

CENTER FOR NUCLEAR WASTE REGULATORY ANALYSES

TRIP REPORT

SUBJECT: Fifteenth Meeting of Probabilistic System Assessment Group (PSAG)
Charge No., 20-5702-723

DATE/PLACE: June 16-17, 1994, Paris (France)

AUTHOR(S): Budhi Sagar

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DATE/PLACE: June 16-17, 1994, Paris (France)

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ATTACHMENTS: Seventeen attachments are included. Please contact the author for any other information.

BACKGROUND AND PURPOSE:

In the field of nuclear waste management, the objective of the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD) is to promote a forum for the exchange of information on waste management policies and practices, to develop a common understanding of basic issues and to promote the adoption of appropriate waste management strategies in member countries. The NEA manages this overall objective through its Radioactive Waste Management Committee (RWMC) of which the NRC is a member. The RWMC has created several working and advisory groups to focus on specific areas. One such group is the Probabilistic Systems Assessment Group (PSAG) which was set up in 1985 with the objective of studying and advancing the application of probabilistic methods to assessing the performance of repository systems.

The PSAG group met approximately twice a year. Initially, the group was started as the SYVAC user's group; SYVAC, a Canadian code, was the main system code available for probabilistic studies. However, it was soon discovered that the majority (some countries, notably Switzerland and Germany, have deterministic standards and do not emphasize probabilistic methods) of the countries were involved in developing their own probabilistic assessment models and hence the name of the group was changed to reflect that. The initial phase of PSAG was related to mainly statistical techniques for data manipulation and sampling for Monte Carlo simulations. Later meetings would consist of two parts—the first part consisting of code inter-comparisons and the second that of technical sessions on a selected topic. In the most recent meetings, the PSAG group was beginning to explore the impact of "conceptual uncertainties" (in contrast to parameter uncertainties which was its main focus). However, only a very preliminary exercise on conceptual uncertainties has been attempted.

In their last meeting, the RWMC had concluded that the group had met its basic objective and decided that after producing a final report, the group should be dissolved. Other NEA groups may undertake the task of studying the impact of conceptual model uncertainties. Accordingly, the fifteenth and the last meeting of the PSAG was held at NEA offices in Paris, France on June 16-17, 1994.

MEETING SUMMARY:

The agenda for the 15th PSAG meeting is provided in Attachment 1. The group was chaired by Jim Sinclair (UK). Following is a brief summary of the meeting. Details are provided in the next section of this report.

Following the recommendation from the RWMC, the activities of the PSAG group will be concluded at the end of this meeting. The topic of Probabilistic System Assessment (PSA) will be under the purview of the Performance Assessment Advisory Group (PAAG) until another group is assigned this responsibility. The RWMC will entertain new proposals in this regard.

The final report on Level S (code inter-comparison of sensitivity analyses) has been completed. Different methods of probabilistic sensitivity analyses were attempted on a common problem. While there was overall agreement between different investigators, large statistical differences remained. Outstanding issues have been identified and discussed in the published report.

The Level 2 model inter-comparison exercise dealt with conceptual model uncertainty using data from the Waste Isolation Pilot Plant (WIPP) in the U.S.A. This exercise is only partially done at this time. A PSAG publication with limited distribution will be prepared.

The PSAG final report is in draft form. A complete report will be presented to PAAG in their October meeting.

DETAILED DESCRIPTION:

Details of the meeting proceedings are provided in the following. The sequence of description follows the agenda (Attachment 1).

ITEM 1. OPENING OF THE MEETING

Jean-Pierre Olivier, Head of NEA's Division of Radiation Protection and Waste Management, opened the meeting by welcoming the attendees to the new NEA facilities at Issy-les-Moulineaux in Paris. Claudio Pescatore, Secretary of PSAG, and Jim Sinclair, Chairman of PSAG also welcomed the attendees. Despite this being the concluding meeting of the group, several new members were present. A list of attendees is provided as Attachment 2. All attendees discussed briefly their roles in their respective nuclear waste programs.

ITEM 2. ADOPTION OF THE AGENDA

The agenda (Attachment 1) was adopted without any change.

ITEM 3. APPROVAL OF THE SUMMARY RECORD OF THE 14th MEETING OF PSAG

In the absence of any comments, the summary record was approved.

ITEM 4. SECRETARIAT REPORT ON NEA ACTIVITIES RELATED TO PA

Mr. Olivier indicated that with the winding up of the PSAG, the RWMC will consider other proposals to advance the PSA work at the NEA. In the mean time, this topic will be under the purview of the PAAG. He also informed the group about a forthcoming NEA document related to collective opinion on environmental and ethical aspects of geologic disposal. He indicated that in this document, the stress will be on philosophical and fundamental reasons (rather than technical issues) that lead to the acceptance of geological disposal. Issues like: (i) does the present generation have a right to make such long-term decisions? and (ii) should we wait for new breakthroughs such as transmutation? will be the focus of this document. Prior to the drafting of such a document, a workshop is being planned for September 1-2 to which several speakers from outside of the nuclear waste field have been invited. Ethical and moral issues will be discussed in this workshop. Drafting of the collective opinion will begin towards the end of 1994.

Mr. Pescatore (NEA) reviewed briefly the proceedings of the 9th meeting of PAAG in the context of their effect on PSAG. He indicated that model validation was discussed in PAAG in a topical session. The consensus was that no new definition of the term "validation" needed to be devised. However, clarity was needed in various waste programs to indicate where validation was possible and to what extent. The PAAG proposes to develop a position paper on "model validation" which is expected to take a couple of years. Mr. Pescatore also distributed a tentative program for the forthcoming GEOVAL workshop (Attachment 3) to be held October 11-14 in Paris. The NRC is scheduled to present its joint NRC/SKI paper in this workshop. In the end, he discussed some new proposals being considered by the RWMC. As a replacement for the INTRAVAL program, a proposal named GEOTRAP (acronym for GEOlogic TRANsPort) is being formulated. Another proposal related to review of national total-system PAs is also under review.

ITEM 5. REPORT AND DISCUSSION OF PSACOIN EXERCISES

Mr. Peter Robinson (Intera Information Technologies Limited, U.K.) discussed the completion of the Level S PSACOIN exercise. This exercise required the participants to apply their preferred method of sensitivity analysis to the earlier completed Level E exercise. The objective was to study the adequacy, efficiency, and flexibility of various methods. During the course of this exercise, a few new methods of sensitivity analyses were developed. The stress was on sensitivity of output probability distributions to change in input distributions. The conclusion of the exercise was that while there was an overall agreement in trends, a large amount of statistical differences remained between the results of various participants. Because of a lack of a systematic method, the results could not be compared in any consistent manner.

Mr. Dan Galson (Galson Sciences Ltd. U.K.) briefly described the status of the Level 2 exercise. This exercise consisted of using the site data from the WIPP project, formulating conceptual models consistent with the data and predicting performance measures. The objective was to understand the extent of conceptual model uncertainty. Because of lack of resources with most of the participating countries, only a few groups participated in this exercise. At the present time, this exercise is only partially done. However, the results from various participating teams have been collected. At least, the results of two teams (the team

from WIPP and the team from Pacific Northwest Laboratory (PNL) differed significantly from the other participants. These teams were asked to review their analyses to determine the reasons for the differences. It appeared that the way accessible porosity (single or double porosity) was conceptualized made a major difference in the results.

One interesting understanding from this exercise was that participants tended to use their favorite codes and any limitation in these codes were embedded as assumptions in the conceptual models. When questioned, many attendees agreed that was an unsatisfactory way of formulating conceptual models. Some of the attendees were not convinced about the conclusion that the porosity representation was the most important part of the conceptual model. Because the PSAG group is concluding its activities and there is not enough time to explore these questions, the manner of reporting the results of this exercise was discussed. The majority opinion was that this exercise should not be reported in the form of an NEA document—only as a PSAG document with limited distribution. A summary of the report will be presented to PAAG in October. Whether this summary will be issued as a green covered NEA document will depend on the comments from PAAG. The subgroup dealing with this exercise has the further action of completing the summary by August 1994. Attachment 4 is an outline of this report.

At this juncture, Mr. Enrico Sartori (NEA Data Bank, Paris) introduced a message from Mr. Andy Saltelli, a former member of PSAG regarding a symposium on Theory and Applications of Sensitivity Analysis of Model Output in Computer Simulation (SAMO '95). The symposium is sponsored by the Environment Institute of the Joint Research Center of the European Commission and is scheduled for 25-27 September, 1995 in Belgirate, Italy. The reader is referred to attachment 5 for more details.

ITEM 6. DISCUSSION OF DOCUMENT ON THE ACTIVITIES/ACHIEVEMENTS OF THE PSAG

Mr. Sinclair (AEA Technology, U.K.) briefed the group on the status of the concluding report of the PSAG that will describe its activities and achievements. An incomplete draft is available at this time and is provided as attachment 6. The document will trace the history of the PSA, briefly discuss each of the PSACoin exercises undertaken by the group, summarize several of the topical sessions and draw conclusions towards the status of the PSA methodology including unresolved questions. Mr. Sinclair asked for comments on this draft and indicated that any suggestions regarding additions to the text will be welcomed.

ITEM 7. (a) TOPICAL SESSION: PHILOSOPHY AND METHODOLOGY OF PSA

Peter Robinson (Intera Information Technologies Ltd., U.K.) emphasized the distinction between uncertainty and variability and stressed that consistent handling of all types of uncertainty in a defensible and quantitative manner was required in a successful PSA. He listed four current methods of uncertainty analyses: (1) best estimate and exploration of "what if" manually; (2) conservative (i.e., worst case) analysis; (3) probabilistic approach which requires approximation of uncertainties as probability density functions (pdfs); and (4) nested set analyses (i.e., fuzzy analyses). He spoke in support of the last method, which according to him, will require only "interval analysis" rather than the analyses of crisp pdfs. A summary of his paper is at attachment 7. A complete paper will be available in the proceedings of SPECTRUM-94 that is to be held in Atlanta.

Brian Thompson (U.K. Department of the Environment) discussed the regulators approach to uncertainty resolution. In his view, a proponent will argue long-term safety of their proposal based on quality of their data and analyses. The regulator will then need to be convinced that the uncertainties have been resolved sufficiently. He suggested that the regulator will use scientific review combined with independent assessment of his own. He briefly discussed the history of PSA as described in the recently published joint paper by him and B. Sagar. He also distributed the set of papers from his group that were presented at PSAM II in San Diego. These are provided as attachment 8.

Dan Galson (Galson Sciences, U.K.) presented the same paper that he had presented at the recent International High-Level Waste Meeting in Las Vegas. The subject of his paper was scenario development for the WIPP in which he outlined an application of the Sandia methodology. Attachment 9 provides his paper.

Jim Sinclair (AEA Technology, U.K.) discussed the issue of convergence in monte carlo simulations as it is related to the number of realizations. He indicated that the empirical rule of using $4K/3$ realizations, where K is the number of random parameters in the simulations has been shown to not always work. He called the inability to determine the number of samples required as an unresolved problem of PSA. Mr. Sinclair discussed some of his recent work regarding upper bounds on output distributions. Attachment 10 is his paper.

Enrico Sartori (NEA Data Bank, Paris) gave a very general talk about status of computing as it applied to monte carlo simulations. Many of the applications he discussed were in areas other than waste disposal. The thrust of his talk was that we should take advantage of parallel processing technology to make monte carlo simulations efficient. His paper is included as attachment 11.

(b) EXPERIENCE OF APPLICATIONS OF PSA IN NATIONAL PROGRAMS

Steve Oldfield (RM Consultants Ltd., U.K.) discussed recent updates to the Her Majesty's Inspectorate of Pollution (HMIP) PSA software, especially the part dealing with statistical analyses of the probabilistic risk assessment (PRA) results. A unique feature of HMIP's PSA code is that it has adopted the environmental simulation approach which simulates the time histories of the system. This applies specifically to climate evolution and the system response to this evolution. The TIME4-Vandal system of codes have been developed for this purpose. The HMIP has adapted the commercially available Statistical Analysis software (SAS) code to perform the statistical analyses of their output. Copies of his viewgraphs are included as Attachment 12.

Peter Bogorinski (GRS, Germany) indicated that in Germany, the performance requirement for the disposal system is that the potential release should be in the range of variation of natural background radiation. This has lead to a deterministic limit of 0.3 mSv/a which has to be met for 10,000 years after closure. Peter indicated that because there is no risk target, probabilistic methods will only be used in assessing performance. He, then described the application of SUSA software to the German site. The reference data set was used to calculate a travel time by a deterministic method. The SUSA software was then used to generate 59 alternate representations of the site. Travel times were calculated for all realizations. While, some realizations lead to shorter travel times than the reference data,

all of the estimates were longer than recommended cut-off times. He, then concluded that the reference data set was acceptable. The reader is referred to Attachment 13 for further detail.

Budhi Sagar (Center for Nuclear Waste Regulatory Analyses, U.S.A.) presented the application of probabilistic methods as embodied in Phase 2 of NRC's Iterative Performance Assessment (IPA). He stressed that proper planning and organization of an interdisciplinary group was essential to the successful application of PSA. The IPA Phase 2 exercise as applied to the potential site at Yucca Mountain was then briefly described. All steps of the IPA from development of the system code to sensitivity and uncertainty analyses were described briefly. Attachment 14 provides the summary.

Jan Morivoet (SCK/CEN, BELGIUM) described the application of the LISA code (developed at ISPRA) to shallow land burial in Belgium. He indicated that for sensitivity analysis, they divide the outputs into two segments, one containing 10 % of the runs that contain the highest doses and the other with the remaining 90%. The important parameters are then determined by applying the Smirnov test on the two empirical distributions thus obtained. A summary of his paper is presented in Attachment 15.

Pedro Prado (CIEMAT, Spain) noted that Spain was a latecomer to the waste management and hence was learning from other participants. At present, only generic studies are performed in Spain. He reviewed the participation of CIEMAT and ENRESA in PSAG activities and drew some conclusions about PSAG's accomplishments which can be seen in Attachment 16. He described the preliminary safety case study that is oriented to evaluating a reference repository design.

ITEM 8. RECENT DEVELOPMENTS WITHIN NATIONAL AND INTERNATIONAL PROGRAMS

The topical session consumed so much time on the second day of the meeting that not much time was left for this item. The Chairman requested that those who had brought a written summary may elect not to speak. The written summaries are included as Attachment 17. In response to this request, only Grant Sheng (Technical Advisory Committee to AECL, Canada) spoke briefly about his recent trip to mainland China and Holland. He briefly discussed the AECL activities in Canada.

ITEM 9. ANY OTHER BUSINESS

The Chairman concluded the meeting by thanking all participants and requested their help in completion of the PSAG final report. A summary record of the meeting will also be issued by the NEA.

IMPRESSIONS/CONCLUSIONS:

Most members of PSAG were concerned that, with the disbanding of the PSAG, the important problem of conceptual model uncertainty may fall through the cracks. The NEA, however feels that the PSAG was not the proper group to deal with that issue. The conceptual model uncertainty apparently comes under

the purview of both the PAAG and the SEDE groups. Mr. Olivier indicated that another group may be set up to study that issue.

PROBLEMS ENCOUNTERED:

Except that I lost my wallet to a pick-pocket, there were no problems.

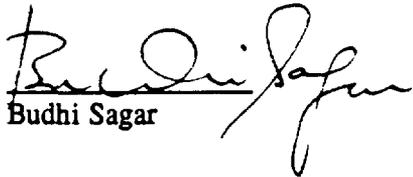
RECOMMENDATIONS:

The NRC was a signatory to the earlier collective opinion issued by the NEA which dealt with the feasibility of geologic disposal. It is recommended that it should consider participating in the workshop related to the second collective opinion that will deal with philosophical and moral issues.

PENDING ACTION:

I will send a short (couple of paragraphs) summary of one of the PSAG topical meetings that was coordinated by Ross Bagtzoglou to Jim Sinclair for inclusion in the final PSAG report.

SIGNATURES:


Budhi Sagar

7/7/94
Date

CONCURRENCE:


R.G. Baca

7/7/94
Date


W. Patrick

7/7/94
Date

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ATTACHMENT 1

ORGANISATION FOR ECONOMIC
CO-OPERATION AND DEVELOPMENT

NUCLEAR ENERGY AGENCY

STEERING COMMITTEE
FOR NUCLEAR ENERGY

RESTRICTED

Paris, drafted: 16-May-1994
OLIS: 19-May-1994
dist.: 24-May-1994

NEA/PSAG/DOC(94)1

English text only

: Canceled & replaces the same document :
: sent on olis 18 May 1994 :

RADIOACTIVE WASTE MANAGEMENT COMMITTEE

PROBABILISTIC SYSTEM ASSESSMENT GROUP

PROPOSED AGENDA
FOR THE FIFTEENTH MEETING

NEA Headquarters
Issy-les-Moulineaux (Paris)
16-17 June 1994

Please note that the meeting will NOT take place at the OECD Château
downtown Paris.

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5. Report and Discussion of PSACOIN Exercises

- Level 1 (intercomparison of different techniques for sensitivity analysis)
Presentation by P. Robinson on the resolution of the issues outstanding at the time of PSAG-14, leading to publication of the final report in June 1993.
- Level 2 (Conceptual Model Uncertainty)
Draft report to be distributed at the meeting
Presentation by Tony Zimmerman or Dan Galson

6. Discussion of Document on the Activities/Achievements of the PSAG

Draft document to be distributed at the meeting
Presentation by Jim Sinclair

7. Topical Session

(a) Talks on Philosophy and Methodology of PSA and Allied Techniques

- P. Robinson (Intera Information Technologies)
- B. Thompson (UK DoE HMIP)
- D. Galson (Galson Sciences)
- J. Sinclair (AEA Technology)
- E. Sartori (NEA Data Bank)

(b) Talks on Experience of Application of PSA in National Programmes

- S. Oldfield (RM Consultants)
- Speakers to be determined: GRS, USNRC/CNWRA
- J. Marivoet (SCK/CEN)
- P. Prado & R. Bolado (CIEMAT/CTN-UPM)
- B. Sundström (SKI)
- N. Kjellbert (SKB)

8. Reports of Recent Developments within National and International Programmes

(5-minute oral presentations and/or 1-2 page written contributions)

9. Any Other Business

It is anticipated that Item 7 will occupy the majority of the second day, and possibly part of the first day.

ATTACHMENT 2

17-06-1994

NEA PROBABILISTIC SYSTEM ASSESSMENT GROUP (PSAG)

FIFTEENTH MEETING

NEA, 16-17 June 1994

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ATTACHMENT 3

Paper No.	Author(s)	Title	Allotted time
	<u>SESSION 1</u>		
	J. Andersson	Objectives and Scope of GEOVAL '94	20 mns
	C. Pescatore	Validation: An Overview of Definitions	30 mns
	C.F. Tsang	Validation and Technical Issues at GEOVAL '90	30 mns
	P. Zuidema, C. McCombie, I.G. McKinley, P. Smith	Validation: Demonstration of Disposal Safety Requires a Practicable Approach	30 mns
	<u>SESSION 2</u>		
	N. Chapman et al.	Developing Groundwater Flow and Transport Models for Radioactive Waste Disposal - Six Years of Experience from the INTRAVAL Project	30 mns
	T.J. Nicholson, R. Hills, M. Rockhold, G. Wittmeyer, T.C. Rasmussen	Conclusions from WG-1: Partially-Saturated Porous & Fractured Media Test Cases Las Cruces Trench & Apache Leap Tuff Studies	20 mns
	P. Andersson, A. Winberg	Conclusions from WG-2: The Analyses of the Finnsjön Experiments	20 mns
	C.P. Jackson	Conclusions from WG-2: The Analyses of the WIPP-2 Experiments	20 mns
	P. Bogorinski	Conclusions from INTRAVAL WG-3: Salt- and Clay-Related Cases	30 mns
	K. Skagius, L. Birgersson	Conclusions from WG-4: The Analyses of the Alligator Rivers Natural Analogue	30 mns

Paper No.	Author(s)	Title	Allotted time
<u>SESSION 5</u>			
	J.-P. Salo, J. Autio, E. Johansson, A. Öhberg, A. Hautojärvi, T. Vieno	Characterization and Tracer Tests in the Full-Scale Deposition Holes in the TVO Research Tunnel	30 mns
	A.J. Hooper	Joint ANDRA/Nirex/SKB Zone of Excavation Disturbance Experiment (ZEDEX) at the Äspö Hard Rock Laboratory	30 mns
	R.L. Beauheim, S.M. Howarth, P. Vaughn, S.W. Webb, K.W. Larson	Integrated Modeling and Experimental Programs to Predict Brine and Gas Flow at the Waste Isolation Pilot Plant	30 mns
	O. Stephansson, L. Jing, C.-F. Tsang, F. Kautsky	Development of Coupled Models and Their Validation Against Experiments - DECOVALEX Project	30 mns
	J.A.T. Smellie, F. Karlsson, B. Grundfelt	The Potential Use of Natural Analogues Studies in Radioactive Waste Disposal: A Review	30 mns
<u>SESSION 6</u>			
	A.J. Hooper	The Approach to Model Testing and Site Characterisation Studies Undertaken by United Kingdom Nirex Ltd	20 mns
	T. Papp, L.O. Ericsson	Coordinated Site Characterization and Performance Assessment - An Iterative Approach for the Site Evaluation	20 mns
	B. Dverstorp, J. Andersson	The SKI SITE-94 Project Approach to Analysing Confidence in Site-Specific Data	20 mns
	M. Federline, J. Andersson	The NRC/SKI Position Paper on Validation Strategy	20 mns
	P. Davies	Evolution of Flow and Transport Conceptual Model Development, Field Testing, and Numerical Implementation at the Waste Isolation Pilot Plant, 1979 to 1994	20 mns

LIST OF ITEMS TO BE ADDRESSED

IN THE WRITTEN PAPERS AND IN THEIR PRESENTATIONS

The recurring theme of GEOVAL '94 is "*validation through model testing with experiments.*" Session 1 will set the scene by reviewing the advancement of the state-of-the-art of validation in the past few years. The bulk of new information will come from Session 2 (INTRAVAL) and sessions 3 to 6. Session 3, 4, and 5 will focus on the lessons learned or being learned within integrated experimental studies, including results from underground research laboratories. Session 6 will focus on strategic approaches for including validation in the planning for repository siting, design and licensing.

In order to favor a fruitful discussion at the symposium both through the Discussion Panel and through interventions from the audience, it is advisable to have a certain degree of uniformity in the presentations and in the materials to be contained in each paper. To that effect, the Programme Committee has prepared a list of questions which **should** be addressed by *all* speakers and *especially* those participating to Sessions 3, 4, and 5. In particular, the latter should strive to convey to the audience and their future readership, **why** the specific experiment(s) and its/their setup(s) has/have been selected, **what** it is intended to show, and **how** this does fit into an overall scope of work including other types of experiments and non-experimental analyses. *The symposium participants will not want to learn about model testing for parameter values but rather for learning basic lessons about validation in an overall repository siting, design and licensing strategy.*

These are the main questions which the Programme Committee has prepared for all speakers:

1. How do you assess success of your model testing. Is it practical or worthwhile to improve success. To what extent your judgement of success takes into account other in?
2. How was the design planned and the experimental design analyzed?
3. What models were tested and how were they tested with experiments. Were alternative conceptual models taken into account and how were they assessed?
4. How were different disciplines integrated?
5. Which was the greatest difficulty: interpretation, design, performance,...?

ATTACHMENT 4

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Index Date...: 940815 Size.....: A4 Text Format.: *
Backfit Ind.: * Nbr Page...: 41pp.

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-----Title/Description-----
"Recent Developments at CTN-UPM on PSA Tools,Variance Reduction Sampling Techniq

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Auth Affil-----Name-----+---Catg-----Reference Numbers-----+--Distribution---
P EEI***** BOLADO,R. | | | | |
S EEI***** MOYA,J.A. | | | | |

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