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Äspö Hard Rock Laboratory

NET. EXCEL

Final Technical Report

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PROJECT CO-ORDINATOR : The Swedish Nuclear Fuel and Waste Management Company (SKB), Sweden

PARTNERS : Posiva Oy (Posiva), Finland

Empresa Nacional de Residuos Radiactivos, S.A (Enresa), Spain

Gesellschaft fuer Anlagen- und Reaktorsicherheit mbH (GRS),Germany

National Radioactive Waste Management Agency of France (Andra), France

Nationale Genossenschaft fuer die Lagerung Radioaktiver Abfaelle (Nagra), Switzerland

Organisme National des Déchets Radioactifs et des Matières Fissiles Enrichies (Niras/Ondraf), Belgium

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Part 1 and 2: Publishable Final Report

Part 1 and 2: Publishable Final Report

Summary

A future efficient use of European resources in research and development of safe methods for final disposal of high level (vitrified and spent fuel) and long-lived radioactive waste is believed to benefit from close interaction between European organisations. The NET.EXCEL project concerns the forming of a network for analysing the present status and future needs in Research, Technical development and Demonstration (RTD) for the three rock media: salt, clay and clay sediments, and crystalline rock.

Eight organisations, responsible for planning of RTD programmes in their respective countries as well as in development of international projects participated in the Project. The work has addressed present status (year 2003) and important future needs of RTD related to final disposal of radioactive waste in deep geological formations. Highly prioritised issues (subjects and problems) in each of the participants' programmes provided the basis for the identification of highly ranked issues that could benefit from future European co-operation. Two approaches were applied for setting priorities on future joint RTD: one in which the quantitative ranking was restricted to a few RTD issues selected on the basis of a qualitative discussion and another in which the quantitative ranking was applied for the full list of RTD issues proposed by the participants.

The initial NET.EXCEL objective was to make a ranking and grouping of the RTD issues into suitable projects, and detailing the projects. This proved to be too optimistic. Instead a list of high priority issues of interest for future cooperation was identified. These high priority issues are to a large extent independent of the three represented groups of host rock, although, of course, the focus for a certain medium is more pronounced in some of the issues than in others. An interesting observation is that one of the main interests relates to the possibility to develop data bases in common.

The high priority issues are, however, broad and need to be broken down to provide defined specifications of activities that can be addressed by RTD in practice. Various methods such as Multi-Attribute Analysis and Analytical Hierarchy Process can then be applied for the assessment of priorities of proposed RTD projects. One could observe that irrespective of the methodology used in NET.EXCEL, some activities on the high ranked list have been already proposed and approved for funding by the 6th Euratom framework programme (2002-2006).

Expert groups utilised for defining joint RTD activities may be supervised by a network of representatives from the European organisations having a national responsibility for the safe management of the radioactive waste, and having a direct interest in ensuring that the RTD work is carried through. Such a network could be developed from the group of participants in the NET.EXCEL project and further extended with other European organisations in a way that is feasible and beneficial to all.

Contents

1 Introduction

1.1 General

A future efficient use of European resources in research and development of safe methods for final disposal of high level and long-lived radioactive waste is believed to benefit from close interaction between European organisations, with the national responsibility for safe handling of the waste, in planning of national programmes as well as in development of international projects. The NET.EXCEL project concerns the forming of a network for analysing the present status and future needs in Research, Technical development and Demonstration (RTD) for the three rock media: salt, clay and clay sediments, and crystalline rock.

Participants in the project are:

Svensk Kaernbraenslehantering AB	SKB	SE
Posiva Oy - Posiva	Posiva	FI
Empresa Nacional de Resíduos Radiactivos SA	Enresa	ES
Gesellschaft fuer Anlagen- und Reaktorsicherheit mbH	GRS	DE
Agence nationale pour la gestion des déchets radioactifs	Andra	FR
Nationale Genossenschaft für die Lagerung Radioaktiver Abfälle	Nagra	CH
Organisme National des Déchets Radioactifs et des Matières Fissiles Enrichies – Nationale Instelling voor Radioactief Afval en Verrijkte Splijtstoffen	Ondraf/ Niras	BE
United Kingdom Nirex Limited	Nirex	UK

This group has worked along a staged route comprising three Work Packages /NET.EXCEL, 2003/:

- WP1. Present status of RTD. The work addressed primarily, waste, canisters, buffer (not for salt or long-lived ILW), backfill, plug, the host rock itself, construction, monitoring, conceptual and mathematical modelling, and performance assessment.
- WP2. Important future RTD issues. This work addresses the same topics as in WP1
- WP3. Highly ranked issues for European co-operation on RTD. The work focus on identifying and ranking projects with common European interest based on methodology and criteria established in the project.

Methodologies for setting priorities were developed in parallel to the work with the WPs and not as a WP of its own.

Firstly, the participants prepared country specific reports on the first two WPs - Country Annexes. Secondly, for WP3 the information presented in the Country Annexes was elaborated and a list, the so-called “100-list”, of prioritised RTD issues in these Country Annexes provided the basis of the ranking work.

1.2 Overview of present status in the participating countries

Final disposal in a geological formation is considered by all the participating organizations except Andra as the favoured option for the long-term management of long-lived and/or high-level waste. Only in some cases, however, is a national strategy for implementation decided. The selection of the host rock is strongly influenced by the respective national geologies. The conceptual designs are selected to provide a high potential for operational and long-term safety. These selections will strongly influence the safety strategies that can be utilized, and thus also the RTD-work needed.

Some of the main barrier characteristics and materials that have been investigated by the participating organizations for long-lived radioactive waste in salt, clay and clay sediments and crystalline rock are summarized in Table 1-2.

Table 1-2 Repository concepts for long-lived waste considered in this report.

Organization	Host-rock and depth	Waste Package	Buffer	Backfill
SKB	Granite, 400 – 700 m	Copper canister with iron insert (SF)	Bentonite	Crushed host-rock – bentonite
Posiva	Granite, 400 – 700 m	Copper canister with iron insert (SF)	Bentonite	Crushed host-rock – bentonite
Enresa - crystalline	Granite, 500 to 1000 m	Carbon steel canister (SF)	Bentonite	Crushed host-rock – bentonite
- clay	Clay sediments ~260 m	Carbon steel canister (SF)	Bentonite	Sand-bentonite
GRS	Permian rock salt, ~ 800 to 900 m	Stainless steel canisters (HLW) Cast iron canisters (SF)	No buffer	Crushed rock salt
Andra - crystalline	Granite, 400 to 800 m	Copper canisters (SF) Steel canisters (HLW) Concrete conditioned ILW	Bentonite	Crushed rock-bentonite
- clay	Clay sediments 420 – 650 m	Non- or low-alloy steels Steel canisters (HLW) Concrete conditioned ILW	Swelling clay or no buffer	Sand – bentonite
Nagra - crystalline	Granite 500 – 1000 m	Carbon steel canister (HLW, SF) Concrete conditioned ILW	Bentonite --	Sand – bentonite Porous concrete
- clay	Opalinus Clay 650 m	Carbon steel alt. copper (HLW, SF)	Bentonite	Sand – bentonite
Ondraf/ Niras	Poorly indurated clays Boom Clay ~200-300 m (alt. Ypresian Clays)	Carbon or low-alloy steels overpack (HLW, SF), alternative stainless steel	Cement or clay-based materials	Sand – clay material or cement
Nirex	Strong fractured rock 300 - 1000 m	Concrete conditioned ILW	--	Porous concrete / Nirex Reference Vault Backfill

A programme for RTD is highly affected by the planned stepwise decision sequence for repository implementation. Thus there are many factors that cause the various RTD programmes to be different even if the host rock and barrier materials are similar. However, the benefits of doing relevant RTD work in international co-operation can often override the differences in priorities or timing. The status in year 2003 and main focus in the countries of the participating organisations on deep geological disposal have been summarized in a few lines for each country:

Sweden: A basic design of the repository system for SF was approved in year 2000. Two sites were approved for characterisation in 2001. Site characterisation is ongoing. A siting license application is planned for 2008 and the operational licence application for 2017.

Finland: Overall concept and site for SF repository decided 2001. Construction of subsurface rock characterization facility has been started in 2004. Application for repository construction license is planned for 2012.

Spain: Siting information developed in a national siting programme 1986-1996. The 1998-2003 R&D-plan is running. Non site specific generic designs both in granite and clay formations have been developed.

Germany: Repository Morsleben for LLW – operation terminated in 1998, backfilling started, licensing for final shut down under way; repository Konrad licensed for non heat-generating waste (LLW and ILW) in 2002; exploration of the Gorleben site suspended in 2000, moratorium to last three to ten years.

France: Project aiming to issue by 2005 reports on assessing the suitability of clay and granite formations for the deep geological disposal of high level and long lived radioactive waste. The National Review Board will report in 2006 to the French authorities on obtained results in the 3 R&D avenues as stipulated in the 1991 Waste Act, through a global assessment report, for the decision-making process. An interim report ("*Dossier 2001 Argile*") on feasibility and safety of a repository at a clay site has been issued by Andra. A similar report was issued in 2002 for outcropping crystalline formations in France. In addition, excavation work, site characterisation and scientific experiments are being carried out in the Andra “MHM” (Meuse-Haute Marne) URL at the clay site near the Bure village (Eastern France).

Switzerland: Proposed site for L/ILW (Wellenberg) vetoed in local referendum 2002. New programme is under development. Activities for SF, HLW and ILW are proposed to be focused on the Opalinus Clay and on a potential siting area in the Zuercher Weinland. To support this proposal, Nagra has submitted the "Opalinus Clay Project", which represents the final step in the demonstration of the feasibility of final disposal in Switzerland (2002). This project is now being reviewed by federal authorities.

Belgium: Methodological R&D has mainly focused on Boom Clay (NE Belgium), in which the HADES URL is located. The programme is not prejudging site selection. The second Safety Assessment Feasibility Interim Report (SAFIR 2) was issued in 2001. Societal dialogue will be started in order to further define the decision-making framework and detail the siting process. Strategic Environmental Assessment is planned for 2008.

United Kingdom: Planning permission for an URL near Sellafield refused in 1997. Public consultation for future national policy launched in 2001. New advisory committee to Government (CoRWM) formed in November 2003. Its recommendations on management of solid radioactive waste are expected in 2006.

When comparing the way the participating organisations in NET.EXCEL manage their RTD, common ground can be found in the roles/responsibilities, and in how priorities are established for RTD work. In general all participating organisations have the primary responsibility to identify, prioritise and initiate the necessary RTD, and also to evaluate and utilise the results. The practical way to carry out the RTD activities and the types of organisations established to do the work are very similar. The research and technical development is mostly carried out on a contractual basis by universities, research institutions, special laboratories and companies. All organisations are allowed to utilise the competence wherever it is found. Some of the specific demonstration activities are carried out in-house in specially developed facilities (underground research laboratories or specific test laboratories). Since these special facilities and demonstrations often are expensive and have very specific environmental characteristics, a substantial international co-operation has already been established. This facilitates an extended co-operation.

2 Lessons learned

2.1 Experience from the compilation and analysis of the national programmes

Structuring the RTD work

The compiling, structuring and comparing of the present programmes and plans of RTD in the participating organisations allow the following conclusions:

- The structure used in presenting the national RTD work in the Country Annexes was found suitable. It includes a sorting of the RTD work on the various containment barriers of the repository and, for each barrier, on the intended use or utility of the information produced (e.g. for selection of materials or concepts, for modelling or evaluation of performance, or for demonstration). The structure facilitates both the accessibility of the information produced, and the comparison of approaches and results.

- The project contractual commitment was limited only to the RTD work done for deep geological disposal. Should there be an extension of the work started with NET.EXCEL the structure could be refined or amended.

- The level of detail in the structuring is quite uneven. Due to the time constraints and the testing character of the NET.EXCEL-project, it was accepted from the outset that the levels of detail would not be normalised across the contributions from the participants. When comparing the RTD areas of high priority it was found that the level of detail was often sufficient to identify areas of common interest with regard to basic knowledge and consensus forming as well as areas that would benefit from competence support or the establishment of joint databases. But a higher level of detail might have made it easier to better identify joint needs for specific projects or experiments.

Identification and prioritisation

The methods used by the participants to identify, prioritise and initiate RTD activities show large similarities. Although none of the organisations is claiming currently to utilise a fully quantified and formalised process they all utilise the same basic input and prioritisation factors, see the boxes “Input…” and “Factors...” below.

The similar operational methods used by the participating organisations for identifying and prioritising their RTD-programme makes it meaningful to identify high priority issues of common interest from the compiled “100-list” of RTD issues

Input used for identification of RTD needs

- Results of RTD activities including the normal scientific review of these results, and the follow-up of scientific/technical progress in general.
- Identification of potential improvements in safety or the proving of safety due to:
  - problems encountered in the development of assessment capability and quantification of processes dominating the system/subsystem performance
  - problems exposed by the performance or safety assessments
  - problems encountered in the design or construction/production of barriers
- Assessment of the uncertainties and the ranking of them with regard to their importance for safety.
- Evaluations and comments given by the regulators in the licensing/approval processes.
- Other stakeholders' concerns and requests (producers, public, local authorities, etc.).

Factors taken into account when prioritising the potential RTD activities

I – Country specific factors- Factors given by the political, geologic and technical framework:

- Timing in the country specific time-plans and stepwise approach.
- Relevance to country-specific selection of repository concept and host rock.
- Importance for the perceived safety and/or acceptance by stakeholders and the public.

II – Concept specific factors - Factors stemming from the safety assessments or standard engineering practice for optimisation and choice of materials/procedures:

- Basic scientific and technical feasibility to meet the long-term safety criteria.
- Importance for the constructability of the repository system, for achieving an acceptable safety level, or for provability.
- Need for reduction of uncertainties, quantification or bounding of conservative simplifications.
- Need for a robust/insensitive system with sufficient flexibility to be able to adjust to new developments in techniques and knowledge.
- Effect on resources, cost and/or optimisation.

III - Other factors - Factors based on subjective evaluations:

- The benefits of a reasonably successful outcome of the RTD activity.
- The resources needed for getting a reasonable chance of success.
- The risk/potential for failure/success.
- The availability of resources, necessary equipment, competence.
- The necessity to develop and maintain a competence base that is sufficient for the perceived needs of the foreseeable future.

2.2 Added value of future joint RTD activities

The primary values (e.g. possibility of cost savings, availability of a broader/better competence base etc.) brought in by undertaking RTD activities in international co-operation have long been recognised, and are the reason for the existing co-operation. Other benefits - like the development and maintenance of joint competence centres and joint utilisation of rare competence - might be increased through an extended co-operation.

The focus of the NET.EXCEL project was to develop a common and systematic basis for priorities and co-ordination of future European RTD work for Radioactive Waste Management, and to suggest areas and priorities for joint RTD-projects. When discussing extended future co-operation different aspects have to be addressed. Such aspects might be e.g.:

- Different timetables for the repository development in the various countries. Many co-operative efforts presume a willingness to participate also in activities that for some partners might not have their full utility until some years in future. In RTD areas where the knowledge base is well advanced and sufficient for the near term needs this might limit the will for broad participation.

- Different geological media. RTD areas that are very site or design specific can be of low interest for a broader group, however, well suited for international co-operation in a smaller group.

- Different needs for quality assurance in different phases of repository development. However, the joint adherence to ISO 9001 and 14001 makes it simpler to establish rules for joint QA procedures and QA levels.

- Reduced availability of independent groups for second opinion and review. Although the forming of centres of excellence and the joint utilisation of rare and scattered expertise often is beneficial for the competence level of the created group, the availability of competence for second opinions and review might be reduced.

The first and second group of prioritisation factors in the box above – the country and concept specific factors (I-II) – have already been taken into account in the “100-list” when ranking the list of priorities with regard to added value from co-operative involvement. Factors for prioritising RTD activities in the third group (III) can be seen in a more international perspective.

3 RTD issues of high priority

3.1 Present status and planned work

In WP1/WP2 the present status and the planned work by the participating organisations in different RTD areas were given in separate reports - Country Annexes. Subsequently, all information from the Country Annexes was compiled to facilitate the identification of issues for European co-operation to be performed in WP3.

The national RTD efforts undertaken and planned are influenced to various degrees by the selected geological media. The geological media considered by the participating organisations for the purposes of this project are given below.

GRS	Ondraf/Niras	Enresa	Andra	Nagra	SKB	Posiva	Nirex
Salt	Clay	Clay Crystalline rock	Clay Crystalline rock	Clay Crystalline rock	Crystalline rock	Crystalline rock	Crystalline rock

To facilitate the identification of common RTD issues, irrespective of geological media the issues were grouped under the following headings:

- Radioactive waste
- Waste package (canister and overpack)
- Buffer
- Backfill
- Plugs and seals
- Geosphere
- Repository construction and operation
- Monitoring
- Performance and Safety Assessment

They do not cover all areas in radioactive waste management, but they represent areas where a substantial amount of work has been undertaken, or is underway in each of the participant's core programmes.

3.2 Important future RTD issues

The compilation of each participant's contribution of prioritised issues into the so called "100-list" provided the basis of the ranking work.

The RTD issues in this "100-list" do in some cases have similar headings, which intuitively calls for grouping of those for consideration as related or single RTD projects. The objectives of this would be both to avoid fragmentation and to enable a close interaction between researchers working on related subjects. Such grouping has been done by taking the "100-list" and investigating the possibility to merge those issues with either similar headings or similar focus, see Chapter 4.

3.3 Procedures to identify joint RTD issues

Based on the similarities in how the participants are carrying out their RTD programmes, the project regards that the ”100-list” of nationally prioritised RTD issues can be used as a basis for an international ranking exercise.

However, the selection of joint RTD issues must be supplemented by taking account of the various types of added value that a co-operative effort could provide. Since there can be very different objectives for different types of co-ordinated RTD activities, the added values that are most appreciated in a specific joint activity would also be different. This is especially evident when looking at co-ordinated activities that are only indirectly affecting the RTD. The objectives of such activities could be:

- Comparison of optional approaches, development of joint strategies or development of consensus.
- Development or preservation of competence.
- Preservation of information.

Various objectives and the values sought in joint activities are exemplified in the table below. These differences must be kept in mind when ranking the possible activities.

Objective of a RTD project	**Most appreciated added value from international co-operation**
To develop a basic understanding	Broad scientific competence and participation, extensive reviews, cost savings
To establish consensus or common strategies	Detailed scrutiny of the issue, thorough mapping of alternatives, extensive reviews, wide dissemination of results
To produce or improve on specific data	High detailed competence, accepted methodologies, high level of QA, joint build-up of competence
To compile or establish joint databases	Shared cost of maintenance and availability, joint and reviewed documentation on data and its quality, longevity
To carry out specific experiments or demonstrations	Shared cost, more or better competence or equipment,
To develop/preserve necessary competence or establish joint centres of excellence	Shared cost, better quality, “critical mass of experts”

The wish of the NET.EXCEL participants to look fully at the possibilities and problems of enhanced co-operation, and the awareness of the various aspects raised by this, evokes a number of questions regarding how such co-ordinated operations should be initiated, organised and managed. Similarly, it is recognised by the participants that a possible future continuation of the activities tested in NET.EXCEL and extension into other areas (e.g. biosphere, near-surface disposal, non- radioactive wastes) or the inclusion of new members might evoke new issues and problem areas to be discussed.

In the NET.EXCEL project two approaches have been applied (see Chapter 4) for the development of ranked lists of RTD issues of high interest as co-operational projects:

1. Quantitative scoring of the full list – A ranking of all the RTD issues in the "100-list" by letting each organisation mark their interest in participating in each of the suggested RTD issues.

2. Qualitative short listing of a selection of high priority issues – A selection of RTD issues with potential for co-operation made by the NET.EXCEL project group in plenum. The list was based on the participants' knowledge of their own national interest, their awareness of what could be suitable co-operative projects and a general understanding of the international status of repository development.

4 Future joint RTD issues

4.1 Quantitative scoring of RTD issues

4.1.1 High priority RTD issues

It was observed that the contribution of RTD issues to the "100-list" was very uneven, both with respect to the number of issues per participant (minimum 3 and maximum 28) and the level of detail in the given definition of the issues. In addition, the participants' contributions do not necessarily cover the need by other organisations in the participating countries. In total the "100-list" comprises of about 130 RTD issues that have been sorted in nine main areas;

- radioactive waste,
- waste package
- buffer
- backfill
- plugs
- geosphere
- repository construction and operation
- monitoring
- performance and safety assessment.

The nine main areas generally include a range of 5 - 15 prioritised RTD issues except the "geosphere" that has about 40 RTD issues. All participants of NET.EXCEL examined the issues in the list and marked their priority.

The RTD issues with highest marks have been regarded to be of highest priority for further work. The project is aware of the fact that there might be systematic differences among the participants due to differences in mandates or host rock. Thus also other suggested activities can be considered, for example the RTD issues to which at least three participants have indicated high interest. It may also be the case that an RTD issue that has got a low priority but is of interest to many participants, e.g. not so urgent at national level, is suitable for international co-operation.

The marking of the RTD issues is not always consistent. Similar issues can have been given different priorities from the same participant due to unclear definitions and/or small differences in the scope of work. In addition, some organisations have marked high interest to all RTD issues whereas other organisations have a more uniform distribution.

In spite of the above mentioned problems the procedure has provided a good basis for identifying the highly ranked RTD issues for European co-operation. Since, however, many RTD issues in the "100-list" are partly overlapping it has been found prudent to merge the issues into a smaller number of so called "thematic areas".

4.1.2 High priority "thematic issues"

Several of the highly ranked RTD issues are related to each other. Future work with the RTD issues will therefore be more effective if they are grouped together. In this section RTD issues that could be co-ordinated are grouped into "thematic issues". The 15 highest ranked RTD issues resulted in the following list of seven "thematic issues":

- Methods and tools in PA/SA
- Dissolution of spent fuel and vitrified HLW
- Buffer saturation and evolution
- Radionuclide speciation and migration in the near field
- Excavation Disturbed Zone
- Gas migration in tight media
- Radionuclide migration in the geosphere

Many of the 13 RTD issues with low marks but given a high priority from more than three participants are already included in the "thematic issues" listed above. However, four additional "thematic issues" were identified:

- Backfill materials
- Plugs and seals
- Repository induced perturbations on the geosphere
- Upscaling of host rock properties

Many of the remaining RTD issues in the list could also be merged into these areas. Thus, in total about 70 RTD issues from the "100-list" have been grouped into the eleven "thematic issues". However, RTD issues related to "waste package" and "monitoring" were given a low priority for co-operative work. Indeed, waste packages, with their possible overpack, are associated to preliminary disposal concepts which today are national and very different between countries. With respect to monitoring, we could forecast some need for technological development of sensors and equipment for signal transmission during the operational phase, but monitoring during the post-closure phase is as well a political and societal issue not yet dealt with.

The "thematic issues" are to a large extent independent of the geological formation, however, some RTD issues are specific to salt formations, e.g. "Rock salt parameters – characterisation of creep" and "Reactive transport modelling in high saline milieu". Below the eleven "thematic issues" are described in more detail under separate subheadings. Each area starts with a box containing the RTD issues from the "100-list" that can be included. The issues are marked with the country specific identifier, originator of issue (BE for Belgium, CH for Switzerland, DE for Germany, ES for Spain, FI for Finland, FR for France, SE for Sweden, and UK for United Kingdom), . For each "thematic issue" comments are given on:

- Status
- Added international value sought

Methods and tools in PA/SA

RTD issues that can be included:

Constitute a coherent set of tools for full PA calculations and prepare arguments for safety cases	BE01
Definition of the contents and methodology of the safety case for the application of the construction license	FI03
Define consistent system and subsystem requirements and verify that the concept is technically feasible and its performance can be predicted for a reasonable scenario selection (KBS-3 type)	FI01
Treatment of uncertainties in PA	DE25
Study possible alternatives to the reference concept (KBS-3 type)	FI02
Descriptive PA model for the release of radionuclide from the waste form (spent fuel).	FI04
Development of appropriate safety indicators	DE24
Biosphere and geosphere modelling	DE26
Integration of component numerical code in PA models	ES11
Geochemical analogues	DE23
Develop and verify models to be used in PA	SE26
PA case studies	DE28
Scenario development and application	DE27

These issues have the objective to support and standardise the approaches, methods and tools used in Performance and Safety Assessments.

Status: There is an existing and well functioning forum within OECD/NEA (the IGSC-Integration Group for the Safety Case) for the discussion of SA/PA and safety case-related issues in general and for the promotion of good practice and joint procedures. Although there are many SA/PA-related RTD activities that should be carried out within specific joint projects outside the NEA, it is important that all suggested projects dealing with joint approaches, methods or models should first be discussed within the existing forum in order to avoid duplication and fragmentation. The EC 6th framework programme has announced a future "call for proposal" that will focus on Performance and Safety Assessments.

Added international value sought: Broad scientific competence and participation, extensive reviews, thorough mapping of alternative approaches, models, data sets, etc., wide dissemination and acceptance of results, transparency of PA methods, benchmarking of PA codes, and practical guideline.

Dissolution of spent fuel and vitrified HLW

RTD issues that can be included:

Dissolution of spent fuel	ES01
Fuel dissolution (experimental work and development of PA model)	SE01
Dissolution of SF and HLW	CH07
Behaviour of HLW / SF in the presence of cement-based buffer	BE02
Determination of the RN inventory for present and new spent fuel types	FI05
Radiolysis in solutions with generation of oxidizing species at surface of waste matrix, particularly at SF (brines)	DE02

Research has been performed and is on-going to understand and model the dissolution processes. However, improved understanding of the processes that determine the radionuclide release from waste matrices under different chemical conditions would enhance the PA accuracy. For example, data are relatively sparse and determined under different laboratory conditions.

Status: The EC supported Integrated Project NF-PRO within the 6th Framework Programme (Understanding and physical and numerical modelling of processes in the near field, and their coupling, for different host rocks and repository strategies) /NF-PRO, 2004/ addresses the processes and mechanisms influencing the release of radionuclides from spent fuel and vitrified HLW under the heading "Dissolution of and release from waste matrix". Dominant processes and process couplings affecting the isolation of nuclear waste within the near field will be addressed as well as application and development of conceptual and mathematical models for predicting the source-term release of radionuclides from the near field to the far field. Results and conclusions of experimental and modelling work will be integrated in performance assessment.

Added international value sought: Build confidence in the conceptual models used to describe the source-term release in safety and performance assessments. Further development needs co-ordinated action because of the complexity and volume of the work to be done. Activities are waste package specific, which may be interpreted as country-specific, but not medium-specific.

Buffer material – emplacement, saturation and evolution

RTD issues that can be included:

Realistic (coupled) description of the bentonite behaviour under transient state of re-saturation	FI11
Bentonite-cement interaction/availability of low-pH cements for grouting	FI12
Chemical evolution and radionuclides migration in compacted bentonite buffer	ES05
THM behaviour during saturation-saturated thermal and saturated isothermal periods	ES04
THM processes during saturation and in the long term perspective	SE07
Bentonite performance in long-term after thermal transient is complete	CH10
Technical development of bentonite pellet emplacement	CH02

Radionuclide speciation and migration in the near field Buffer of swelling clay is primarily foreseen to be installed in repositories in crystalline rock and clay/clay sediments, but applications in salt are also studied. Work has been conducted in small laboratory scale to full scale field experiments during a long period of time, and in many geological environments, but the performance of the barrier is essential for the safety case. In addition, better understanding of possible variation of properties is important, as the knowledge may be utilised in decreasing margins.

Status: Large scale experiments have been and are carried out in salt, crystalline rock and clay/clay sediments. A wealth of data has been and is collected, primarily on THMC processes taking place. Numerical modelling is advanced with respect to coupled THM processes, and coupled THC and THMC modelling is in an advancing state. But for developing more advanced models and for verifying the capability of models with the C component new mock-up or full scale experiments would enhance the accuracy. The project NF-PRO will study the state-of-the-art in THMC conceptual and numerical modelling, and aim at enhanced predictive capability of the existing models. The ESDRED project will investigate, notably through large scale demonstrations, the engineering issues concerning bentonite pellet or ring manufacturing and their emplacement technique in the disposal cell.

Added international value sought: The main benefits from an international participation are shared cost and joint utilisation of well planned mock-up and large scale field tests.

Radionuclide speciation and migration

RTD issues that can be included:

Radionuclide distribution and speciation - Strengthening of the scientific basis	CH01
Radionuclide solubility and speciation - Supporting data on radionuclide mobility	ES02
Radionuclide retention, improvement of understanding, consolidation of existing database.	BE14
Real scale verification of the key retention processes in granite, clay and bentonite barriers.	ES10
“Geocodes validation”	ES12

Beside the radionuclide migration in the geosphere (see below) there are a number of highly ranked issues that focus on the further development of understanding of mechanisms and of improving data for radionuclide release and migration in the near field.

Status: In this area there is already substantial international co-operation. The project NF-PRO addresses the sub-issue “Dissolution of and release from waste matrix”. The NEA Thermochemical Database Project provides quality assured data on the solution properties of a wide range of safety-relevant radioelements. An increased effort in this area must be discussed and defined in specialist working groups.

Added international value sought: Broad scientific competence and extensive reviews lead to an improved understanding and a better data base. The improved data base must be developed by accepted methodologies and a high level of quality assurance. The cost savings for large scale experiments may be important.

Excavation Disturbed Zone (EDZ)

RTD issues that can be included:

EDZ evolution and demonstration of self-sealing (Clay)	CH03
Technical development of EDZ characterisation techniques	CH05
EDZ in clay (part of NF-PRO)	FR04
EDZ-Liner evolution in clay repository	ES08
Excavation techniques and EDZ	SE19
EDZ and self-healing - Long-term evolution under different geological and repository conditions (rock salt)	DE17

A number of activities address the EDZ, which is an issue in the programmes of all three types of host rock that are considered in the NET.EXCEL project. The focus is on characterisation of main parameters, the importance of the EDZ in the long-term perspective, and development of design-guidelines to minimise the effect of the EDZ.

Status: Work has been going on for a long time and has resulted in conceptual understanding of the geometry and properties of the zone. Numerical modelling is developed on processes taking place in the zone in a short term perspective, and on the impact of the zone on safety in the long term perspective. In the 5th FP, a specific project on EDZ and self-sealing in clays was launched but is not yet finalised. The EC has also gathered all current experience and knowledge on EDZ in a recent conference and workshop /CLUSTER EDZ, 2004/. A broad approach is taken in the project NF-PRO on quantifying THMC phenomena in the EDZ and to provide Performance Assessment with fundamental parameters.

Added international value sought: Cost sharing and limited availability of sites for large scale field experiments are major factors giving added values from international co-operation. The development and application of experimental methods and numerical models in joint projects will contribute to a better understanding of long-term processes such as the creeping of elasto-plastic rock formations under different site and load conditions. For the development – and acceptance – of design guidelines for clay repositories, a broad participation by those working in clay sediments is favourable.

Gas migration in tight media

RTD issues that can be included:

Gas migration in tight media	BE13
Gas transport in host rock including EDZ (Clay)	CH04
Gas migration in bentonite, Lasgit modelling	SE06
Gas transport in bentonite	FI13
Tightness of rock salt - Gas storage capacity and mechanical behaviour at overpressure	DE16

The activities are related to the dispersion of gas that is produced mainly from the corrosion of iron after saturation of the repository.

Status: A number of small and bench scale laboratory experiments and tests have been conducted, and several experimental and modelling activities are going on or are in the planning phase. The area is regarded as important and urgent in the present plans for many participants. The activities could favourably be co-ordinated by a working group of specialists. One sub-issue concerning gas effects on the THM behaviour of clay buffer will be addressed in the project NF-PRO.

Added international value sought: The activities focus on understanding, modelling and large scale experiments for testing, modelling development and numerical code confirmation. A broad scientific competence and participation would enhance the quality and effectiveness of work in this area. Other important added values of international co-operation here are cost savings and availability of competence and equipment.

Radionuclide migration in the geosphere

RTD issues that can be included:

Retention and sorption of RN in geosphere	FR01
Actinide migration in rock (Radionuclide transport and retention (Experiments in Äspö HRL: TRUE, LTDE, Colloid, CHEMLAB, Microbe)	SE17
Radionuclide retention • Improvement of retention processes understanding • Consolidation of existing databases for key parameters (e.g. diffusion) • Maintenance of favourable geochemistry over geological timeframes	BE14
Real scale verification of the key retention processes in granite, clay and bentonite barriers	ES10
Solute transport in host-rock	CH06
Tracer migration in rock at in situ conditions	SE16
Radionuclide migration in rock	SE27
Microbial processes - Influence of microbes on radionuclide transport and the chemical stability of groundwaters	SE15
Sorption in far field	DE21

The activities are related to improved understanding of radionuclide migration (transport and retention processes) in geological formations, and compilation and maintenance of databases.

Status: A large number of experiments have been conducted on small laboratory to large field scale by the participants and others, often in collaboration between several organisations. Numerical modelling work has resulted in good agreement between experimental data and modelling result based on the experimental result. The status of thermodynamic sorption models has been subject to an international benchmarking exercise in the NEA Sorption Forum where a wide range of models, covering all established mechanistic approaches, were used in blind predictions of quality assured sorption data. Radwaste management agencies are presently engaged in the preparation of the EC FunMig proposal for the 6th EC Framework Programme.

Added international value sought for: Joint development and verification of numerical codes. Shared cost of compilation, maintenance and availability, joint and reviewed documentation on data and its quality, extensive reviews, and wide dissemination of results.

Backfill materials

RTD issues that can be included:

Backfill material for high salt contents in groundwater (Long-term development of backfill, material selection, experiments in Äspö HRL: B&PT)	SE09
Define performance requirements for operational and long term safety	BE09
Performance of the backfilling materials	SI14
Establish the chemical interaction between crushed rock and bentonite	SE08
Backfill properties in rock salt	DE13
Geochemical milieu - Testing of additives in the backfill for long-term geochemical stabilisation (rock salt)	DE19
Sorption in near field - Developing of additives in the backfill for specific radionuclides (rock salt)	DE20

The backfill has basically the task to decrease the open voids underground when the repository is being sealed and closed. There are requirements set for the performance in the short as well as the long run, which may be fulfilled by careful selection of material and backfill technique, and development of numerical tools for describing the performance.

Status: Reference materials and techniques have been developed for each programme, but the specification of the chemical environment and the requirements on performance have gradually increased the need for more detailed knowledge of material properties and long-term behaviour. The aim to provide a barrier effect from the backfill has also initiated RTD work.

Added international value sought: The further development of backfilling materials and methods for other parts of repositories may favourably be addressed in joint co-operation. Concepts aim in many cases to utilise similar type of materials, and in others to similar methods for backfilling and quality control of the result. To some extent this thematic area is medium-specific, but also has significant elements that are not medium-specific.

Plugs and seals

RTD issues that can be included:

Temporary seals and concrete/bentonite interaction	ES06
Performance of the bentonite plugs	FI15
Systematic way of plugging in conjunction with sealing	SE11
Temporary plugs concrete or steel?	SE10
Shaft seals - Development of sealing systems and demonstration of long-term behaviour (in rock salt)	DE12
Drift plugs and dams - Investigation of material properties and system behaviour (in rock salt)	DE11
Performance of the distance blocks in KBS-3H	FI16
Plugging of investigation boreholes	SE25

The objectives are to develop concepts and techniques for operational and permanent plugs/seals e.g. in repository tunnels and shafts, and in investigation boreholes. Besides backfilling of drifts and open rooms underground at closure plugs and seals are necessary tools to use in specific areas for providing as tight stops as possible against groundwater movement at that location. Materials may be different in different host media, but the strategy for complying with stated requirements is very similar in all geological disposal concepts.

Status: Many experiments have been carried through from bench scale up to full scale, many in URLs. The EC supported Integrated Project ESDRED (Engineering studies and demonstrations of repository designs) /ESDRED, 2004/ will address the sub-issue on temporary sealing of drifts with cementitious materials with a pH below 11 (which in the context is "low").

Added international value sought: Formulation of international standards such as requirements to be fulfilled e.g. under different timeframes and for different environmental conditions.

Repository induced perturbations on the geosphere

RTD issues that can be included:

Limiting waste- and repository-induced perturbations in order to maintain favourable barrier properties of the host formation	BE10
Oxidation + alkaline plume - Limiting waste- and repository-induced perturbations in order to maintain favourable barrier properties of the host formation	BE11
Geosphere stability - Investigation of FEPs making up the long-term isolation potential	DE18

The repository introduces in many ways changes in the virgin rock volume selected for the final disposal of the waste. Rock is taken away and new materials are introduced. The rock around the excavation is damaged to a certain distance from the opening and is disturbed to a larger distance which is more difficult to identify than the former one. Many studies have been conducted and most materials introduced underground have been analysed.

Status: Materials used for repository construction are fairly well characterized and quantified. Investigations have for a long time been going on regarding the impact of cement/concrete on bentonite. The present focus is on the pH plume the cement/concrete may emit, and the deep salt water up-coning that may occur. Modelling work is going on having the aim to create a tool for long term predictions of processes, basically chemical processes, and their impact. The EC Integrated Project NF-PRO addresses these issues in the task on the evolution of the near field with special interest in EDZ evolution and the effect from concrete degradation.

Added international value sought: Much information and knowledge are available in other fields of research than radioactive waste management, and the fact-finding is most efficiently done in international co-operation. Centres with specific specialities exist in different countries, and the access to laboratories with these specialities would enhance the quality and efficiency of the work.

Up-scaling of host rock properties

RTD issues that can be included:

Up-scaling of hydro-geological, geochemical and mechanical properties of the geological barrier (Clay, granite)	ES09
Skin zone studies - To understand predictions (site investigations, up-scale, gw flow)	SE12

This issue has the objective to develop a realistic approach of the extrapolation in space and time of rock parameters (e.g. T, H, M, and C) measured in boreholes and URLs. The focus is on the verification of the effects when the scale is increased. Large scale experiments and long-term evolution characterization in natural analogues and URL system are needed coupled with modelling and data revision.

Status: Up-scaling has been studied in rock mechanics for a long period of time. Fracture systems are analysed with the aid of numerical tools, and the results are transferred to geo-hydraulic factors which result in quantitative values on groundwater flow. The so called skin zone around an opening is a parameter used in calibrating fracture system data of inflow to real inflows into excavated openings.

Added international value sought: Shared cost, more or better utilisation of competence and equipment.

4.2 Qualitative short-listing of RTD issues

The qualitative short-listing of RTD issues was made by the NET.EXCEL group in plenum at a workshop meeting. The participating organisations presented as a starting point the national lists of most important RTD issues. A list of nine RTD issues of high interest for co-operative efforts was selected from the combined national list "100-list" after discussion and some merging of similar issues. The selection method focused on quantity, i.e. favouring of issues, which are addressed in present RTD programmes by many of the participants. In addition, issues being part of any EC programme were set back, as the objective was to focus on future joint RTD co-operation and not repeat ongoing work.

In a next step the nine RTD issues were used for testing procedure and principles for the ranking of issues of high interest for co-operative efforts. Each organisation evaluated the suggested RTD issues by giving them a weight and the weighting numbers were added to give a ranking number.

It was observed that the differences in focus and interest in the various issues suggested for co-operation made it necessary to augment the titles with substantial amounts of comments. At the workshop the nine RTD issues were therefore further developed in detail. A short description of the RTD issues is given below.

Long-term stability HMC (clay and salt)

Prediction of the long term HMC behaviour of argillaceous materials and salt rocks with respect to external events as well as to the effects caused by the repository (e.g. excavation and construction, operation, and post-operational processes).

Gas transport capacity of rock

Obtain basic understanding of the capacity of the host rock to efficiently transport gas from the repository waste emplacement areas without causing detrimental effects on radionuclide retention by the host rock.

Radionuclide retention (mainly clay material)

Developing phenomenological models of processes governing migration (transport and chemical retention) of key radionuclides in the host rock.

High pH radionuclide dissolution and migration

The objective is to build confidence in conceptual models used to describe the release mechanisms of key radionuclides as a basis for safety assessment source-term models.

Plugs and seals strategy

Develop designs of plugs and seals that fulfil PA expectations of long-term performance. Examples of activities are development of joint approaches and identification of data needs.

Backfilling materials techniques

The objective of the project is to develop backfilling concepts for repository tunnels that meet the defined performance objectives. This means; definition of the performance criteria, development of backfilling materials and techniques, and testing and demonstrating that the criteria are met.

Gas generation by organics

The objective is to build confidence in mechanistic models used to quantify the volumes and types of gas released from organic wastes (in particular TRU wastes) and the rate of release as a function of environmental conditions for use in safety assessment source term models. The main activity would be integrated modelling and testing (mainly by suitably designed experiments at the laboratory scale).

Criticality

The objective is consensus forming and potentially sharing of databases. The output would be approaches to assuring sub-criticality that are developed in common and are focused on assuring regulatory acceptance for the associated arguments, design approaches and analyses. Organisations would use these elements in support of their design approach for dealing with this issue in their safety case.

Confirmation of diffusion database (clay material)

The diffusion is the key process for radionuclide transport in clay materials (host rock and buffer). There are many data bases containing diffusion coefficients, but the values are often influenced by the experimental procedure used for their acquisition. The project consists of a systematic analysis and revision of the “Diffusion Data Bases”.

4.3 Selection procedure

Obviously there are large similarities between the highly ranked issues discussed in Section 4.1 and 4.2. Some of the issues can be found in both, e.g. the gas transport capacity and the radionuclide retention.

In the qualitative short-listing approach, common ground was found during discussions for a number of activities by raising specific questions, (e.g. the C-14 focus in radionuclide dissolution/migration under high pH conditions) or by broadening the scope (e.g. long term stability of the HMC characteristics in clay and salt). These "adjustments" and the development of details for each of them allowed the documentation to be more precise than for the activities that are only described in the "100-list". Still for each of them it is recognised there is a need for further refinement by working groups.

The activity called "Plugs and seals strategy" is an example of an area in need of consensus-forming recognised by many. Such an activity would need a broad participation to be able to satisfy the specific needs of all the interested parties, perhaps also outside the implementing organisations. The "Criticality" item is an issue of recognised interest by all but regarded by most participants to be in no need for urgent activities. Both of them might be good examples of areas where specific competence needs might be identified so well in advance that it can be developed over a longer period in a joint activity.

The "thematic issues" listed in Section 4.1 should not be seen as projects for co-operation, but rather as indicative of areas where projects of high joint interest could be identified. Some of the items in Section 4.2 could well be kernels of such projects. Some could be broadened and some could be made more specific.

Satisfying the interest of many participants is part of the objective and ambition of the project. Nonetheless, if e.g. at least three participants indicate high enough interest, then a small group of organisations might consider a project to be established despite low interest by others.

The favouring of broad definitions was looked into by applying a next step in the short-listing approach. By development of details the possible RTD activities that would be in focus were specified. This step clarified the difference between the issues having a main focus in common and those having the same terminology but with somewhat different objectives. This step also suggested that it is important to achieve a rather detailed specification of proposed activities before the activities are merged into headings.

The nature of the two prioritisation approaches presented here is that they:

- Favour interest from many participants in one issue over high prioritisation of an issue by a few.
- Favour broadly defined issues as opposed to those with specific definitions.

Problem areas

A number of problematic areas have been seen repeatedly when discussing or comparing activities for co-operative efforts within the project:

- One is the fact that the added value sought from the co-operation can be very different and hard to compare, sometimes requiring very broad participation and discussions (e.g. in order to develop common understanding), and sometimes only focusing on cost sharing or joint utilisation of resources in a well defined and specific experiment or demonstration.

- There are a number of identified RTD issues aiming for development of common methods, procedures or strategies. These form a specific category of activities. They often require many participants in order to cover all aspects and to be able to develop consensus. And the work is often not easy to limit in time since they are more like processes than projects. Examples of such are the IGSC group working on PA/SA in NEA and the groups that have been focused on the biosphere BIOMOVS, BIOMASS within IAEA.

- Another item is the fact that the delimitations and the level of details provided in the original suggestions for possible co-operative activities are very different. Sometimes the scope is very wide so it will be unrealistic to include all aspects in the same activity, sometimes it is unnecessarily limited because of the specific interests of the initiator. This requires a stepwise approach of focusing or broadening. An optimum must be found between satisfying the needs of many participants, defining the scope to those aspects that support each other in a realistic way, and limiting the project to a manageable size. Such efforts require more time and manpower than what was available in the project.

5 Summary of high priority issues for future co-operation

The main result of the NET.EXCEL project is a list of high-priority issues with high potential for future co-operation among European waste management organisations. The nature of this list is "thematic" rather than "detailed" and further iterations by expert groups will be required to identify suitable projects.

The identification and selection of high priority issues made within the project are described in Chapter 4. The resulting list of 14 high priority issues is given in the table below. The list comprises eleven "thematic issues" originating from the highly ranked RTD issues in the "100-list" (bold) merged with the nine RTD issues from the qualitative short-listing made by the NET.EXCEL group in plenum (italic).

The further elaboration of the high priority issues by detailing activities, will indicate the common denominators, which can lay the basis for joint projects in contrast to fragmented projects.

High priority issues for future co-operation	PA	Waste	Repository barriers	Geosphere
Methods and tools in PA/SA	X			
Dissolution of spent fuel and vitrified HLW *High pH radionuclide dissolution and migration*		X		
Criticality		X		
Gas generation by organics		X		
Buffer saturation and evolution			X	
Backfill materials *Backfill materials and techniques*			X	
Plugs and seals *Plugs and seals strategy*			X	
Radionuclide speciation and migration *Confirmation of diffusion databases*			X	X
Excavation Disturbed Zone			X	X
Repository induced perturbations on the geosphere			X	X
Gas migration in tight media *Gas transport capacity of rock*			X	X
Radionuclide migration in the geosphere *Radionuclide retention*				X
Up-scaling of host rock properties				X
Long-term stability (clay and salt) HMC				X

Bold – Thematic issues from the "100-list"
Italic – Qualitative short-listing by NET.EXCEL group

6 Discussion

In Chapter 2 the NET.EXCEL approach to structure the RTD work and the knowledge-base established for the repository development was presented, as well as the methods used in the participating organisations to identify, prioritize and carry out the national work. Chapters 3 – 4 presented the NET.EXCEL activities to test various procedures for jointly analysing existing and future RTD needs, and for establishing areas that are of joint high priority. The resulting list of 14 "high priority issues" is presented in Chapter 5. Below the experience gained from performing the activities mentioned above is discussed, with a focus on the two major objectives of the project being:

- Suggested/identified issues and priorities for joint European projects.
- Common and systematic basis for priorities and co-ordination of future European RTD work for radioactive waste management.

6.1 Future RTD needs of high priority as seen today.

The resulting list of high priority issues presented in Chapter 5 is judged to be a feasible start for the building of a future European co-operation. It is still not complete but could be improved both by scrutinizing of the RTD issues, and by addressing RTD issues in other fields of radioactive waste management research, like biosphere, monitoring, and integrated modelling of repository components. The work may also be extended to other types of radioactive waste.

A major factor influencing the possibilities within the frame of this project to identify the future RTD that is jointly regarded to have a high priority is the level of details in the national lists of RTD needs. In the NET.EXEL effort it was early recognised that the basis provided by the participants in the Country Annexes was quite uneven with regard to elaboration and details.

In the two approaches used, the quantitative scoring (Section 4.1) encountered problems in being able to define the primary objectives and delimitations in the suggested RTD issues in the "100-list". This made it difficult to do an early merging. However, the RTD issues were prioritised by the participating organisations and high prioritised issues have been merged into "thematic issues" with a higher level of generality. To be able to identify well framed and internally consistent projects these have to be further analysed in specialist groups. The methodology for this has not been tested.

The above problems were not encountered in the qualitative short-listing of RTD issues made by the NET.EXCEL group in plenum (Section 4.2) since the picking of suitable activities was often done by the experts with their suitability for international co-operation in mind. The problems encountered here were mainly connected with the traceability of the decision - i.e. why some activities were chosen and others were not.

Even if the list of high priority issues were developed in different ways, there can be seen large similarities. For the NET.EXCEL the main use of the list with high priority areas would be to provide an input for the EC discussions on the 7th FP and internally as a check to see whether the results agree with the general understanding in the participating organisations.

For this purpose the level of "thematic issues" is considered to be adequate. Since, at this stage, neither the selection of organisations to carry out the RTD-activity nor the implementers that will participate are decided. There are still negotiations and adjustments to be expected regarding project focus and scope. This also supports the belief that the priorities should be presented at a quite generic level.

Thus the project finds that the identification of high priority issues by expert opinion (at large the most often used method for initiating international co-operation up to now) is adequate for the purpose. It is organisationally simple and swift. A disadvantage is that the bases for the judgements made by the experts are not easily documented in the absence of a formal decision-aiding method. By developing a specific format for the national inputs regarding the information needed and the level of details, the method of identifying high priority issues and to merge or delineate them could be improved and the problems encountered in the NET.EXCEL project could be reduced.

6.2 Procedures that might enhance the future co-operation

If the future procedure for identifying RTD issues, ranking them and defining projects for co-operation is to result in a substantially higher level of co-ordinated RTD in Europe or internationally, it must be systematic.

The procedure or methodology should:

- be able to show that no major areas of higher interest has been missed
- be able to define projects in such a way that the merged activities
  - support each other
  - provide a forum for discussions among the engaged persons on methods, work and interpretation, and
  - give a possibility for the effective co-use of instruments and models
- be able to suggest organisational forms suitable for the added value sought in the international co-operation.

The deliberations and the results should be documented in a traceable way and enable the revisiting of areas without having to redo the work.

The network or group carrying out the work should provide a link between the interests of:

- the established implementing organisations as well as newly constituted organisations or programmes,
- the European Commission and other organisations supporting research, and
- the existing high competence centres in the world.

Assuming that the exploration of possibilities for an enhanced RTD co-ordination is of interest for the participating organisations, the following staged approach for identifying RTD issues, ranking them and defining projects for co-operation is based on the experience gathered in the NET.EXCEL project.

1) The starting point can be a list like the "100-list" that can be compiled from national programmes or needs. At this stage the level of details in the input has to be sufficiently clear. Based on the development of repository concepts, of the safety and uncertainty analyses, and also on reviews by regulators and the scientific community, the list can be successively updated.

2) The RTD issues are categorised with regard to different areas and objectives or added value sought for, and are evaluated by the participants with regard to their interest to participate.

3) It is necessary at this stage to identify areas already covered in existing projects to avoid duplication of research work.

4) For areas that have many suggested activities and also are of high joint interest, groups of specialists are formed to discuss the suggested activities, define them further and merge them into appropriate projects with regard to the needed competence or equipment and the possibilities for spin-off. In this job decision aiding methods like multiple attribute analysis or expert opinion elicitation could be used for larger areas or in complicated cases. The same specialist group should also recommend the competence centres that are available to carry out the project.

5) Normal negotiations and adjustments will precede the appointment of lead, definition of scope, financing and contracting. An appropriate organisational structure will be selected for the work.

6) In specific areas, where many activities will be going on over long times, the same specialist groups could be made semi-permanent to review the results for further guidance, revise the mandates or take new initiatives. Such types of co-ordinating groups already exist in international co-operation for safety and performance related activities and within the biosphere area.

The NET.EXCEL experience indicates that the early intentions to try to make the ranking, the grouping of the RTD activities into suitable projects, and detailing the projects were too optimistic. And the option to remedy the lack of definition by developing a very detailed starting list would require much work that would need the specialist input anyway. By the above procedure a reasonable focusing and area-based ranking could be done without too many demands on a detailed definition of the national inputs, and the national specialists could discuss what aspects should be detailed.

The mechanisms used by the participants to identify national RTD activities and evaluate their priorities could be used also for potential co-operative efforts. The added value of doing different types of activities jointly could be further developed by addressing preservation and availability of information, and by discussing also means of fulfilling requirements from quality assurance and quality control.

The establishment of a recommended procedure should not hinder the use of less formal methods in cases when the selections are simple and straight forward. There are further aspects of this procedure that are strongly affected by a possible enlargement of the participating group, by possible extension of the subject areas covered, the umbrella such a group would work under, and the level of required formality.

6.3 To build future co-operation

The key issue for a successful development of a future co-operation is that a common understanding exists of the main principles for setting priorities as well as that the differences between national approaches and the international dimensions are well understood. This understanding has been developed in the project and can be explored. It is, however, probably so that the progress made in some national programmes (and with the experience gained in this project) would provide new insight on some of the RTD issues. This could of course affect the relative priorities of the identified RTD issues. It would be beneficial if all participants were to provide national contributions at a common level of technical detail.

Of necessity, issues in the salt programme have got much less attention than the corresponding issues in the granite and clay programmes because the latter have more countries with interest in the particular geology. In order to overcome this deficiency the identification of RTD-themes and issues which have a high priority for a wider range of host rock formations and/or disposal concepts and which are – to some extent – site or concept independent may reveal a greater potential for future co-operation. In this context the classification of rock-types, e.g. in elastic and elasto-plastic rocks or tight and permeable rocks can provide a broader basis for the prioritisation of safety related and technical RTD issues. This applies in a way also to the development and testing of long-term seals and plugs which are essential components for any underground waste repository.

Whether the presented list of high priority issues would be supplemented or not, the future process for defining activities to the detailed level that is needed for practical RTD projects is foreseen to be the same. This detailed assessment can be made by experts and with the aid of tools like “Multi-attribute Analysis” and “Analytical Hierarchy Process”. However, these do not substitute for precise definitions of RTD needs. Each expert covers only a specific topic, and basically each thematic area need to be addressed by separate experts, or more likely by expert groups. The interaction between those groups, as well as the weighting and prioritisation among different thematic areas and different activities of those would be done by a group representing the consumers. That is, the organisations which have the national responsibility of developing safe and acceptable methods for waste management.

This particular group has further come to the conclusion that the networking developed during the NET.EXCEL project could provide continuing input to the assessment of joint RTD activities. The network would represent existing disposal concepts in Europe in crystalline rock, clay and clay sediments, and salt, and it would possess the capability to evaluate results and summarise progress and achievements of joint RTD activities. NET.EXCEL naturally discovered that many areas are well covered by existing projects, and some new research areas were identified, although further clarification is needed on these topics.

The issue of an extension of the network may be an ambition with time. Such a network may be developed from the group of participants in the NET.EXCEL project and further extended with other European organisations in a way that is feasible and beneficial to all.

An attractive way forward would be to set up a road map for research infrastructures with the same key elements as is discussed within the European Commission. Such a road map should preferably feature development through a process that is transparent and based on appropriate criteria, e.g. scientific need and significance on a European scale. The set-up should also encourage non-European participation.

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8 References

NET.EXCEL references

The following references are available at respective organisation:

NET.EXCEL, 2003. Project Work Plan. Deliverable 1 to the European Commission. Issue date 2003/02/27.

Belgium - Country Annex Clay WP1/WP2, April 2004, Ondraf/ Niras.

France - Country Annex Clay WP1, 3 Nov 2003, Andra.

France - Country Annex Clay WP2, 3 Nov 2003, Andra.

France - Country Annex Granite WP1, 3 Nov 2003, Andra.

France - Country Annex Granite WP2, 3 Nov 2003, Andra.

Finland - Country Annex Granite WP1/WP2, March 2004, Posiva.

Germany - Country Annex Salt (extended summary), WP1/WP2, April 2004, GRS.

Spain - Country Annex Clay WP1/WP2, August 2003, Enresa.

Spain - Country Annex Granite WP1/WP2, August 2003, Enresa.

Sweden - Country Annex Granite WP1/WP2, July 2003, SKB.

Switzerland - Country Annex Clay WP1/WP2 version 2, 11 Nov 2003, Nagra.

United Kingdom - Country Annex Granite WP1/WP2, July 2003, Nirex.

Other References

CLUSTER EDZ, 2004. Proceedings of an European Commission CLUSTER Conference and workshop on - Impact of the Excavation Disturbed or Damaged Zone (EDZ) on the Performance of Radioactive Waste Geological Repositories, Luxembourg, LU, 03-05 November 2003, Nuclear Science and Technology, EUR 21028 EN"

ESDRED, 2004. EC/FP6 Integrated Project ESDRED: Engineering studies and demonstration of repository designs, Contract No. FI6W-CT-2003-508851, 1 February 2004

NF-PRO, 2004. EC/FP6 Integrated Project NF-PRO: Understanding and physical and numerical modelling of the key processes in the near field, and their coupling, for different host rocks and repository strategies, Contract No. FI6W-CT-2003-02389, 1 January 2004

Part 3: Management Final Report

Part 3: Management Final Report

3.1 List of deliverables

The list of deliverables in the contract is presented in Table 3.1. The contract was signed with a duration time of 15 month with month 1 being November 2002. The duration time was later, by November 15th 2003, extended by two months to 17 months.

Deliverable D1 was compiled according to the time plan and was first submitted in draft for the European Commission's review, and later in an adjusted final version.

Country Annexes have been compiled and used as background material for summaries as indicated in deliverables D2 and D3. The whole result was eventually merged into this Final Technical Report which is marked D4. A draft was submitted electronically to the European Commission on time for approval. Review and consequent adjustments have resulted in the present D4 report.

Table 3.1. List of deliverables

Deliverable No[1]	Deliverable title	Delivery date [2]	Nature [3]	Dissemination level [4]
D1	Project Work Plan	2	Re	PU
D2	Present status of RTD	4	Re	RE
D3	Important future RTD areas	9	Re	RE
D4	Highly ranked areas and issues for European co-operation on RTD	15	Re	PU

[1] Deliverable numbers in order of delivery dates: D1 – Dn

[2] Month in which the deliverables will be available. Month 0 marking the start of the project, and all delivery dates being relative to this start date.

[3] Please indicate the nature of the deliverable using one of the following codes:

Re = Report **Da** = Data set **Eq** = Equipment

Pr = Prototype **Si** = Simulation **Th** = Theory

De = Demonstrator **Me** = Methodology **O** = other (describe in annex)

[4] Please indicate the dissemination level using one of the following codes:

PU = Public

RE = Restricted to a group specified by the consortium (including the Commission Services).

CO = Confidential, only for members of the consortium (including the Commission Services).

3.2 Comparison of initially planned activities and work actually accomplished

The objective of the project was to develop a common and systematic basis for priorities and co-ordination of future European RTD work for Radioactive Waste Management, and suggest issues and priorities for joint RTD-projects.

The work was planned to be carried through in three work packages:

WP1. *Present status of RTD*. Focus should primarily be on waste, canisters, buffer (not for salt), backfill, plug and the host rock itself.

WP2. *Important future RTD issues*. Focus should be on the topics in WP1 and in addition areas of interaction between different repository components, repository technology, modelling and performance assessment.

WP3. *Highly ranked issues for European co-operation on RTD*. Focus should be on identifying and ranking projects with common European interest based on methodology and criteria established early in the project.

Methodology for setting priorities and jointly agreed procedures were developed in parallel to the work with the WPs and was not a WP of its own.

The first step to meet the project objective was accomplished early by forming a network among the main European organisations given the national responsibility to develop systems for safe handling and disposal of long-lived radioactive waste. These organisations represent repository programmes for salt and clay formations as well as for crystalline rock.

Four milestones were specified in the contract:

- Milestone 1 at December 2002: Specification of work issues in the Project Plan in draft
- Milestone 2 at February 2002: Finalising of WP 1 with Summary Report in draft
- Milestones 3 at July: Finalising of WP 2 with Summary Report in draft
- Milestone 4 at January 2004: Finalising of WP 3 with Project Final Report in draft

Following the approved extension of the project duration the deadline for Milestone 4 became March 2004.

The original plan for WP1and WP2 was challenged at the kick-off meeting in Stockholm in November 2002 resulting in an adjustment of the plan, so that both WP1 and WP2 could be worked at in parallel. The milestone and delivery of a combined WP1/WP2 report was set to November 2003. The reason was to be able to maintain the aim of covering the prime issues in the original proposal, but to do the work during a shorter time period than in the proposal. Plans for WP3 were maintained.

The actual project work adapted to these renewed plans and Country Annexes were compiled accordingly. The co-ordinator then compiled all issues in a list, the so called "100-list". Ranking procedures were discussed in parallel to the compilation of Country Annexes and two methods were tested in the project. All this as well as the results are presented in the technical part of this Final Technical Report. WPs were completed in accordance to the renewed time plan, but the combined WP1/WP2 report was completed in draft as a working material but not completed as a document. The material was instead merged into this Final Technical Report (WP3 report) in order to complete this report in time. As the discussions on ranking continued to take much longer time than planned, and the phase of detailing topical issues to a level where actual joint RTD projects could be identified was not possible to complete. The project result ended with the list presented in the technical part of this Final Technical Report.

3.3 Management and co-ordinating aspects

The network of project participants has met four times:

- Stockholm: kick-off on November 27-28th, 2002
- Barcelona: March 17-18th, 2003
- Basel: September 29-30th, 2003
- Nice: February 17-18th, 2004

All participants have focused on the same and current issues and taken active part in the decisions and documentation, besides producing and presenting respective Country Annexes.

The contacts in each organisation are presented in Table 3.2

Table 3.2. Contact details concerning follow-up of the project

Participant	Represented by	Address	Contact
Svensk Kaernbraenslehantering (SKB)	Christer Svemar	Box 5864 102 40 STOCKHOLM Sweden	E-mail: christer.svemar@skb.se phone: +46-8 459 8593 fax: +46-8 661 57 19
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Empresa Nacional de Residuos radiactivos, S.A (Enresa)	Julio Astudillo	Empresa Nacional de Residuos Emilio Vargas, 7 28043 MADRID Spain	E-mail: jasp@enresa.es phone: +349 1 566 81 00 fax: + 349 1 566 81 69
Gesellschaft fuer Anlagen-und Reaktorsicherheit (GRS)	Wernt Brewitz	Teodor-Heuss-Strasse 438122 BRAUNSCHWEIG Germany	E- mail: brw @grs.de Phone: +49 531 801 22 26 Fax: +46 531 801 22 00
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