.

7.1.1 Ways of interaction with CS during the project

According to the perspective developed by the SITEX (2012-2013) project, transparency of the Decision-Making Process (DMP) includes several requirements such as to maintain over time consultations and interactions with interested parties in the DMP, in particular with CS. According to SITEX definition, one task of the expertise function is to improve the quality of interactions between institutional experts and CS. The future SITEX network is therefore expected to support the development of these interactions at different levels of governance and at different steps of the DMP. The IAEA INSAG 20 report [33] on "*Stakeholder involvement in nuclear issues*" indicates in section 2 that "*operators and regulators confronted with questions and concerns from stakeholders may have to re-examine the basis for previous decisions*. […] *Investigating such questions provides clarity, prevents complacency, and may expose unforeseen problem areas*".

In line with these conclusions, the SITEX-II project experimented ways of interaction between

technical experts supporting the regulatory authorities and CS, in the perspective of the Aarhus Convention. WP4 has conceived, developed and implemented several methodological tools in order to support CS access along long term technical DMP characterised by complex socio-technical stakes, and notably the "double wing" deployment of a small team of more involved CS experts with a larger group of CS representatives (see Figure 7).

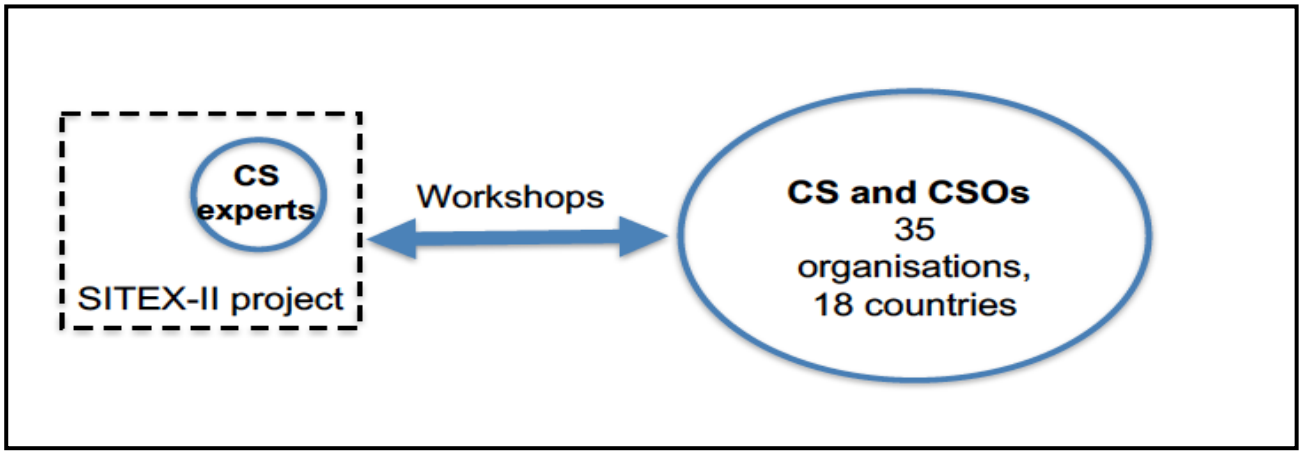

Figure 7: Model of double wing interaction with civil society

The SITEX-II CS partners (Energyaklub, MKG, Mutadis, REC, Symlog) interacted all along the project with a larger group of European Civil Society Organisations (CSO) and non-institutional experts engaged in following RWM activities at EU or national level, gathering representatives of 35 organisations from 18 countries in Europe, reflecting a variety of situations at national level (Figure 7). This CSO group has been assembled by the Working Group for RWM of the Nuclear Transparency Watch (NTW) network co-ordinated by MKG. The CSO participants in this group were not expected to represent NTW as one organisation but rather to provide a variety of European CSO viewpoints. Strengthening and maintaining a high level of nuclear safety in Europe is a common concern for all members of this group without prejudice to their position vis-à-vis nuclear energy.

WP4 interacted with the larger group of CSO representatives within dedicated workshops that were organised along the course of the project. An inception meeting gathering some thirty WP4 partners and potentially interested CSOs was held on 28 August 2015 in Paris, at the beginning of the project. Three workshops organising exchanges between institutional experts and CS were also organised at three different locations:

- in Ljubljana for workshop No 1 on 22-23 February 2016,
- in Budapest for workshop No 2 on 28-29 June 2016 and,
- in Brussels for workshop No 3 on 15-16 November 2016.

The inception meeting was an opportunity to discuss their interest in the SITEX-II project as well as the conditions (and concerns) for their potential involvement in the project. In Ljubljana, the overview of literature survey and first principles of the PEP approach (see § 7.1.4) were presented and discussed. In Budapest, the PEP game was played by all participants coming from different

groups (NGOs and institutional experts). Finally, in Brussels, the different requirements and provisions coming from legal framework and international conventions related to the RWM and four sets of issues related to intergenerational aspects were discussed.

Each task of WP4 had therefore the opportunity to bring its findings and to discuss them with the larger group of CSO representatives during these workshops. It gave the opportunity to report regularly to the CSOs group on the progress of the work of the different tasks, to collect additional inputs from the CSOs group in this work and to develop concrete interactions between institutional experts and representatives of CS (non-institutional experts and CSOs).

CS interaction methodology is already being tested in the BEACON EU technical project [16], with a dedicated work package on CS interaction.

7.1.2 CS interacting with R&D

Task 4.1 experimented a specific methodology to support CS engagement along the development of the SITEX Strategic Research Agenda - the concept of "Knowledge Sharing and Interpretation"- articulating the "double wing" deployment of a small team of more involved CS experts with a larger group of CS representatives. Task 4.1 formulated R&D key technical and socio-technical issues that CS expects to be developed in R&D programmes and reviewed the SITEX-II Strategic Research Agenda (SRA) by highlighting the CS interests in the developed research matrix

The CS group identified issues implicitly covered by some areas of the SITEX-II SRA: the characterization of "historical" specific waste and potentially incoming waste, corrosion issues, transitional phenomena related to waste such as gas generation from metallic containers, microbiological processes, long term conditions such as climate change or geological event, operational security and safeguard issues. Other issues could possibly be covered by extension of some areas of the SITEX-II SRA: plutonium waste disposition issues, sensitivity analysis of geological, mechanical and hydrological modelling, interaction between RWM strategy and development of the disposal, monitoring and CS follow up, retrievability and reversibility, long term storage vs. disposal, long term security and safeguards issues.

To the contrary, few technical, most of methodological issues and almost all societal issues identified by CS do not appear in the scope of SITEX-II SRA, such as the global balance of risks associated with a disposal strategy in the framework of a global RWM strategy, the methodological development regarding selection of a site, a comparison of various disposal concepts and designs, a comparison of different pathways leading to various combinations of storage and disposal facilities, the practical meaning of guidelines such as "precautionary principle" or "best available"...

- As a result of this methodological approach, specific CS contributions to the SITEX-II SRA have been drawn by WP4 creating the conditions for them to be "duly" taken into account by the group of institutional partners (TSOs, Regulators) of the project. The participation of CS in the development of the SRA has more specifically contributed to contextualise the technical scope of research themes in order to better grasp the complex dimension of the questions at stake in long term RWM. As a result of this, a set of sociotechnical questions has been incorporated into the SITEX SRA:R&D knowledge transfer and interpretation;
- Uncertainty, epistemology and social trust along RWM and geological disposal (GD)

implementation;

- Aggregating a diversity of people, unfold capacities of collective intelligence along RWM and GD implementation;
- Safety culture in the context of GD;
- Ontological and axiological commitments of GD stakeholders;
- Background democratic culture of GD implementation.

To summarize, the possibility for CS through the CSOs group to directly take part in the SITEX-II project and to work with the SITEX-II SRA has been successfully demonstrated. The work has provided a capacity for CSOs to take part in EU projects such as in the future projects of EU R&D on RWM through the EJP. The capacity-building as well as finding methods for working with CS will be useful in the future

7.1.3 CS contribution to safety culture and safety case review

Task 4.2 investigated how safety culture can be shared through different interested parties and what concrete conditions and means are necessary for an efficient public engagement. With the help of a questionnaire and workshops, commonalities and differences were identified in the vision on safety culture in RWM of non-institutional (NGOs) and of institutional actors (regulators, TSOs, researchers), as well as their respective expectations regarding the engagement of CS in the safety case review of geological disposal facilities.

Starting with a proposed first generic definition of safety culture based on the performed literature review, each of the interviewees has suggested his own definition. Despite some differences, a universal rationale can be converged towards "*a common set of values, principles and references governing safety*". The performed analyses led further to the investigation of what could be a shared safety culture between institutional actors (regulators, TSOs) and non-institutional actors (independent experts, NGOs). The discussion held during the project underlined that while sharing understanding of safety culture is recognised as a means to achieve powerful collaboration among the different parties, the corporate and societal understanding of safety culture does not necessary have to be identical (the parties have different roles and duties vis-à-vis safety review). However, the need to identify the elements that can be shared (namely e.g. principles of optimization, defence-in-depth) at the societal level is recognised as a key asset for establishing cooperation. Identifying conditions and the means to involve CS along the DMP is a central requirement for constructive engagement of non-institutional actors; it will lead to effective interactions between the interested parties and will be driven by the consideration of safety as a "common good". To that end, CS must take part in the DMP from its inception. The nature of the public engagement process should carry a deliberative character. Participants expect to be given sufficient time to consider and to discuss each issue in depth before they come to a considered view. Several other fundamental conditions for public engagement have been pointed out, namely transparency of information, of DMP and of reporting of participants' views, as well as access to information, to justice, to resources and to expertise.

Regarding transparency, the participants underlined that accessibility to information is one of the crucial points in the process of public engagement; a culture of openness to information should be developed; information should be carefully and purposely understandably drafted and come from

clearly identified organisations and publications; the input from different interested parties, including CS, must be taken into account and included if appropriate.

Although data was limited by the qualitative nature of the methodology and limited number of performed interviews, the conclusions drawn by Task 4.2 provide a comprehensive picture of the expectations of different actors regarding the conditions and means for meaningful interactions with CS along the safety case review process.Better understanding of the current situation in the area of RWM leads to highlighting future milestones towards the improvement of DMPs, sharing of common elements of safety culture between institutional and non-institutional actors, and the reinforcement of the participation of CS in a long-lasting perspective necessary to achieve broad intergenerational trust.

7.1.4 Intergenerational governance of Geological Disposal

Task 4.3 reviewed the literature in international organisations or projects dedicated to intergenerational governance and in the same perspective, discussions and interviews were achieved on the provisions and requirements related to intergenerational aspects of RWM in different international and EU legislation. Task 4.3 examined the work performed by IAEA and NEA/OECD, by the EU projects Insotec [35], MoDeRn [36], SITEX and LAKA [37] as well as by DOE (U.S.) and NWMO (Canada). The findings of each of these works are summarized in the SITEX-II deliverable 4.1 [34]. The criteria for evaluating the intergenerational issues were the management of risks and risk transfers, the governance guarantees or requirements, the values and overall ethics of the strategy developed.

This desk review of previous works on intergenerational governance in RWM shows interesting convergence on the fair conditions for intergenerational public engagement in the context of Geological Disposal development. A focal point regarding intergenerational governance lies in the management of uncertainties that are expected to be dealt with all along the process until closure and after. Current practices show that the reversibility and/or retrievability approaches need to be addressed as response to public concerns. CS is to be involved in successive steps of RWM decision-making, including post closure phase; monitoring is an important tool in this perspective. In current generations, it is needed to achieve an ethical approach to handling resource allocation and public involvement in DMP (intra-generational equity); forms of process/involvement will differ between countries/institutions/political systems but the importance of public involvement in “key decisions”, such as the timing of waste disposal actions, is clear.

Based on this literature review, Task 4.3 also conceptualized, developed and tested an exercise of participative and comparative assessment of different parallel alternatives scenarios of long-term RWM, entitled Pathway Evaluation Process (PEP), in the form of a serious game. PEP is an innovative support tool to pluralistic dialogue on RWM and GD, provides opportunities to develop in the future new types of interactions between stakeholders (notably between technical experts and CS representatives) and possibly as a way to support the engagement of coming generations along the successive stages of decision-making on the medium and long term.

The PEP is based on the concept of “Pathways”, defined as strategies retracing the steps of a possible evolution from the current situation of RWM as a whole to a final state, the “Safe Terminus” (ST), a situation where the safety of all considered categories of waste do not anymore

entail an active human contribution, after a period that does not exceed an order of several generations. To seek a ST does not mean having a predetermined solution in mind from the start. The PEP exercise is not a predictive instrument or a tool to select the "best" technical option but a discussion tool aiming not to reach a consensus but to make explicit the implicit.

Engaging in the PEP process underlies for the participants to agree on the following prerequisites:

- Adopting the objective of reaching a ST as a common target for long term RWM,
- Recognizing that the ST objective can be reached through different strategies according to various legitimate preferences of stakeholders regarding safety and reliability. These preferences cover a range of approaches that typically goes from open to oriented or driven approaches. Driven approach, on the one end of the spectrum, would concentrate efforts and resources to reach as soon as possible a given technical option of ST. Open approach, on the other end of the spectrum, would not choose from the start a specific technical option as ST. Oriented approaches would investigate on a step by step basis a given technical option while preserving a potential for other options as alternatives.

The PEP materials[3], developed during SITEX-II project, correspond to three sets of "board games" (representing three typical inventories of waste: nuclear countries with reprocessing, nuclear countries without reprocessing, non-nuclear countries), technical sheets presenting the boards, testing conditions and evaluation cards and also evaluation grids. A set of "board games" is composed of three boards representing three basic "pathways" for a given typical inventory of waste, integrating the different attitudes towards RWM issues: open, oriented, driven.

The PEP exercise consists in testing condition and evaluation cards. Each participant tests the robustness of a pathway by choosing one testing condition card (TC) associated with one or two Evaluation Criteria cards (EC), positioned on a specific period described on the board: from now to a few decades, in hundred years (Mid term), in few centuries (Long Term). The testing card describe a challenge facing by the pathway. Three categories of challenges have been designed: unplanned changes, disruptive events and decision-making challenges. The EC cards ask questions aiming at assessing the reaction of the pathway in regards of the challenge it is facing. Three sets of questions have been developed: questions on management of risk and risk transfer, questions on governance quality, questions on values and ethics.

The result produced by the PEP is a participatory analysis of "pathways" by the various participants, through different sets of assumptions and criteria. In the end, the results of the exercise of PEP are twofold:

- Evaluation elements shared by the participants of the PEP exercise or in any case emerging out from a dialogue on different possible RWM pathways.
- Elements of explicitation of the cognitive assessment framework specific to each participant that could provide a better understanding of each other's positions on RWM and on existing attitudes toward the question of safety and confidence building in a context of uncertainty.

[3] All the PEP material is available in the minutes of the second SITEX-II workshop (June 2016, Budapest) on the SITEX-II website.

The SITEX-II project governance provided a secured framework to enable fair participation of a plurality of actors in the PEP process. During the different tests, at national and international levels, the PEP exercise has demonstrated its capacity to enlarge the basis of understanding of the key issues at stake regarding long term RWM and to help the participants to grasp the complexity of RWM that is considered here as a socio-technical issue.

7.2 IMPLEMENTATION OF ACTIVITES OF INTERACTION WITH CIVIL SOCIETY IN THE FRAME OF A FUTURE SITEX NETWORK

The SITEX-II project offered an opportunity to test an original model of "double wing" involvement of CS in European Research (see Figure 7 above) allowing fruitful interactions between institutional experts and representatives of CS.

In addition, future developments of the PEP will be considered in the framework of the SITEX network that should provide the specific governance framework securing plurality of views requested for such PEP developments. A first possible development is to use PEP as a permanent training tool in the context of the SITEX network; the results of the first training session in Lithuania are encouraging to do so (see SITEX-II Deliverable D3.4). Addressing RWM complexity (considering technical and non-technical issues of the process) and confronting plurality of views in a non-polarized way, PEP constitutes also an original and intergenerational tool for safety. A second possible development that could be supported by the SITEX network is therefore to consider the PEP in the perspective of training successive generations. Then PEP is a mean to confront technical experts with non-technical dimensions of RWM and to reinforce the safety system, overcoming "in silo" specialization; for CS representatives, it is an opportunity to learn about RWM topics and to bring external information and their specific points of views to experts; improving mutual understanding is an important aspect of the considered interactions of experts with CS. As a third development envisioned for the future, the SITEX network could think about the PEP as a methodology to support discussion among various stakeholders where national discussions are implemented. The prerequisites to enter the exercise could change according to the specific context. For Most Advanced Programmes (MAP), PEP could be developed by focusing on specific phases, for instance considering possible path for pre-licensing (inventory to account for, site selection, design options…) in the context of several technical options. It is also a way to avoid path dependency by broadening the views of the involved actors. For Less Advanced Programmes (LAP), PEP could constitute an opportunity to initiate the discussion without any constraints inherited from the past (as RWM programmes have not started yet). Therefore, PEP could be a tool preparing the ground for co-constructing the national programme and to allow skill improvement of the different actors.

8 Establishing the framework for a sustainable SITEX network

In order to ensure an independent technical Expertise function related to the safety of geological disposal of radioactive waste, the former EC SITEX project (2012-2013) proposed the creation of a network. This former SITEX project identified key issues to be solved prior commencing a sustainable SITEX network and summarized them in a Term of Reference (ToR) of the network. Four expertise activities as Review of Safety Case, Implementation of R&D related to the safety

issues of geological disposal, Training and tutoring and Interaction with Civil Society were identified. Beyond these technical activities addressed in the previous chapters of this SITEX-II final report, establishing the foreseen network required further developments, in particular in areas of (i) legal bases for the network operation, (ii) formal position of interested organisations, (iii) provision and mobilization of resources for its functioning, (iv) specification of working procedures, and (v) coordination of activities with other existing international platforms, projects or initiatives active in the area.

Thus, SITEX-II further developed this independent expertise function implementation and, in its Action Plan for establishing SITEX network, provided necessary practical modalities to ensure sustainability of the foreseen network, including expected administrative framework as SITEX_Network statutes, etc. The work on the Action Plan for establishing SITEX network, based an analysis of existing platforms and networks was done by the SITEX-II project beneficiaries, in particular by organisations supporting regulatory authorities and/or by the regulators themselves, together with a strong support of members of SITEX-II Associated Group and by an interaction with CS representatives.

The action plan for establishing a SITEX network was elaborated in the frame of the SITEX-II work package 5 (WP5), Task5.4 led by CVREZ with IRSN, LEI, Bel V, FANC, REC and Mutadis.

Vision of the network

The general objective of the SITEX network is to promote activities aiming at fostering at international level the high quality and independent expertise in the field of safety of RWM in general and radioactive waste disposal in particular.

The SITEX network shall support regulatory authorities as well as the public in the perspective of RWM. With respect to the complexity of RWM, the network should involve actors with a plurality of views and competencies (regulators, TSOs or similar and CSOs) from different programmes of different levels of advancement.

Management of the network

The future SITEX network could be established in the statute of a French non-profit association. Its bodies and functionalities are, as described in Figure 8 below,

- the General Assembly (GA) organized in 3 colleges;
- the Management Board (MB) elected by the colleges and its Bureau.

Each college represents a type of function as defined in the SITEX (2012-2013) project:

- College 1: Technical Expertise Function (comprises Technical Safety Organisations (TSOs) or other entities assuming this function for the Regulators, such as Research Entities (REs));
- College 2: Regulatory Function (comprises Nuclear Regulatory Authorities (NRA));
- College 3: Civil Society Function (comprises CSOs stakeholders who may either be individuals or groups, such as non-institutional experts, NGOs…).

Members of the network should be natural persons or legal persons qualified in the fields to which the objectives of the network relate. Members can belong only to one college at a time. Candidatures to such SITEX network would have to be duly justified with regard to the candidate national or international role, as well as the choice of the college (if a candidate is in position to choose between several colleges).

In addition, an Associated Group would consist of institutions or individuals interested in the network topics and stand by SITEX network vision and objectives, before a potential application for becoming Members. They would be also committed to the SITEX network Statement of Support, may be Observers at SITEX network GA or at other general meetings and can take part in selected activities when agreed by the MB (e.g. training, workshops, Working Groups…). A limited duration may be decided for such a position.

Concerning financial resources expected, assets should consist of the annual membership fees, the level of which would have to be established by the General Assembly, other financial contributions and donations; members could also bring any other kind of assets such as equipment, offices, and intellectual property rights. Assets should not be used to remunerate any of its members.

All other legal and administrative conditions are identified and described in the proposed network statutes which form one of Action Plan annexes. The Statutes are divided into several sections : (i) legal form, name, registered office, objectives and term; (ii) members; (iii) management and control; (iv) General assembly; (v) budget accounting and assets; (vi) miscellaneous.

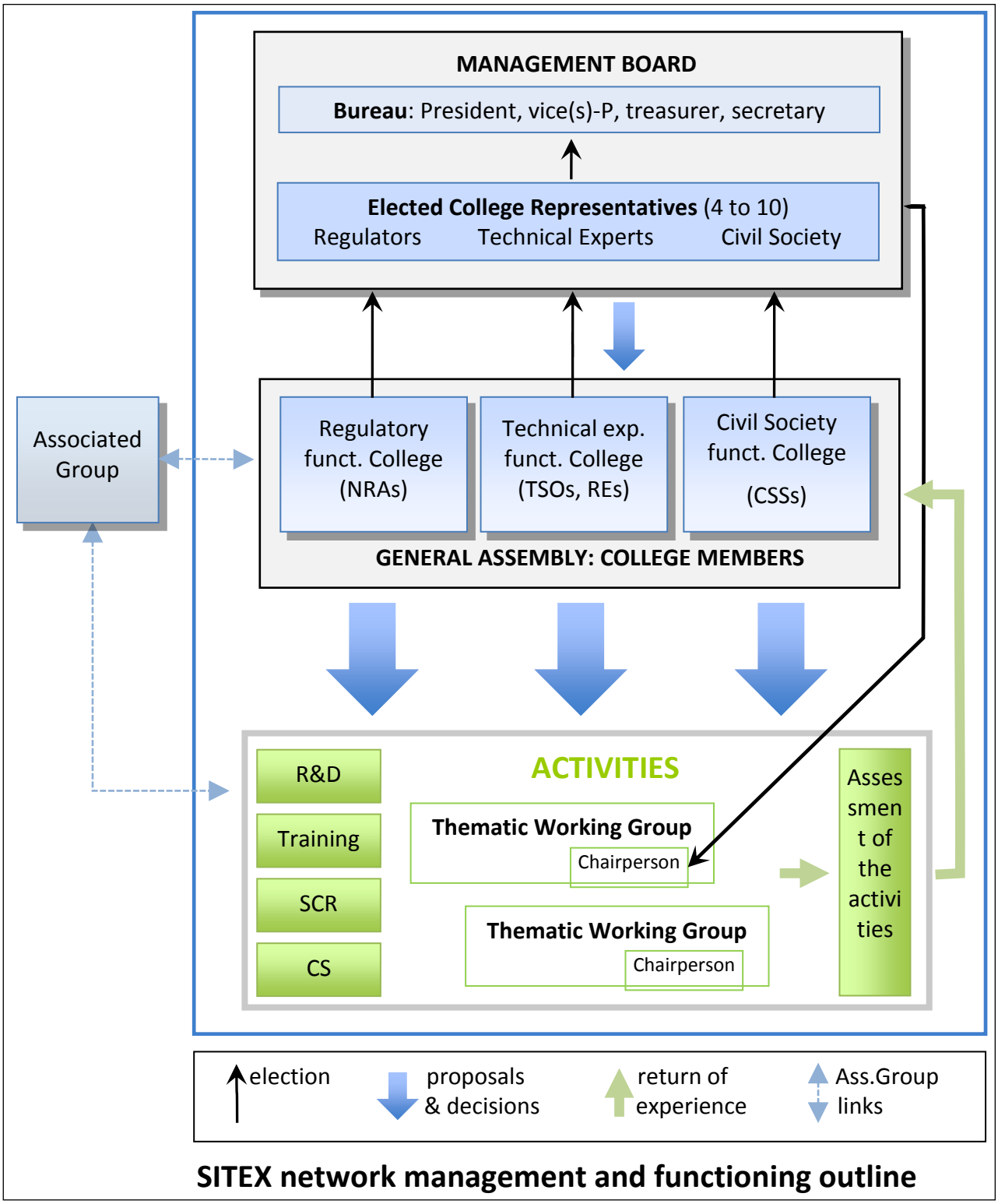

Figure 8: Management of a SITEX network and functioning outline (CS: Civil Society; SCR: Safety Case Review)

Activities of the network

SITEX_Network should carry out various activities in order to support, facilitate and strengthen the Expertise function of its members in the RWM field; however, in its starting period it will first focus on geological disposal safety.

Performing its activities in accordance with the orientations set by its members, SITEX_Network should define a strategy for reaching its purpose, as well as a programme of activities, resources and infrastructures that the achievement of this strategy requires. The SITEX network should record its strategy in a Roadmap. The Roadmap should be developed, maintained, and promoted, in interaction with the scientific and technical community in Europe and beyond, all publicly available. In addition, an exchange with leading international entities dealing with RWM should be ensured.

The paramount activities of a future SITEX network, which would have to be identified and prioritized by the Management Board and the General Assembly in a Roadmap, may entail:

- R&D related activities: development, or contribution to, high quality R&D project proposals, coordination or facilitation of participation in international projects (e.g. European Joint Programming, EJP), or of joint research within the network, guidance and advice to organizations fulfilling an Expertise function in initiating R&D activities related to waste management safety;
- Activities related to Safety Case Review (SCR) methodology and practices: exchanging on guidance and requirements, when appropriate formulating position papers or harmonizing approaches and practices (e.g., development of safety case reviewing procedures, development of safety case reviewing tools);
- Training activities: development of professional capabilities, preparation and delivery of training programmes at European level for generalist experts and about specific technical domains, that may include training courses, seminars, visits to disposal facilities sites and underground research facilities, safety case review exercises;
- Work on how to promote efficient interaction with Civil Society: developing the PEP tool, establishing further ways for the dialogue and transparency between the Expertise function and the CS, strengthening knowledge and skills, adapting culture and practices of the Expertise function and the CS to accommodate the active contributions of CSOs, acting in complement to WMOs where public expects an independent view on its scientific and safety concerns and expectations,.

Further, SITEX network would carry out dissemination and planning activities, such as:

- Knowledge exchange: providing a forum for information exchange and sharing data among Members; supporting Less Advanced RWM Programmes (LAPs);
- Interaction with international entities: organize interactions with international entities involved in regulatory activities (e.g. WENRA, ETSON, ENSREG, ENEN, IAEA, OECD/NEA) or

in implementing activities (e.g. IGD-TP): possible interactions could be dissemination, consulting for harmonization of the existing regulations and guidance, regular informing of the progress and outcomes of SITEX network activities, establishing cooperation with specific projects (e.g. IAEA GEOSAF), etc.;

- presenting its activities and results of joint effort at different international events, such as established conferences and seminars;

In order to carry out activities, Thematic Working Groups (WG) may be established to elaborate particular technical or "coordinated and support" activities. A WG will be composed of a Leader responsible for coordination of the work and by eligible participants. The creation of a WG and nomination of its Leader will be proposed by the Management Board and endorsed by the General Assembly. Each WG will produce an annual report of its activities to be presented to the General Assembly.

SITEX_Network is opened to any institution or individual party having interest in independent regulatory assessment of RWM activities and willing to join SITEX_Network activities while proactively contributing to support SITEX_Network vision and objectives

The added value to other existing TSOs and regulator's networks is seen in bringing together different categories of contributors to /end-users of the expertise, such as TSOs, REs, NRAs and CSOs. This will ensure a plurality of views in all the foreseen SITEX_Network activities described above and on RWM safety as this plurality is considered as a way forward to build a strengthened and comprehensive expertise function.

9 Conclusions

The SITEX (2012-2013) project identified and initiated different types of activities for an independent Expertise function, i.e. R&D implementation, Reviewing a safety case, Training & Tutoring and Interaction with Civil Society; in SITEX such initiation essentially consisted in "programming" these activities (first mode of interaction). SITEX-II continued fulfilling this mode of interaction ("programming") that consists in sharing national experiences, practices and prospective views by:

- finalizing the programming of the R&D needed for a high quality and independent expertise in the field of safety of RWM through the establishment of the SITEX-II SRA,
- seeking for harmonization on the understanding and implementation of international safety requirements and recommendations regarding regulatory review, with a focus on four topics identified among SITEX priorities,
- carrying out an overview of existing training and tutoring practices used by partners located in Europe and Canada and identifying the needs in competence building for technical experts (safety case reviewers),
- investigating the main communalities and differences in the vision of safety culture between the different types of actors as well as the expectations regarding the engagement of CS in the decision making process.

In addition, activities were carried out by SITEX-II at increasing levels of interaction, i.e. implementing activities by developing joint work and sharing resources, or developing interactions and partnerships, as a unique harmonized SITEX entity, with external entities. In particular, SITEX-II accomplished the following tasks:

- interacting activities with external entities on R&D to build the possible European Joint Programming on RWM including disposal, notably through the JOPRAD project and subsequent Core Group;
- discussing on the collective position issued by SITEX-II on safety review topics within international tribunes (NEA, WENRA…);
- fulfilling a pilot training session for "generalist experts". Based on the first evaluation of this pilot training session, there is a reasonable background to promote SITEX training activities within and outside EU through future network's links to external entities such as IAEA, WENRA, etc. This will be part of activities of future network management and will contribute to harmonisation of experts' training across EU and therefore will strengthen the technical expertise of safety case reviewers;
- implementing an original model of "double wing" for interaction with the civil society, within SITEX-II as well as in a European project allowing fruitful interactions between institutional experts and representatives of CS. This model, articulated with the concept of "Knowledge Sharing and Interpretation", will constitute the basis for the organisation of the future SITEX network interaction with CS and the potential involvement of CS in European Joint Programming. These two elements will fulfill the third mode of interaction of harmonizing and linking with external entities.

Thanks to the work carried out under the SITEX and SITEX-II projects with the support of the European Commission, significant progress has been made to align European players on the orientations to give to research, on the safety assessment practices for geological disposal of radioactive waste, and on the means of interaction between institutional bodies and civil society. Building on this achievement, the new SITEX_Network association was created as a French law's Association on January 9, 2018, with NRA, TSOs or similar and CS organisations. The association will give them the necessary continuity to pursue their objective: to develop high-level expertise in the field of RWM that is independent of industrial operators and which provides support to the safety authorities, without losing touch with civil society.

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Appendixes

APPENDIX 1. SITEX-II PARTICIPANTS

SITEX-II participants	Country	
Institut de Radioprotection et de Sûreté Nucléaire (IRSN)	FR	TSO
Lithuanian Energy Institute (LEI)	LT	RE
Bel V	BE	TSO
Federal Agentschap voor nucleaire Controle- Agence Fédérale de Contrôle Nucléaire (FANC)	BE	RA
MUTADIS CONSULTANTS SARL (Mutadis)	FR	CSO
DECOM, a.s. (DECOM)	SK	TSO
Canadian Nuclear Safety Commission (CNSC)	CA	RA
Energiaklub Szakpolitikai Intezet Modszertani Kozpont Egyesulet (ENERGIAKLUB)	HU	CS
Nuclear Research and Consultancy Group (NRG)	NL	TSO
Centrum výzkumu Řež s.r.o. (CVREZ)	CZ	TSO
Gesellschaft für Anlagen-und Reaktorsicherheit mbH (GRS)	DE	RE
European Nuclear Safety Training and Tutoring Institute (ENSTTI)	/	
Miljöorganisationernas kärnavfallsgranskning (MKG)	SE	CS
Geologicheski Institut Pri Ban St. Dimitrov (GI-BAS)	BG	RE
Autorité de Sûreté Nucléaire (ASN)	FR	RA
Regional Environmental Center for Central and Eastern Europe, Country Office Slovenia (REC)	HU	CS
SYMLOG	FR	CS
Paul Scherrer Institute (PSI)	CH	RE

APPENDIX 2. PLAN FOR THE DEPLOYMENT OF SITEX-II SRA

The table in the following pages identifies the current possible plans for the deployment of actions associated to each SITEX-II SRA issue. These plans will have to be refined in the future, especially when the scope of the EJP1 activities will be finalized.

The legend used in the table is the following.

- Horizontal Activities :
  - EP: Exchanges on Practices
  - SA: Establish States of the Art
  - TK: Perform Transfer of Knowledge
- R&D WP of EJP 1 (WP #)
  1. Modelling of process couplings and numerical tools applied to Performance Assessment
  2. Assessment of chemical evolution of ILW and HLW disposal cells
  3. Mechanistic understanding of gas migration (mainly in clay-based materials)
  4. Influence of temperature on clay-based material behaviour
  5. Cement-Organics-Radionuclide-Interactions
  6. Fundamental understanding of radionuclide mobility
  7. Spent Fuel characterization and evolution until disposal
- Networking WP of EJP1 (WP #)
  1. Waste management routes in Europe from cradle to grave
  2. Understanding of uncertainty, risk and safety by different actors

Concerning the EJP1 Knowledge Management WP, at this stage of the EJP1 proposal development, the identification by the mandated actors of the activities of this WP is still pending. In the following table, the column related to this EJP1 WP represents thus a first view of SITEX-II and was completed in a grey colour (i.e. a different colour than the one used for the RD&D and the Networking WPs) , considering:

- The SRA issues that are associated to JOPRAD PD subdomains with a M or a H common priority;
- The SRA issues that are not or not fully covered by the current other WPs of the EJP1 and by other European projects.

SITEX SRA Main topics and issues						Possible Deployment Plan				
#	Description	R&D activity	Horizontal activity			Wait results of on-going EC Project	Candidate for deployment in EJP1 Phase 1			Candidate for deployment in SITEX_Network
			EP	SA	TK		R&D WP #	Networking WP #	Knowledge Management WP **	
Main Topic 1: Waste inventory and source term										
#1.	Uncertainty about databases and methodologies used for defining waste inventories (including historical waste)					CHANCE Project		WP # 1 & 2		
#2.	Evolution of the waste inventory due to possible neutron activation									
#3.	Understanding of the release processes and speciation of the radionuclides for different types of wastes					DISCO Project	WP # 5 WP # 7	WP # 2		
#4.	Waste acceptance criteria					THERAMIN Project		WP # 1		
Main Topic 2: Transient THMBC conditions in the near-field										
#1.	Oxidative transient									
#2.	Chemical conditions induced by metallic and/or cement materials and components						WP # 2	WP # 2		
#3.	Transients associated with gas production and migration									
#3.1	Generation processes and rates of safety-relevant gases other than H2					CAST Project				
#3.2	Influence of gas on geochemistry and microbial activity in HR and EBS					MIND Project	WP # 3			
#3.3	Gas migration through EDZ and EBS						WP # 3	WP # 2		
#4.	Co-disposal of waste: interactions between different types of wastes									
Main Topic 3: Evolution of EBS material properties										
#1.	Heterogeneous behaviour of bentonite components					BEACON Project				
#2.	Behaviour of metallic components						WP # 2			
#3.	Behaviour of cementitious components					CEBAMA Project	WP # 2			
Main Topic 4: Radionuclide behaviour in disturbed EBS and HR										
#1.	Competition between sorption of radionuclides and other elements from EBS/waste						WP # 6			
#2.	Influence of organic matter on radionuclide migration						WP # 5	WP # 2		
#3.	Influence of the thermal transient on RN migration in EBS and HR						WP # 6	WP # 2		
#4.	Influence of microbial activity on RN migration					MIND Project				
#5.	Transport of volatile radionuclides in the disposal system						WP # 3	WP # 2		

Main Topic 5: Safety relevant operational aspects										
#1.	Efficiency of the monitoring system over the operational period					MODERN2020 Project				
#2.	Assessment of the risk of fire and explosion									
#3.	Assessment of the risk of flooding									
#4.	Influence on long term safety of pre-closure disturbances									
Main Topic 6: Managing uncertainties and the safety assessment										
#1.	Uncertainties associated with site characteristics							WP # 2		
#2.	Management of uncertainties associated with geodynamics and tectonic movements							WP # 2		
#3.	General methodologies for the safety assessment							WP # 2		
#4.	Safety assessment models						WP # 1	WP # 2		
Main Topic 7: Lifecycle of a disposal programme and its safety case										
#1.	Methods to review the safety case									
#2.	Assessment of the technical feasibility of a geological disposal concept									
#3.	Evolution of the safety case content with the lifecycle of the disposal programme							WP # 2		
#4.	Organization of the pre-licensing phase									
#5.	Reversibility and Retrievability									
Main Topic 8: Pre-disposal radioactive waste and spent fuel management *										
#1.	Ageing of waste in storage conditions									
#1.1	Monitoring and assessing the state of the waste package and the state of the waste form in storage conditions							WP # 2		
#1.2	Consequences on safety of the ageing of the waste and consequences of the uncertainty about the actual state of the waste after a long storage period							WP # 2		
#1.3	Determination in which circumstances a re-processing of the waste should be performed and what type of re-processing is appropriate									
#1.4	Integrity of dry casks for spent fuel storage: stability in terms of ageing effects of the cask and the spent fuel over prolonged interim storage time							WP # 2		
#2.	Safety of storage facilities awaiting the availability of geological disposal							WP # 2		

* This Main Topic is not included in the SITEX-II SRA but was of common interest in the JOPRAD TSO Working Group.
** These activities are not identified yet in the current EJP1 proposal development phase. This column represent thus a first view of SITEX and not a common position between EJP1 mandated actors.