ANNEX 2: Summary of the Topical Session on

"Analysing and Addressing Uncertainties and Sensitivities"

Chair: Lucy Bailey, NDA, UK

Rapporteur: Klaus Röhlig, TU-Clausthal

The Topical Session and this summary report were prepared by Lucy Bailey (NDA, UK, session chair), Allan Hedin (SKB, Sweden) and Klaus-Jürgen Röhlig (TUC, Germany, session rapporteur).

1 Background

Uncertainties are an inevitable feature of producing an assessment of the evolution of a geological disposal facility for radioactive wastes over a timescale of hundreds of thousands of years. The recently completed NEA MeSA project[1] identified that internationally, there is now consensus on the types and sources of uncertainty in safety assessments; and such uncertainties are typically classified into scenario uncertainties, model uncertainties and data and parameter uncertainties. However, it is important to note that these uncertainty classes are related to each other, rather than being mutually exclusive, so that in practice particular uncertainties can be handled in different ways, as one or more of these classes.

The MeSA project also confirmed that strategies for treating uncertainties within the safety assessment are well established, generally falling into one or more of the following five categories:

1. Demonstrating that the uncertainty is irrelevant to safety;

2. Addressing the uncertainty explicitly;

3. Bounding the uncertainty;

4. Ruling out the uncertain event or process;

5. Using an agreed stylised approach to avoid addressing the uncertainty explicitly.

There is a variety of methods and techniques for implementing these approaches to addressing uncertainties and for analysing the sensitivity of the safety assessment outcome to specific uncertainties, including those developed in the EC PAMINA project and subsequent NEA MeSA project.

[1] Methods for Safety Assessment of Geological Disposal Facilities for Radioactive Waste. Outcomes of the NEA MeSA Initiative. OECD, Paris 2012, NEA No. 6923, ISBN 978-92-64-99190-3. http://www.oecd-nea.org/rwm/reports/2012/nea6923-MESA-initiative.pdf

2 Aims and scope of the Topical Session

The topical session explored examples of methods and techniques to addressing uncertainties and sensitivities, discussing their relative strengths and weaknesses, with a view to assessing their value in building confidence in the safety case. The aims of the topical session were to:

- Share recent developments regarding addressing and analysing uncertainties and sensitivities in all aspects of the safety case (including R&D, construction, assessment methodology, etc.);
- Share and discuss actual experiences in applying a range of methods, techniques and analytical tools for managing uncertainties in the safety case;
- Discuss the role of regulatory guidance and constraints regarding the treatment of uncertainty in the safety case;
- Discuss how we can have confidence to make decisions in the presence of uncertainties and how best to communicate this confidence to those outside the safety case community;
- Consider the value of producing an NEA IGSC position paper or flyer on the management of uncertainties in the safety case.

3 Presentations

Presenters were asked to discuss real examples that have been (or will be) applied in support of a safety case as far as possible, and to describe what worked well and what worked less well, together with any lessons learned. They were further asked to focus on building confidence in the safety case and communicating that confidence to different audiences (for example regulators and stakeholder communities). The issues and key questions to be addressed by the topical session presenters (if possible / where appropriate) were communicated as follows:

- Please use real examples as far as possible.
- Please report what worked well and what worked less well with regard to (i) safety case compilation and (ii) communication to different audiences.
- If possible, provide examples about decisions in the presence of uncertainties (what was “good enough” for you?).
- Specify the uncertainty (-ies) to be addressed in your talk, its nature and source(s). If possible, use the terminology of the MeSA report.
- Describe the analytical means to address the uncertainties and the strengths and weaknesses of the approach.

- Summarise the results and implications for repository development activities such as site investigation, R&D, repository layout, etc.
- Provide a statement of confidence: What has been achieved by the approach described? What questions are left open and how significant are they?
- Explain how you arrived at conclusions regarding overall performance and safety in the light of all the various aspects of uncertainty addressed in the safety case.

The following presentations were given:

- Regulatory Guidance for Deep Geological Disposal Facilities (UK): Managing Uncertainties. *Doug Ilett, Environment Agency, UK*
- Uncertainty Treatment in the Waste Isolation Pilot Plant (WIPP) Safety Case *Abraham Van Luik, Carlsbad Field Office, US Department of Energy*
- Uncertainty management tools to steer the RD&D of a geological disposal programme *Manuel Capouet, Christophe. Depaus & Marten Van Geet, Ondraf/Niras, Belgium*
- Strategies for addressing Model Uncertainty *Lucy Bailey, Alex Carter & Mike Poole, NDA-RWMD, UK*
- Management of Uncertainties *Fabrice Boissier & Lise Griffault, Andra, France*
- Repository layout accounting for uncertainty concerning the location and size of fractures. Establishing the link between assessment and engineering *Allan Hedin & Raymond Munier, SKB, Sweden*
- Analysing sensitivities: Sophistication of mathematical tools versus practical application *Klaus-Jürgen Röhlig, Elmar Plischke, Sebastian Kuhlmann, TUC, Germany*
- Addressing Uncertainties in Geologic Disposal: A WIPP (Primarily) Perspective *Thomas Peake, US EPA*

4 Observations from the presentations and the ensuing discussion

In the following, only a selection of issues is addressed (generally the ones the discussion was focused on and for which new aspects arose). For further details, the full set of presentations can be found at http://www.oecd-nea.org/download/igsc/IGSC-14_000.htm.

4.1 Systematic, traceable and transparent approach to confidence building during programme evolution

In the UK, compiling a "register of significant uncertainties" is a regulatory requirement to direct the implementer towards establishing a systematic, traceable and transparent approach to confidence building during programme evolution as well as enhancing stakeholders' confidence in the strategy for addressing outstanding issues (e.g. by R&D) (see presentation by Doug Ilett, http://www.oecd-nea.org/download/igsc/documents/6-a-2___Ilett_____2012.pdf). This requirement had been "tested" during the compilation of NDA's recent generic Safety Case and will be further developed as the disposal facility development programme progresses and a site-specific safety case starts to be developed. In Sweden, where this idea had also been raised, the regulators, in their review of the Swedish SR-Can assessment, jointly decided after consideration not to require such a register of uncertainties because no obvious advantage was identified to justify the required effort. Rather, the regulators pointed to the importance of justifying and explaining methods to handle different uncertainties in the different phases of the safety assessment, and that it is clear where in the safety report the different uncertainty analyses are documented.

The discussion focused on the pros and cons of compiling and maintaining such a register. It was noted that such a register could be a good tool for demonstrating a systematic approach and to record and demonstrate evolution and progress when addressing uncertainties in a programme. On the other hand, a thorough register would require considerable resources, and the decision about which issue is to be considered 'significant' might not always be easy. Also, the 'significance' of an issue or an uncertainty might change over time with programme evolution and is a subjective judgment upon which stakeholders might not agree.

There was unanimous agreement that establishing and documenting a systematic, traceable and transparent approach to confidence building throughout the programme evolution is an indispensable element of safety case development which is needed to aid the developer's work as well as to inform stakeholders. Several existing and potential tools were mentioned (e.g. issues registers, process registers, safety functions, safety statements) which might be, or are already, helpful for directing and documenting the confidence building process. Studying such tools more systematically might be beneficial. It was also observed that the term 'register' might create too formalistic an impression which could be detrimental.

4.2 Complexity as a specific challenge

It was noted that complexity of systems (or models) is, despite all attempts to keep systems (and models) robust and thus simple, an often inherent feature which is related to, but not the same as, uncertainty. Being a potential source for uncertainties, complexity issues might lead to needs for R&D or for design optimisation. However, the level and kind of awareness concerning complexity issues is not necessarily the same for different staff members (modellers, developers). Appropriately communicating the nature of the problem(s), the need for systematic identification and analysis, and ways of addressing them in a repository programme between different specialist teams is essential. Some national programmes have developed and applied various tools and procedures for establishing efficient internal and external communication of such issues, e.g. safety functions and statements (Andra, Ondraf/Niras), audits and data clearance systems (Nagra), but further development may be beneficial (see for example, the presentations by Manuel Capouet (http://www.oecd-nea.org/download/igsc/documents/6-a-4___Capouet_Uncertainty_mgt_IGSC14_D.pdf) and by Lise Griffault (http://www.oecd-nea.org/download/igsc/documents/6-a-6___Boissier_Andra_uncertainties_management.pdf)).

The presentation by Allan Hedin (http://www.oecd-nea.org/download/igsc/documents/6-a-7__Hedin_IGSC-2012_HedinMunier.pdf) can be seen as an example for which, in order to address the specific problem of avoiding inappropriate locations for emplacement boreholes, such communication worked well in both ways: Developers were informed by modellers about the nature of the problem, a layout approach was developed and risk reduction as a result of applying this approach was demonstrated.

4.3 The role of conservatism

Modelling, especially when aiming at compliance demonstration, might cover complex issues by taking approaches erring on the conservative side. Such conservatism often serves well but its usefulness depends on the stage of repository development and lifecycle. Often, dependent on the purpose of the analysis and on the component to be studied, but especially when options are to be compared for optimisation purposes, moving towards less conservative approaches, which are closer to our understanding of the system and its details, is necessary. Such less conservative approaches are often, also amongst specialists, called "realistic". It was, however, noted that the antonym of "realistic" is not "conservative" but "unrealistic" and that the use of the term "realistic" is not the best way of expressing what is meant. Alternatives such as "best guess" or "best estimate" were briefly discussed but no firm conclusion about a better term was reached. It was also observed that moving to a less conservative approach during programme evolution – possibly accompanied by decreasing estimates of risks – might by some be perceived as dubious or unsound. In any case, and independent of the degree and kind of conservatism introduced, it is essential to communicate clearly the level of understanding for each process at stake – be it internally, for the purpose of regulatory review, or to wider audiences. Having done this, it becomes more straight-forward to recognise and to explain conservatisms applied.

4.4 Modelling

The presentation by Lucy Bailey (http://www.oecd-nea.org/download/igsc/documents/6-a-5__Bailey_modelling_strategies_presentation.pdf) focused on confidence building in models and their applications. NDA uses two approaches (bottom-up and top-down) to develop a model hierarchy (of process – component – total system models) from two different view-points. The bottom-up and top-down models have different uses (e.g. process understanding versus system description) and can be seen as related to different psychologies of cognition. In the discussion, related issues such as "code uncertainty" and "code bias" were raised but not fully explored. It was concluded that, again, robustness is key for addressing uncertainties related to conceptual understanding, modelling and coding, and data. Modelling is now recognized as having several roles, for example to aid process and system understanding, inform R&D and optimisation, in addition to calculating risks; and it has now found its appropriate place in safety case development and presentation.

4.5 Communicating confidence building

The discussion briefly touched upon, but did not thoroughly address, communication issues. The challenge of communicating the concept of decision making in the presence of uncertainty, or, in other words, the iterative process of confidence building, was addressed. In particular, the point was raised that non-specialists tend to see a system as *per se* either "safe" or "unsafe" and that it is sometimes hard to communicate that a programme can and has to move forward despite the existence of uncertainties. It is essential to communicate open issues honestly and, at the same time, to communicate clearly the way to address each issue (e.g. by R&D). Instead of allowing the presence of uncertainties to be perceived as a lack of safety, it should be

communicated that the process of identifying open issues and challenging assumptions is part of optimising the system, building confidence and thus achieving safety. It is especially important to communicate that safety will not rely on model assumptions. Rather, understanding and its communication comes first.

4.6 Terminology issues

It was observed that terminology should be used with care; the examples of the usage of terms such as "register of significant uncertainties" or "realistic modeling" (cf. above) show that even "internally" (i.e. amongst specialists) there is potential for confusion and misunderstanding. This is all the more valid when communicating approaches or results to non-specialists.

4.7 Role of, and methods for, sensitivity analysis

In the presentation by Klaus-Jürgen Röhlig (http://www.oecd-nea.org/download/igsc/documents/6-a-8_Roehlig_Analysing_sensitivities_version02.pdf) a number of approaches to sensitivity analysis were introduced which, despite being able to detect sensitivities which will remain hidden when applying the more widely used methods, and despite efforts undertaken e.g. in the EU PAMINA project (http://www.ip-pamina.eu/downloads/pamina2.1.d.1.pdf) are hardly ever used in "real" safety assessments. It was also noted that the claim often made that sensitivity analyses can help identify R&D needs, is lacking in substantiating examples. However, in the discussion the point was made that sensitivity analyses can contribute to confidence building by confirming what was assumed about sensitivities or lack thereof. Instead of identifying R&D needs they may support the safety case by confirming that uncertainties are *not* sensitive with regard to safety. However, it should be kept in mind that sensitivity by nature is about models rather than about systems. If a process is not mapped or conservatively simplified in a model, sensitivity analyses will hardly reveal sound information about its importance. Additionally, if a model does not account for a relationship (e.g. a non-monotonic one or a parameter interaction), sophisticated methods able to identify such a relationship are of no use. In general, it was observed that the simpler, mostly regression or rank regression-based methods presently being applied usually serve their purpose well. The value of more sophisticated methods for waste disposal safety assessment remains still to be shown. The same applies for the possibility of applying sensitivity analyses to process models and safety function indicators.

5 IGSC flyer on confidence building

The IGSC agreed to produce a flyer about the process of confidence building during the evolution of the safety case. Several issues addressed at this topical session will find their way into the flyer which will, however, maintain a generic level. A drafting group consisting of Lucy Bailey (NDA), Claudio Pescatore (NEA), Klaus-Jürgen Röhlig (TUC) and Abe van Luik (DOE/WIPP) will initiate the development of the flyer during which the discussion within IGSC, e.g. on terminology, might be commenced.