Publishable Executive Summary Year 3

The Integrated Project known as ESDRED (Engineering Studies and Demonstrations of Repository Designs) is a joint research effort by major national radioactive waste management agencies (or subsidiaries of those agencies) and by research organisations, representing nine European countries. ESDRED is co-ordinated by the French National Radioactive Waste Management Agency (ANDRA) and is part of the European Union's 6th Euratom Framework Programme for Nuclear Research and Training. The five year Project has a total budget of EURO 18.7 million, of which 7.3 million is from the EU's Framework Programme.

The 13 partners (Contractors) from 9 countries in this project are:

Radioactive Waste Management agencies:
ANDRA, France
ENRESA, Spain
NAGRA, Switzerland
NIREX, United Kingdom
ONDRAF/NIRAS, Belgium
POSIVA, Finland
SKB, Sweden

Technological R&D organisations:
AITEMIN, Spain
CSIC, Spain
DBE TECHNOLOGY, Germany
ESV EURIDICE EIG, Belgium
GRS, Germany
NRG, the Netherlands

ESDRED is focused on technology and has three main objectives. The first is to demonstrate, at an industrial scale, the technical feasibility of some very specific activities related to the construction, operation and closure of a deep geological repository for high level radioactive waste. The work is organised inside four (4) Technical Modules and essentially involves the conception, design, fabrication and demonstration of equipment or products for which relevant proven industrial counterparts (mainly in the nuclear and mining industry) do not exist today. At all times this work is meant to be carried out within the framework of compliance regarding the requirements for operational safety, long term safety, retrievability and monitoring.

Each of the four technical Modules involves from 3 to 7 Contractors and as many as 6 different national disposal concepts may be represented. The programmes within these Modules are provided below:

Module # 1: **Buffer Construction Technologies** for horizontal disposal concepts

Module # 2: **Waste Canister Transfer and Emplacement Technology** for horizontal and vertical disposal concepts

Module # 3: **Heavy Load Emplacement Technology** for horizontal disposal concepts

Module # 4: **Temporary Sealing (using low pH cement) Technology** for construction of sealing plugs and for rock support using shotcrete techniques

A second and equally important objective is to promote a shared European vision in the field of radioactive waste disposal technology. This is accomplished through the INTEGRATION process, which is one of the key objectives that identify EURATOM's 6th Framework Programme. Among other things integration involves working together within Work Packages and/or Modules; sharing information; comparing one another's input data and functional requirements for consistency; ensuring that, where possible, fabricated components are compatible; and coordination of demonstration activities.

The third objective involving communication and training is deemed to be sufficiently important to merit a separate Module. Among other things it involves the dissemination of knowledge by way of press releases, pamphlets, technical articles and presentations, videos and eventually an international event. Training, with a focus on New Member States, is to be accomplished via conferences, workshops and courses.

A general project schedule is shown in **Figure 1** below:

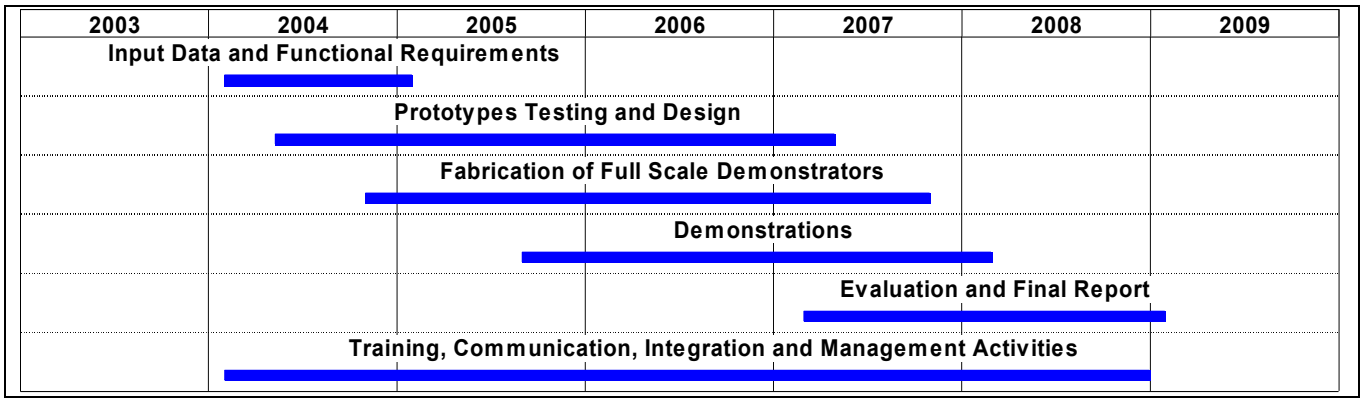

Figure 1: General Schedule of the ESDRED Project

The third year of the Project, which terminated at the end of January 2007, can again be characterized as a success, given that the major objectives for the period were successfully achieved. These include:

- Successful demonstrations in each of the four technical modules. Two of these demonstrations were vetted by members of the ESDRED Experts Committee.
- The fabrication of buffer/backfill components, at full or near full scale level, for different HLW disposal designs.
- Putting the essential features of buffer/backfill fabrication technology to the test.
- Testing the saturation dynamics of a high gas permeability seal in a second laboratory mock-up and the start of in-situ testing of 4 similar seals at Mont Terri in Switzerland.
- Starting a programme of non-intrusive monitoring experiments at Mont Terri.
- Completing the basic design for the vertical emplacement in salt concept.
- Essentially completing a desk study regarding retrievability.
- Finalising modifications to the KBS-3H deposition equipment and essentially completing the SAT (site acceptance tests).
- Successfully demonstrating the emplacement of spent fuel canisters and sets of bentonite rings in a surface workshop facility.
- Constructing a plug made of low pH shotcrete in the Äspö HRL and then testing this plug to failure using step wise hydraulic loading.
- Developing a low pH shotcrete mix suitable for rock support and then testing this mix at the Äspö URL in Sweden as well as at Hagerbach Test Gallery in Switzerland.
- A major training activity, involving 17 lectures, was provided to Masters level students at the University Polytehnica of Bucharest, Romania.

- Major improvements to the ESDRED web site which had recorded over 9000 visitors to the end of the year 2006. For the first time we have been able to provide videos and photos.

- ESDRED partners presented papers and/or participated in conferences and workshops in at least 11 different countries on 3 continents.

- Planning is very well advanced for an International Conference in Prague, in the Czech Republic, to be held in June 2008. This is being organised in cooperation with the Czech Technical University and RAWRA the Czech national waste management agency.

- Planning is also very well advanced regarding the third Low-pH workshop in France in June 2007. There will be presentations from the European arena of course but also from Canada, Japan, and the USA. About 30 participants are expected.

THE TECHNICAL WORK ACCOMPLISHED DURING THE THIRD YEAR INCLUDES:

Module 1: **Buffer Construction Technology**

In the third project year, the bulk of Work Package 3 was performed, which was the in-workshop demonstration of the construction of the buffer/backfill component. The main purpose of this demonstration was to test and further elaborate the different technologies for constructing the buffer/backfill component within the HLW disposal concept of the concerned ESDRED partners and to verify if the requirements associated to this component could be met. The tests have been successfully performed. ANDRA, O/N and NAGRA each have succeeded in fabricating a buffer/backfill component corresponding to their HLW disposal design on a full or near-full scale level.

The GRS tested the saturation dynamics of the high gas permeability seal in a second laboratory mock-up. The saturation proved to proceed slower than expected, so that it was decided to prolong the test. Now, at the end of the third project year, the test is still ongoing, albeit that the seal is near complete saturation. In Work Package 4.2, the in-situ test at Mont Terri, the first pilot seal saturation test has been running satisfactorily. Hence, the tests in the other three boreholes were started up in November 2006.

In Work Package 5, NIREX in cooperation with NAGRA and the Technical University of Zürich have been pursuing the program of non-intrusive monitoring experiments at Mont Terri. Measurement Campaign 1 (within the empty HGA micro tunnel) and Measurement Campaign 2 (within a sand-backfilled micro tunnel) have been successfully completed. In October 2006, the saturation of the backfill with water was started, after which Measurement Campaign 3 will be undertaken. In total, four Measurement Campaigns are foreseen.

Figure 2: Andra - View of Bentonite Ring just after stripping operation (Dec 2006)

Figure 3: Andra - View of Dummy concrete rings loaded on air cushion test bench launch table

Figure 4: Ondraf/Euridice – Mock-up for backfilling with grout

Figure 5: Ondraf/Euridice – Mock-up for backfilling with granular material

Module 2: Waste Canister Transfer and Emplacement Technology

The basic design is complete for the vertical (German) emplacement concept and the corresponding deliverable was issued. With a small delay, the selection of contractors for detailed design and manufacturing of components was also done. Detailed design work for each of the components, which together constitute the emplacement system, was launched and is still going on. As a result of the basic design phase it was decided to design and manufacture a new transport cart instead of using an existing one. The appropriate basic design was completed and the detailed design launched as well.

For the horizontal (French) emplacement concept a general critical review of the repository concept in argillite (carried out in the summer of 2006 at the request of ANDRA's management) led to a temporary interruption of design activities which were only restarted at the end of 2006. Consequently the following project phases for the industrial demonstrator have been delayed. According to the new scheduling, the industrial demonstrator will now be available for demonstration tests during the second half of 2008.

The retrievability desk study investigations were completed by NRG for the horizontal (French) case study and the findings were reviewed with ANDRA. The work for the vertical (German) case study was completed as well and a draft final report has been submitted to DBE-TECHNOLOGY. The final version of this Deliverable on Retrievability is scheduled for the end of March 2007.

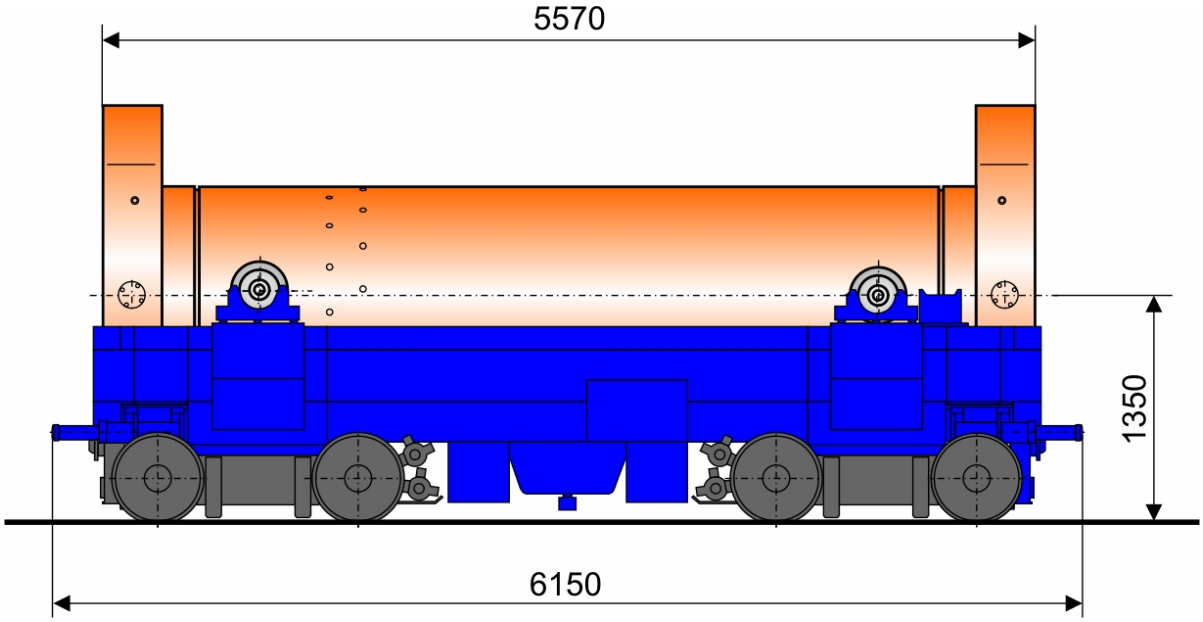

Figure 6: DBE-Tec - Illustration of the new transport cart design

Module 3: **Heavy Load Emplacement Technology**

Concerning the KBS-3H deposition machine (Swedish concept developed by SKB, based on water cushion technology), the Factory Acceptance Tests (FAT) were completed at the supplier's workshop, CNIM, during February 2006. The emplacement system was then transported to the Äspö HRL and installed in March 2006. The preparation for the Site Acceptance Tests started at the end of March 2006 and the equipment was shown during the ESDRED meeting at Äspö HRL, 28th and 29th March, 2006. The official SAT, initially scheduled to commence on April 3rd 2006 was however postponed after it was discovered that the deposition machine could not control the container whenever it was geometrically out of balance. A trouble-shooting period took place with much back and forth activity between the factory and the test site. This led to various technical modifications, which have now been completed.

The official SAT were effectively performed on 16th February 2007 (beginning of Year 4).

ANDRA started in May 2006 and completed in September 2006 the test campaign for the full scale demonstrator of the CU1 canister emplacement using air cushion technology. After a trouble shooting period, all the test cases were satisfactorily run. The required performance specifications were all achieved and the ESDRED Partners, together with the EC Project Officers attended the early period of the test campaign, in June 2006).

Between October 2006 (after adaptation of the test bench) and January 2007, the test campaign for the emplacement of the sets of Bentonite Rings was also demonstrated in a very satisfactory way. The test bench is now dismantled and stored, waiting for its transportation and re-erection in ANDRA's temporary show-room, at Limay (near Paris).

Figure 7: SKB - View of KBS-3H emplaced in the Aspö test drift during the SAT in Feb. 2007

Figure 8: Andra - View of CU1 emplacement test bench in The Hague (Summer 2006)

Module 4: (Temporary Sealing Technology)

The short low-pH shotcrete plug constructed by the end of 2005 at Äspö URL was hydraulically loaded stepwise up to failure in the beginning of 2006. A data base was created. The plug was dismantled, carefully sampled and the site decommissioned. The results of the test provided valuable information about the mechanical behaviour of a confined granite-shotcrete interface, and these was used to improve the plug design calculation procedure.

A new full-scale (4 m-long, 3.5 m in diameter) low-pH shotcrete plug has been planned and will be constructed in the Grimsel Test Site (Switzerland) early 2007. The aim is to demonstrate the behaviour under realistic conditions of an underground repository, including among other things the installation of bentonite blocks which will be rehydrated to provide loading pressures. A preliminary shotcreting test has been carried out in December 2006 in a full-scale mock-up set constructed in the subcontractor's facilities in Sargans (Switzerland).

Figure 9: Short low-pH shotcrete plug test at Äspö URL (Sweden)

Figure 10: Preliminary shotcreting test in Sargans (Switzerland)

The recipe for shotcrete for rock support has been successfully been tested in pilot scale in February 2006 in Sweden and later in a field test at Äspö HRL in April 2006. The recipe has thereafter been modified by Nagra and they have performed laboratory and pilot tests in Switzerland in November 2006.

Figure 11: Site test at Äspö URL (Sweden) with low-pH shotcrete for rock support

Figure 12: Pilot tests with low-pH for rock support in Hagerbach (Switzerland)

COMMUNICATION, TRAINING, AND INTEGRATION PROGRESS DURING YEAR 3:

The third year of the project has again been quite busy with a strong international dimension. This is when ESDRED completed its first major activity outside of the countries represented within ESDRED. At the same time the planning for a second major international event which will take place in 2008 in a New Member State was well advanced. Various ESDRED partners made presentations of their work at different venues throughout the year and/or have had abstracts accepted for presentations on 2007.

Module 5: (Training & Communication)

In the area of training the highlight of the year was the presentation of 17 lectures, by 8 ESDRED partners, at the University Politehnica in Bucharest Romania in November 2006. These lectures were part of a 33 lecture course called "**Radioactive Waste Management**" (worth 10 ECTS credits) which is part of the University's 2 year (Bologna Accredited) Master of Science programme in "**Radioprotection & Nuclear Safety**". A total of 32 students took the course including 11 full time and part time students and 21 young professionals working the Romanian State Agencies or for industry and end users. The course was very positively evaluated by the students afterwards and generally considered a success all around.

ESDRED partners also participated to 2 international workshops. In June we contributed to the IAEA workshop on **"Technological Implications of Retrievability on Geological Disposal of Radioactive Waste"** in Vienna and in September to the NEA workshop on EBS held in Tokyo, Japan.

ESDRED partners were equally active in the area of Communication. Various partners made presentations or provided papers to events in Belgium, Finland, Germany, Spain, the UK as well as at the **"International High-Level Radioactive Waste Management Conference**" April 30 – May 4, 2006 in Las Vegas USA.. We have also had abstracts accepted for presentations in Tucson USA and Montreal Canada during the coming year.

Module 6: (Integration)

This challenging Module is the responsibility of the ESDRED Project Coordinator, also known as the IPC or Integrated Project Coordinator. Among other things the work in this Module involves managing a committee of independent Experts who are given certain documents to review or tasks to perform and who report directly to the Board of Governors, with copy to the Commission. During the past year these Experts reviewed and commented favourably on a comprehensive Deliverable dealing with "Common Features of Design Studies". They were also able to witness 2 demonstrations. The first involved loading to failure a concrete plug which had been constructed at the Äspö HRL using low pH shotcrete. The second took place in a workshop facility at Beaumont-Hague where ANDRA's air cushion heavy load transporter was demonstrated, while simulating various operating conditions.

Elsewhere ANDRA & SKB cooperated very closely regarding the final design and commissioning of their respective heavy load transporters. Also 4 ton bentonite rings (Module 1) were transported and emplaced using one of the heavy load transporters and the mock-up disposal cell (Module 3). Finally the partners demonstrated considerable cooperation/integration in preparing lectures and other forms of presentations.

CONCLUSIONS:

A lot of physical work was accomplished during this third year of the project and although it was not always easy all obstacles were eventually overcome. Pressing of the 4 ton bentonite rings using the 65 000 ton capacity press at Issoire proved to be a challenge but all rings were successfully fabricated during the last days of the year. The water cushion heavy load transporter initially suffered from stability problems but that too has been overcome early in the New Year. Other projects such as the sealing and monitoring experiments are on-going at Mont Terri in Switzerland. Buffer backfilling work is either well advanced or completed in Belgium and in Switzerland and a second low pH plug is about to be constructed and prepared for long term monitoring.

The heavy load emplacement projects involving ANDRA, POSIVA and SKB are more or less complete. On the other hand the design and fabrication and testing related to the "Waste Canister Transfer and Emplacement" project for lighter loads (2 to 5 tons) will get into high gear in 2007 and be competed in 2008.

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