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Consensus memorandum for D5.10 Expert Elicitation

EE documentation from Expert Group EE meeting inputs and outcomes concerning Work package 5 final deliverable's Expert Elicitation

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ABSTRACT:
This memorandum summarises the quality assurance outcomes of the expert elicitation that was carried out for the DOPAS Work package 5 final report draft D5.10 dated 18 April 2016. The elicitation was carried out during 20 May 2016 to 30 July 2016.

RESPONSIBLE FOR ORGANISING THE ELICITATION AND DOCUMENTING THE OUTCOME:
Posiva Oy, Marjatta Palmu, WP6 leader

REVIEW AND OTHER COMMENTS:
This memorandum was reviewed and approved by WP5 elicitation experts Paul Marschall, Nina Müller-Hoppe, Guillaume Pépin, Jan-Marie Potier and Marjut Vähänen by 28 July 2016. Experts' comments related to the consensus meeting were included into this memorandum.

The memorandum produced does not represent the views of the DOPAS consortium or those of the individual consortium organisations.

APPROVED FOR SUBMISSION:
by Johanna Hansen, DOPAS Project coordinator on 31August 2016

Contents

Expert elicitation of WP5 final report D5.10 - Consensus meeting on 20 June 2016

Date	Monday 20 June 2016 from 8:30-18:00 hrs
Place	GRS, Kurfürstendam 200, 10719 Berlin, Germany Meeting point at GRS reception (5th floor)
Participants:	Paul Marschall, Nagra, (PA expert) Nina Müller-Hoeppe, DBE TEC (Domain expert) Marjatta Palmu, Posiva Oy (EE facilitator) Guillaume Pépin, Andra (PA expert) Jan-Marie Potier, consulting services (Domain expert) André Rübel, GRS (WP5 leader, observer) Marjut Vähänen, Posiva Oy (PA expert)

1 Introduction

1.1 EE - what is it?

The expert elicitation (EE) carried out in the DOPAS Project is based on the methodology developed for Posiva's Safety Case expert elicitation by Ms. Kristiina Hukki from VTT (Posiva Working Report 2008-66). This elicitation work belongs under the task T6.3 in Work package 6. The view taken in the elicitation is that the elicitation and validation process is regarded as a collaborative and cross-disciplinary whole.

The systemic character of the process sets requirements for the formal EE procedure (for expert judgment) as described in the report in detail. The procedure itself was deliberately designed to fulfil these requirements by supporting collaboration of the participating disciplines.

In general, structured performance, transparency and traceability are goals for an elicitation and validation process from the quality assurance point of view. If this process is considered from the safety case point of view as it was originally designed, the goal is to conduct the process in a way that efficiently produces valid input for safety analysis. The efficiency is dependent on the way of the participants' interact. Reaching a consensus on the validity of the input data or the common view formulated in the elicitation is desirable. A further desirable feature relates to the level of motivation and trust of individual persons participating in the process.

Thus the expert elicitation process aims at collecting and documenting the different expert's review comments related to the target of elicitation in a transparent manner using a preset framework of review comments.

In the DOPAS Project, the objective of the expert elicitation (EE) is to be a quality assurance tool for the final deliverables of the project's RTD and DEMO Work packages WP2-WP5.

The application of this methodology for the DOPAS Project was tested in a pilot elicitation carried out during May - October 2013 on the POPLU test plan and its consensus meeting outcomes were documented as the deliverable D6.1.1 Pilot EE consensus memorandum for D3.25 POPLU test plan. The process was further applied to the WP2 deliverable D2.4 in September - November 2015 and to the WP3 and WP4 deliverables at the same time as for the WP5.

The common grounds for the formal elicitation are based not only on the questionnaire tools used, but also on sharing the same descriptions about the elicitation target as a background. In the case of WP5 "*Performance assessment of plugs and seals system*", the descriptions were included into the D5.10 WP5 final integrated report itself in Chapter 11 and suggestions for their improvement were given to the report's main editor. Unlike in the elicitation for safety case, the requirements for experts selected for the elicitation are that they are fully independent of the direct DOPAS work itself and that their backgrounds include different disciplines and professional experiences related to the work under elicitation. Here the WP5 elicitation had a minor deviation.

The elicitation results reported in this WP5 EE Consensus Meeting memorandum present the outputs of the expert elicitation carried out on the DOPAS WP5 summary deliverable D5.10 *"WP5 final integrated report"*.

1.2 About DOPAS Work package 5

The DOPAS WP5 had the following objectives according to the project's description of work.

General aim is to understand the implications of the plugs and seals performance on the overall safety of the whole reference period of a final waste repository of one million years.

The following more detailed objectives for the work included the actions:

- to develop justification of model simplifications for long-term safety assessment simulations;
- address process modelling of experiments performed in WP3 to gain understanding;
- to identify the main processes that are relevant and thus to be considered for predicting the short and long-term behaviour of plug and sealing system;
- to identify remaining uncertainties and their influence of performance assessment;

- the development and justification of conceptual models of plugs and seals for the different disposal concepts and geological environments;
- simulation of processes and their evolution within individual sealing components;
- further develop and apply the PA methodology and (conservative) PA models for analysing the system behaviour.

The objectives were slightly refined for the experts in the background material provided for them to address the work done on the development, design and implementation of the three full-scale plug/seal structures, and the work methods (compaction) and materials developed for the ELSA experiment.

The plan for WP5 included the production of a total of ten different deliverables including D5.10 final integrated report. Almost all of the WP5 deliverables with the exception of the D5.7 *"Models and summary report for EPSP"* and D5.9 *"Integration of results of demonstrators in total repository system's PA by special performance indicators"* had been produced by the time the elicitation was started. A new deliverable D5.11 was also included:

- *DOPAS D5.1 Modelling plan for Experiment 2 EPSP PA.*
- *DOPAS D5.2 Report on Andra's PA Methodology for Sealing System.*
- *DOPAS D5.3 Report on Andra's Understanding of Processes involved in Time and Space.*
- *DOPAS D5.4 Report on Andra's approach concerning uncertainties.*
- *DOPAS D5.5 Status report on ELSA/LAVA related laboratory tests (D3.28) and on process modelling activities (D5.5)* - ***draft version.***
- *DOPAS D5.6 Status report on conceptual and integrated modelling activities (GRS)* - ***draft version.***
- *DOPAS D5.8 Final report on conceptual and integrated modelling activities (GRS)*- ***draft version.***
- *DOPAS D5.11 Status report on ELSA/LASA related laboratory tests (D3.28) and on process modelling activities (D5.5) (GRS).*

In addition to the WP5 deliverables, the final version of D2.4 report and the final drafts for elicitation of D3.30 and D4.4 were also distributed as a background material to the experts together with other published deliverables from these work packages.

The amount of background materials was somewhat overwhelming because the WP5 was the last work package. This was mentioned by one of the experts. The purpose of the background material was to ensure sufficient evidence for the experts that even though not all details are provided in the summary report D5.10, the background information is available and included in the other public deliverables of the DOPAS Project.

The work of the WP5 intended to focus on the assessment of long-term safety performance of the experiments to the degree this was the objective of the experiments. The assessment of short-term (during construction until initial state) performance is covered in WP4 reports i.e. the individual experiment summary reports and the integrated report D4.4.

Additional elicitation challenges encountered were due to the following reasons:

- All three remaining Work package 3, 4 and 5 summary reports were in the elicitation process at the same time;
- The D4.4 *Integrated report* was originally foreseen for publication (in December 2015) and the original intention was that this report was providing a link from the experiments to WP5 work.
- Due to the work in progress, the reports in the previous two work packages WP3 and WP4 and in some of the WP5 deliverables, the report did not have a clear referencing baseline to all of the relevant reports.
- WP5 assessment work was not very well integrated with the assessments made in WP4. In addition, much of the work carried out was on predictive modelling for the experiment designs. The experiment monitoring results for especially long-term assessments were not available for the performance assessment by the time of the D5.10 data freeze or during the DOPAS Project with few exceptions.
- The structure and approach of the D5.10 report was significantly different from the other Work packages' final deliverables. The D5.10 approach was to compile individual inputs under one report without significant attempt to homogenize the inputs in terms of terminology or providing a comprehensive storyline tying the individual pieces of work reported and done together.

1.3 Target of WP5 elicitation

The WP5 D5.10 target of elicitation was defined as:

"Is the D5.10 report complete and consistent regarding the objectives set for the work and is it "fit for use" i.e. representing an acceptable level of quality as a work package deliverable (not too much and not too little) and how well does the D5.10 achieve its task to integrate the performance assessment and modelling work done in DOPAS at the time of the writing of the report? What would be the suggestions for further linking the reporting (and work) of WP5 to the other work packages?

The elicitation's focus is to assess the completeness of the predictive process modelling and the related understanding on the overall safety and the subsystem safety in the context of the repository and in the context of the experiments as reported in D5.10. In addition, the focus is on the improvements of the state-of-the art of the process modelling in the context of the integrated performance assessment and in linking the work in a larger extent to the other work packages.

Further the elicitation aims to look at

- how the work carried out under WP5 has supported the experimental work and construction of large scale plugs and seals (closure) by predictive process modelling;
- how WP5 work has helped to understand the implications of plugs' and seals' performance on the overall safety for the whole reference period of a repository;
- what are the improvements in the body of knowledge related to process modelling and its abstractions in integrated performance assessment;
- what type of uncertainties and controversies can be identified in the work carried out?

The elicitation should identify potential uncertainties, ambiguities/deviations/ unjustified conclusions, and controversies in the work and stronger linking of the work to the experiments.

The report focuses on individual cases and on an integrative approach derived from the cases in DOPAS.

The assessment is carried out in respect to the original objectives, to the report content and to experts' previous experiences."

1.4 The steps in the elicitation process

The generic process for the expert elicitation as defined in Hukki (2008) included the following steps:

- Selection of issue (generally something not easily agreed, but requiring judgment and consensus)
- Selection of forum
- Selection of domain experts (probabilistic SA)
- Selection of shared conceptual frameworks (description production)
- Preparatory work of safety analysts
- Training of domain experts
- Instruction of domain experts

- Independent work of domain experts
- Iterations (consensus meeting)
- Treatment of possible controversies (consensus meeting)
- Validation of expert judgments for later use
- Final documentation of the process (facilitator)

In the DOPAS elicitation process, that does not require for example the use of probabilistic safety assessment, some steps have been omitted from the preparatory stage of the elicitation and both performance assessment and domain experts meet simultaneously at the same kick-off forum. If the elicitation process is applied in the original context of WR 2008-66, these steps should be maintained as a part of the process.

1.5 Participants and timetable of the process

The experts who participated in the expert elicitation were selected by the consortium from experts inside the participating organisations and from external experts. The European Commission representative screened the produced short list, the relevant experts were recruited, and their final number was based on their availability to participate in the elicitation within the agreed timeframe ranging from May 2016 to July 2016. Main extension to the timetable after the process start resulted from the difficulty of finding a common date for the consensus meeting. The kick-off meeting was held on 23 May 2016, the experts' review results were produced by June 10, 2016 and the consensus meeting was held on 20 June 2016 with the draft minutes out on 18 July 2016 for commenting and approval in a week.

The experts consisted of the following professionals in geological disposal:

Mr. Jan-Marie Potier, M.Sc., Domain expert being the expert that participated in all of the WP6 elicitations for overall consistency of the process and its results. Mr. Potier has worked a long career in both underground mining industry and geological disposal at Andra, the French waste management agency. Since his retirement in 2009 from the position of IAEA's Head of Waste Management Section, he continues to be an active technical expert working on temporary assignments for the IAEA.

Dr. Paul Marschall, Performance Assessment/Safety Assessment Expert, works at Nagra, the Swiss waste management organisations over 20 years. He is Nagra’s project leader responsible for phenomenological modelling activities in support of safety assessment (SA) and engineering design (ED). His work includes the development of traceable workflows for phenomenological model analyses of the engineered barrier systems (EBS) and the geosphere, aimed at demonstrating the barrier integrity (total system and individual components) for a wide range of initial and boundary conditions, their testing for system robustness within the framework deterministic / stochastic sensitivity analyses. Further his work includes comprehensive model abstractions associated with traceable propagation of conceptual and parametric uncertainties complementing the workflow of phenomenological modelling.

Dr. Nina Müller-Hoeppe, Domain Expert, works currently at DBE TEC and has a background in civil engineering and has worked in nuclear waste management for 25 years. Dr. Müller-Hoeppe has been involved in generic safety cases in rock salt (SEK) as well as being responsible for the preparation of the German preliminary safety assessment VSG's work package considering plugs and seals. She was involved in the closure plan activities for the ILW and LLW Morsleben repository and their precautionary backfilling measures which are already completed. Dr. Müller-Hoeppe is currently responsible for technical proof and final evaluation of functionality of seals that are built in the Asse repository in the context of its emergency plan.

Dr. Guillaume Pépin, Performance Assessment/Safety Assessment Expert, is the head of Andra's Performance Assessment and he has worked at Andra since 20 years. He has worked with safety assessment, numerical modelling and simulations for all types of nuclear waste repositories and is specialised in multiphysical descriptions for performance assessment. Dr. Pépin has co-authored DOPAS Project deliverables D5.3 and D5.4.

Mrs. Marjut Vähänen, Lic.Sc. (Technology) in surface physics, Performance Assessment/Safety Assessment Expert, is currently the programme manager for clay programme including R&D, manufacturing and planning of the supply chain & production of clay components at Posiva. Mrs Vähänen joined Posiva in 2003 and has been the R&D and research manager and head for long-term safety at Posiva from 2005 until 2015. She has also been in charge of Posiva's safety case process for the construction license of Posiva's geological disposal facility.

2 Agenda of the consensus meeting

The agenda of the consensus meeting was the following after it was modified somewhat during the meeting:

1. Opening, overall view and recap of the objectives of the WP5 EE process
2. Working during the day - Discussions and proposed modifications
3. General findings and improvement suggestions to the WP5 D5.10, the way forward

3.1 General findings and their handling
3.2 Modelling strategy and uncertainties
3.3 Deliverable structure and content improvements
3.4 Other findings
3.2 Recap of the main findings

4. Refinement of the contextual and structural descriptions in D5.10
5. Clarification of the ELSA experiment context
6. Timing of approval of consensus meeting memorandum
7. EE process - experts' experiences from the process and feedback

Closing

3 Inputs to the elicitation process - Summary of the experts inputs by quantity and type

The WP5 expert elicitation meeting's inputs were based on the replies of the different experts on the expert elicitation questionnaires. The questionnaire forms are attached as Appendices 1 and 2.

The replies on the questionnaires were compiled by the facilitator and they formed the basis of the discussion point 3 on the consensus meeting agenda.

As a result a total of around 200 comments were received from the five experts, several of the comments were overlapping. Main comments addressed the structure of the report, traceability of input information, and modelling and uncertainty management issues related to the work done and reported in D5.10. The themes and nature of the comments varied as summarized in the following table:

Types of inputs	Number of comments	Additional information and the handling of comments
Overall general findings	203	The overall general comments included both favourable and improvement comments about the report itself. These will be included into the text of the D5.10 into existing relevant chapters and also into new chapter/s of the D5.10 report, if necessary. Further a part of these general findings will be used in the final project summary reporting D6.4 with the referencing to their original source when applicable.
Controversial findings between experts	none	No controversial finding resulted from the experts' inputs.
Improvement recommendations for D5.10 from the	137+14	The general findings included improvements that are intended to be put into the D5.10 report. These help to set

Types of inputs	Number of comments	Additional information and the handling of comments
general findings and from the recap in the consensus meeting. These are broken down by themes in below:		the described experiments into their relevant contexts and highlight the need for clarity and referencing in the text to other DOPAS work. These additions will assist the reader in achieving the overall picture of the scope of and the work done in WP5. Also direct recommendations to correct factual errors are included. The overall improvements are detailed in section 4.2 of this memorandum with a breakdown of the main type of themes for improvements.
Report structure findings	30	The context and the work package structure would need to be clarified in the report by adding clarifying information into the D5.10 Chapter 2 and adding missing chapter on the Lesson learned and the way forward. Adding some other missing information to the report is needed and indicated in the general findings and in the section 4.2.2 of this memorandum.
Modelling, its related limitations, and uncertainty treatment related	43	Modelling strategy, model limitations, classification of and uncertainty handling related improvements to the D5.10 are included in section 4.2.3.
Content related findings	36	In addition to the terminology, the content comments relate to the different approached taken to the performance assessment and safety case; to the process understanding, and improvements in the codes. The table 11.1 presentation of the code information benefits, if it is reorganised by the type of codes instead of their availability or an additional table added. The quality assurance process was not visible in the report cases. The needed additions relate to the interface between rock and plug, to the limits of long-term aspects from the work done. Linking the safety functions and requirements tighter to the D5.10 experiment work needs

Types of inputs	Number of comments	Additional information and the handling of comments
		more referencing to the other DOPAS deliverables (see 4.2 and its subsections).
Lessons learned, conclusions and future use of the results	12	The experts agreed with the conclusion that up-scaling the results of the work done is a source of uncertainty. In addition they stated some lessons learned, conclusions and potential future use of the results (see subsection 4.2.5 and Chapter 5 in memorandum).
Omissions from the D5.10	3	The inputs from the D5.5 status report covering the work related to the four different experiments are missing as described in the DoW except for ELSA and this is reflected on D5.10. The description of the division of work between WP4 and WP5 is needed to clarify the scope of the work done in WP5 (and also in WP4). Lessons learned are not included. Referencing needs improvement like also the link between the experiments and their long-term safety requirements including their stage in the design basis development (see D2.4 work flow).
Terminology and acronym comments	5	Reference to IAEA glossary (2007) is needed as agreed and some key terminology explained e.g. the assessment period - the definition of safety function is quite inconsistent with the above especially in D5.10 Ch. 10; The terminology in each chapter needs to be consistent with each other (and also the units of parameter - also listed in IAEA 2007); List of acronyms requires many additions for completeness.
Description (Figure 11.1) Contribution of WP5 to the safety assessment and the development of safety case	1	The figure needs modifications. The input of the work in different stages was discussed. This figure is simplified and a misunderstanding can result that the inputs are the only inputs needed for safety case and safety assessment for the proof of constructability
Description (Figure	1	The original description takes advantage

Types of inputs	Number of comments	Additional information and the handling of comments
11.2) of the DOPAS and WP5 context differences over time		of the animation function and the role of DOPAS Project in the overall timeline of the RD&D programmes being at different stages of development is not so clear in such a static figure. Thus this figure description, too, benefits from improvement and from additional explanations e.g. in the figure text.
Factual corrections and editing comments	various minor comments	These are mentioned as a separate section 4.2.8 in this memorandum.

4 Main comments and outcome of their handling as input to D5.10 final draft for EE

4.1 Overall evaluation of the content of the report - "Fitness for use" of the report

4.1.1 Overall findings and conclusions

The experts concluded that it appears that the material provided in the D5.10 deliverable more or less fulfils the general objectives assigned to WP5, it is consistent and contributes to stepwise improvement of global confidence and increase of global knowledge in performance assessment. Most of the results given in the report have contributed to preparation, execution, validation of the experiments, and have given relevant information to interpret results of experiments, material behavior, designing seals, and testing models.

The "story" of the Work package 5 was not easily found in the report. The scope and the organisations are described in a concise and traceable manner and a distinction between reference designs and experimental designs is highlighted. In general, the experts found the report to quite complex in its format and structure. It was acknowledged that the work presented in WP5 of DOPAS is only a small part of the huge work incorporated in the national R&D programmes. This context is not fully described except in the case of the work done by Andra in Ch. 5. Such context is not found in the chapters: Ch. 3, Ch. 4, Ch. 7; and Ch. 9-10.

The structure used by Andra was seen fit also for describing the other experiment related work in the D5.10. The common reporting structure could benefit also from using a safety case outline including the statements about the safety functions and uncertainties. The other work package summary reports have benefitted from the use of the same editor for the reporting. The same structure has made the comparison of the information related to the different experiments easier for the reader than the various different chapter structures used in D5.10.

Also grouping the Chapters 4-10 directly under the four work package tasks in the WP5 would clarify the purpose of the work done and reported in these chapters. It was also concluded that since at this stage it is not feasible to change the full report structure, the report changes should focus on making the story comprehensive by complementing the introduction, conclusions, and lessons learned chapters of the D5.10 reporting.

The somewhat hesitant statement made by the experts about that the report appears to fulfil the objectives is partly due to the reason that the reported work is not fully transparent due to lacking references. The referencing to the sources of information requires improvements in the D5.10. The tracing of the stated information back to the original background reports and to the other DOPAS Work package reports was not easily done even though the information is available in them especially about safety functions, requirements and results. It was also stated that it was seen a pity that the DOMPLU experiment related performance monitoring was not part of the DOPAS WP5 work and thus it was not included into this summary report either.

The experts noted the specificity and added value of the D5.10 in its objective to provide feedback from the performance assessments, which helps strengthening the design basis at the different stages and thus contributes to increasing the robustness of the plug/seal designs. The WP5's additional dimension is related to the long-term aspects of the sealing systems, mostly from a long-term safety perspective but also in terms of materials behavior or sealing system performance over time.

In its time perspective, the work performed in WP5 complements the activities carried out in WP3 and WP4 despite the limitations to the work: i.e. the extent of the long-term behavior addressed by the experiments; the limited objectives and/or duration of the DOPAS project experiments; and the set data-freeze dates for the WP5 (and WP4) reporting. It was also difficult to see the connection between the experiments and the long-term safety requirements, existing technical guidelines (like Eurocodes) and regulations. Here the need to make the references more transparent, especially to D4.4 but also D3.30 and D2.4 reports, was highlighted again. An explicit clarification of the division of work between WP4 and WP5, and the mutual links need to be stated in both D4.4 and D5.10. Sufficiency of information without unnecessary duplication in both reports can be balanced by using appropriate referencing to each other's content.

An introduction to the role of plugs and seals in long-term safety is expected as part of the reporting because the aim of the work was to address the role of plugs and seals in the whole repository system with regards to the long-term safety (taking into consideration the different types of plugs and seals for different functions) and the assessment period (for safety) in relation to the relative long- and short-terms in the context of disposal concept

Important attention by the experts was placed on the conclusions of the D5.10 report. The question from the experts in the elicitation was about what has been done and what has been achieved in the WP5 work regarding the safety functions. The link of the achievements in respect of the WP2 D2.4 workflow on the Development of design basis (Figure E.1 in D2.4) can help with this area.

It was mentioned, too, that when one looks at the WP5 objectives and at the conclusions of the report, there is a mismatch. The experts expected to see the lessons learned as expected in the reporting and also the work for the future developments based on the results now achieved under each work package task. An indication on relevance to the work done for the national R&D programme is also welcome.

4.1.2 Generic Performance Assessment related findings

As mentioned above, the report is a complex report with various views. From previous experiences it was known to the experts that a performance assessment (PA) work package in an EC project targeted to experimental work is a challenge and not least due to the limited duration of the projects. Thus also regarding to the "completeness of story" - a consistent safety concept cannot be covered in a single report and thus the reports focus needs to be on few main messages derived from the work.

From the PA point of view the work is adequate and the experiments at the time of data freeze form a basis for it. The technical limitations due to duration of experiments and the restricted observation time have to been taken into account. The limitations of the work have been clearly identified including the data freeze consequences. Whether the plugs and seals meet the long-term requirements cannot be stated at this stage, but much input has been provided also for future work.

Even if the main results from big scale experiments were not available during the DOPAS Project, and the fact the different levels and stages for each organisation led to heterogeneous chapters in the report, the overview of the report shows consistency in the different approaches, confidence building in models and concepts, and an improvement of global understanding of physical processes that affect plugs and seals in granite, clay and salt.

The exception including the ELSA experiment's material development addresses also the longer-term material behaviour (incl. modelling corrosion mechanism in LAVA subproject). It is partly covered in WP5 reporting in Chapter 7. The REM experiment in Chapter 5 contributes to long-term performance assessment, too. All short-term (until initial state) performance assessment information is included into the WP4 reporting dealing with the performance assessment of the experiments against their requirements and their technical results.

A report reader expects to find both comparable results and integrated results, which is not always available since the experiments are at a different stage of design basis development. The recommendation from the expert is to have the introduction of the report to address the types of performance assessment, types of process modelling, and target of modelling. Further the introduction can address whether there is consistency in the outcomes since the different targets are at very different development levels and have different objectives. More detailed recommendations are given by the experts in section 4.2.3 in addressing the modelling.

An important issue warranting special attention in the experiments and in the reference designs is the direct interaction to the adjacent host rock, and its safety function and quality. These have been discussed in D2.4 (*Factors affecting design basis*) indirectly by addressing the required host rock characteristics and the factors influencing e.g. the safety-critical functions.

Since the national and host rock contexts and the underlying safety concepts are so different, the terminology and expressions clarification. One term having an important underlying influence is the duration of the "assessment period" in the different geological disposal concepts since the length of this period varies significantly depending on the national legislation. Like in the case of Germany, a short-term seal is expected to last for 50 000 years and in the crystalline KBS-3V concept the plug design life is couple of hundreds of years. Thus clarifications about the expressions short and long-term in the different contexts are needed.

This chapter's following sections and the Chapter 5 address the more detailed improvements and future applicability of the results that the experts recommend to be included into the D5.10 report.

4.2 Specific improvements to the report content

4.2.1 Summary of main needs to complement the report D5.10

This section summarizes the main improvement needs of the D5.10 report. Their details correction needs are explained in the other sections of 4.2.

- Clarify the context of experiment and other cases and context of the experiments including the repository concept applied and potentially use the structure of Chapter 5 as a model;

- Structure the D5.10 report objectives, work and conclusions to match the four tasks of the WP5;
- Explain the modelling strategy/strategies and limitations, quality assurance and classification, quantification and treatment of uncertainties in the modelling using the more generally accepted terminology and existing classifications;
- Give the justifications for selected test methods, models, parameters for monitoring and input data. Provide a view on the level of confidence on the models and input data e.g. with sufficient referencing to the relevant sources of information;
- Clarify the underlying experiments and sealing elements that are modelled in ELSA i.e. give the context (see also sections 4.2.2, 4.2.3 and Appendix 7);
- Reference and cross-reference in the D5.10 to the other work packages final and supporting reports with traceable and detailed level for easy tracking of information.
- Add the lessons learned from the WP5 and address the future work that can benefit from the work carried out in WP5. The corresponding section in D4.4 gives a good benchmarking example for this purpose.
- Add abstract or executive summary, key terminology glossary using terminology consistently in the report and complement the list of acronyms into the beginning of the report.

4.2.2 **Context** of the cases in D5.10 and the context of the individual experiments

The experts noted that the WP5 workflow is not clear for the reader. The D5.10 report objectives, work, and conclusions are required to match the four tasks of the WP5. This can be done by revising the structure or using other type of linking of the different chapters to the tasks and by improving also the Figures 11.1 and 11.2 (in Appendices 5 and 6).

The experts noted that as the different experiments in the DOPAS Project are in different stages of the design basis development (D2.4), the relevant context of the experiments needs to be given in the report in a clear way to enable better comparison of the experiment results and the experiment aims:

- The full-scale experiments FSS, DOMPLU and POPLU are part of the Basic Design Basis development stage as described in the D2.4 workflow for design basis development. For these experiments, the reference design or alternative experiment design requirements have been developed and described in WP2 and their design in WP3 is based on these requirements.
- In contrast to the French, Swedish and Finnish experiments, the EPSP and the ELSA experiments are still at the Conceptual

Design Basis stage targeting to develop the more detailed requirements for their future reference plugs or seals.

Summarizing shortly in the Chapter 1 about the DOPAS Project what is the main content of all the work package summary reports is a useful way to clarify the division of work between the different work packages. The timeline for the work done under DOPAS WP5 is recommended to be included e.g. into the Chapter 2 introduction like it is done in D3.30 for clarifying the timetables of the work done in relation to the data freeze, too.

Chapter 3 has a transparent structure and gives an overview of the safety functions of seals/plugs and the sealing scenarios in the sealing concepts of the different WMOs, but the terminology is not fully in alignment with IAEA 2007 glossary. The information concerning the sealing concepts of the different WMOs has not been checked for factual correctness by representatives of the WMOs and a disclaimer on the limited correctness of the information needs to be included. Some information also appears as being out of date, e.g. on Belgium's Safir 2 from 2001. The validation of Chapter 3 information and of interpretations has not been carried out by the relevant organisations and time does not permit it prior the DOPAS Project finishes. The original aim for producing this summary needs to be included either into the chapter or into the preceding Chapter/s 1 or 2. This chapter was produced for RWM's internal use and uses RWM Ltd specific terminology not matching the IAEA Safety glossary or the terminology of the DOPAS Project or of the organisations' whose safety case work is described in the chapter.

For the Chapters 4-9 there is need to clarify the context of cases and context of the experiments including the repository concept applied and potentially use the structure of Chapter 5 as a model for the individual cases reported.

The current way of presenting the different modelling approaches does not facilitate the comparison of individual DOPAS partners' approach with each other. The expert comments state that the partners' contributions are patchy in the report. Performance assessment of plugs and seals system approaches require an introduction to the cases in the Chapters 4-9. An alternative is to include this type of comparative information into a section of lessons learned (currently missing from the report) using a common structure template.

For some of the cases, there is also a need to give a simple description of the experiment design to support the reader (relevant for FSS, EPSP, the simplified design concept is given for POPLU and ELSA). The clarification of the context including the role and function of the plugs and seals and the role and the contribution of the DOPAS experiments to the national R&D programme for each experiment is needed, too.

In Chapter 5 (ANDRA), Andra's general uncertainty assessment approach in support of SA is presented and this chapter gives a good model how to report also the other chapters' work. Also the way of dealing with uncertainty is a good approach and worth including also into the lessons learned of WP5.

Chapter 6 (DBETEC) follows much of the same structure as Chapter 5. This chapter provides also the place in the report to clarify the scope of the work done under DOPAS "ELSA" in relation to the German ELSA project (see also Appendix 7). The referencing to the D3.30 report is missing from this report and vice versa.

In Chapter 7 model-based analyses of a mock-up experiment performed are reported. They aim at validating HM-process models and estimating the corresponding model parameters. Linking this work to the ELSA context by referencing to the previous chapter is required in addition to adding the overall aim for the work done. The assessment of model uncertainties and parametric uncertainties are not discussed in detail due to the limited experimental data base. Therefore it is required that this limitation is included into the conclusions about the work and also as an indication for future work.

In Chapter 8, further work on the German experiments is reported. The chapter refers to three repository options, which are actually not explained or references to except with a general comment to the VSG. The context link to the DOPAS "ELSA" work is missing. It is not clear to the reader what is integrated/coupled in the LOPOS performance assessment code. These points require clarification in the chapter's existing sections. This chapter also includes a multitude of acronyms not included in the listing.

Chapter 9. The EPSP context is missing including the aim of the modelling. Uncertainties are not discussed.

Chapter 10: An interesting appraisal is made aimed at linking demonstrator activities with performance assessment by the use of indicators. This chapter refers to widely accepted PA workflows and terminologies (e.g. PAMINA project), thus setting an excellent framework for the overall objectives of WP5. Due to the chapters more general nature, some of the information presented in this chapter or even this chapter could potentially be moved also to the beginning of the D5.10 to the introductory chapter's prior Chapter 3.

The used terminology in the chapter does not match the agreed DOPAS Project's convention. Here is a further need to explain the term performance assessment (potentially also term safety assessment for completeness) used in PAMINA and in this chapter. The IAEA Safety glossary definition does not necessary require the assessment of radiological impacts (IAEA 2007) in PA unlike in the case of risk assessment and safety assessment (see section 10.1.4)[1].

Chapter 11: The main conclusions in this chapter need to refer to the objectives and specific objectives as given in D5.10 Chapters 1 and 2 and in the WP5 objectives presented in DOPAS Description of Work (DoW) respectively. This report part needs to be dedicated to the evaluation of actual achievements of the WP5.

Other information can be addressed in a **Lessons learned chapter that is currently missing** from the report. Alternatively, the lessons learned can be produced separately for each chapter or experiment and then summarized at the end of the report. This chapter or information is recommended to be reported by similar themes for each chapter. Alternatively a consolidated concluding chapter in D5.10 addressing the technical and long-term performance relating to the tests and taking into account the work and results from each experiment would facilitate also the preparation of the Lesson learned chapter to the report.

The experts also acknowledge that for the large scale tests there is not yet any comparison between the modelling and experimental results due to the unavailability of the information. In smaller scale tests where the results were available, the comparison was quite good.

The report also needs to address how the link between WP4 and WP5 is established according to the objectives of the WP4 and WP5. If such a link does not exist, a justification for it needs to be given in both reports D5.10 and D4.4. The D5.10 report and simultaneously the D4.4 report need to be described in clear terms the division of work between the two work packages WP5 and WP4 as this is not clear in the reports (see also the chapter specific comments above):

- For the experiments FSS and EPSP (include clarifying figure of experiment as part of the context), the main objective was to test the technical feasibility of the plug construction and this objective was achieved and the technical feasibility and performance assessment of these experiments during the run time of the DOPAS Project is included in the WP4 reporting, especially in the experiment summary reports D4.8, D4.7, and D4.4 Integrated Report.
- The performance of the DOMPLU plug until the initial state ("short term" up-to a maximum of 100 years) is excluded from the WP5 work and is solely addressed in the experiment summary report D4.3 and D4.4 even though the Task 5.4 in DoW states that the description of all five experiments' safety concept is addressed.

[1] Please note also the discussion related to the GEOSAF TECDOC and the use of safety envelop in the context of safety and performance assessment (in Appendix 3 for information)

- POPLU experiment related modelling under WP5 was predictive modelling related to the plug design decisions and the modelling is reported in WP5 and D5.10. The two functions of the plug (mechanical integrity and hydraulic limitation) were clearly defined in the text. Same could be done for the other experiment chapters, too. The pressurisation of the POPLU plug was started in January 2016 after the data freeze date for the D5.10 report. These results addressing the relative short term performance like for DOMPLU experiment are included in the experiment summary report of WP4 D4.5, but lessons learned can be received from the results for inclusion into the D5.10 Chapter 4 with the proper referencing to the source of information.
- The FSS experiment was complemented with the metric scale mock-up test REM that is intended to produce performance assessment results also for assessing the longer time frames with regards to plug bentonite mixture saturation process and resulting loading. The detailed steps of REM are explained in D3.30 section 2.2 and can be referenced in D5.10 for further clarity.
- The overall structure of the work done in DOPAS under "ELSA" title requires clarification for the reader. The shaft sealing elements as described in Figure 6.1 in D5.10 require a clear description. The Appendix 7 includes a draft clarification of the ELSA work that resulted from the WP5 elicitation consensus meeting.

Some additional recommendations related to the structure are included in 4.1.1 and 4.2.1.

4.2.3 **Modelling and management of uncertainties** in the D5.10 reported work

The safety functions and the requirements as the starting point of the modelling work are described in detail in the WP2 deliverables. The corresponding transparent referencing is needed in the D5.10 chapters including the modelling cases or the relevant safety functions needed to be included into the context descriptions of the chapters. This is also needed to be able to assess the "appropriateness" of the modelling activities.

The document describes the difference between reference and experimental design and this is important for the interpretation of the modelling results derived from performance modelling instead of design modelling.

All experiments and their related work are required to have a quality management system. The reporting does not include any description of the management system /quality system or comment on the importance of using such a system in the work in producing the D5.10 results. An exception relates to the handling of uncertainties in the D5.10 Chapter 5.

Part of the quality system needs to address the formal process how and on what basis to move forward to the next step of the design basis development work flow (as in D2.4) based on the performance assessment results of the DOPAS work. I.e. in the work carried out, the use of the results acquired are required to have consistency with the identified workflow since they serve as inputs to the safety assessment/safety case as a part of the iteration process defined in this workflow.

The experts expect to find conclusions about the ”goodness” and related uncertainty evaluation of the predictive modelling carried out from the global system's or subsystem's safety/performance assessment point of view.

The conclusions of the D5.10 should also include the iterations between technical solutions (constructability) and the performance besides the information derived from the Fig. 11.1 processes before the desired/expected/required design targets (within the safety envelope) are to be met for the plugs and seals.

The assessment of the expert related to the modelling in WP5 and its reporting in D5.10 concluded that the modelling strategies are not addressed in the report. There is no discussion on the model identification, validation and scaling, types of performance assessments or types of processes in general that could be used for classifying or comparing the modelling activities carried out in the D5.10 besides the short description given in Chapter 11 Conclusions. In a similar way the treatment of uncertainties, their identification and classification is not discussed with the exception of Chapter 5.

Modelling strategy

The report would benefit from identifying in the D5.10 text the strategy/strategies for modelling, which serves the different experiments in their relevant chapter context. This has not been discussed in the report beyond the identification of different types of modelling in Chapter 11 (and partly in Ch. 2).

Process understanding and using the right/real data and models are the key issues in PA. Care needs to be taken when choosing the right processes from the FEP[2] evaluation. The details given in the report are not sufficient to establish the compliance and relevancy for assessment by the experts and they have to be found in references of each chapter. In some chapters (e.g. Ch. 4) do not list all mentioned references. In the DOPAS Project context, the experts had to assume the use of correct conceptual and calculation models resulting from the internal quality

[2] FEP = features, events and processes

management procedures of the partners even though these are not mentioned in the reporting.

Only a small part of the input data for modelling comes from the experiments (in WP3) themselves. Much of the parameter inputs are derived from previous works and their reports. The focus of the quality assurance is mainly on the process simulations and not on the global performance of the seals.

There is a need to include a preliminary analysis giving a better description of physical processes addressed in the modelling. They have to be quantified for each experiment and for global overall safety. The processes need to be known in order to select the right parameters and to ensure that the monitoring is correctly installed.

This information is not included into D5.10 and there is a need to include into D5.10 the referencing in detail to the relevant DOPAS deliverables in WP3 and WP4. Making this information transparent gives confidence in the data acquired and strengthens the appreciation of the relevancy of models and calculations by the experts and the readers.

Alternatively, the report needs to include an assurance or a statement that the quality assurance of the inputs is handled in each organisation according to their internal quality assurance and control procedures to increase the confidence of the results.

Due to the short duration of the experiments, the efficiency of the instrumentation and of the methods cannot be judged or conclusions made about them from the WP5 performance assessment point of view for the long-term. One cannot make sure that the right parameters are measured in order to compare the experimental data with the pre-modelled values.

Identification of the types of modelling and codes used

The Chapter 11 identifies the modelling used in D5.10 in terms of their purpose. The experts also asked to include a classification of the modelling types based on the target of the modelling e.g. is it a phenomenon or some other type of target that is modelled. Like in the case of Andra, phenomenological model is used.

Furthermore, such a classification clarifies the terminology that current remains unclear in the reporting. Such confusing expression in terms of their meaning in D5.10 context include e.g. “process modelling”, “process-level modelling”, “integrated performance assessment modelling”.

One recommendation by the experts for classifying and distinguishing between the modelling categories is as follows:

1. **Modelling in support of *experimental design* and *design optimisation*** (reliable and robust test set-up, temporal evolution of the experiment and optimisation thereof). Typical modelling tools / strategies are simple (forward) scoping calculations, sensitivity analyses and scenario assessments, aimed at assessing the experimental procedures for a representative range of initial and boundary conditions.
2. **Model development and model validation** (e.g. development of phenomenological / process-level models; development of integrated (sub-) system models; development of model abstractions). Model development needs a clear and traceable verification and validation strategy (code and calculation verification, model validation, specification of performance measures) in the framework of prediction-evaluation benchmarks.
3. **Model-based experiment analyses with verified codes and validated models** (e.g. model calibration, analyses of conceptual and parametric uncertainties). Typical modelling tools / strategies are inverse modelling and (stochastic) conditional simulations.
4. **Modelling in support of performance assessment,** aimed at assessing the expected temporal evolution of the reference (sub-) system and deviations from the expected behaviour. Typical modelling tools / strategies are (deterministic/stochastic) sensitivity analyses and scenario assessments.

An alternative report addition is to give the WP5 specific key terminology definitions related to the modelling part, too. In a similar way the work done needs to be identified with clarity. It is important to note that the reader of the summary report is very unlikely to be an expert in performance assessment.

Many of the codes used in model calculations are commercial or freeware codes. Their underlying conceptual models were taken as given. Also some model uncertainties and parameter uncertainties were investigated, however the scenario uncertainties were only briefly noted and not in direct connection with the cases of the WP5. The recommendation is to add another table to the Chapter 11 to classify the codes used also by the types of modelling for which they have been used in DOPAS Project.

Regarding the predictive modelling there are big differences. In some cases the results of the predictive modelling showed the expected behavior, in other cases it was stated that predictive modelling was impossible because the results of different but similar experiments had to be fitted individually using completely different parameters values. Thus, reliable predictions were not received according to the experts.

For the Chapter 4 on POPLU full-scale experiment, it is recommended to add some midterm results to highlight the importance of the interface between the rock and the concrete monolith. This addition would also contribute to lessons learned of the WP5.

In the case of ELSA (Chapters 6-8), the experiment design is still quite preliminary and specific seal requirements are missing. It was therefore difficult to the reader to see how this work (under ELSA phase 2) described in D5.10 contributes to the future full-scale ELSA experiment in the German ELSA project phase 3. Further it remains unclear what is integrated in the LOPOS modelling: potentially EDZ and corrosion of salt concrete?

For the relevant cases where comparison was possible (GRS, UJV, DBETEC in Chapters 6, 7 and 9), models fitted correctly with observations and experiment data. This good agreement (no or low deviation were observed) led to increased confidence in modelling.

In Chapter 9 (UJV), the description of the experiments and the models applied were not found to be fully traceable. The experts concluded that maybe hidden assumptions are applied that are not recorded, e. g. in Tables 9.1 and 9.2, the parameters P1 – P3 are explained but not parameters P4 - P5. An explanation to the table text is required.

The most of the ELSA work and e.g. the REM work reported in D5.10 is done based on small (centimetric to decametric) or medium (decimetric to metric) scale laboratory (surface, mock-up) experiments and is aiming at improving the models predictions to be applied at real scale outside the DOPAS Project's scope.

To make it clearer to follow the conclusions (in Figures 11.1 and 11.2), the role of mock-up experiments and in-situ experiments in support of Safety assessment needs be clarified (e.g. a validation of process models, validation of integrated system models, validation of model abstractions, proof of constructability).

In the work carried out, on one hand, the role of predictive modelling as a tool, and the role of predictive evaluations as a process (including e.g. risk assessment) on the other hand have different uses in the experiments' modelling. A discussion is expected in the report on the evaluation of the results and especially the role of the smaller scale experiment modelling results in support of the in-situ full-scale experiments given the limitations related to the up-scaling from these smaller scale experiments, too. This can be given in connection with the uncertainty treatment, too.

Uncertainties and their management

How are the uncertainties of the work done in WP5 identified, classified and managed remains unclear for the experts and the reader in all cases except in Chapter 5 (Andra). How are the combined uncertainties (epistemic, stochastic) on models and input data and on the sensors (errors of measurements) taken into account. How are uncertainties on the numerical tools considered and how is up-scaling on space (representativeness of smaller scale to bigger scale) and time (good calibration at t=0, but not ensured later) managed? These remain currently unaddressed in D5.10, but need be addressed in the text.

Uncertainties related to performance assessment are classified into three main categories (e.g. ref. FP6 PAMINA and Ch. 3). The uncertainties of the work done in WP5 and reported in D5.10 are recommended to be identified and classified according to these categories to ensure their systematic treatment in the report. These commonly agreed classification comprises of parametric uncertainty, conceptual/model uncertainty, and scenario uncertainty. In probabilistic assessments, uncertainties can be grouped in the categories of aleatoric and epistemic uncertainty. This classification has not been applied to the cases presented in Chapters 4-9. Scenario uncertainty is mentioned, but not treated at all.

In the DOPAS project, ANDRA (Chapter 5) and GRS (Chapter 8) used a probabilistic approach ("stochastic uncertainty analysis"). In the Chapter 5, too, the associated terminology benefits from further clarification in alignment with the identified uncertainty categories. Potentially also a disclaimer related to the use of the terminology is needed especially if the definitions are not fully clear.

One main uncertainty in the WP5 work was that the predictive capability of the models was partly insufficient. In other words, the knowledge on some material behavior is still limited (poor) e.g. for salt concrete. One further data uncertainty relates to when if there is no real and/or site specific data available. Also the models used have their constraints that need to be taken into account.

A discussion on the model and code validation in general needs to be referenced to and a discussion of the case specific validation for the modelling needs to be discussed in the reporting. The related uncertainties are to be included into the treatment of uncertainties of the individual modelling cases, when not done in all of the reported cases.

As an example listing of uncertainties identified by the experts the following list is given:

- Ability to up-scale (space and time) from experiment design to reference design (physical and geometrical representativeness);
- Quality of data measurements provided by experiments or other sources, which lead to define epistemic uncertainty on data. Unless one data is available, a range a variation should have been systematically defined assessing evolution of experiment managing PA/SA at larger scales;
- Uncertainties of numerical simulation (errors) due to the use of numerical tools (accurate solver, time step and grid enough fine to

reduce numerical uncertainty); in numerical simulations this uncertainty is very difficult to quantify because it would need a comparison with an analytical solution. Thus, indications giving 'the good use and rules' that lead a converged, accurate and robust result would be relevant, as well as description of a good experiment;

- In order to quantify better an accepted range on some complex problems, such as couplings, correlations between input data (the example of permeability/porosity/diffusion) have to be managed. This part is not well mentioned in D5.10.

There is no uncertainty given for the calculation model or for situation models. It was however noted that this is quite difficult e.g. due to the impact of the level of complexity of the model.

4.2.4 Other **content** improvements

The D5.10 does not itself contain a reliable assessment on the soundness of the technical implementation and performance of each DOPAS experiments using the materials supplied. However, this information is included in D4.4 in addition to information that confirms the plugs meeting the key design specifications of the plug experiments. There needs to be a referencing to this source in D5.10.

It was noted that the report does not contain any discussion of flow forces and large gradients producing cracks that can apply in /represent the real repository conditions (linked strongly to the importance to manage uncertainties). A referencing could be made to the experiment summary reports of WP4. Hydraulic conductivity was identified as the most relevant parameter (Chapter 10). However, the influence of interfaces between seals /plugs and host rock is not discussed adequately and no experimental setup covers this aspect at least in the D5.10 report. Part of the discussion is done in WP3 and WP4 work from the short-term perspective and could also be referenced in the D5.10.

The point that the radionuclide release is rated (e.g. the border of the containment providing rock zone or the ground surface) should be specified for each PA to improve clarification, It was acknowledged that the DOPAS Project work does not consider radiation hazards in the experiments (out of the scope).Recommendation is to add the information related to global performance assessment together with the assessment period as part of future work. The Chapter 10 references to radionuclide release limitation resulting from the PAMINA work, but it was noted by the experts that part of text was to be is a bit confusing. In addition, terminology used in the chapter is not consistent with the DOPAS Project agreement (see section 4.2.5).

The connection of the experiments described in the report and the PA cases considered needed improvement, too, as discussed earlier. The use and handling of the experimental results in PA was questioned as it was seen that the linking is via defining the need for experimental results from PA.

4.2.5 Improvements of **conclusions** and lessons learned

For the long-term assessment, the relevant processes are so slow that in order to get relevant data and to assess if the performance of the design meets the safety functions, the four years project is not long enough irrespective of the date of the data freeze for reporting. The slowness of the saturation processes influenced the choice of the upstream structures of POPLU (no swelling seal included into the experimental design). For the same reason the two different Andra experiments were set up: REM metric scale test to address the slow processes and FSS to address the industrial feasibility of constructing the seal. This is recommended to be included into the conclusions.

The lessons learnt once provided in the report D5.10 from the work will be useful for seal system developer in terms of relevancy of experiments at small scales, proof/validation of feasibility of expected performance, and global schedule and link (input/output) between each part of the work to be done. The feasibility of large scale test is one issue that the future plug designer could benefit, too.

It would also be valuable to see if there have been some errors and difficulties during the project implementation because those are usually the most beneficial lessons learnt.

4.2.6 Improving **integration**

The experts' addressed the question related to improving the integration of the work in D5.10 as followed:

The different PA methodologies should be linked to technical methods to prove functionality. And the experiments performed should be investigated whether they could form a basis for suitability tests included in their terms of reference. A known problem is that industrial scale suitability tests for materials have to be included in the experiment's terms of reference. However, if suitability tests last too long they cannot be performed in an adequate time period and thus the results are not available.

As stated earlier, the challenge of incorporating performance assessment work into a limited duration project containing full-scale experimental work exists and limits the results for performance assessment use.

Terminology and acronym listing

Glossaries

There was a comment made to the lack of definitions of the main key terminology in D5.10 deliverable regarding the used terminology as in all other summary reports. The glossary is needed for the WP5 specific terms.

Definition of "short-term" and "long-term" in the different repository contexts (ensure the same definition in D.4.4 and D5.10) is also required. The assessment periods differ significantly in the different repository and experiment contexts and this requires clarification for the reader. "Assessment period" itself needs a definition.

In general, in the DOPAS Project it has been agreed that reference to IAEA glossary (2007) is made in the introductory text and reference list as it has been agreed in the project to use this glossary for the terms, which are not specifically described in the report's glossary.

Checking the terminology used in figures 10.2 and 10.3, since *upstream* is the *part behind the plug* as at least in crystalline rock not in front of it, since the tunnels are inclined towards the mouth of the tunnel to allow water to flow out of the tunnel, similarly *downstream* is referred to the side of the plug on the side of the tunnel opening.

Complementing the list of acronyms

The list of acronyms in the report covers only a limited part of the acronyms stated and used in D5.10.

All acronyms need to be included into this listing - lot of them are unexplained e.g. TSPA, HZ20, BFZ099, ONK-PH20, ANOVA, LECBA, CSH, MSH, LAVA, LASA, HOOKE....; Or sometimes inconsistent like EDZ, BBM exist in the acronyms, too. The listing given is not a full listing. The whole report needs to be checked for full coverage of acronyms.

4.2.7 **Editing**, technical corrections and detailed clarifications to D5.10

Editing comments are handled as edits into the final report not requiring further discussions. Some of the edits are listed in this section and additional comments are provided to the author in a separate file.

Corrections are needed in the D5.10 report to:

- Small factual errors are included in the names and dates: In the page 20 there is misprint in TURVA-12. It should be TURVA-2012, the same error is on the next page too. Same applies to "Dossier 2015 Argile" name and referencing.
- Some of the figures were quite low in resolution like figures 5.12, 5.13, 5.14, 5.17, 5.18, 5.20, 5.21, 7.6, 7.7, 7.10 (left part), 7.11, 10.4 and 10.5 and figure legends require complementing. The poor resolution reduces the traceability of the information further in addition to the lack of detailed referencing.

- The consistency in the use of units needs to be check. The IAEA 2007 safety glossary provides a listing of SI units and prefixes according to ISO 1000 in its appendix as a guideline.
- Figures 10.2 and 10.3 and text in Chapter 10: In general *upstream* refers to part of the deposition tunnel or plug tunnel that is left behind the plug (at higher bottom level of the tunnel) and *downstream* (at lower bottom level of the tunnel) refers to the tunnel part that is open to the other rock openings after plugging. In Chapter 10, these terms are used in a reverse order than in general in the DOPAS reporting. The terms come from the use of inclination in the tunnel to direct the flow of the water out from the tunnels naturally. Correction is needed for consistency.
- Total system performance assessment (TSPA): definition and applicability to the waste management programmes of the different countries (this RWM Ltd term is in conflict with the IAEA glossary and with most of the terminology used at the DOPAS partner organisations, where safety case and safety assessment are more frequently used in the same meaning).
- Safety functions: the NEA[3] context is given in subsection 10.1.2, however, it seems that the term is confused in several paragraphs with the associated safety function indicators and the corresponding indicator criteria. Note that the definition of safety functions is identical in most national programmes for plugs and seals, but the corresponding indicators and indicator criteria are strongly dependent on the repository concept. **In the DOPAS context, it was agreed to use the definition of the IAEA (2007) glossary and the definitions of the WP2.**

The referencing and references in the D5.10 do not comply with the more general conventions (e.g. Harvard referencing) are also internally inconsistent in the report and not detailed enough.

4.3 Identified uncertainties from the WP3 elicitation as an additional check list for D5.10

The experts carrying out the elicitation for the WP3 have identified the following uncertainties, which are included in the approved consensus memorandum of the WP3 elicitation. As these uncertainties are potentially already included into the reporting of the WP4 and WP5 reporting this listing is presented in this memorandum and in the WP4 memorandum to serve as a check list for the D4.4 and D5.10 work package summary reports.

- The crystalline rock experiments highlighted the uncertainties related to rock conditions and selection of the underground site and also the need to develop construction contingency

[3] OECD/NEA Nuclear Energy Agency

procedures to take care of possible problems like unexpected water inflows (in DOMPLU site). Such a risk was also identified for the POPLU experiment location, but it did not realise. The missed water bearing structures may lead to hydraulic bypass of the plug and eventually to faster than intended radionuclide transport through the host rock. There is a need to develop contingency plans to address unexpected deviations from the desired state as these result from various environmental underground conditions and cannot be always prevented in advance.

- The WP3 EE experts concluded that for the plugs without hydraulic limitation function there is no relevant uncertainty regarding performance assessment/safety assessment as they play neither a short-term nor a long-term safety role concerning radionuclide transport from the repository. It was also noted that the length of short-term and long-term in time is dependent on the stipulated safety assessment periods for the different repository concepts.
- The permeability of the seal made of crushed salt depends on the creep induced convergence of the surrounding salt. For that reason it is combined with a seal made of salt concrete. For the latter the inherent uncertainty is related to the EDZ permeability of the host rock: too slow decline of permeability leads first to a large inflow of brine and after the full flooding into the expulsion of contaminated brine due to salt creep induced convergence. The combination of inherent uncertainty concerning EDZ behaviour and the procedural uncertainty can also be overcome by strict quality control.
- A main uncertainty relates to the up-scaling of the results from this experimental work to industrial scale in a repository.
- All of the experiments were challenged by logistic concerns. This will be the case in the future, too. The quality of the sufficient quantities of high standard quality of concrete materials and other materials is a concern resulting from the transportation needs of industrial scale material quantities. This challenge has already been experienced and addressed at LLW[4] repositories.
- One uncertainty relates to the inadequate quality and heterogeneities in the bentonite material emplacements into the underground openings especially into the upper parts of the sealing structures. In bentonite seals too low swelling pressure leads to high hydraulic conductivity and potential erosion of the seal. The relationship between the void and dry density of the bentonite used is a critical parameter. The successful filling of

[4] Low-level waste

voids and requirement for a smooth surface are limitations of the construction technique causing procedural uncertainty. This can be addressed with strict quality control during the construction.

Also related to uncertainties, the WP3 elicitation concluded that the safety margins are not clear for the DOPAS experiments. For this purpose the concepts of safety envelope and design targets (*ref. to GEOSAF final draft IAEA TECDOC 2015)* and an extract of the text defines the concept if the safety envelope:

"The Safety Envelope represents the boundaries within which, at the start of the post-closure phase, the state of the disposal system (i.e. the parameters expressing the safety functions important for post-closure safety) must fall in order to deliver the post-closure safety functions."

See also the Appendix 3 for more information on the GEOSAF concept.

5 State-of-the-art at the end of WP5 work and the future opportunities

5.1 Future development needs and opportunities

The D5.10 overall conclusions state that much of the work is still not finished and needs to be continued to confirm e.g. the predictive modelling. This means further detailing of the results with updated models including e.g. better physical processes and geometry also with more experimental results. Thus most of the results from the work cannot be directly used in PA/SA at larger scale in overall safety point of view.

Individual conclusions are also made in the different chapters of the report. As mentioned in the comments related to the structure of the report, the recommendation is to clarify the identified future development needs and lessons learned in the concluding chapters of the D5.10. This is needed also for having a clear state-of-the-art picture of the performance assessments related to the plugs and seals.

The transferability of the experimental design to the reference design is not discussed from long-term performance point of view. From the technical solution perspective this is discussed in D4.4 and D3.30. The referencing can be made. The more mature the design, the more applicable are the results for the use in the future. The early phase experiment performance assessment results can give input for setting up the requirements and future feasibility studies.

Especially for the future there is a need to define: Which processes are better understood at the end of the DOPAS project and what are the underlying performance measures? Which advancements of the sealing concept have been made? How is the confidence in concept and models gained? In the WP5 only the laboratory work has included this work cycle, the other experiments are not yet completed, but there is a potential to do a comparison of preliminary midterm results of the large scale experiments.

Although all repository sites should be chosen for long term safety reasons based on limitation of radionuclides transfer to the biosphere, each site has its own geological stability and characteristics and its own phenomenological behaviour. Thus, THMC[5] conditions prevailing in and around a repository are specific. However for all repositories, experimental demonstrators are made today for a (very) limited time compared to the repository lifetime and more specifically compared to the total duration they should be efficient. This duration is also plug/seal dependent. But, assuming the test site is representative of the repository site at actual, in general, the differences should be searched on the long term evolution, mainly in terms of THMC conditions as listed below:

T: climate evolution, ice age;
H : hydrogeological evolution linked to climate evolution and ice ages;
M : seismic evaluation, possibly erosion; and
C: chemical interactions between geological media and engineered barrier systems (EBS).

Of course, coupling can be strong between these processes, and the coupling level may evolve with time, which is also to take into account, and all these phenomena are site specific.

In addition to the above, large amount of constraining (technical) factors are identified by experts and these needed to be addressed in the future work. They include (as identified in D3.30 and D4.4):

- *Relying on methods, techniques and procedures ensuring workers' safety, e.g. providing adequate roof support during excavation and using suitable equipment (e.g. scaffolding) when performing work at a height;*
- *Preserving workers' health, e.g. providing adequate ventilation and air filtration or addressing the dust issue when handling bentonite materials;*
- *Compliance of selected construction methods with the constraints of the work environment, e.g. exiguity of work space, limited headroom, etc.;*
- *Compliance of selected construction techniques with the allowable tolerances defined at the design stage such as smoothness of excavated rock;*
- *Relying as much as possible on proven technologies already used in the mining industry or for civil engineering works;*
- *Preference given to selecting techniques for excavation or backfilling relying on robust and reliable equipment;*

[5] thermo-, hydraulic, mechanical and chemical process relevant to the repository site, far-field and biosphere

- *Need for extensive testing and development programme before selecting the materials for the construction of plugs / seals, including the most suitable emplacement techniques;*
- *Preference given to construction materials available locally;*
- *Plugs / seals heavily instrumented to monitor the construction and to measure the performances in order to validate the choice of materials and the construction methods;*
- *Cost-effectiveness and cost-optimization of plugs / seals construction taking into account the large number to be constructed and their complexity, the large quantities of high-standard materials needed;*
- *Increasing safety and effectiveness of repetitive construction activities, e.g. placement of bentonite blocks, by moving from manual work to the use of remotely-operated machinery.*

The experimental setup may simplify or make the reality of the plug more complex in producing results that are setup specific. In a real repository, the situation is unlikely to be so specific and for this reason the number of experiments with different experimental setup may need to be increased for reducing the sources of uncertainty. The number of experimental cases to cover the varying in situ conditions especially for the cases in the conceptual design basis development is partly depending on the national legislative or regulatory requirements.

In addition, it was identified that **gas migration** has not been taken into account in any cases and there could be good reasons for that but in overall it has to be justified somehow. E.g. in the KBS-3V concept, the requirements related to gases did not exist when the work on DOPAS was started.

5.2 Applicability of the PA experiences and the results in the repository implementation

The experts were asked for their assessment on the potential applicability of the work experiences and results presented in D5.10 for other plugs and seals or even for other repository components implementation.

The experts noted that

- Whatever the application, the safety functions that are required for the plugs and seals are strongly linked to hydraulic performance (permeability and tightness) and mechanical integrity.
- It has been proven that the expected hydraulic performance with swelling clay (bentonite) could be obtained in the studied host rock and boundary conditions.
- The scenarios for future events and hence the evolution and safety relevance of the plug depend on the requirements and repository conditions (rock, clay etc.) and they vary between different countries, thus limitations to harmonisation and standardisation do exist.

- The PA methods can be applied to the plugs´ and seals´ but from the view of a technical proof of function, they are incomplete at this stage of the work. The PA methods should be investigated to their suitability of application within a technical proof of function and maybe improved further on.
- In some countries, the authorities' approval is needed for the application of PA/SA methods, especially for fully probabilistic methods.

The same codes were used for simulations and calculations in some cases and learning around their utilisation can be shared especially when doing calculations on similar type of materials and structures.

6 Recommendations and expectations on content to be included in the other Work package reports

There is a need to include a clarification about the scopes of work carried out in WP4 and WP5 and also to address in both D4.4 and D5.10 about the link of the work in these two work packages.

As stated by the experts in WP3 elicitation and noted in the WP5 elicitation, the results of the full scale experiments in WP3 cannot directly be used in Performance or Safety assessment (as defined in WP5, D5.10): these results will only become available in the work described in WP4 D4.4 except for the initial state which can be used in simulations of WP5.

The results of the laboratory experiments concerning hydraulic conductivity and permeability (from WP3 and WP4), as well their development over time as function of circumstances can certainly be used in PA/SA: they provide central and distributions data to be used in the appropriate models.

During the elicitation, the need to cross-reference to the summary reports D3.30, D4.4 and D5.10 in sufficient detail for finding the relevant information was identified. And this applies not only to the items listed above, but also in general. Also the use of the D2.4 work flow forms a basis for each work package giving an overall process and context of the work carried out in DOPAS.

7 Good practices

The way the uncertainties in the REM experiment related work are addressed in Ch. 5 (Andra) section 5.3.3 is a good benchmark for other cases, too, as part of the quality management of the work.

8 Use of the Expert Elicitation results

The expert elicitations form an integral part of the quality assurance of the DOPAS Work packages' final deliverables. Thus the consensus outcome approved by the experts shall be included into the next version of the final draft or to the final report. This timing is dependent on whether the report will still undergo an organisational quality assurance review or if the report draft that has been submitted to the expert elicitation has already been reviewed in the organisation in lead of the work package in question.

The main author or editor of the reviewed deliverable is responsible for the inclusion of the experts' recommendation and the final check is made by the coordinator of the DOPAS Project when approving the final deliverables for submission to the European Commission and for publication on the DOPAS website at http://www.posiva.fi/en/dopas.

9 Feedback related to the EE process

The typical features of the EE process include

- looking at the same target from different perspectives
  - applying a defined role in working for the project
  - looking at the face evidence provided by the documents
- producing a transparent view of one’s underlying thinking
  - contrasting the evidence with one’s own experience
  - explaining and making visible why one is in agreement or why something is not agreeable or is omitted from the material subject to elicitation =>
- providing an opportunity to expand both sides’ knowledge and views on the EE target of the process

with the purpose of giving directions for improved and more structured and complete outcome for the future work that has been elicited.

Based on the WP2 elicitation feedback, the WP3-WP4 elicitation forms were commented by Mr. Potier prior the elicitations started. Also a Czech expert was sought for the WP4 or WP5 elicitation, but an expert was not available for this task.

9.1 Feedback from the experts on the process and tools

9.1.1 On experts' work and the questionnaires

The questionnaires especially for PA experts were seen to contain lot of redundancies. It was acknowledged that each expert also understands the question differently and provides thus different answers.

The time allocated to review the report and answer the WP5 elicitation questions was much too short, only less than three weeks as in principle a month should be available for the work. This was due to the lack of finding common dates for the kick-off and for the consensus meetings.

The purpose of the questionnaires was seen as catalysing the process and at the same time it was difficult to be innovative in the process. Lots of issues were brought up in the replies and the process was considered good.

A concern was related to the impact of the elicitation taking into consideration the late time of the elicitation in the schedule of the DOPAS project especially for the author/s of the report to improve it. At the same time it was noted that not all of the experts' remarks were so specific that the author could directly locate them and address them in the report editing.

Based on the experiences from the other work package elicitations, the general editor's role was seen very important in providing a comparable and common structure for the summary reports.

9.1.2 Timing of the elicitation

The question about the timing of the elicitation was placed. This timing was considered too late for the reporting process and for improving the structure of the reported work.

The original timetable for the elicitations did not work out due to the delays and uncertainty about the availability of the work package summary reports for the elicitation being one of the last steps in the reporting process.

Also an earlier EE of the work planned could be of advantage to improve the structure of the work in general; however, e.g. in two steps at the project planning phase and at the end like done now.

Overlapping of the elicitations (not originally planned or desired) resulted also in difficulties to find earlier common dates for the kick-off and consensus meetings. The summer season also caused some delays due to author's and experts holidays.

9.1.3 How to carry out the process

A suggestion was made to have all reports elicited in one elicitation for the overview. This was discussed in the original WP6 plan, but it was decided that it is not feasible in this project.

It was important and advantageous to have the one expert to participate all of the elicitations (and also this person could have been involved in the beginning). The need to have a view on the final report (D6.4) was asked.

The independence of the experts of the work is important. In this respect there was a minor deviation regarding the WP5 elicitation experts regarding some previous contributions made to the French deliverables in the DOPAS Project. However, this did not influence the overall outcome of the elicitation.

9.2 The facilitator's underlying views on the forms and process

The forms are intended to speed up the process. The use of the form enables a faster tracking of the different perspectives from the experts vs. reviewing direct comments on a track changes or commented report as the forms have matching questions though from a different perspective. This highlights the discussion topics for the consensus meeting quicker. Also to ensure the different perspectives, the directions for replying the questions are with purpose left open for the experts. In the replies, this has proven to provide a wider range of comments from the experts. The use of wording "uncertainties" relates in this context to content in the report that leaves the expert in doubt about e.g. the factual correctness of the information presented in the report. However, also during the process the length of the questionnaires has increased, which needs to be addressed in the future especially for the WP5 forms, if such a process is applied.

The practical elicitation in just one elicitation meeting would be very difficult to manage feasibly since the extent of the input material would be large and it would be available at too late a stage in the process to be able to provide the needed quality assurance for the deliverables. Already now the overlapping elicitations had an adverse impact on the last consensus meetings and on the reporting of the elicitation results.

The question of engaging the experts earlier into the project in the role of project advisers would potentially change the role of the experts from independent reviewers to reviewing work where they themselves have provided input. The expert elicitation was from the beginning of the DOPAS Project intended to be an alternative approach compared with the expert advisory review group of the Euratom RTD projects.

10 Final acknowledgement

The DOPAS Project thanks the experts for their valuable input for the DOPAS Project. The research leading to these results has received funding from the European Union’s European Atomic Energy Community’s (Euratom) Seventh Framework Programme FP7/2007-2013, under Grant Agreement No. 323273 for the DOPAS project.

Appendices

Tools:

1. WP5 Performance assessment expert's form
2. WP5 Domain expert's form
3. GEOSAF concept of safety envelope and design target

Descriptions:

4. Summary experimental and analysis work in WP3 and WP4
5. Fig. 11.1 "Contribution of WP5 to safety assessment and development of the safety case" - revision needs
6. Fig. 11.2 "DOPAS in the life time of the experimental program to investigate plug and seal behaviour" - revisions needs

Other materials:

7. Draft of ELSA context and work carried out for improvement

APPENDIX 1

DOPAS Expert Elicitation for WP5 20 May 2016 V1
Domain Expert (Form 1)

DOMAIN EXPERT'S ELICITATION FORM
(DOPAS EE WP5)

The summary of the work in DOPAS WP5 is reported in the final report D5.10. This report is currently at the final draft stage. After the elicitation, the D5.10 will further undergo GRS's internal quality assurance prior publication. This report is quite independent from the other DOPAS work packages but has a link with the work preceding the experiments and the WP2 requirements and safety functions. The D5.10 report includes a more **generic integrating** part of the DOPAS performance assessment work in connection with the overall RD&D[1] programmes of the waste management organisations. In your elicitation keep in mind the main objectives of the Work package 5 as described in the DOPAS project's WP5 description.

Elicitation Task/Topic under elicitation (WP5)

Is the D5.10 report complete and consistent regarding the objectives set for the work and is it "fit for use" i.e. representing an acceptable level of quality as a work package deliverable (not too much and not too little) and how well does the D5.10 achieve its task to integrate the performance assessment and modelling work done in DOPAS at the time of the writing of the report? What would be the suggestions for further linking the reporting (and work) of WP5 to the other work packages?

The elicitation's focus is to assess the completeness of the predictive process modelling and the related understanding on the overall safety and the subsystem safety in the context of the repository and in the context of the experiments as reported in D5.10. In addition, the focus is on the improvements of the state-of-the art of the process modelling in the context of the integrated performance assessment and in linking the work in a larger extent to the other work packages.

Further the elicitation aims to look at

- how the work carried out under WP5 has supported the experimental work and construction of large scale plugs and seals (closure) by predictive process modelling;
- how WP5 work has helped to understand the implications of plugs' and seals' performance on the overall safety for the whole reference period of a repository
- what are the improvements in the body of knowledge related to process modelling and its abstractions in integrated performance assessment;
- what type of uncertainties and controversies can be identified in the work carried out?

The elicitation should identify potential uncertainties, ambiguities/deviations/ unjustified conclusions, and controversies in the work.

The report focuses on individual cases and on an integrative approach derived from the cases in DOPAS.

The assessment is carried out in respect to the original objectives, to the report content and to experts' previous experiences and stronger linking of the work to the experiments.

Name of expert replying

Explain your expertise*) in regard to the target under elicitation:

[1] Research, development and demonstration

*) I.e. your personal involvement in experimental and structural design and monitoring and in the technical implementation and feasibility assessment of large structures planned or designed for underground, and/or supervising such structure constructions or test plans, and other relevant experience in the area in general including previous engagement in similar activities.

DE1. <u>General impression</u> on the appropriateness and completeness of work carried out and described in D5.10 in the context of the DOPAS project. Appropriateness and completeness of the outcomes/results received to be able to make conclusions about the soundness of the usefulness of the predictive modelling for the plugs/seals experiments from the technical experiment implementation point of view.

a) How complete, appropriate and helpful is the work carried out in the WP5 and DOPAS project for the individual component testing or experiment implementation? Have the technical limitations of the work done been identified and evaluated in making conclusions and further suggestions based on the outcomes at the time of the data freeze and also for the following stages?

b) How well has the predictive modelling served the experiments and what type of deviations from the predictions have been identified at the time of the data freeze? Are these related to the performance assessment methodologies used or to technical constraints in the experiments or mock-ups?

c) What type of uncertainties in general relate to the work carried out and reported in D5.10?

d) How clear and consistent is the terminology used in the different cases produced and included as a part of the D5.10 reporting? What suggestions for improvement would you make in this regard?

DE2. Assessment of the role of expert judgment used in the <u>predictions modelled and in carrying out corrective actions based on the performance results.</u>

a) What type of role and influence does expert input have in the use of the models, and in the analysis and assessment results and how have these been applied to the practical experiment work? Have any deviations identified from the performance assessment results been applied to DOPAS requirements and design bases an appropriate manner or recorded for the future use in D5.10 as a result? Where should these be included?

b) What influence can be seen from the fact that experiment designs were tested instead of the reference design? How did the results achieved and reported in D5.10 change the underlying assumptions related to the experiment design vs. reference design. Are the conclusions in the D5.10 about this warranted and justified based on your experience if applicable in the cases presented?

c) What type further modifications were made or suggested for the future to the input data and into the design including the material choices for the implementation process and how have they been justified? How feasible are these modifications in respect to the original input requirements and design basis?

d) What are the main uncertainties and possible biases related to the collection and interpretation of data resulting from the experiments? Does the D5.10 provide evidence of the relevance, accuracy and quality assurance of collected experiment results and of the assessment processes?

e) How could these potential uncertainties or biases influence the technical implementation of the current experiments' corrective actions or the experiments planned in the future?

f) What type of uncertainties and differences can be potentially identified in the expected initial state of the plugs resulting from the implementation compared with the implementation of plugs for a final repository design?

g) Do you identify any omissions or uncertainties related to the application of the performance assessment related knowledge that have not been identified in the report?

DE3. Technical feasibility and performance of selected and tested materials for the experiments and related uncertainties.

a) How has the meeting of the criteria for the material choices been demonstrated in the performance assessment cases? Is the evaluation of the results transparently presented and well grounded against the criteria and the related choices in D5.10 (where applicable)? Do you think they include direct or embedded expert judgments?

b) What is your assessment on the soundness of technical implementation and performance of the experiments and/or their component/s using the materials applied and resulting from the performance assessment testing and based on how their use and performance have been described in the D5.10?

c) What judgment would you make on the conclusions and lessons learned from the technical and long-term performance point of view relating to the tests, method tests and their plans used based on your reading of the report and experiences? Are they in alignment with the report's conclusions and lessons learned? Are they feasible from the technical design and implementation point of view?

d) What uncertainties do you identify at this stage of the process related to the implementation of the tests and methods for the materials' performance assessments carried out?

DE4. Rationale underlying the parameters used in the performance assessment as input or outputs from the experiment point of view and their potential uncertainties and potential for improvement.

a) What are the grounds for the input and output parameters selected for the case tests from the technical performance point of view the test plan? How have the measured or observed parameters and testing methods been chosen?

b) Who is or are the main customers for the outputs of the performance assessments? What have been the drivers in the selection and use of the outputs? Have these been reported in a transparent way? Your view on the "customer selection"? What is expected by the customer?

c) Are the report's conclusions and lessons learned in your view in alignment with the selected parameters or customer expectations? Why/Why not?

d) What are the uncertainties related to the desired initial state of the plugs taking into consideration the collected outputs (and parameters) from the test plan implementation (from the instrumentation and methods used)? What are the potential limitations related to making conclusions about these?

e) Do the work cases presented in D5.10 demonstrate consistency with the state of the art or improvements in performance assessment (areas) in general?

f) What performance assessment issues related to plugs have now been resolved and how? And what outstanding issues remain? How well have their potential commonalities been identified and justified from the project results?

g) How can the results and activities carried out for the cases be used to improve the state-of-the art of performance assessment processes and results, and the overall understanding of the initial state[2] of the full-scale plug or plug/seal components?

h) What type of constraining factors have been taken into account and which approaches or methods have been used to tackle the constraints during the implementation of the experiments and in measuring their performance? Are these adequate when keeping the set objectives of the plug experiments in mind?

i) What type of potential limitations exists in the use of these methods in a repository environment?

j) Could the identified inadequacies in the implementation and in the interpretation of the performance outcomes influence the desired performance (or the performance assessment results) and the compliance with the desired initial state of the plugs (as defined in the safety case)? If so, in which ways?

k) Is there any possible bias for performance assessment and technical feasibility in the transposing of the testing results methods and experience gained from an experimental pilot project to an industrial-scale operation? If so, how to prevent them?

l) What type of integration potential has been identified from the implementation of the different PA methodologies used among the experiments and beyond the experiments for other uses?

DE5 Rationale for lessons learned, conclusions, and suggestions from the experiment implementation from both technical feasibility and technical performance point of view.

a) How have the lessons learned and the results from the DOPAS project learned to date contributed to the ability of plugs and seals designs to meet safety functions specified in disposal concepts? (DOPAS contribution to the current technical body of knowledge?) (see also DE4 about state-of-the-art)

b) What judgment would you make on the conclusions and lessons learned from the technical performance, test results, and feasibility point of view related to the design, materials used, monitoring parameters chosen and results achieved? What uncertainties do you identify at this

[2] the state in which the plug (or its component) is after the last man-made action targeted to the plug and its near-field

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state of the process related to them?

c) Do you feel that the lessons learned from the performance assessment areas of experiments plugs/seals experiments have been well captured and reported in the D5.10 report? What is your assessment of the value of the feedback resulting from the work?

Challenges in producing the D5.10 report itself and its completeness

DC1 Have there been identified difficulties / what were the difficulties possibly encountered in producing the report and its conclusions. What were / might have been the reasons for the difficulties (are these transparent in the reporting)?

DC2 What areas do you see that need complementing in the c sections of the report? On what grounds?

Universal applicability of the results in repository and other implementation

DU1 And what parts of these PA experiences could be universally applied to all types of plugs'/seals' development and safety assessment work? What parts cannot be applied? And on which grounds?

DU2 What type of broader application potential do you identify for the results and the work presented in D5.10 in your technical field of expertise beyond the plugs/seals subsystem, components and materials?

DU3 To what extend could the construction, materials and instrumentation development work done in these experiment works be used for other repository components than plugs (and seals)?

Other review comments related to the D5.10 (e.g. other information to be included to the report concerning terminology, theories, referencing to other work related to plugs and seals)

Feedback on the EE process and the form:

This is a pilot process. What are your proposals for changes or additions concerning the questions and visual appearance of this form, needed for improving the usability of the form as a tool in the formal expert elicitation process of this type of full-scale demonstration project?

APPENDIX 2

DOPAS Expert Elicitation for WP5 20 May 2016 V1
PA/SA Expert (Form 2)

PERFORMANCE ASSESSOR'S (/SAFETY ANALYST'S) ELICITATION FORM
(DOPAS EE WP5)

The summary of the work in DOPAS WP5 is reported in the final report D5.10. This report is currently at the final draft stage. After the elicitation, the D5.10 will further undergo GRS's internal quality assurance prior publication. This report is quite independent from the other DOPAS work packages but has a link with the work preceding the experiments and the WP2 requirements and safety functions. The D5.10 report includes a more **generic integrating** part of the DOPAS performance assessment work in connection with the overall RD&D[1] programmes of the waste management organisations. In your elicitation keep in mind the main objectives of the Work package 5 as described in the DOPAS project's WP5 description.

Elicitation Task/Topic under elicitation (WP5)
Is the D5.10 report **complete and consistent regarding the objectives set for the work and is it "fit for use"** i.e. representing an acceptable level of quality as a work package deliverable (not too much and not too little) and how well does the D5.10 achieve its task to integrate the performance assessment and modelling work done in DOPAS at the time of the writing of the report? What would be the suggestions for further linking the reporting (and work) of WP5 to the other work packages? The elicitation's focus is to assess the completeness of the predictive process modelling and the related understanding on the overall safety and the subsystem safety in the context of the repository and in the context of the experiments as reported in D5.10. In addition, the focus is on the improvements of the state-of-the art of the process modelling in the context of the integrated performance assessment and in linking the work in a larger extent to the other work packages. Further the elicitation aims to look at • how the work carried out under WP5 has supported the experimental work and construction of large scale plugs and seals (closure) by predictive process modelling; • how WP5 work has helped to understand the implications of plugs' and seals' performance on the overall safety for the whole reference period of a repository • what are the improvements in the body of knowledge related to process modelling and its abstractions in integrated performance assessment; • what type of uncertainties and controversies can be identified in the work carried out? The elicitation should identify potential uncertainties, ambiguities/deviations/ unjustified conclusions, and controversies in the work and stronger linking of the work to the experiments. The report focuses on individual cases and on an integrative approach derived from the cases in DOPAS. The assessment is carried out in respect to the original objectives, to the report content and to experts' previous experiences.

Name of expert responding

Explain your expertise*) in regard to the target under elicitation:

[1] Research, development and demonstration

*) personal involvement in the input data/test plan production, implementation and/or results assessment related to practical technical and long-term safety related requirement setting, performance assessment of design bases and in the monitoring and interpretation of performance related inputs and outputs from geological disposal related experiments and/or in the assessment of technical feasibility of safety important structures/components in disposal.

PA1. General impression on the appropriateness and completeness of work carried out and described in D5.10 in the context of the DOPAS project. Appropriateness and completeness of the outcomes/results received to be able to make conclusions about the soundness of the predictive modelling for the plugs/seals experiments.

a) How complete and appropriate is the work carried out in the WP5 and DOPAS project? Have the limitations of the work done been identified and evaluated in making conclusions and further suggestions based on the outcomes at the time of the data freeze and also for the following stages?

b) How well has the predictive modelling served the experiments and what type of deviations from the predictions have been identified at the time of the data freeze?

c) What type of uncertainties in general relate to the work carried out?

d) How clear and consistent is the terminology used in the different cases produced and included as a part of the D5.10 reporting? What suggestions for improvement would you make in this regard?

PA2. Appropriateness and completeness of the individual <u>conceptual and calculation model/s and codes</u> used in the presented generic cases and individual DOPAS experiment related cases for making conclusions and assessment about the performance of the individual laboratory, mock-up or the experiments on plug/seal or their components.

a) What are the main uncertainties related to the conceptual or calculation model/s or codes applied in the work? How appropriate and transparent are the different types of models and related calculations used from the performance or compliance assessment point of view? Have their limitations been described sufficiently?

b) What other alternatives would have been available for the use for the same purposes? Is the choice among the alternative grounded in the reporting?

c) What are the main uncertainties related to the application/use of the models and concepts (and code), the testing methodologies and the used approaches in making the evaluation about the impact of the test outcomes on the function/safety functions of the plugs, plug components or component materials?

d) What type of uncertainties, omissions or risks can you identify regarding the data sources (resulting from the models used) and the outcomes from the experiments and the tests carried out or from their interpretation in reaching compliance with the set requirements and eventually the desired/expected initial states for the plugs?

e) Are the identified uncertainties transparent in the reporting?

f) Is the use of results' data in performance or safety assessment (PA/SA) directly possible/feasible or do the results present an intermediate outcome in the data production chain for compliance assessment of the design basis? If the result data cannot be directly applied to PA/SA, what would need to be done to make use of the results for this purpose?

PA3. Role of the expert input and output in the data use and interpretation of the results from the experiments: about the initial state for the performance assessment and for the safety case (consider this also in the context of the reference design, not only in the experiment design context, if possible based on the case information given).

a) What type of role and influence does expert input have in the use of the models and codes, and in making the analysis and assessment process? Have the DOPAS requirements and design bases been applied in an appropriate manner and what influence (if any) can be seen in the performance assessment from the fact that the experiment designs were tested instead of the reference design? How did the results achieved and reported in D5.10 change the underlying assumptions related to the experiment design vs. reference design. Are the conclusions in the D5.10 about this warranted and justified based on your experience if applicable in the cases presented?

b) What kind of assessment about the completeness of the experiment or component and their materials' related modelling and process understanding in respect to the overall objectives of demonstrating compliance of the design basis with a) the reference designs and b) with the experiment designs can now be made about their performance after the results from the experiments are available? Is your assessment in alignment with the D5.10 conclusions?

c) What are the main uncertainties and possible biases related to the collection and interpretation of data resulting from the experiments? Does the D5.10 provide evidence of the relevance, accuracy and quality assurance of the collected results (from the cases) and of the assessment processes?

d) What steps would need to be complemented in the descriptions of D5.10 to present a useful process for demonstrating consistency with the state of the art the process understanding, abstractions and integrated modelling? Do you see them adequate to achieve the expected or set objectives for assessing the plugs experiments and/or the objectives set for them in DOPAS or at the following programme stage? On what grounds?

e) What type of constraining factors have been taken into account and which approaches or methods have been used to tackle the constraints in the assessment and evaluations made? Are these adequate when keeping the set objectives of the experiment/s in mind?

f) Do you feel any additional doubt concerning the adequacy of the produced experiment itself or its outcomes for carrying out a performance assessment or using the outcomes for a safety case based on the D5.10? Are there difficulties in handling the identified uncertainties in performance assessment or in the assessment of other compliance with the requirements? If so, about what and why, what are the reasons?

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g) How can the results and activities carried out for the cases be used to improve the state-of-the art of performance assessment processes and results, and the overall understanding of the initial state[2] of the full-scale plug or plug/seal components?

h) What are the conditions in the repository environment to be expected underground, which may have a more severe influence compared to those prevailing on the experimental test site from the performance and long-term safety point of view? How could they possibly influence the plug/seal performances at different stages of this subsystem evolution?

i) Is there any possible bias for performance assessment and technical feasibility in the transposing of the testing results methods and experience gained from an experimental pilot project to an industrial-scale operation? If so, how to prevent them?

j) Could any identified inadequacies in the implementation (construction of plug/seal) influence the desired performance (or the performance assessment results) and the compliance with the desired initial state of the plug/seal (as defined in the safety case) and what would the influence of this be for the performance assessment?

PA4. Preliminary assessment of the adequacy of and uncertainties related to the data collection, measurement and monitoring systems used.

a) Have the potential quality related errors related to the data input and output processes been identified in the reporting?

b) What type of uncertainties or reductions in quality of outputs can be identified (if any) from the presented D5.10 solutions with regard to the technical performance 1) within the time frame of DOPAS project, 2) with regard to the expected performance at initial state or 3) with regards to the long-term safety related performance?
Please take into account the different objectives and lifetimes of the various individual experiments in their respective repository concept or otherwise as e.g. some experiments represent only technical feasibility testing.

c) What are the major or most significant uncertainties resulting from the above?

PA5. Rationale for lessons learned, conclusions, and suggestions from the experiment implementation from long term performance and safety point of view.

a) What judgment would you make on the conclusions and lessons learned from the technical performance, test results, and long-term performance point of view related to the design, materials used, monitoring parameters chosen and results achieved contrasted with the case example results of D5.10? What uncertainties do you identify at this state of the process related to them?

b) How have the lessons learned and the results from the DOPAS project learned to date contributed to the ability of plugs and seals designs to meet safety functions specified in disposal concepts? (DOPAS contribution to the current body of knowledge in performance assessment?)

[2] the state in which the plug (or its component) is after the last man-made action targeted to the plug and its near-field

Challenges in producing the report itself and its completeness

PC1 Have there been identified difficulties / what were the difficulties possibly encountered in producing the report and its results what were / might have been the reasons for the difficulties? Are these transparent in the D5.10? What would you suggest to improve the link between the reporting in WP5 to the other work packages?

PC2 Is the information provided in the report adequate for any future plug and seal system developer to benefit from the lessons learned and experience gained by the DOPAS project partners throughout the development process? What is especially transferable to a seal system developer? How can the links between technical design and technology development and performance assessment be improved?

PC3 Does the report contain relevant recommendations on the organisation, resources and competencies needed to plan for, design and implement and test a plugging/sealing system and its performance?

PC4 What areas do you see that need complementing in the design, material development, instrumentation/monitoring/test planning, results collection and interpretation, and construction sections of the report? On what grounds?

Universal applicability of the results in repository implementation

PU1 And what parts of the experiment implementation experiences could be universally applied to all types of plugs'/seals' development, testing, and construction work? What parts cannot be applied? And on which grounds?

PU2 What type of broader application potential do you identify for the results and the work presented in D5.10 in your field of expertise (PA/SA) beyond the plugs/seals subsystem?

PU3 To what extend could the testing and assessment work done in these experiment works be used for other repository components than plugs and seals (from the performance and safety assessment perspective)?

PU4 Could possible inadequacies in the work process influence the desired performance (or the performance assessment results) and the compliance assessment with the set requirements for state of the plug/seal (as defined in the safety case)? If so, in which ways?

PU5 What type of uncertainties do you see remaining related to the chosen models, use of process models and experimental work and analyses related to these and for making the report's conclusions (individual cases or integration in the report)? How has this been tackled in the reported work?

Rationale and way of thinking underlying your preliminary assessment (previous)

PR1 What are the assumptions and grounds[3] underlying your assessment?

PR2 Did you experience difficulties in making your assessment? If so, what kind of difficulties and for why? What were the reasons?

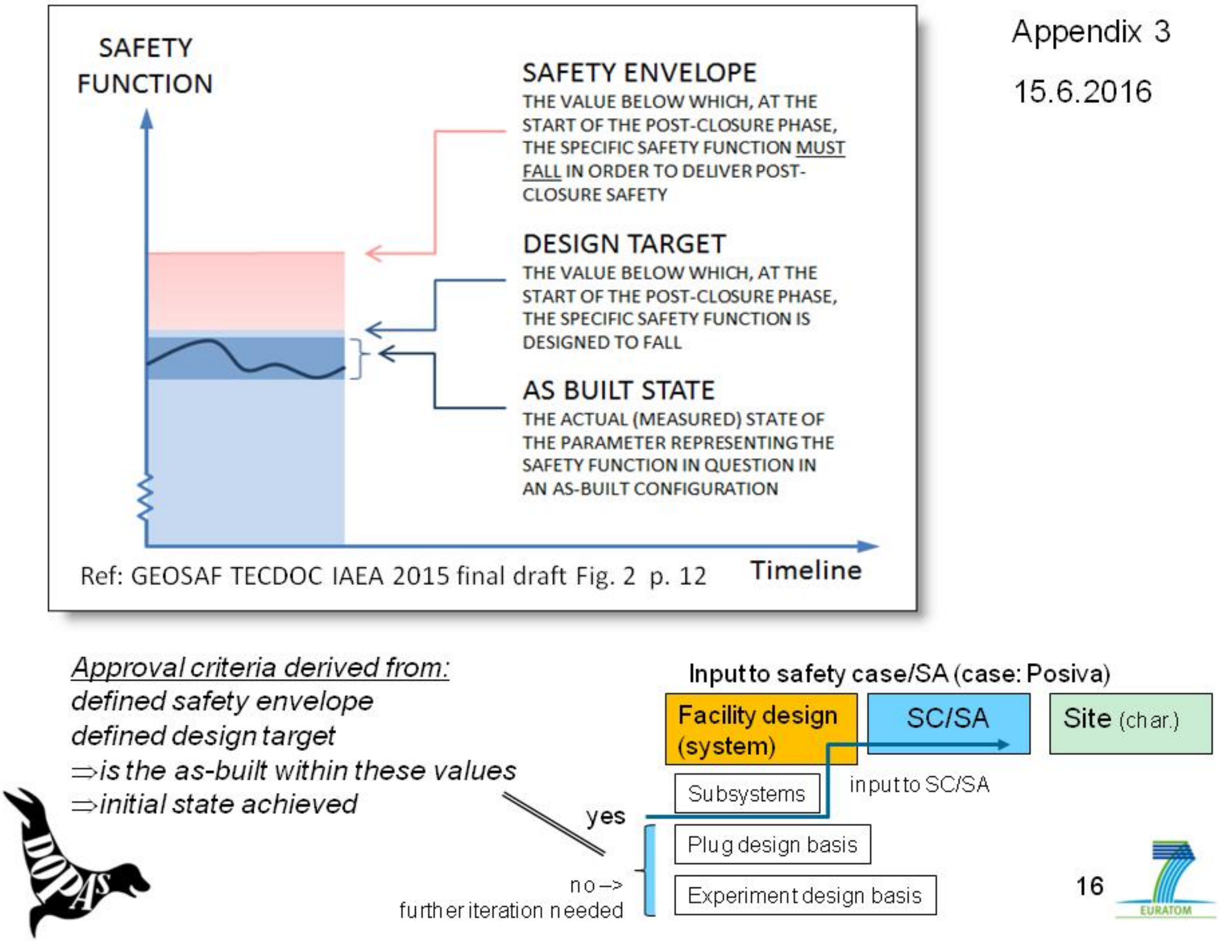
[3] e.g., literature, pilot modelling results, sensitivity analysis, use of conservatism, authorities' requirements

PR3 Do you feel any doubt concerning the adequacy of your assessment? If so, about what and for what reasons?

Other review comments related to the D5.10 (e.g. other information to be included to the report concerning terminology, theories, referencing to other work related to plugs and seals:

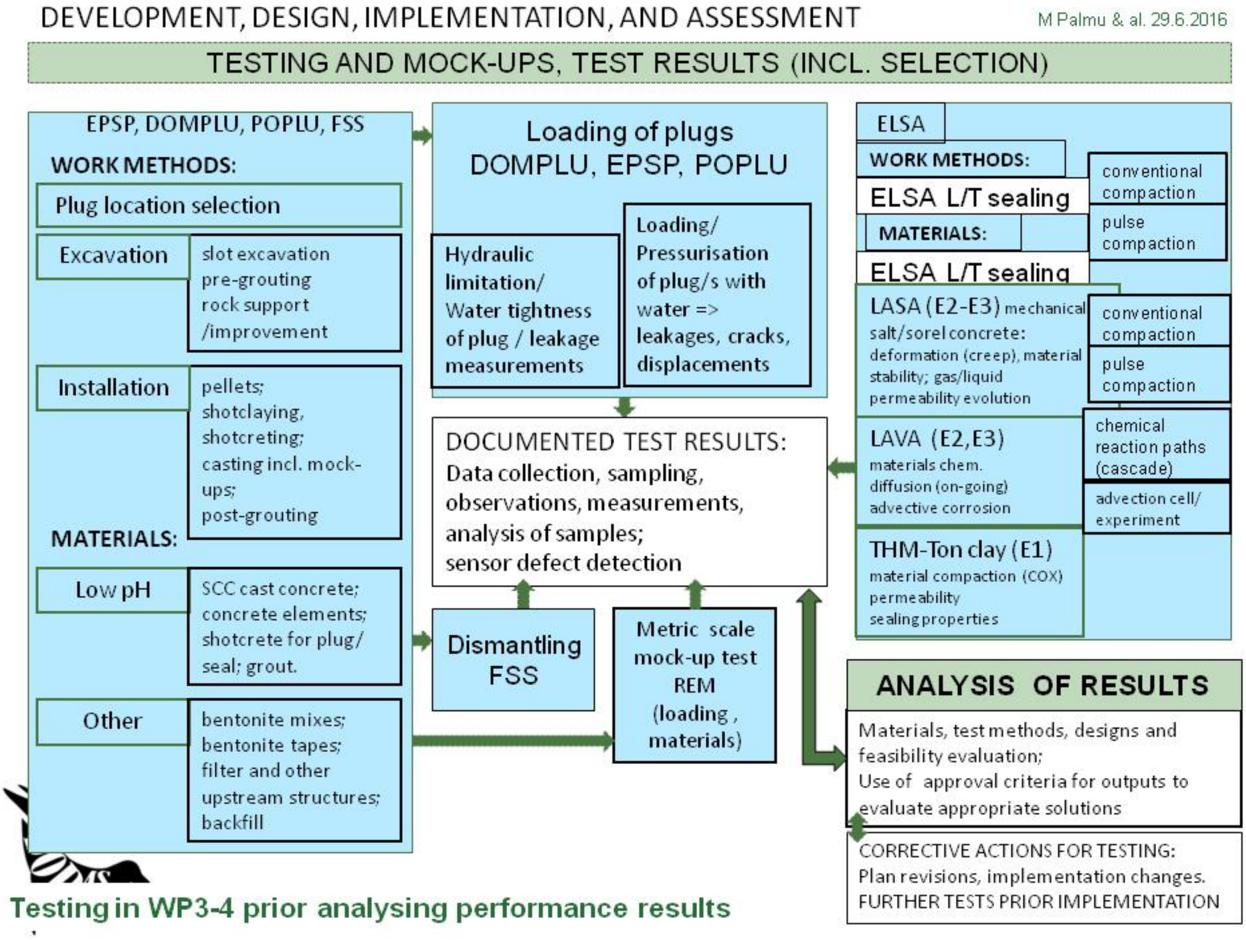
Feedback on the EE process and the form:

This is a pilot process. What are your proposals for changes or additions concerning the questions and visual appearance of this form, needed for improving the usability of the form as a tool in the formal expert elicitation process of this type of full-scale demonstration project?



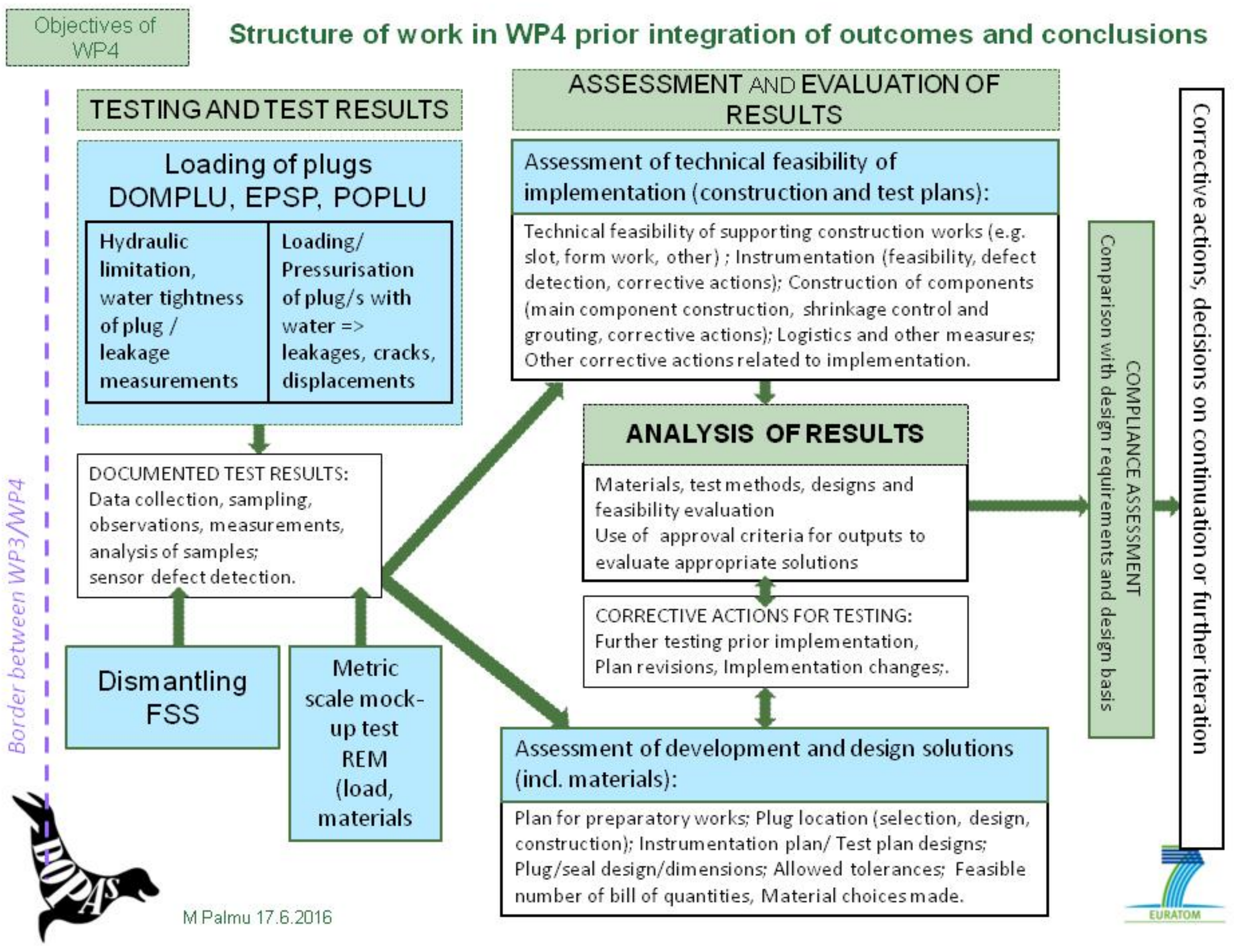
Appendix 3
15.6.2016
SAFETY FUNCTION
SAFETY ENVELOPE
THE VALUE BELOW WHICH, AT THE START OF THE POST-CLOSURE PHASE, THE SPECIFIC SAFETY FUNCTION MUST FALL IN ORDER TO DELIVER POST-CLOSURE SAFETY
DESIGN TARGET
THE VALUE BELOW WHICH, AT THE START OF THE POST-CLOSURE PHASE, THE SPECIFIC SAFETY FUNCTION IS DESIGNED TO FALL
AS BUILT STATE
THE ACTUAL (MEASURED) STATE OF THE PARAMETER REPRESENTING THE SAFETY FUNCTION IN QUESTION IN AN AS-BUILT CONFIGURATION
Timeline
Ref: GEOSAF TECDOC IAEA 2015 final draft Fig. 2 p. 12
Approval criteria derived from:
defined safety envelope
defined design target
⇒is the as-built within these values
⇒initial state achieved
yes
no –>
further iteration needed
Input to safety case/SA (case: Posiva)
Facility design (system)
SC/SA
Site (char.)
Subsystems
input to SC/SA
Plug design basis
Experiment design basis
16

APPENDIX 4-1

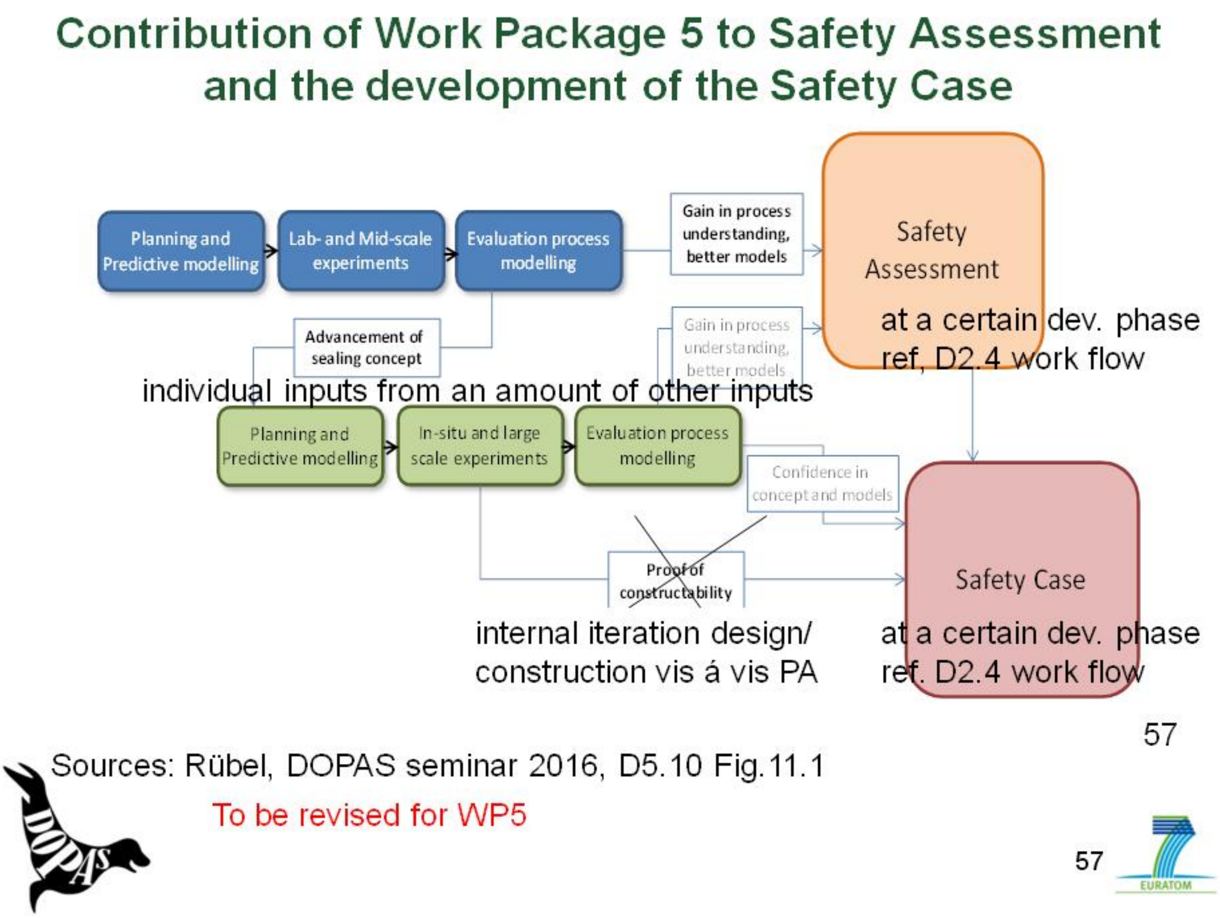


DEVELOPMENT, DESIGN, IMPLEMENTATION, AND ASSESSMENT
M Palmu & al. 29.6.2016
TESTING AND MOCK-UPS, TEST RESULTS (INCL. SELECTION)
EPSP, DOMPLU, POPLU, FSS
WORK METHODS:
Plug location selection
Excavation
slot excavation pre-grouting rock support /improvement
Installation
pellets; shotclaying, shotcreting; casting incl. mock-ups; post-grouting
MATERIALS:
Low pH
SCC cast concrete; concrete elements; shotcrete for plug/ seal; grout.
Other
bentonite mixes; bentonite tapes; filter and other upstream structures; backfill
Loading of plugs DOMPLU, EPSP, POPLU
Hydraulic limitation/ Water tightness of plug / leakage measurements
Loading/ Pressurisation of plug/s with water => leakages, cracks, displacements
DOCUMENTED TEST RESULTS: Data collection, sampling, observations, measurements, analysis of samples; sensor defect detection
Dismantling FSS
Metric scale mock-up test REM (loading , materials)
ELSA
WORK METHODS:
ELSA L/T sealing
conventional compaction
pulse compaction
MATERIALS:
ELSA L/T sealing
LASA (E2-E3) mechanical salt/sorel concrete: deformation (creep), material stability; gas/liquid permeability evolution
conventional compaction
pulse compaction
LAVA (E2,E3) materials chem. diffusion (on-going) advective corrosion
chemical reaction paths (cascade)
advection cell/ experiment
THM-Ton clay (E1) material compaction (COX) permeability sealing properties
ANALYSIS OF RESULTS
Materials, test methods, designs and feasibility evaluation; Use of approval criteria for outputs to evaluate appropriate solutions
CORRECTIVE ACTIONS FOR TESTING: Plan revisions, implementation changes. FURTHER TESTS PRIOR IMPLEMENTATION
Testing in WP3-4 prior analysing performance results

APPENDIX 4-2

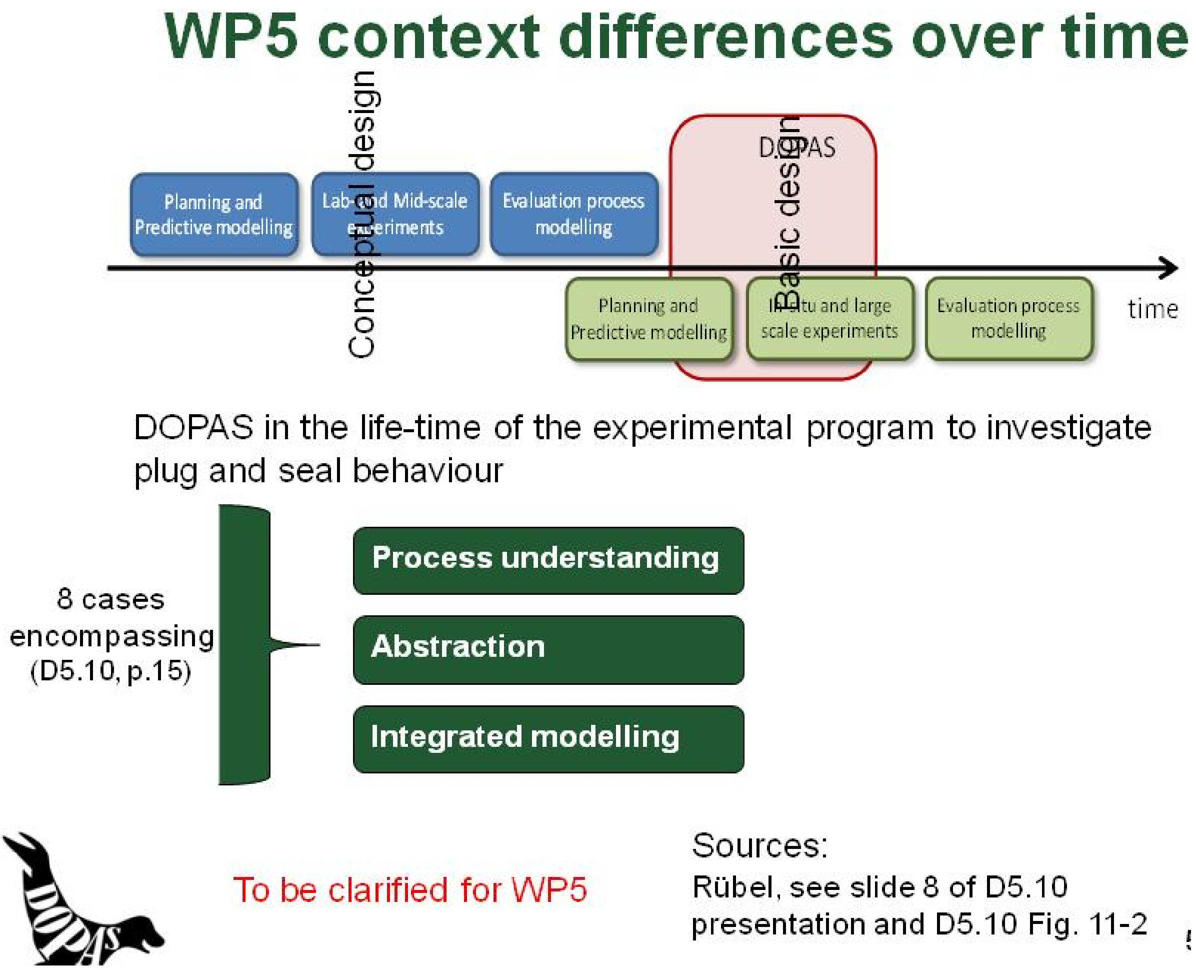

Objectives of WP4
Structure of work in WP4 prior integration of outcomes and conclusions
TESTING AND TEST RESULTS
Loading of plugs DOMPLU, EPSP, POPLU
Hydraulic limitation, water tightness of plug / leakage measurements
Loading/ Pressurisation of plug/s with water => leakages, cracks, displacements
DOCUMENTED TEST RESULTS: Data collection, sampling, observations, measurements, analysis of samples; sensor defect detection.
Dismantling FSS
Metric scale mock-up test REM (load, materials
Border between WP3/WP4
ASSESSMENT AND EVALUATION OF RESULTS
Assessment of technical feasibility of implementation (construction and test plans):
Technical feasibility of supporting construction works (e.g. slot, form work, other) ; Instrumentation (feasibility, defect detection, corrective actions); Construction of components (main component construction, shrinkage control and grouting, corrective actions); Logistics and other measures; Other corrective actions related to implementation.
ANALYSIS OF RESULTS
Materials, test methods, designs and feasibility evaluation
Use of approval criteria for outputs to evaluate appropriate solutions
CORRECTIVE ACTIONS FOR TESTING: Further testing prior implementation, Plan revisions, Implementation changes;.
Assessment of development and design solutions (incl. materials):
Plan for preparatory works; Plug location (selection, design, construction); Instrumentation plan/ Test plan designs; Plug/seal design/dimensions; Allowed tolerances; Feasible number of bill of quantities, Material choices made.
COMPLIANCE ASSESSMENT
Comparison with design requirements and design basis
Corrective actions, decisions on continuation or further iteration
M Palmu 17.6.2016

APPENDIX 5

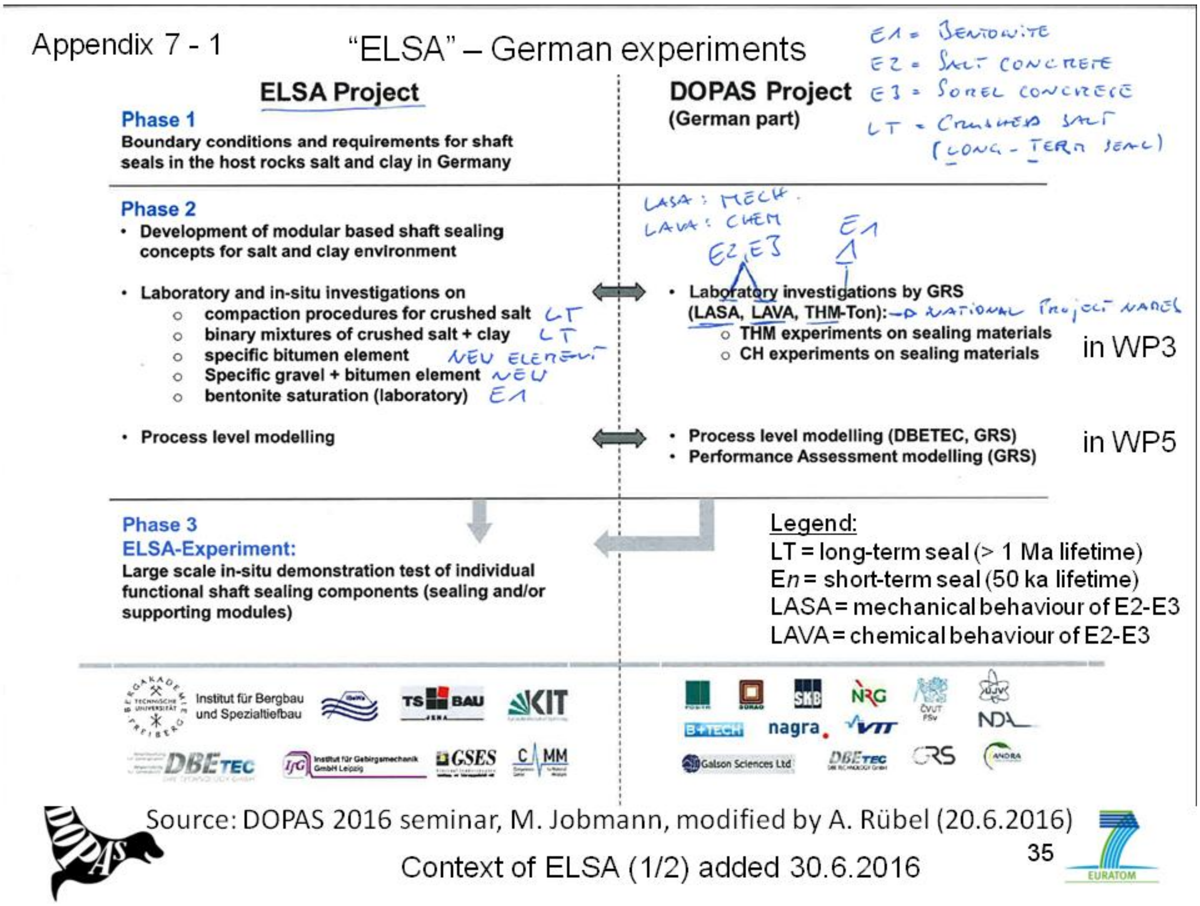


Contribution of Work Package 5 to Safety Assessment and the development of the Safety Case
Planning and Predictive modelling
Lab- and Mid-scale experiments
Evaluation process modelling
Gain in process understanding, better models
Safety Assessment
at a certain dev. phase ref, D2.4 work flow
Advancement of sealing concept
Gain in process understanding, better models
individual inputs from an amount of other inputs
Planning and Predictive modelling
In-situ and large scale experiments
Evaluation process modelling
Confidence in concept and models
Proof of constructability
Safety Case
internal iteration design/ construction vis á vis PA
at a certain dev. phase ref. D2.4 work flow
57
Sources: Rübel, DOPAS seminar 2016, D5.10 Fig.11.1
To be revised for WP5
57
EURATOM

APPENDIX 6



WP5 context differences over time
Conceptual design
Basic design
DOPAS
Planning and Predictive modelling
Lab- and Mid-scale experiments
Evaluation process modelling
Planning and Predictive modelling
In situ and large scale experiments
Evaluation process modelling
time
DOPAS in the life-time of the experimental program to investigate plug and seal behaviour
8 cases encompassing (D5.10, p.15)
Process understanding
Abstraction
Integrated modelling
To be clarified for WP5
Sources:
Rübel, see slide 8 of D5.10 presentation and D5.10 Fig. 11-2

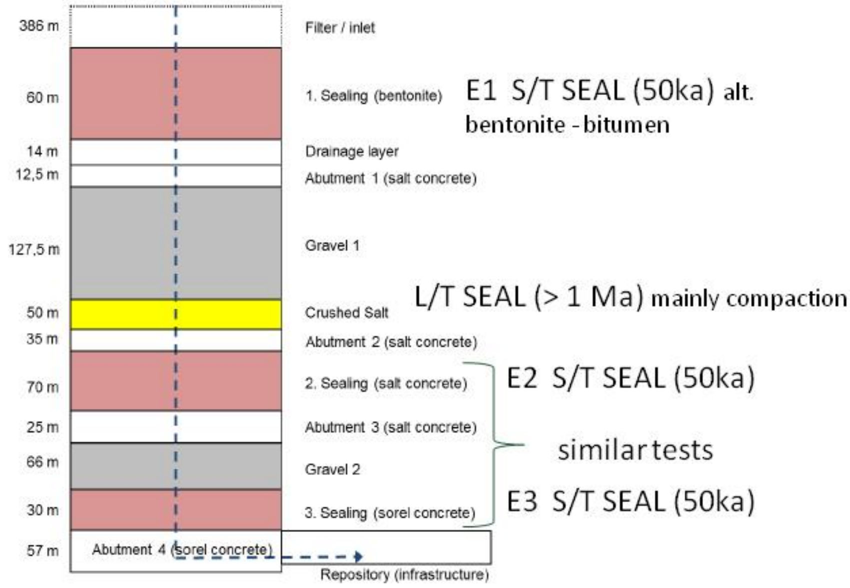


The new elements (specific bitumen element and specific gravel + bitumen element) are not yet included in the calculations described in D5.10 Chapter 6 (see Fig. 6.1), Chapter 7, and Chapter 8 of the WP5 final report due to on-going work.

Appendix 7 - 2

Schematic test model for the shaft sealing

Context of ELSA (2/2) added 30.6.2016



M. Palmu 29.6.2016

Source of test model: D5.10, p.125, see also Fig. 6.1 in D3.30
See previous slide for details of seal types