

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Trip report for the Nuclear Energy Agency (NEA) and the Integration Group for the Safety Case (IGSC) workshop on "Management of Uncertainty in Safety Cases and the Role of Risk"

DATE/PLACE: February 2-4, 2004, Stockholm, Sweden

AUTHORS: Sitakanta Mohanty

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NRC FOREIGN TRIP REPORT

Subject

Trip report for the Nuclear Energy Agency (NEA) and the Integration Group for the Safety Case (IGSC) workshop on "Management of Uncertainty in Safety Cases and the Role of Risk".

Dates of Travel and Countries/Organizations Visited

Meeting Dates: February 2-4, 2004
Country visited: Sweden

Author, Title, and Agency Affiliation

Sitakanta Mohanty, Principal Scientist, CNWRA

Background/Purpose *(What was the reason for the trip? What led to it? Why is NRC involved? Traveler may wish to draw upon justification in NRC Forms 445 and 279.)*

The purpose of this trip was to make presentations and participate in discussions at the workshop. The titles of the CNWRA papers presented at this workshop were: "Use of Risk Information in Regulatory Reviews" (by B.Sagar, R. Benke, and S.Mohanty) and "Global Sensitivity Analyses Methods for Generating Risk Information" (by O. Pensado, B.Sagar, and S.Mohanty).

Dr. B. Sagar, a regular participant in the series of workshops organized by the Nuclear Energy Agency (NEA), was invited to make presentations and participate in the discussions. Because he could not travel to attend this workshop, S. Mohanty traveled on his behalf. S. Mohanty was one of the three participants from the United States; the other two were Dr. George Apostolakis and Dr. Stephen Hora.

The aim of the workshop was to create a platform for a better understanding of the different approaches used in different national waste management programs to manage uncertainty in post-closure safety cases and regulatory evaluations. The principal objectives of the workshop were to: (i) identify common elements in different approaches for managing uncertainty; (ii) facilitate information exchange and to promote discussion on different technical approaches to the management and characterization of uncertainty; (iii) explore the merits of alternative approaches to risk-informed decision making; and (iv) identify the potential for further development of methods or strategies to support the management of uncertainties.

The CNWRA was involved to gain an understanding of the various approaches to managing uncertainty. The CNWRA also participated in response to an invitation from the organizers of the workshop to discuss the NRC risk-informed, performance-based methodology for conducting a review of a potential license application and the approach to risk assessment when the system being analyzed has a high degree of uncertainty.

Abstract: Summary of Pertinent Points/Issues *(By Commission directive, the abstract must summarize the discussions; identify any policy matters that need to be brought to the Commission's attention; identify any issues that need management attention; assess whether the interaction was worthwhile and achieved the desired outcomes; and identify any "best*

practices" that should be considered by NRC. Additional question to be addressed: Should NRC participation in this activity be continued?)

The discussions at the workshop were carried out by three working groups under three broad topical areas: (1) Risk Management and Decision-making, (2) Regulatory Requirements and Review of Uncertainty and Risk in Safety Cases, and (3) Practical Approaches and Tools for the Management of Uncertainty. The discussions led to the identification of differences and similarities in the treatment of uncertainties by various countries and the role risk analysis plays in repository development and the decision making process. The greatest similarities among countries were found to be the importance placed on presenting information to the decision makers and the stakeholders in a transparent and traceable manner. It was recommended that greater emphasis needs to be placed on developing approaches that will make the repository development and licensing process as transparent and traceable as possible. Another area that participants from various countries agreed is that the regulatory focus should be as much on the basis for the results as it is on the results themselves. It was apparent that the key source of difference among various countries is the regulatory context and how it is influenced by the cultural aspects. This was evident in the manner in which various risk analysis terminologies are used by various countries. The difference in terminologies used at this workshop were so diverse that a suggestion was made to develop a common guideline for use by all NEA countries. Later, it was felt that although a uniform terminology and approach would benefit technical experts, there was little to be gained by trying to change approaches to risk assessment in a way that conflicts with legal frameworks and cultural influences. Instead, the participants concluded that developing an understanding of the different approaches, with their associated strengths and drawbacks, would help to provide assurance to stakeholders and decision-makers that any particular approach was fit-for-purpose.

Discussion *(Include a more detailed description of/observations about the meetings/conference/facility visit, what was accomplished, and what its benefit was to NRC or to the national interests.)*

The key objective of the working group discussion on Topic 1 (Risk Management and Decision Making) was to build a bridge between those who prepare safety cases and those who make decisions by identifying needs and preferences of the end-users of information on risks and uncertainties. The discussion focused on higher-level end users, such as the public, politicians, and administrators. The working group discussed this wider risk management perspective, including the sequence of risk assessment, decision-making, and the subsequent activities that affect the system (the "realization" of the risk). The following are the key points from the working group discussion on Topic 1.

- The general importance of stakeholder involvement and the end-user needs were acknowledged, but stakeholders and decision makers were also recognized to be different in different countries. A shift toward customer-oriented risk communication was evident, but cultural traditions and legal framework affected the practices.
- The possibility and feasibility of risk management by active "after-sale service" were considered still questionable. It was acknowledged, however, that waste disposal risks can be managed through the use of a step-wise approach to decision making, the adoption of designs allowing reversibility/retrievability, and monitoring after emplacement. There was no overall agreement within the group on the part played by such actions in risk management and decision-making, although all agreed that decision making should be risk-informed rather than risk-based.

- The working group felt that it is important for the decision makers to present a clear definition of the problem from their own standpoint and clearly describe the decision-making process. The decision maker should know the consequences of his/her decision. Experience shows that environmental impact assessment is a very valuable tool for public participation, and that information on alternatives and the possibility of future modifications of the disposal concept is important. For example, in Finland, the discussion has focused on comparison of alternatives as much as on the issue of disposal safety. Other lessons are that a dialogue with the public in which the public is able to ask the questions has been preferred (the public wants to understand how things work and how it is possible to know about the future). It is important to show understanding of the processes and that science has an important role. An "active" transparency (i.e, providing information as required) is preferable to drowning participants with information.

The working group discussion on Topic 2 (Regulatory Requirements and Review of Uncertainty and Risk in Safety case) focused on the regulatory requirements of various countries. The following are the key points that resulted from the working group discussion on Topic 1.

- There is ambiguity in the meaning of key terms and concepts used by various countries, which makes it difficult for participants to understand the details of the approaches expected by regulators in different countries (e.g., deterministic vs. probabilistic approach, risk-based approach vs. non risk-based approach). The main concern was if the "experts" could not understand each other, then there is less hope for communicating such concepts with stakeholders. Development of a thesaurus to link definitions in regulations and guidance from different programs was recommended.
- Participants gained insights into regulatory expectations in different countries. For example, participants realized that the differences are not as great as previously considered. As various programs matured, there appears to be a convergence of different assessment approaches. Site-specific (or context-specific) guidance is developed as a developer's proposal matures (e.g., US, Finland). Several regulations also have combined dose and risk criteria for different sets of scenarios (e.g., Switzerland, Finland). It was recommended that a follow-up after the workshop should take place with dialogue between regulators and other interested parties on the treatment of uncertainty and the role of risk (i) to ensure the lessons learnt in one country can be transferred to others and (ii) to avoid stakeholders' perceptions of differences causing concerns.
- It was observed that there are differences in the extent to which regulations prescribe the approach to be followed in assessments. For example, the US regulations prescribe transport pathways, discharge area, characteristics of the RMEI etc. Proposed regulations in Germany indicate how scenarios should be selected and categorized. UK guidance expects the developer to take the lead in proposing assessment approach.
- Participants discussed the differences between "probabilistic" and "deterministic" approaches. This is not the same as the differences between regulations with a dose criterion and those with a risk criterion. For example, Yucca Mountain standards expect probabilistic calculation of dose. Sweden has a risk criterion, but guidance does not prescribe a calculational approach (so far). The difference is strongly linked to the

extent to which the regulator expects aggregation (probabilistic) vs. non-aggregation (deterministic) of consequence and likelihood.

Topic 3 (Practical Approaches and Tools for the Management of Uncertainty) discussions encompassed (i) classifying and characterizing uncertainties, (ii) determining the scope of uncertainty analyses and risk assessment, and (iii) presenting uncertainty analyses and risk assessments. The following are the key points from the working group discussions on Topic 3.

- Classifying uncertainties (i.e., aggregation and disaggregation) were viewed as important. Aggregation analysis needs to be done to get an idea of important facts where as the disaggregated analyses needs to be done to understand the system better. Aggregation can be done at different levels: (i) aggregation of all possible evolutions in one parameter (risk) to aggregation of scenarios, (ii) situations in a scenario, etc., up to aggregation of elementary phenomena. Aggregation of situations into scenarios are useful when situations are comparable in terms of effects on safety functions. Dis-aggregation is necessary for the purposes of presenting results, useful for showing system understanding, and identifying key factors/processes. Dis-aggregation is required to (i) inform correctly the choices in design and research priorities and (ii) account for correlations. Consequently, the need for dis-aggregation depends on the characteristics of system evolution. The degree of dis-aggregation/aggregation depends on the goal of the assessment and the safety functions. Dis-aggregation should be done only to the level where data are available.
- The working group felt it would be difficult to represent uncertainties via probability in several areas such as (i) conceptual model uncertainties (e.g., climate evolutions/changes [depending on complex phenomena], boundary conditions, etc.), (ii) future human behavior, and (iii) the probability of missing important FEPs. There were diverging views on the relevance of using current probabilities to predict long-term human behavior.
- In the situation that uncertainties cannot be assigned probabilities, several approaches were favored to represent uncertainties: (1) to the extent possible, in the analysis argue in favor of the robustness of the repository in the presence of this uncertainty; (2) use stylized assumptions, possibly with guidance from regulators; (3) choose a conservative assumption for compliance purposes; (4) use alternative conceptual models; (5) use a probabilistic approach to explore the sensitivity to uncertainty.
- Expert judgement: A formal process with the experts is designed to structure/ systematize the interrogation process to achieve traceability (e.g., assumptions made). There should be opportunity to break away from the formal process, if necessary, to express uncertainties that do not fit into the formalisms. Correlations should be specifically addressed. It is important to ask the "correct" questions in an elicitation process, especially not biased by potential use of the data (e.g., ask for expected values and ranges). Only questions regarding measurable quantities should be asked. Consistency checks and iterative approaches with the experts providing the input data was highly recommended when dealing with very uncertain topics.
- Scenario probabilities: Quantified scenario probabilities are not easy to assess except for scenarios based on one single aleatory event. Qualitative likelihood of scenarios may be important for evaluation and communication. Scenario probability is not sensible for "what-if" scenarios. It is, however, possible to come up with a probability for

scenarios based on aleatory causes (i.e., feedback from other sites etc). It may be more difficult to come up with scenario probabilities, if not impossible.

- **Tools:** Currently used tools (deterministic methods, Monte Carlo methods, etc.) were viewed as fit for analyses purposes. More experience, however, is needed before it can be decided if unconventional tools (e.g., fuzzy logics, possibilistic analyses, interval analyses) bring new kind of information to performance assessment. Their use as complementary lines of argument should be encouraged, with the intent of exploring ways of communicating results. Some, however, questioned whether the benefits justify the extra work and potential increase in complexity.
- **Risk Dilution:** Risk dilution is an unavoidable consequence of some combinations of systems analyzed and applicable regulations. Regulators should provide guidance as to how to apply regulations in the context of possible risk dilution. Comparing mean-of-the-peak consequences and the peak-of-the-mean consequences was viewed as a good approach to illustrate the effect of risk dilution.

Pending Actions/Planned Next Steps for NRC *(Indicate any open actions, including unresolved problems/issues, and NRC follow-up necessary and/or useful.)*

None.

Points for Commission Consideration/Items of Interest *(Highlight information the Commission needs to know or in which it would be interested. Indicate whether Commission action is required and, if so, how/when Commission guidance/engagement will be sought.)*

The content of this report is not likely to be of interest to the Commission.

No issues developed at this workshop needs the Commission's action or an immediate management action. The interaction with the other NEA countries, however, was worthwhile and achieved the desired objective. Some of the practices adopted by other countries should be reviewed by NRC as useful information. In this regard, participation by the NRC/CNWRA in such workshops should be continued to promote information exchange.

Attachments *(Include the agenda, if available, and pertinent documents only, listed by title.)*

Meeting agenda.

"On the Margins" *(Indicate any additional information obtained which is of probable interest to NRC but not directly related to the purpose of the trip.)*

None.

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3/11/2004

Date

CONCURRENCE:

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Gordon Wittmeyer
Manager, Performance Assessment Element

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Date

Budhi Sagar

Budhi Sagar
Technical Director

3/11/2004

Date

ANNEX 2:

AGENDA OF THE WORKSHOP

**Workshop on Management of Uncertainty in Safety Cases
and the Role of Risk**

**2-4 February 2004
STOCKHOLM, SWEDEN**

DAY 0 Sunday 1 February 2004

Arrival and check-in at Rånäs Castle

SSI offers a light evening meal

DAY 1 Monday 2 February 2004

Please note! The meeting will take place in the old mill next to the manor.

08:30 – 09:00 Registration (in the plenary meeting room in the old mill)

Introduction

09:00 – 09:10 Welcome address
Lars-Erik Holm (SSI, Sweden)

09:10 - 09:20 Scope of workshop
Sylvie Voinis (NEA, France)

Plenary Session I: Key note presentations

Chairperson: Lars-Erik Holm (SSI, Sweden)

Session rapporteur: Roger Wilmot (Galson Sciences, UK)

09:20 - 10:00 Risk in Technical and Scientific Studies: General Introduction to Uncertainty Management and the Concept of Risk
George E. Apostolakis (Massachusetts Institute of Technology)

10:00 - 10:30 Risk Perception as a Factor in Policy and Decision-Making
Lennart Sjöberg (Stockholm School of Economics, Sweden)

10:30 - 11:00 Coffee break

11:00 - 11:40 The Collection of Expert Judgments for Environmental Risk Studies
Stephen C. Hora (University of Hawaii at Hilo, U.S.A)

11:40 – 12:10 Survey of the Role of Uncertainty and Risk in Current Regulations
Roger Wilmot (Galson Sciences, UK)

12.10 – 12.20 Discussion

12:20– 13.50 *Buffet Lunch*

Plenary Session I (continued)

Chairperson: Hiroyuki Umeki (NUMO, Japan)

Session rapporteur: Roger Wilmot (Galson Sciences, UK)

- 13.50-14:30 Case Study 1 - Management of Uncertainties and the Role of Risk in Andra's Program
Arnaud Grevoz (Andra, France)
- 14:30- 15:10 Case Study 2 – Treatment of Uncertainty in the US Department of Energy's Yucca Mountain Repository Total System Performance Assessment (TSPA) with a risk criterion
Abraham Van Luik (US Department of Energy, Las Vegas, Nevada) and Eric Zwahlen (Golder Associates, Inc., Las Vegas, Nevada) - presentation through speaker phone
- 15:10- 15:30 *Coffee break*
- 15:30 – 16:10 Risk Considerations in the Domains of Protections Against Major Accidents in Comparison with Risk Control for Nuclear Power Plants
Felix Gmünder (Basler & Hofmann Consulting Engineers, Switzerland) and Patrick Meyer (Swiss Federal Nuclear Safety Inspectorate, Switzerland)
- 16:10-16:50 Development of Safety Criteria in Germany: Aim, Process and Experiences
Bruno Baltes and Klaus-Jürgen Röhlig (Gesellschaft für Anlagen- und Reaktorsicherheit, GRS, Köln, Germany)
- 16:50-17:20 Consideration of Unlikely Events and Uncertainties in the Finnish Safety Regulations for Spent Fuel Disposal
Esko Ruokola (Radiation and Nuclear Safety Authority, Finland)
- 17:20-17:50 Enhancing transparency and public participation in nuclear waste management
Magnus Westerlind (SKI, Sweden)
- 17:50 – 18:20 Uncertainty Governance: An Integrated Framework for Managing and Communicating Uncertainties
Hiroyuki Umeki (NUMO, Japan), Morimasa Naito (Numo, Japan), and Hiroyasu Takase (Quintessa, Japan)
- 18:20 – 18:30 Discussion and conclusions
- 18:30 *End of session*
- Workshop dinner hosted by SSI**
- 19:15 *Refreshment and a presentation of the historical Background of Rånäs Castle (representative of Rånäs Castle)*
- 19:45 *Dinner*
Dinner speech by Torsten Carlsson, (former mayor of Oskarshamn municipality, Sweden)

DAY 2	Tuesday 3 February 2004
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09:00 – 09:30 Instructions to working groups (in plenary)
SSI

09:30 - 17:30 **Working Group Sessions**
½ hour coffee breaks at 10:30 and 15:20
Lunch Buffet between 12:00 and 13:30
Oral supporting presentations that will be presented at the beginning of each working group session will last 10 minutes each. Should the chairperson decide to increase the duration of the presentation, he/she will contact the speakers.

WG1: **Risk Management and Decision Making**
Working Group leader: Juhani Vira (Posiva, Finland)
Working Group rapporteur: Harald Åhagen (Municipality of Oskarshamn, Sweden)

Introductory presentations:

- Discussion of Risks in the Context of the Environmental Impact Assessment of the Spent Fuel Repository in Finland
Juhani Vira (Posiva, Finland)
- Experience of Risk Perception from Oskarshamn Municipality
Harald Åhagen (Project LKO, Municipality of Oskarshamn, Sweden)
- Concepts of Uncertainty Classification and New Methods of Risk Assessment for the Disposal of Radioactive Waste
Gy.Bárdossy (Hungarian Academy of Sciences, Budapest, Hungary), J.Fodor (Department of Biomathematics, Szent István University, Budapest, Hungary), and F. Frigyesi (PURAM, Paks, Hungary)

WG2: **Regulatory Requirements and Review of Uncertainty and Risk in Safety Cases**
Working Group leader: Björn Dverstorp (SSI, Sweden)
Working Group rapporteur: Patrick O'Sullivan (NRG, the Netherlands)

Introductory presentations:

- SSI's Regulations in Connection with Post-Closure Radioactive Waste Disposal
Mikael Jensen (Swedish Radiation Protection Authority)
- The Management of Uncertainties in the French Regulation on Deep Disposal: The development of a Non-Risk Based Approach
Phillippe Raimbault (DGSNR, France)

- Estimates of Post-Closure Risk in Regulatory Decision-Making: Environment Agency Issues and Options
S L Duerden, I J Streatfield, and R A Yearsley (Environment Agency, UK)
- Proposed Review of Current Regulatory Safety Criteria for the HLW
Christian Kirchsteiger and Ricardo Bolado-Lavin (European Commission, DG JRC, Institute for Energy, the Netherlands)
- Use of Risk Information in Regulatory Reviews
Budhi Sagar, Roland Benke, and Osvaldo Pensado (CNWRA/NRC, USA)

WG3

Practical approaches and tools for the management of uncertainty
Working Group leader: Arnaud Grevoz (Andra, France)
Working Group rapporteur: Eva Simic (SKI, Sweden)

Introductory presentations:

- The Issue of Risk Dilution in Risk Assessments
Peter Robinson (Quintessa, UK) and Roger Wilmot (Galson Sciences, UK)
- Risk Assessment using Probabilistic Standards
Rodolfo Avila (Facilia, Sweden)
- Methodology for Risk Assessment of an SNF Repository in Sweden
Allan Hedin (SKB, Sweden)
- Sensitivity Analyses Methods for Generating Risk Information
Osvaldo Pensado, Budhi Sagar, and Sitakanta Mohanty (CNWRA/NRC, USA)
- Physically Based Probability Criterion for Exceeding Radionuclide Concentration Limits in Heterogeneous Bedrock
Anders Wörman (Swedish University of Agricultural Sciences, Sweden), Shulan Xu and Björn Dverstorp (SSI, Sweden)
- Risk and Uncertainty Assessment for a Potential HLW Repository in Korea: TSPA 2006²
Y S Hwang and C H Kang (Korea Atomic Energy Research Institute)
- Uncertainty Propagation in a Radionuclide Transport Model for Performance Assessment of Nuclear Waste Disposal
*Anne Dufloy and Marie Bouton (EDF, France)*³ (tbc)

17:30

End of session

Social activities and Workshop Dinner hosted by SKB

17:30 – 20:00

Sauna (with refreshments), outdoor hot tub, cool bath in lake and other activities

20.00

Workshop Dinner

² Supporting paper for discussion only.

³ Supporting paper for discussion only.

DAY 3	Wednesday 4 February 2004
08:30 – 09:30	Working Group Sessions (continued)
09:30-10:00	<i>Coffee break</i>
	Plenary Session II: Working Group Summaries and Final Discussion <i>Session Chair: Carl-Magnus Larsson (SSI, Sweden)</i> <i>Session Rapporteur: Roger Wilmot (Galson Sciences, UK)</i>
10:00 - 11:30	Working group presentations <i>WG rapporteurs/leaders 1-3</i>
11:30 – 12:00	Discussion of Working Group Summaries
12:00 – 13:00	Personal reflections on workshop <i>Steve Hora (University of Hawaii, USA)</i>
	Final Discussion
	Closing Remarks <i>NEA and host</i>
13:00	End of workshop
13:00 - 14:00	<i>Lunch</i>
14.15	Bus transport to airport (Arlanda)