January 8, 2004

MEMORANDUM TO: ACRS Members

FROM: Michael Snodderly, Senior ACRS Staff Engineer,

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE ACRS SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT, OCTOBER 10, 2003 - ROCKVILLE, MARYLAND

The minutes of the subject meeting, issued December 4, 2003, have been certified as the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

electronic cc: J. Larkins
S. Bahadur
H. Larson
S. Duraiswamy

MEMORANDUM TO: M. R. Snodderly, Senior ACRS Staff Engineer

FROM: G. E. Apostolakis, Chairman
Reliability and Probabilistic Risk Assessment Subcommittee

SUBJECT: CERTIFICATION OF THE MINUTES OF THE JOINT MEETING OF THE ACRS SUBCOMMITTEES ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT AND HUMAN FACTORS, OCTOBER 10, 2003 - ROCKVILLE, MARYLAND

I do hereby certify that, to the best of my knowledge and belief, the minutes of the subject meeting on October 10, 2003, are an accurate record of the proceedings for that meeting.

[signature] Dec. 13, 2003

George E. Apostolakis, Subcommittee Chairman — Date

PRE-DECISIONAL

December 4, 2003

MEMORANDUM TO: G. E. Apostolakis, Chairman
Reliability and Probabilistic Risk Assessment Subcommittee

FROM: M. R. Snodderly, Senior ACRS Staff Engineer

SUBJECT: WORKING COPY OF THE MINUTES OF THE MEETING OF THE ACRS SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT, OCTOBER 10, 2003 - ROCKVILLE, MARYLAND

A working copy of the minutes for the subject meeting is attached for your review. Please review and comment on them at your soonest convenience. If you are satisfied with these minutes please sign, date, and return the attached certification letter in the pre-addressed envelope attached.

Attachment: Minutes (DRAFT)

cc: Reliability and Probabilistic Risk Assessment Subcommittee Members

S. Bahadur
S. Duraiswamy
J. Larkins
H. Larson

CERTIFIED BY: G. Apostolakis

Issued:12/4/03
Certified:12/13/03

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MEETING OF THE ACRS SUBCOMMITTEE ON
RELIABILITY AND PROBABILISTIC RISK ASSESSMENT
MEETING MINUTES - OCTOBER 10, 2003
ROCKVILLE, MARYLAND

INTRODUCTION

The ACRS Subcommittee on Reliability and Probabilistic Risk Assessment (PRA) held a meeting on October 10, 2003, in Room T-2B3, 11545 Rockville Pike, Rockville, MD. The purpose of this meeting was to discuss the status of the probabilistic risk assessment research program. The meeting was open to public attendance. Mike Snodderly was the Designated Federal Official for this meeting. There were no written comments or requests for time to make oral statements received from members of the public. The meeting was convened by the Subcommittee Chairman at 8:30 a.m. and adjourned at 2:59 p.m. on October 10, 2003.

ATTENDEES

ACRS Members

G. Apostolakis, Subcommittee Chairman
M. Bonaca, Member
S. Rosen, Member
W. Shack, Member
M. Snodderly, Designated Federal Official

Principal NRC Speakers

P. Baranowsky, RES
B. Brady, RES
M. Cheok, RES
M. Cunningham, RES
G. De Moss, RES
D. Dube, RES
J. Flack, RES
J. S. Hyslop, RES
P. Kadambi, RES
S. Magruder, RES
D. Marksberry, RES
D. O'Neal, RES
P. O'Reilly, RES
D. Rasmuson, RES
K. Welter, RES
R. Woods, RES

Other Principal Speakers

M. Modarres, U of MD
A. Mosleh, U of MD

There were approximately four other members of the public in attendance at this meeting. A complete list of attendees is in the ACRS Office File and will be made available upon request. The presentation slides and handouts used during the meeting are attached to the office copy of these minutes.

OPENING REMARKS BY CO-CHAIRMAN APOSTOLAKIS

George Apostolakis, Chairman of the ACRS Subcommittee on Reliability and PRA convened the meeting at 8:30 a.m. Dr. Apostolakis stated that the purpose of this meeting was to discuss the status of the probabilistic risk assessment research program with representatives of the NRC Office of Nuclear Regulatory Research (RES). He said the subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee. The rules for participation in the meeting were announced as part of the notice of the meeting published in the Federal Register on October 1, 2003.

DISCUSSION OF AGENDA ITEMS

Feasibility of Applying Formal Decision Methods to NRC Activities

Prasad Kadambi, RES, began by reminding the Committee that in its 2002 Safety Research Report it recommended exploration of formal decision methods. In response to that recommendation, RES initiated a technical assistance contract and NUREG/CR-6833, "Formal Methods of Decision Analysis Applied to Prioritization of Research and Other Topics," October 2003. Dr. Kadambi discussed where elements of formal decisionmaking are practiced in a number ongoing NRC activities, such as, the Planning, Budgeting and Performance Management process, Phenomena Identification and Ranking Table, and the Reactor Oversight Process. He explained that the objective of NUREG/CR-6833 was to provide NRC staff with a compilation of tools and methods from the vast field of formal decisionmaking that would likely be useful for regulatory application.

Dr. Kadambi argued that formal adoption of formal decisionmaking methods would improve the focus on structure, transparency, and the treatment of uncertainty. He proposed five steps for accomplishing this objective. The first step is to construct the utility function. The second step is to formulate action alternatives. The final steps would be to generate the expected utilities, rank order the alternatives, and finally choose an alternative. Dr. Kadambi proposed to establish an inter-office working group to provide a focal point for formal decisionmaking and developing a nucleus of knowledgeable staff. He said there was a need to identify case studies for implementing the formal decisionmaking methods.

Dr. Kadambi summarized by saying that NUREG/CR-6833 provides tools and methods that enable the staff to begin using formal decisionmaking methods. He said that successful case studies may alleviate discomfort with terminology and offer evidence that objectivity and transparency can advance performance goals. He continued by saying that identifying appropriate regulatory issues to use as case studies is a significant challenge. He invited the Committee's suggestions on possible case studies. He concluded by saying that if the Commission agrees that formal decisionmaking is worth pursuing beyond the exploratory phase then the staff now has the requisite foundation on which to build.

General Comments and Observations From the Subcommittee Members

- Dr. Apostolakis commented that structuring the objectives as part of a formal decisionmaking process is of great value. He thought that the reactor oversight process had benefitted tremendously from it. Dr. Flack, RES, agreed and added the advanced reactor research program as another area that had benefitted from the process.

- Dr. Apostolakis warned that the analytic hierarchy process (AHP) is just another tool to be used in support of decisionmaking. He said that If you mention AHP to a decision theorist, they will attack you because, unfortunately, AHP was presented as an alternative to decision theory. AHP should be used to support decision theory by getting the utilities or eliciting information from experts but not making the decision.

- Dr. Apostolakis said it was interesting that the reviewers found the concept complex. He thought conceptually the method was simple but that applying it was more difficult. For example, one of the latest problems is how do you accommodate economic losses from routine failures and from core damage. Dr. Apostolakis pointed out there is a tremendous difference between the two. He said you go from a few thousand dollars to billions of dollars which creates a challenge in accessing utilities. It seemed to him that the implementation is more complex and subtle than the conceptual formulation.

- Mr. Rosen suggested that the way to introduce this is to talk about the way decisions are made now. Then what aspects of what you do now are, in fact, parts of the formal decisionmaking process and what additional pieces formal decision making theory would add. Dr. Apostolakis thought that would be a great way of educating the users.

- Mr. Rosen asked what training on FDM is available. Dr. Kadambi's response indicated that a training program does not exist at this time. He said that developing a training course was a valuable suggestion. Mr. Rosen suggested that a FDM course for managers would be particularly useful in formalizing the decision making process of the agency.

- Dr. Apostolakis said that not only are case studies important but cases that demonstrate the value of FDM. Apply FDM to a difficult decision that had been made and show how it could have benefitted by FDM. Dr. Apostolakis indicated that the Subcommittee would be receptive to reviewing these case studies in the future.

PRA Safety Research Program

Mr. Mark Cunningham, Acting Deputy Director, Division of Risk Analysis and Applications, provided an overview of his division's research program. The division has a staff of 55 full time equivalents and a budget of $14.8 million dollars. He then covered the division's major areas of responsibility which included the following: operating experience, security, risk methods, risk studies, PRA standards, and advanced reactors. Mr. Baranowsky, Chief, Operating Experience Risk Analysis Branch, RES, then briefed the Committee on data collection and analysis. Data is collected from review of LERs and the EPIX database. He discussed how data coding and analysis is being standardized. Mr. Baranowsky described the Accident Sequence Precursor (ASP) Program as a resource that gives us information on significant events over a period of time and has become a part of what the agency uses in their report to Congress to identify how well we're doing.

Mr. Baranowsky said that parametric and model uncertainty are getting more attention. He said that his branch was not taking on decisions in light of uncertainty but was attempting to bring uncertainty out. As an example, Mr. Baranowsky discussed a low service water flow incident to the diesel generator coolers at the Cook plant. He showed a chart which included both model and parameter uncertainties. Mr. Baranowsky said that the purpose of the analysis was to determine if further follow up on this issue was necessary as opposed to whether they got the risk number right to within a factor of 10.

Mr. Baranowsky said that he was not going to spend a lot of time on the Industry Trends Programs because they had briefed the Committee on this issue within the last two months. Currently, all analyzed events are treated equally. A large break LOCA is counted the same as an innocuous reactor trip or turbine trip, where the plant is started up a few hours later. In the future, analyzed events will be weighted based on risk importance measures and potential impact on core damage frequency. He went on to say that the SPAR models will be used for this. The initial development work has been completed and will be forwarded to NRR shortly. A decision needs to be made whether or not to do some trial implementation while the revised program is fine tuned.

The next item discussed was the SPAR Model Development Program. Seventy Two full power Level 1, Revision 3 SPAR models have been developed. RES has completed the on-site QA reviews for all of the models which was an ACRS recommendation two years ago. They and the licensee compared each other's model. The designation "i" means the differences between the two models have been identified and not yet addressed. When the identified differences have been addressed then the "i" designation is removed. These reviews were done in conjunction with NRR's benchmarking of the SDP notebook for the plant. For low-power and shutdown events, RES has completed the BWR and PWR templates. Mr. Baranowsky indicated that low-power shutdown is a little bit different because no two outages are identical so it's not a push-button model. It's more of a model with a procedure for making it fit what you have actually observed. Dr. O'Reilly said that the onsite QA reviews for the low-power shutdown models have been put on hold because the plants involved are also participating in the Mitigating Systems Performance Index (MSPI) comparison exercises and they didn't want to over burden the license's PRA staff.

The next topic for discussion was large early release frequency (LERF) models. RES has completed bridge models from the core damage states to the containment failure states. The bridge models have been internally peer reviewed. Mr. Cheok pointed out that these models would represent the next step in the evolution of LERF estimation. Currently, the staff uses NUREG/CR-6595, "An Approach for Estimating the Frequencies of Various Containment Failure Modes and Bypass Events," as suggested in RG 1.174 for estimating LERF.

The final topic presented by Mr. Baranowsky was efforts involving the MSPI. The MSPI is in response to promptly address some problems associated with the current performance indicators. It accounts for unavailability and unreliability. He said it was more plant specific than the current set of indicators and eliminates the fault exposure time problem and the cascading effect of cooling system failures onto front line systems. Dr. Dube said the only outstanding issue was the extent to which the contribution of common cause failures is included in the importance measures and whether that should be part of the MSPI methodology. Mr. Baranowsky then discussed a recent article in "Inside NRC." The issue is related to PRA quality and whether or not the staff can use licensees' PRAs as they exist to do the MSPI calculation. RES has tried to identify what impact different assumptions have on calculating MSPI values. For example, what is the impact of using certain success criteria from RELAP instead of the MAPP code. RES plans to run some simulations to verify how sensitive these issues are.

General Comments and Observations From the Subcommittee Members

- Dr. Shack asked if the $14.8 million budget is their contracted budget. Mr. Cunningham said it was and that the division also had a piece of the $8.5 million security budget.

- Dr. Shack asked how the web based data collection was carried out and if the data was reviewed and commented on by its users. Mr. Baranowsky said no and that the process for collecting the data has been documented and peer reviewed and now the process is a routine production activity. Mr. Baranowsky added that if a new element was included then it would go through a more rigorous process, the usual peer review activity and most likely be documented in a NUREG.

- Mr. Rosen asked if the staff has been impacted by the less descriptive inspection reports associated with the ROP. Mr. Marksberry replied that most conditions identified as inspection finding usually result in an LER. Mr. Marksberry said that his branch starts with the inspection report and the associated LER. If additional information is needed then they contact the inspector or the SRA in the region to get additional information.

- Mr. Rosen asked about overlap with the significance determination process. Mr. Baranowsky estimated that about 60 percent of the Accident Sequence Precursors have an overlap with the SDP and about 40 percent don't. He went on to say that the SDP looks at performance deficiencies and his branch is looking at what is the risk out there which is a broader scope question.

- Dr. Apostolakis mentioned that the Fleming report indicated that as much as 20% of the ASPs were not modeled in the licensee's PRAs. Dr. Apostolakis asked what progress is being made to ensure that these sequences are being incorporated into the PRAs. Mr. Baranowsky said that he couldn't say what progress was being made but he thought the issue was finally being addressed. One of the recommendations from the Davis-Besse Lessons Learned Task Force resulted in an Operating Experience Task Force. One of the purposes of the Operating Experience Task Force is to improve the dissemination of operating experience, information, and insights. Mr. Marksberry said the task force was scheduled to brief the Committee in the next several weeks.

- Mr. Rosen recommended that Mr. Baranowsky review Persensky and Flack's presentation to the ACRS on October 9, 2003 and look at the last three charts in their presentation which are potential performance indicators of the cross-cutting issues. Mr. Baranowsky said he appreciated that.

- Dr. Apostolakis mentioned that one of the requirements in the ASME internal events PRA standard is to identify the key assumptions that affect your results. Another group in RES is developing guidance on how to perform uncertainty and sensitivity analyses in support of risk-informed decisions. Dr. Apostolakis said that Mr. Baranowsky's group has developed insights from their work on how sensitive certain results are to particular assumptions. He encouraged Mr. Baranowsky to pass these insights on to the people developing the guidance. Mr. Baranowsky said that he is feeding this information to them.

- Mr. Rosen asked Mr. Baranowsky to summarize the status of the MSPI. Mr. Baranowsky thought they could resolve all the technical issues but there are still issues related to its acceptability as a replacement for the current process which involves a performance indicator and/or a significance determination evaluation on single component failures. Mr. Baranowsky believes that this is best done through reliability analysis because of the context of false positives and false negatives. Mr. Rosen encouraged implementation of the MSPI process.

- Mr. Rosen challenged Mr. Baranowsky to take the lead in investigating potential performance indicators for the safety conscious work environment corrective action program and human performance. Dr. Apostolakis suggested raising the issue of developing performance indicators for the safety conscious work environment corrective action program and human performance in the Committee's annual Safety Research Report.

Treatment of Uncertainties

Dr. Apostolakis reconvened the meeting at 12:30 p.m. Dr. Ali Mosleh, University of Maryland, began with his objective to develop a conceptual unified framework and methodology for treating model and parameter uncertainty. Dr. Mosleh said that their next task would be to apply the methodology to fire risk models and then other applications including thermal-hydraulic model uncertainty. He said that they have developed a Bayesian framework which treats models as sources of evidence concerning the unknown of interest. This has allowed them to formulate solutions for several important classes of model uncertainty problems encountered in PRA applications. Dr. Mosleh stated they have demonstrated the method in two fire risk analysis problems (COMPBRN model uncertainty and line fire temperature model uncertainty).

Dr. Mosleh said that likelihood functions are composed of information from models and on models. Information from models consists of point estimates, probability distributions and bounding the unknown. Information of models consists of performance data and assessment of the quality and applicability of the model. Dr. Mosleh then went over two examples. COMPBRN is used to estimate the cable jacket temperature as a function of time of a group of cable trays in compartment fires. COMPBRN was used to simulate a group of experiments performed by SNL. The other example was estimating plume temperature in a line fire by using a point source fire model prediction. Dr. Mosleh said that the Bayesian framework for an integrated assessment of model and parameter uncertainties provides the flexibility to incorporate performance data as well as subjective evidence about the models. He said that procedures are available for assessing confidence in a model, model applicability and dependence among models. Dr. Mosleh concluded by discussing some of the limitations of the methodology. He said that the methodology focuses on the model output, and the assessment of uncertainty is based on the perceived quality of the model.

Dr. Modarres said that another objective of this work is to bring lessons learned in to code development. He said there is a task at the end to develop a procedure for analyzing uncertainty before revising or embarking on a calculation with a thermal-hydraulics code such as RELAP or TRACE. Dr. Modarres than provided a detailed explanation of the fracture mechanic uncertainty analysis that was performed in support of the PTS work.

General comments and observations from the Subcommittee members

- Dr. Apostolakis asked if guidance had been developed on the use of expert judgement. Dr. Mosleh said they use a simple method of decomposition of the attributes of a model. The model is designed for context alpha and you are using it for context beta. One lists the attributes within context alpha that are important in context beta and you list the attributes, the physical models, the aspects of the physical process that you need to address. Then one asks do I need to introduce a bias term. Do I need to broaden my uncertainty range. He said that kind of a one-to-one assessment is the method they use to make a comparison between the two context and model attributes and reduce them to a single number. He called this an analytic hierarchy type process which gives you a number that is an overall qualitative assessment of applicability of a model alpha to context beta. Dr. Apostolakis commented that they have structured the judgement process. Dr. Mosleh agreed

- Dr. Apostolakis asked if there were any examples where for the same physical situation there were more than one model. Dr. Mosleh said they have not come across that in the examples thus far

- Dr. Shack cautioned about using this methodology that you have to be careful if the parameter of interest is history dependent.

- Mr. Rosen commented that the observations of treatment of uncertainties and complex multi-disciplinary technical assessments is very useful for a common understanding of why doing uncertainty analysis is important and also when to do uncertainty analysis and who should do it and how it should be done. Mr. Rosen thought it had some useful insights and he thanked Dr. Mosleh.

- Dr. Shack complimented Dr. Modarres on how they came up with the uncertainty in the RT_{NDT}. He said it was a good idea and it made the whole thing possible because otherwise you were left with an intractable kind of a problem.

<u>SAPHIRE Peer Review</u>

Mr. Dan O'Neal discussed the SAPHIRE peer review. He said the SAPHIRE code helps develop and run probabilistic safety assessment models. INEEL developed and maintains the code. Earlier this year, a peer review of the SAPHIRE verification and validation process was performed by NRC staff. Mr. O'Neal said one objective of the peer review was how the current testing, verification and validation process matched up with the IEEE standard for software verification and validation. They also constructed and analyzed a database of the changes that were made. For example, they looked at whether or not the changes in the change log were related to a vital feature of the SAPHIRE code, would affect the PRA results, were repetitive or were related to a risk measure, importance measure, or uncertainty analyses. They looked at about 500 changes. Some were significant. A significant change was related to an error in the code which could affect the correct numerical results but it does not alert the model developer. Mr. O'Neal said that all of the identified significant errors had been corrected.

General Comments and Observations From the Subcommittee Members

- Dr. Apostolakis and Mr. Rosen asked if past users were alerted about code errors. Mr. O'Neal said they have a website which has the change logs on it so anytime that there is an error or a change made to the log because of something that was found it's posted. He added that this is a very recent feature. Mr. O'Neal said that there is a SAPHIRE and SPAR Model Users Group.

- Dr. Shack asked if the errors were discovered by users rather that the V&V process. Mr. O'Neal said it was a mixed bag. He was aware that there have been users that have found significant change errors in the code and those get fed back to the laboratory. The laboratory corrects it and puts up a new subversion.

- Dr. Apostolakis heard from outside users that somebody picks up the phone, calls and says, "Hey, I found this error." The guy on the phone fixes it and that's it. There is no formal mechanism for evaluating the error or fixing it and communicating that to end users. Mr. O'Neal sais there is a formal process now for making the changes.

Fire Risk Research

Mr. J.S. Hyslop, RES, discussed fire risk research program activities. He quickly reviewed the following eight program activities: fire protection SDP revision, circuit analysis, risk-informed, performance-based fire protection rulemaking (NFPA 805), ANS full power fire standard, NRC/EPRI fire risk requantification studies, fire model benchmark/validation, Hemyc and MMT fire barrier testing, and international activities.

General Comments and Observations From the Subcommittee Members

- Mr. Rosen asked if the low-power and shutdown model addresses fire. Mr. Hyslop said it does not but the staff is participating in the development of an international fire event database under the auspices of the OECD. Mr. O'Neal added that RES is conducting a feasibility study of expanding the scope of the fire requantification project to include low power and shutdown.

Low Power and Shutdown Risk Research

Mr. Dan O'Neal, RES, discussed low power and shutdown risk research activities. He said the highest priority activity was supporting development of a low power shutdown standard which is being written by the American Nuclear Society. RES is on the writing committee and the standard is projected to be completed around December 2004. In support of the standard, RES is revising NUREG/CR-6595 which provides a simplified method for evaluating larger release frequencies. RES added a chapter specific on how to estimate large release frequencies for low power and shutdown conditions. Mr. O'Neal then discussed activities with the international community on low power shutdown risk. RES participates in international meetings of the Cooperative PRA Working Group for low power shutdown and the Committee on the Safety of Nuclear Installation Working Group. With regard to the COOPRA work, he said the United States had the lead for writing a topical report on initiating events. That was based upon responses to a questionnaire from the various member countries on what can be learned from low power and shutdown initiating events.

General Comments and Observations From the Subcommittee Members

- Mr. Rosen said that sooner or later someone will have an event during shutdown under the ROP and then there will be a big debate about whether it was white or red or yellow and it would be helpful to have a better database. Mr. O'Neal said RES was developing the models for low power shutdown and updating the frequencies in those models.

- Mr. Rosen commented on cycle risk optimization. He discussed the importance of having a shutdown risk calculational method that would allow meaningful risk comparisons or tradeoffs among these operational conditions. For example, to help one determine whether it is less risky to perform a particular maintenance activity at power or during shutdown. He encouraged the staff to do whatever they can to move this effort along.

STAFF AND INDUSTRY COMMITMENTS

The Operating Experience Task Force is to brief the ACRS on improvements in disseminating operating experience, information, and insights to industry PRA practioners. Dr. Apostolakis asked for examples of where model and parameter uncertainty were considered as part of ASP analysis. Mr. Baranowsky said that three or four could be provided.

SUBCOMMITTEE DECISIONS AND ACTIONS

Dr. Apostolakis recommended a follow-up meeting to discuss digital I&C reliability models. The Subcommittee decided that the information gathered would be useful in developing the annual Safety Research Report. The Subcommittee will reassess the need for future interactions after reviewing a first draft of the report in December 2003.

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE PRIOR TO THIS MEETING

1. Subcommittee status report, including agenda.

2. Letter dated August 19, 2003, from Ali Tabatabai, Link Technologies Inc., to John Larkins, Executive Director, ACRS, Subject: Status and Next Steps - 2004 Research Report (For Internal ACRS Use Only)..

3. Staff Requirements Memorandum (SRM)–issued on March 26, 2003.

4. Draft NUREG/CR, "SPAR-H Model," manuscript completed November 2002.

5. NUREG/CR-6833, "Formal Methods of Decision Analysis Applied to Prioritization of Research and Other Topics," October 2003.

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<u>Note:</u> Additional details of this meeting can be obtained from a transcript of this meeting available for downloading or viewing on the Internet at "http://www.nrc.gov/ACRSACNW' or can be purchased from Neal R. Gross and Co., Inc., (Court Reporters and Transcribers) 1323 Rhode Island Avenue, NW., Washington, DC 20005 (202) 234-4433.

Committee Management Secretariat, General Services Administration.

FOR FURTHER INFORMATION CONTACT: Andrew L. Bates, Office of the Secretary, U.S. Nuclear Regulatory Commission, Washington, DC 20555; Telephone: 301–504–1963.

Dated: September 25, 2003.

Andrew L. Bates,

Advisory Committee Management Officer.

[FR Doc. 03–24852 Filed 9–30–03; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards; Joint Meeting of the ACRS Subcommittees on Reliability and Probabilistic Risk Assessment and on Human Factors; Notice of Meeting

The ACRS Subcommittees on Reliability and Probabilistic Risk Assessment and on Human Factors will hold a joint meeting on October 9, 2003, Room T–2B3, 11545 Rockville Pike, Rockville, Maryland.

The entire meeting will be open to public attendance.

The agenda for the subject meeting shall be as follows:

Thursday, October 9, 2003—8:30 a.m. until the conclusion of business.

The purpose of this meeting is to discuss seismic, digital I&C, and human factors research activities. The Subcommittees will hear presentations by and hold discussions with representatives of the NRC staff and other interested persons regarding this matter. The Subcommittees will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Members of the public desiring to provide oral statements and/or written comments should notify the Designated Federal Officials, Mr. Michael R. Snodderly (telephone: 301–415–6927) or Dr. Medhat M. El-Zeftawy (telephone: 301–415–6889) five days prior to the meeting, if possible, so that appropriate arrangements can be made. Electronic recordings will be permitted during the meeting.

Further information regarding this meeting can be obtained by contacting one of the Designated Federal Officials between 7:30 a.m. and 4:15 p.m. (ET). Persons planning to attend this meeting are urged to contact one of the above named individuals at least two working days prior to the meeting to be advised of any potential changes to the agenda.

Dated: September 23, 2003.

Sher Bahadur,

Associate Director for Technical Support, ACRS/ACNW.

[FR Doc. 03–24851 Filed 9–30–03; 8:45 am]

BILLING CODE 7590–01–P

NUCLEAR REGULATORY COMMISSION

Advisory Committee on Reactor Safeguards Meeting of the ACRS Subcommittee on Reliability and Probabilistic Risk Assessment; Notice of Meeting

The ACRS Subcommittee on Reliability and Probabilistic Risk Assessment will hold a meeting on October 10, 2003, Room T–2B3, 11545 Rockville Pike, Rockville, Maryland.

The entire meeting will be open to public attendance.

The agenda for the subject meeting shall be as follows: *Friday, October 10, 2003—8:30 a.m. until the conclusion of business.*

The purpose of this meeting is to discuss the status of the probabilistic risk assessment research program. The Subcommittee will hear presentations by and hold discussions with representatives of the NRC staff and other interested persons regarding this matter. The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full Committee.

Members of the public desiring to provide oral statements and/or written comments should notify the Designated Federal Official, Mr. Michael R. Snodderly (telephone: 301–415–6927) five days prior to the meeting, if possible, so that appropriate arrangements can be made. Electronic recordings will be permitted during the meeting.

Further information regarding this meeting can be obtained by contacting the Designated Federal Official between 7:30 a.m. and 4:15 p.m. (ET). Persons planning to attend this meeting are urged to contact the above named individual at least two working days prior to the meeting to be advised of any potential changes to the agenda.

Dated: September 23, 2003.

Sher Bahadur,

Associate Director for Technical Support, ACRS/ACNW.

[FR Doc. 03–24853 Filed 9–30–03; 8:45 am]

BILLING CODE 7590–01–P

SECURITIES AND EXCHANGE COMMISSION

[Release No. 35–27726]

Filings Under the Public Utility Holding Company Act of 1935, as amended ("Act"); The Connecticut Light and Power Company (70–10163)

September 25, 2002.

Notice is hereby given that the following filing(s) has/have been made with the Commission pursuant to provisions of the Act and rules promulgated under the Act. All interested persons are referred to the application(s) and/or declaration(s) for complete statements of the proposed transaction(s) summarized below. The application(s) and/or declaration(s) and any amendment(s) is/are available for public inspection through the Commission's Branch of Public Reference.

Interested persons wishing to comment or request a hearing on the application(s) and/or declaration(s) should submit their views in writing by October 20, 2003, to the Secretary, Securities and Exchange Commission, Washington, DC 20549–0609, and serve a copy on the relevant applicant(s) and/or declarant(s) at the address(es) specified below. Proof of service (by affidavit or, in the case of an attorney at law, by certificate) should be filed with the request. Any request for hearing should identify specifically the issues of facts or law that are disputed. A person who so requests will be notified of any hearing, if ordered, and will receive a copy of any notice or order issued in the matter. After October 20, 2003, the application(s) and/or declaration(s), as filed or as amended, may be granted and/or permitted to become effective.

Notice of Proposal To Amend Charter Or, Alternatively, Waive Charter Provision; Order Authorizing the Solicitation of Proxies

The Connecticut Light and Power Company ("CL&P"), 107 Selden Street, Berlin, Connecticut 06037, a wholly owned public-utility subsidiary of Northeast Utilities ("NU"), a registered holding company, has filed a declaration ("Declaration") with the Securities and Exchange Commission ("Commission") under sections 6(a)(2) and 12(e) of the Public Utility Holding Company Act of 1935, as amended ("Act") and rules 54, 62, and 65 under the Act.

Currently, the ability of CL&P to incur or assume unsecured indebtedness is limited by a provision in its Certificate of Incorporation ("Charter"). The Charter provides that, except with the

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
JOINT MEETING OF THE SUBCOMMITTEES ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT AND HUMAN FACTORS
ROOM T-2B3, 11545 ROCKVILLE PIKE, ROCKVILLE MD
OCTOBER 9, 2003

Contact: Michael Snodderly (301-415-6927, mrs1@nrc.gov)

-PROPOSED SCHEDULE-

	TOPICS	PRESENTERS	TIME
I.	**Opening Remarks**	G. Apostolakis, ACRS D. Powers, ACRS	8:30-8:35 a.m.
II.	**Seismic Research**	A. Murphy, RES	8:35-9:40 a.m.
III.	**General Discussion**	G. Apostolakis, ACRS D. Powers, ACRS	9:40-9:45 a.m.
	BREAK		**9:45-10:00 a.m.**
IV.	**Introductory Remarks**	G. Apostolakis, ACRS J. Sieber, ACRS	10:00-10:05 a.m.
V.	**Digital I&C Research and Digital Systems Risk**	S. Arndt, RES H. Hamzehee, RES	10:05-11:55 a.m.
VI.	**General Discussion**	G. Apostolakis, ACRS J. Sieber, ACRS	11:55-12:00 p.m.
	LUNCH		**12:00-1:00 p.m.**
VII.	**Introductory Remarks**	S. Rosen, ACRS	1:00-1:05 p.m.
VIII.	**Human Factors and Human Performance Research**	J. Flack, RES	1:05-1:50 p.m.
IX.	**Organizational Safety Culture Research**	J. Flack, RES J. Persensky, RES	1:50-3:15 p.m.
	BREAK		**3:15-3:30 p.m.**
X.	**Human Reliability Research**	H. Hamzehee, RES	3:30-4:25 p.m.
XI.	**SPAR-H Model**	P. O'Reilly, RES	4:25-5:25 p.m.
XII.	**General Discussion**	S. Rosen, ACRS	5:25-5:30 p.m.
XIII.	**Adjourn**	S. Rosen, ACRS	5:30 p.m.

NOTE:
- Presentation time should not exceed 50 percent of the total time allocated for specific item. The remaining 50 percent of the time is reserved for discussion.
- 35 copies of the presentation materials to be provided to the Subcommittee

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-PROPOSED SCHEDULE-

	TOPICS	PRESENTERS	TIME
I.	**Opening Remarks**	G. Apostolakis, ACRS	8:30-8:35 a.m.
II.	**Plan for Application of Formal Decisionmaking Methods in Integrated Regulatory Decisions**	P. Kadambi, RES	8:35-9:20 a.m.
	BREAK		**9:20-9:30 a.m.**
III.	**Overview of the PRA Safety Research Program**	M. Cunningham, RES	9:30-9:40 a.m.
IV.	**Program for Risk-Based Analysis of Reactor Operating Experience** A. ASP Program B. Industry Trends Support C. SPAR Model Development Program D. Reply to ACRS Letter on Risk-Based Analysis of Reactor Operating Experience	P. Baranowsky, RES	9:40-11:30 a.m.
	LUNCH		**11:30-12:30 p.m.**
V.	**Planned Activities in Development of PRA Methods and Standards** A. Integrated Uncertainty Research B. SAPHIRE Peer Review C. Low Power and Shutdown Risk	H. Hamzehee, RES	12:30-2:30 p.m
VI.	**General Discussion**	G. Apostolakis, ACRS	2:30-2:45 p.m.
VII.	**Adjourn**	G. Apostolakis, ACRS	2:45 p.m.

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETING ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

OCTOBER 10, 2003
Date

NRC STAFF SIGN IN FOR ACRS MEETING

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NAME	NRC ORGANIZATION
JOHN FLACK	RES/DSARE/REAHFB
Kent Welter	RES/DSARE/SMSAB
DON DUBE	RES/DRAA/OERAB
STU MAGRUDER	RES/DRAA
Pat O'Reilly	RES/DRAA/OERAB
Dale M. Rasmuson	RES/DRAA/OERAB
Don Marksberry	RES/DRAA/OERAB
Patrick Baranowsky	RES/DRAA/OERAB
Bennett Brady	RES/DRAA/OERAB
Gary DeMoss	RES/DRAA/OERAB
ALAN RUBIN	RES/PRAB

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

SUBCOMMITTEE MEETING ON RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

OCTOBER 10, 2003
Date

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NAME	AFFILIATION
W Arcieri	ISL, Inc
B Dolan	Progress Energy
SPYROS TRAIFOROS	LINK
CURTIS SMITH	INEEL

Master

FEASIBILITY OF APPLYING FORMAL DECISION METHODS TO NRC ACTIVITIES

Presentation to ACRS Subcommittee on Reliability and Probabilistic Risk Assessment

October 10, 2003

N. Prasad Kadambi, REAHFB

Office of Nuclear Regulatory Research

OUTLINE

- Background

- Context for Formal Decision Methods (FDM)

- NUREG/CR-6388, "Formal Methods of Decision Analysis Applied to Prioritization of Research and Other Topics"

- Ideas for formal methods.

- Implementation possibilities.

- Summary

BACKGROUND

- The ACRS noted in a letter to the Commission on February 14, 2002 that their review of the safety research program had recommended exploration of formal decision methods.

- Specifically, under "Use of Formal Decision-Making Methods to Support Regulatory Decisions" it was stated that:

  - In NUREG-1635, Vol. 4, we observed that the decision-making processes used in the regulatory framework process often appear overly subjective and recommended that the staff initiate a research program to investigate how best to use formal decision-making methods to make regulatory decisions more objective and transparent and, thus, more defensible."

- On March 29, 2002, the EDO responded that, "... RES recognizes the merits of the recommendations and will explore the feasibility of applying these methods in its work."

- Soon after, we initiated a technical assistance Task Order and the NUREG/CR-6833 is the result.

CONTEXT FOR FORMAL DECISION METHODS

- Exploration of FDM for prioritization of research was opportune in early 2002 because of the "Advanced Reactor Research Plan" (SECY-03-0059).

- We recognized all along that the methodologies had widespread applicability.

- Elements of FDM are practiced in a number of ongoing activities:

  - The agency effort in Planning Budgeting and Performance Management (PBPM), including consideration of the four performance goals, represents identification of elements of the NRC's utility function.

  - The existing methods for prioritization, including the Phenomena Identification and Ranking Table (PIRT) have a degree of formality.

  - Performance-based regulation, which attempts to set performance measures at as high a level as practicable, reveals the importance of a formal structuring of objectives.

  - Success of the Reactor Oversight Process (ROP) can substantially be attributed to the formal structuring of objectives.

NUREG/CR-6388, "FORMAL METHODS OF DECISION ANALYSIS APPLIED TO PRIORITIZATION OF RESEARCH AND OTHER TOPICS"

- Our objective for NUREG/CR-6833 was to provide NRC staff with a compilation of tools and methods from the vast field of FDM that would likely be useful for regulatory application.

- In addition to the customary management review, the report was reviewed by staff from NRR, NMSS, and NSIR. The comments from these reviews were extremely valuable.

    - Comments recognized value of structured decision process.

    - Elements of FDM were recognized in various ongoing NRC activities.

    - Unfamiliar terminology and conceptual complexity were considered to be significant obstacles.

    - The importance of demonstrating usefulness by application to familiar examples was a common theme among the comments.

- Overall, the research provided evidence in support of NRC continuing to pursue FDM.

NUREG/CR-6388, "FORMAL METHODS OF DECISION ANALYSIS APPLIED TO PRIORITIZATION OF RESEARCH AND OTHER TOPICS" (Contd)

- Staff using NUREG/CR-6833 would be introduced to:
    - Utility theory
    - Value-of-Information techniques.
    - Types of performance measures, scales and indicies.
    - Hypothesis testing.
    - "Receiver Operating Characteristic" Curves.
    - Objectives hierarchies.
- The information is presented in a context that addresses some current regulatory issues, such as decision making under uncertainty. Information is also provided on the Analytic Hierarchy Process and the Code Scaling, Applicability and Uncertainty Evaluation Methodology, which are more familiar to staff.
- Mention is made of potentially useful performance measures for research such as value added by assessing change in uncertainty.

IDEAS FOR FORMAL DECISION METHODS

- The success experienced by the ROP, and the Commission's stress on performance-based regulation, offer the potential that familiarity with FDM could increase.

- Opportunities could arise from diverse activities, e.g. the PBPM process stresses consideration of the strategic performance goals. Multi-attribute utility theory may have potential application for developing guidance for the staff for implementing the Strategic Plan.

- RES is evaluating options, including consideration of pilot projects, while establishing the required foundation of tools and methods available from decision theory.

- Participation by other program offices is essential for the eventual success of our initiative to offer to the staff improved decision making tools and methods. External factors, such as OMB's recent requirements relative to formal program assessment and rating, as well as internal factors, such as common prioritization of staff activities, may combine to create opportunities for FDM based concepts.

- Suggestions from other stakeholders, such as ACRS, would be most welcome and appreciated.

IDEAS FOR FORMAL DECISION METHODS (Contd)

- Formal adoption of FDM would improve the focus on structure, transparency, and the treatment of uncertainty.

- We are proposing five steps using the utility concept as the basic process for FDM.

- The first step is to construct the utility function.
  - Identify elements of the utility function.
  - Combine the elements with preferences of the decision maker.
  - Formulate and screen scenarios; note constraints such as legal requirements.

- The second step is to formulate action alternatives.
  - With stakeholder input, test for incorporation of elements and preferences.
  - Also test for policy preferences, eg. RI, PB, RIPB, and traditional approaches.

- The third step is to generate expected utilities.
  - Identify quantitative/qualitative factors with natural/constructed measures.
  - Identify figure-of-merit (performance index)
  - Identify decision rules.

- Rank order alternatives

- Select alternative, if appropriate.

IMPLEMENTATION POSSIBILITIES

- The initial focus for implementation should be closing the gap in terminology.
- Establish Inter-Office Working Group
  - Provide focal point for FDM
  - Develop nucleus of FDM-knowledgeable staff
- Identify case studies
  - Explore regulatory issues that could benefit from FDM
  - Develop internal consensus on expected benefits
  - Address resource issues
  - Establish assignments, schedules, deliverables

IMPLEMENTATION POSSIBILITIES (Contd)

- Obtain wide range of stakeholder input
  - Higher level management briefings
  - Advisory Committee presentations
  - Public meetings, as appropriate.
- Conduct case studies
  - Working group interacts with staff for appropriate level of FDM application.
  - Compare results with expectation
- Prepare NUREG report
  - Internal stakeholder interaction (including Advisory Committees)
  - External stakeholder interaction
- Report to Commission

SUMMARY

- RES followed up on ACRS's suggestions on FDM and agrees that NRC activities could benefit significantly from such applications.
- The staff's exploration has resulted in NUREG/CR-6833, which could provide a resource for tools and methods that would enable staff to get started.
- An evolutionary approach that gradually expands on applying decision theoretic methods is considered to be the most practical path forward.
- Successful case studies may alleviate discomfort with terminology, and offer evidence that objectivity and transparency can advance performance goals.
- Identifying appropriate regulatory issues to use as case studies is a significant challenge. ACRS suggestions are welcome.
- It is crucially important to obtain Commission acquiescence on a broad application of FDM in NRC activities.
- If the Commission agrees that FDM is worth pursuing beyond the exploratory phase, the staff now has the requisite foundation on which to build.

Master

Division of Risk Analysis and Applications

Mark Cunningham
Acting Deputy Division Director
October 10, 2003

DRAA Overview

- Staff – 55 FTE
- Budget - $14.8M
- Major Responsibilities
  - Operating Experience
  - Security
  - Risk Methods
  - Risk Studies
  - PRA Standards
  - Advanced Reactors

Operating Experience

- SPAR Program
- ASP Growth
- New data system
- MSPI
- Task Force recommendations
- Support international meetings/workshops

Security

- Vulnerability Study Use
- Research Plan
- Decisionmaking
- Briefings for international community

Risk Methods

- HRA
  - Atheana
  - Human reliability data
  - Halden
- Fire Risk
  - Requantification studies
  - Barrier testing
  - SDP revision
- Materials and Waste
  - Draft safety goals
  - Tools, methods, data, guidance

Risk Studies

- Option 3 - 50.44; 50.46
- PTS
- Dry Cask
- GSI 191 - PWR Sumps
- Steam Generator Tube Rupture

PRA Standards

- DG 1122 – ASME/Peer Review
- External Events - ANS
- Low Power & Shutdown- ANS
- IAEA/NEA/NRC/CNSC PSA Quality Workshop
- Support Guidance
  - Sensitivity
  - Uncertainty

Advanced Reactors

- Technology Neutral Framework
- ACR-700
- PRA Tools - Passive equipment

Support

- PRA Steering Committee
- RIRIP
- RILP
- NMSS Risk Steering Committee

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RISK-BASED ANALYSIS OF REACTOR OPERATING EXPERIENCE

Presentation for ACRS Subcommittee on

Reliability and Probabilistic Risk Assessment

OCTOBER 10, 2003

PATRICK W. BARANOWSKY, CHIEF

OPERATING EXPERIENCE RISK ANALYSIS BRANCH
OFFICE OF NUCLEAR REGULATORY RESEARCH

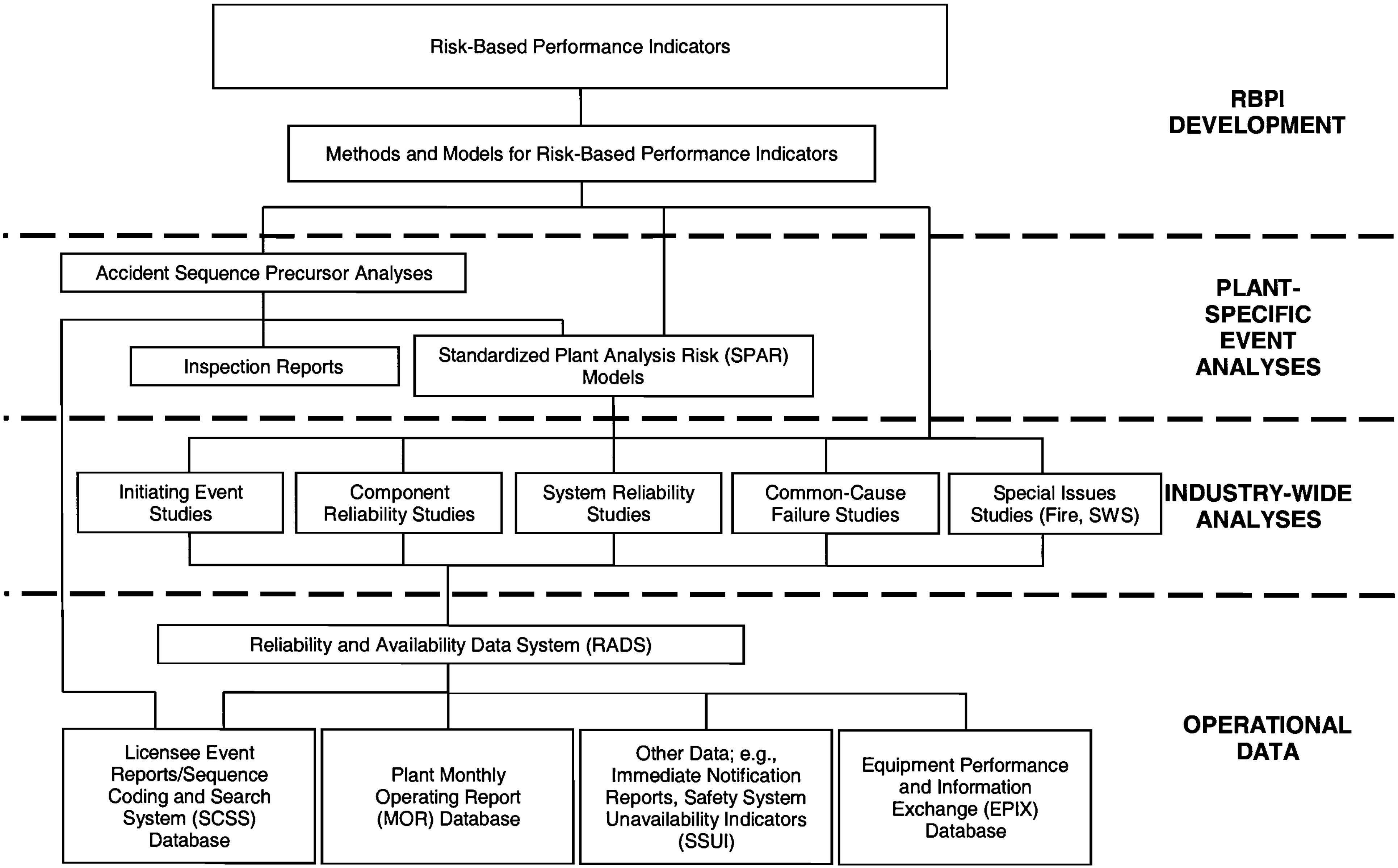
CONTENTS

Introduction

OERAB Support to Agency

- **Accident Sequence Precursor Program**
  - Report to Congress Input
  - Trends
  - Independent Analysis
- **Reactor Oversight Process and Trends Support**
  - Performance Indicators and industry trends (initiating events, safety system reliability, common-cause failures, component performance, etc)
  - Thresholds for trends
- **NPP Performance Data Collection and Analysis**
  - Initiating Events
  - Safety System Performance Data
  - Component Performance Data
  - Common-Cause Failures
- **SPAR Model Development Program**
  - Power operation (Rev. 2QA, Rev. 3i)
  - Low Power/Shutdown
  - Level 2/LERF
  - External events (earthquake, flood, and fire)

RISK-BASED ANALYSIS OF REACTOR OPERATING EXPERIENCE PROGRAM



Data Collection and Analysis

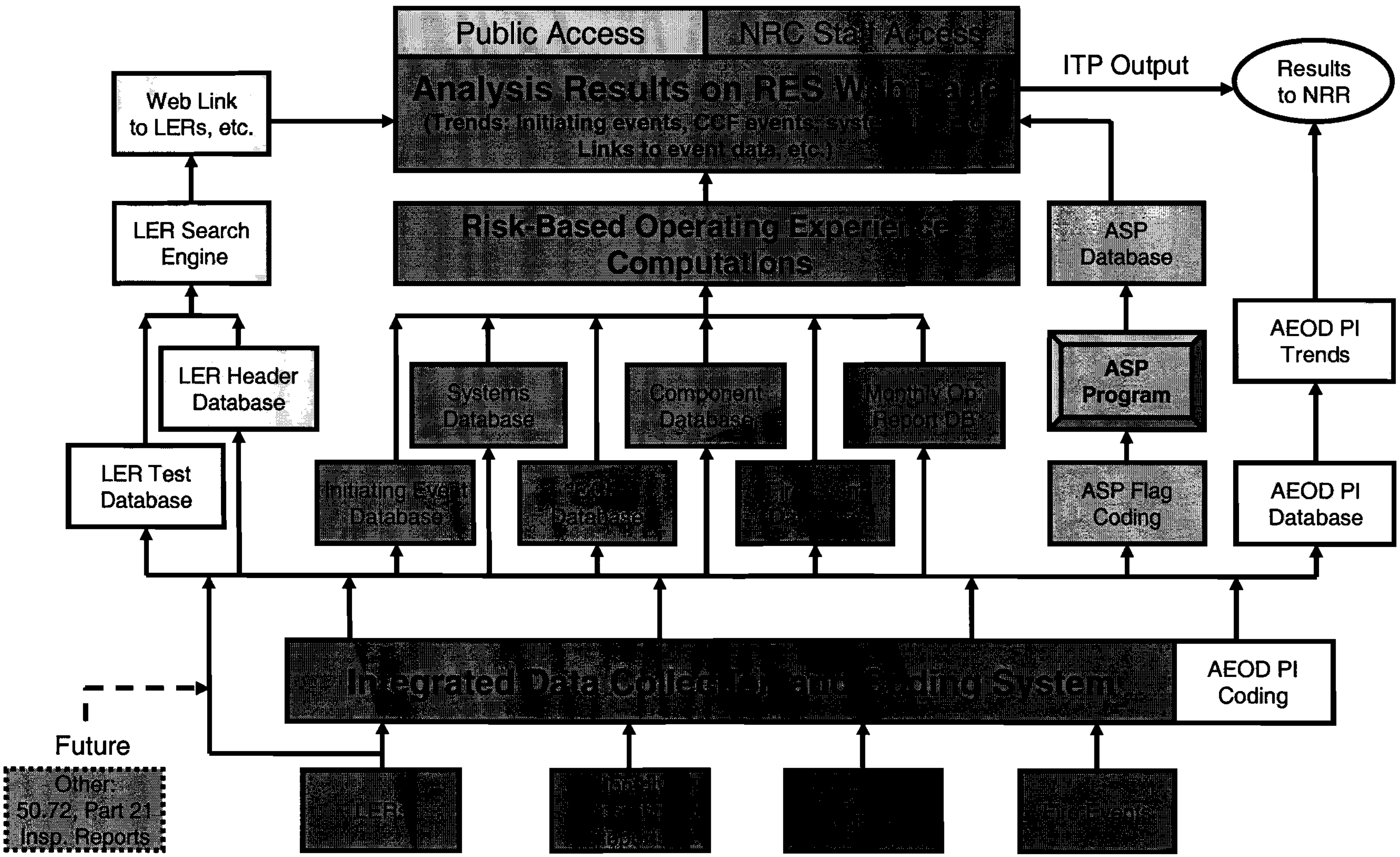
CONSOLIDATED DATA COLLECTION AND ANALYSIS

- Integrated Data Collection and Coding System
  - LERs are reviewed and coded once for:
    - Initiating events
    - Systems reliability
    - Component reliability
    - Common-cause failures
    - Fire events
    - Candidate ASP events
  - Similarly, EPIX data from INPO reviewed and coded once for:
    - Component reliability
    - Common-cause failures
    - Fire events
  - Standardize data coding and analysis
    - Same definition for fields such as "failure cause" for all studies
    - Analysis techniques standardized for all studies
    - Data structure being standardized (Microsoft Excel database)

CONSOLIDATED DATA COLLECTION AND ANALYSIS (Continued)

- Status and schedule
  - System developed and trial testing started - August 2003
  - Reactor Operating Experience Results and Databases web page available in beta version on NRC internal web site - October 2003
  - Available on NRC external web site - TBD
    - Questions need to be addressed on security, proprietary data, Operating Experience Task force recommendations
    - Add text search of other document types such as inspection reports, 10 CFR 50.72 reports, and 10 CFR 21 reports - TBD

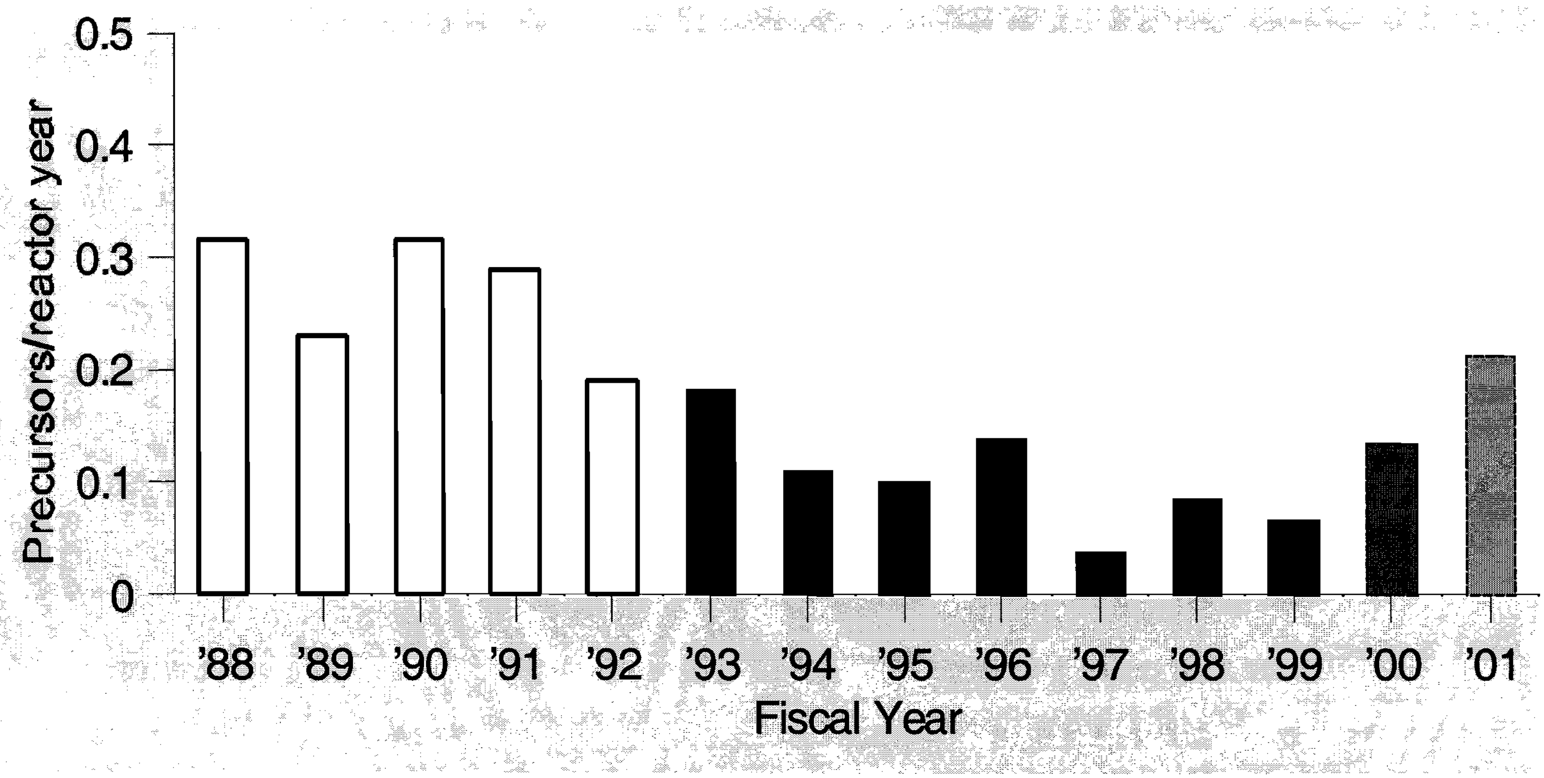
Integrated Operating Experience Data Collection and Analysis



Accident Sequence Precursor (ASP) Program

ACCIDENT SEQUENCE PRECURSOR (ASP) ANALYSES

- Objectives
  - Systematically evaluate U.S. nuclear plant operating experience to identify, document, and rank operating events most likely to lead to inadequate core cooling and severe core damage (precursors), if additional failures had occurred.
  - Provide a measure for trending nuclear plant core damage risk.
  - Provide a partial check on PRA-predicted dominant core damage scenarios.



All Precursors – occurrence rate, by fiscal year. No trend detected during the FY 1993-2001 period.

INSIGHTS FROM ASP PROGRAM (FY 1993-2002)

- Analysis of trends in ASP events for period FY 1993-2002
  - May be an increasing trend over past 6 years
  - "Significant" precursors (CCDP or ΔCDP ≥ $1x10^{-3}$) occur about once every 4-5 years; last one in 1996 (potential one in 2002)

- Most (~80%) precursors are consistent with IPE/PRA results in frequency of occurrence and also in dominant contributors

- However, a number (~20%) of precursor events involved event initiators or conditions that are typically not modeled in PRAs/IPEs
  - Blowdown of the RCS to the RWST at hot shutdown
  - Reactor trip with loss of one train of essential service water due to frazil ice and the unavailability of the turbine-driven AFW pump
  - Potential failure of all CCW pumps due to steam intrusion resulting from a high-energy line break
  - Potential LOCA due to control rod drive mechanism degradation and reactor vessel head corrosion

Industry Trends Program

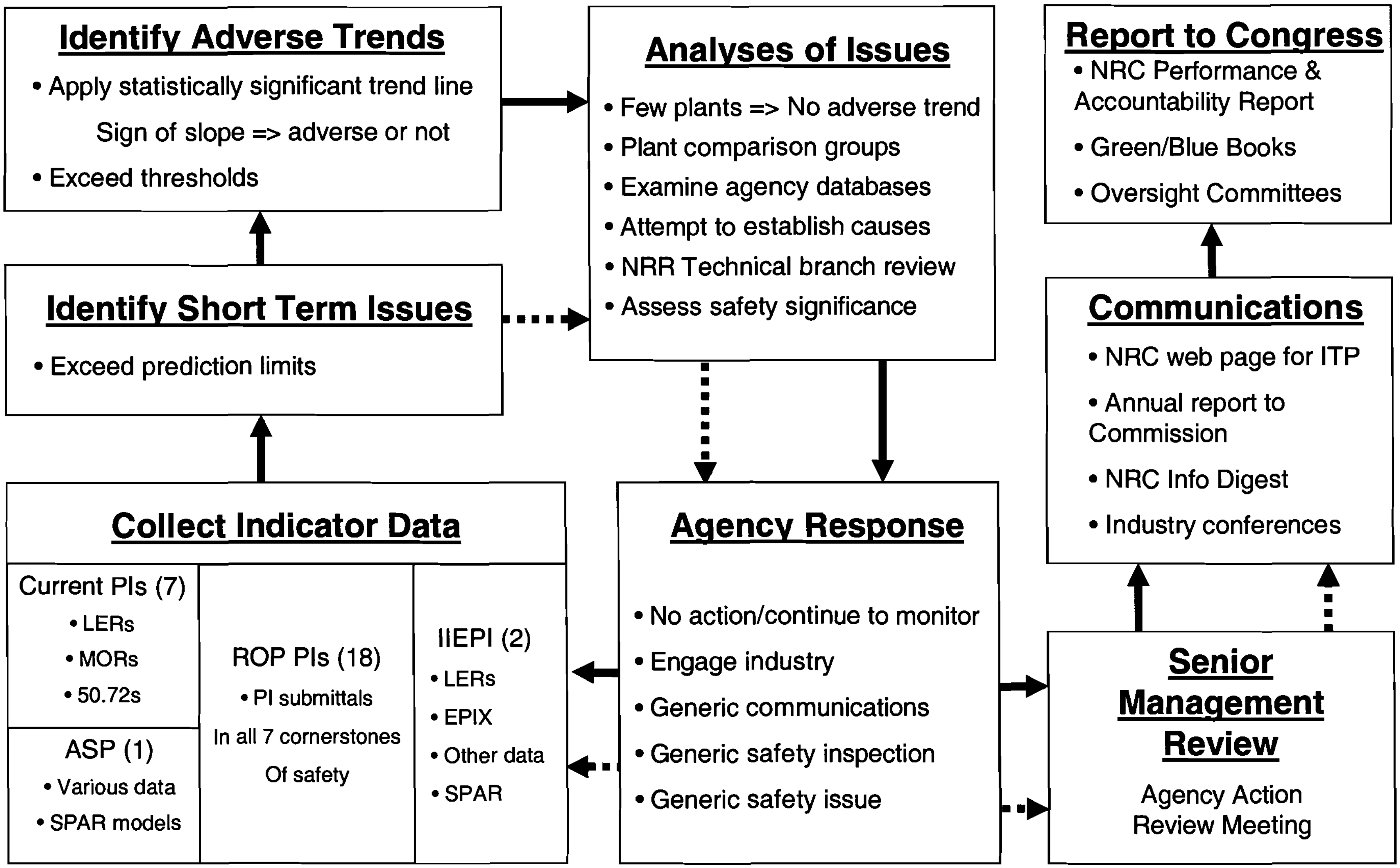
Industry Trends Program (ITP)

- The ITP is designed, in part, to complement the Reactor Oversight Process (ROP).
- The ITP focuses on multi-plant/ multi-site performance, while the ROP focuses on plant-specific performance.
- ITP complements generic communications and generic safety issues processes.

ITP Objectives

- Collect and monitor industry-wide data to assess whether the nuclear industry is maintaining safety performance of operating plants and to provide feedback to the ROP and other NRC processes.
- Assess the safety significance and causes of any statistically significant adverse trends.
- Communicate industry-level information to Congress and other stakeholders.

ITP Process



Identify Adverse Trends
• Apply statistically significant trend line
Sign of slope => adverse or not
• Exceed thresholds
Analyses of Issues
• Few plants => No adverse trend
• Plant comparison groups
• Examine agency databases
• Attempt to establish causes
• NRR Technical branch review
• Assess safety significance
Report to Congress
• NRC Performance & Accountability Report
• Green/Blue Books
• Oversight Committees
Identify Short Term Issues
• Exceed prediction limits
Communications
• NRC web page for ITP
• Annual report to Commission
• NRC Info Digest
• Industry conferences
Collect Indicator Data
Current PIs (7)
• LERs
• MORs
• 50.72s
ASP (1)
• Various data
• SPAR models
ROP PIs (18)
• PI submittals
In all 7 cornerstones
Of safety
IIEPI (2)
• LERs
• EPIX
• Other data
• SPAR
Agency Response
• No action/continue to monitor
• Engage industry
• Generic communications
• Generic safety inspection
• Generic safety issue
Senior Management Review
Agency Action Review Meeting

Integrated IE Indicator Development

- Monitoring 10-15 risk-significant IEs can provide better insights than current set of industry indicators.
- Roll-up indicator can simplify communications to Congress/stakeholders.

SPAR Model Development Program

LEVEL 1, REVISION 3 SPAR MODELS

Accomplishments through 9/30/2003

- Completed production of entire set of 72 Revision 3i SPAR models on November 2002.
- Completed onsite QA reviews of all 72 models on August 2003.
- Performed review/evaluation of comparison exercise results for the 11 SPAR models representing the 20 plants in the MPSI pilot program.

LEVEL 1, REVISION 3 SPAR MODELS

Future Plans/Enhancements

- Upgrade level of detail based on results of MSPI pilot program comparison exercise.
- Improve models to address issues identified from onsite QA reviews.
- Revise models as necessary to address user feedback.

LOW POWER/SHUTDOWN (LP/SD) SPAR MODELS

Accomplishments through 9/30/2003

- Completed BWR and PWR templates.
- Completed eight preliminary LP/SD SPAR models.
- Conducted onsite QA review of LP/SD SPAR model for Surry 1 & 2.

LOW POWER/SHUTDOWN (LP/SD) SPAR MODELS

Future Plans

- Conduct additional onsite QA reviews.
- Produce additional LP/SD SPAR models (e.g., Diablo Canyon 1 & 2; River Bend).

LERF SPAR MODELS

Accomplishments through 9/30/2003

- Completed draft bridge trees and containment event trees.
- Incorporated peer review comments.
- Completed initial quantification of LERF SPAR model for first lead plant (W PWR w/large, dry containment [Comanche Peak]).

LERF SPAR MODELS

Future Plans

- Revise model to address comments from key users.
- Develop LERF SPAR models for other lead plants.

Mitigating Systems Performance Index (MSPI)

Mitigating Systems Performance Index (MSPI)

- MSPI evolved from feasibility study of Risk-Based Performance Indicators (RBPI) in NUREG-1753.
- MSPI addresses recognized issues with current PIs.
- MSPI is highly risk informed simplification to RBPIs with the following features:
  - Unavailability and unreliability consistent with PRA.
  - Accounts for plant specific design and performance data.
  - Eliminates fault exposure time.
  - No cascade failure of cooling water support systems.
  - Scope consistent with at-power internal events level-1.
  - Performance thresholds consistent with basis for current PIs.

MSPI Pilot Objectives

- Exercise MSPI Guidance:
  - System boundary and component identification.
  - Data collection.
  - MSPI computation.

- Validation and Verification:
  - Issue identification & special studies.
  - SPAR model comparisons.
  - Duplication of Pilot Plant results.
  - Comparison to SDP (Table top).

- Perform Temporary Instruction Inspections.

- ACRS Subcommittee briefed in July 2003; follow-up to present Pilot results anticipated early 2004.

Master

An Overview of UMD Research in Treatment of Uncertainties

Center for Technology Risk Studies
University of Maryland

ACRS October 10, 2003

Topics

- Integrated Model and Parameter Uncertainty
- Physical Models Uncertainty
  - Thermal-Hydraulics
  - Fracture Mechanics

2

Framework for Integrated Treatment of Model and Parameter Uncertainties

Ali Mosleh
Center for Technology Risk Studies
University of Maryland

ACRS October 10, 2003

3

Objectives

- Develop a conceptual, unified, framework and methodology for treating model and parameter uncertainties
- Provide guidelines for practical applications
- Apply to representative cases from fire risk models

4

Results

- Developed a Bayesian framework treating models as sources of evidence concerning the unknown of interest
- Demonstrated that many popular methods are special cases of the general Bayesian framework
- Formulated solutions for several important classes of model uncertainty problems encountered in PRA applications
- Demonstrated the method in two fire risk analysis problems (COMBRN model uncertainty, and line fire temperature model uncertainty)

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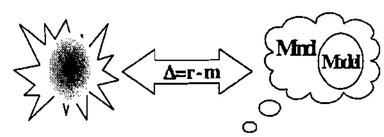
Model Uncertainty



Examples of Sources of Model Uncertainty:
- Conceptualization of a reality aspect
- Implementation into a particular form
- Several plausible models reflecting different interpretations of reality

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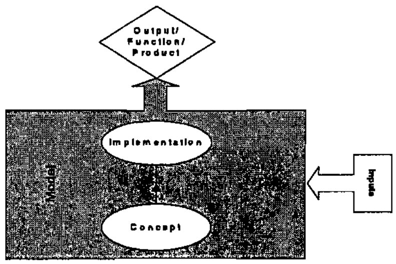
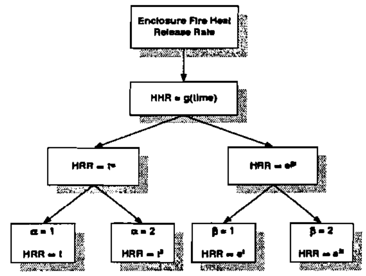
Models



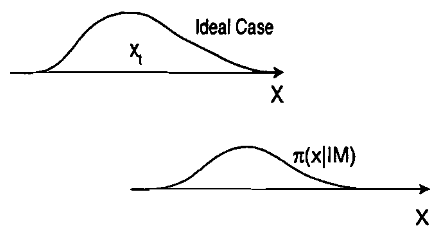
Form and Parameter



Model Uncertainty

- A successful treatment of model uncertainty results in an expression of uncertainty that includes the true value at some stated level of confidence.
- History of science provides ample evidence that in any modeling endeavor there is a non-negligible chance that the spectrum of the available models at a given point in time may not actually include the appropriate model

Which Question Is Being Answered?



Restating the Question

"What can we say about *X* given *IM* ?"

- *IM* refers to:
  - Information *from* the model(s)
  - Information *about* the model(s)
- With the problem stated in this way, Bayes Theorem is the natural choice as a framework for utilizing the available information *IM* to express the state of knowledge about *X*

Bayesian Framework

$$\pi(x \mid IM) = \frac{L(IM \mid x)\pi_0(x)}{\int_x L(IM \mid x)\pi_0(x)\,dx}$$

$$IM = (IM_1, IM_2, \ldots, IM_n)$$

where

$\pi(x \mid IM)$:	uncertainty distribution of X given information IM
$\pi0(x)$:	the distribution for X before the evidence IM is available
$L(IM \mid x)$:	(likelihood function) the probability of observing evidence IM when the true value is x

Characterization of IM

- The evidence, IM, can be grouped into two major categories:
  - Information **from** models ($\underline{x}^*$, an estimate of X):
    - o Point estimate
    - o Probability distribution
    - o Bounds for the unknown X, such as $x_l \leq x \leq x_h$
    - o A statement concerning X, such as "X is high"
  - Information **about** models (D):
    - o Performance data
    - o Assessment of the quality and applicability of the model

$$IM \equiv \{\underline{x}^*, \underline{D}\}$$

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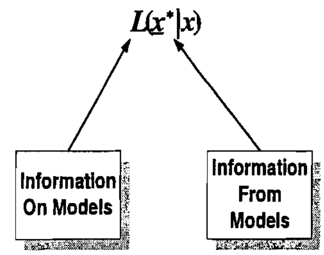
Constructing The Likelihood Function



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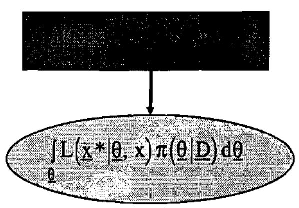
Constructing the Likelihood Function (Parameterization Strategy)



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Likelihood Function: An Example

- Information about the model: $\underline{D} = \underline{D}^p, \underline{D}^\alpha$
  - $\underline{D}^p = \{E_1, \ldots, E_n\}$: Performance data
  - $\underline{D}^\alpha$: Qualitative information on model quality and applicability
- Corresponding parameters in the likelihood: $\underline{\theta} = \{\underline{\theta}^p, \underline{\theta}^\alpha\}$
- An example is the Error Model:

$$L\left(x^*\middle|\underline{\theta}^p, x\right) = L\left(x^*\middle|b, \sigma, x\right) = \frac{1}{\sqrt{2\pi}\,\sigma} e^{-\frac{1}{2}\left[\frac{x^*-(x+b)}{\sigma}\right]^2}$$

where

$$\underline{\theta}p = \{b, \sigma\}$$

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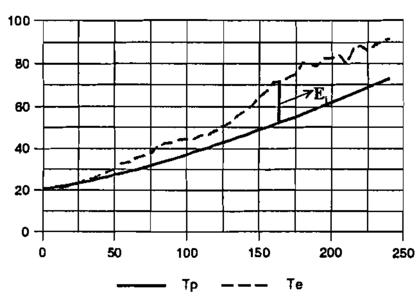
Likelihood Function: An Example (cont)



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Multiple Models

- Posterior Uncertainty Distribution

$$\pi(Q|Q_1, Q_2) = \frac{L(Q_1, Q_2|Q)\pi(Q)}{\int_Q L(Q_1, Q_2|Q)\pi(Q)\,dQ}$$

- For independent models:

$$L(Q|Q_1, Q_2) = \prod_{i=1}^{2} L(Q_i|Q)$$

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Example: Cable Jacket Temperature Prediction

COMPBRN is used to estimate the cable jacket temperature, T_{cj}, at time t, of a group of cable trays in compartment fires.

COMPBRN was used to simulate a group of experiments performed by SNL.

Question: Given COMPBRN prediction, T, and what we know about COMPBRN performance, what can we say about the actual cable jacket temperature ?

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Example: Cable Jacket Temperature Prediction

- The performance information is based on the SNL/UL ex. 2

Time (sec)	Cable Jacket Temperature (K)		
	Experimental Result (T^e_{cj})	COMPBRN III $\eta = 0.85$	
		T^p_{cj}	T^p_{cj} / T^e_{cj}
60	360	375	1.042
180	425	430	1.012
300	455	470	1.033
480	505	500	0.990
720	575	520	0.904
900	575	500	0.870

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Construction of the Likelihood (Homogeneous Performance Data)

- Posterior:

$$\pi(T_{cj} | T, D) = \frac{\int_b \int_\sigma L(T | b, \sigma, T_{cj}) \pi_0(b, \sigma | D) \, db \, d\sigma}{\int_{T_{cj}} \int_b \int_\sigma L(T | b, \sigma, T_{cj}) \pi_0(b, \sigma | D) \, db \, d\sigma \, \pi_0(T_{cj}) dT_{cj}}$$

- Likelihood function:

$$L(T | b, \sigma, T_{cj}) = \frac{1}{\sqrt{2\pi}\, \sigma T} e^{-\frac{1}{2}\left[\frac{\ln T - (\ln T_{cj} + \ln b)}{\sigma}\right]^2}$$

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Construction of the Likelihood (Homogeneous Performance Data)

- Updating model predictive capabilities:

$$\pi(b, \sigma | E_1, E_2, \ldots, E_6) \propto \prod_{i=1}^{6} \frac{1}{\sigma} e^{-\frac{1}{2}\left(\frac{\ln E_i - \ln b}{\sigma}\right)^2} \pi_0(b, \sigma)$$

- Assumption: $(E_1, \ldots, E_6)$ are independent and each E_i is distributed according to a Lognormal distribution:

$$L(E_i | b, \sigma) = \frac{1}{\sqrt{2\pi}\, \sigma E_i} e^{-\frac{1}{2}\left(\frac{\ln E_i - \ln b}{\sigma}\right)^2}$$

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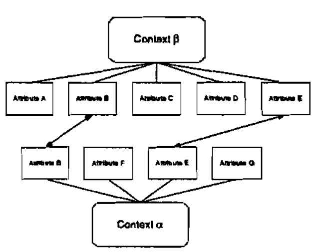
Applicability of Models



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Applicability of Models (cont)

- Establish what is important in estimating the unknown in context β;
- Identify what is covered by model *M* under context α;
- Perform a similarity assessment by comparing the attributes under context α with the attributes under context β, i.e., assess the degree of match;
- Perform an importance assessment, i.e., assess how important are each of these attributes in applying model α as a model for β.

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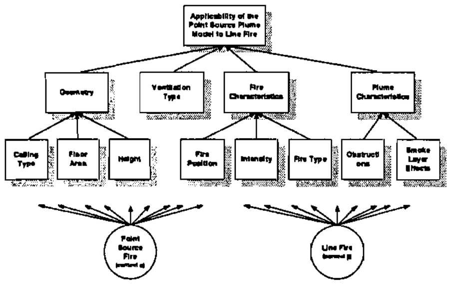
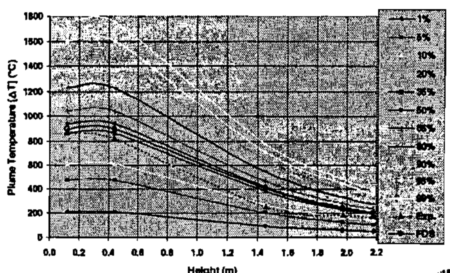
Example: Line Fire Plume Temperature



Example: Line Fire Plume Temperature

- Estimate plume temperature in a line fire by using a point source fire model prediction
- Available information:
  - 4 experimental tests by NRC/SNL on point source fires
  - Experimental data on line fires
- Approach:
  - Assessment of the applicability concerning the FireDS model
  - Assessment of the line fire plume temperature uncertainty given FireDS prediction and point source data

Posterior Uncertainty Distribution



In Summary...

- Bayesian framework for an integrated assessment of model and parameter uncertainties
- Treats models as source of evidence concerning the unknown
- Accounts for an individual model's bias and precision as well as possible dependencies among models
- Allows for the use of various types of information ***from*** models:
  - Quantitative
    - Point estimates
    - Probability distributions
  - Qualitative statements

In Summary... (cont)

- Provides the flexibility to incorporate performance data as well as subjective evidence ***about*** the models themselves into the state of belief about the unknown
- Procedures are suggested for assessing
  - Confidence in a model
  - Model applicability
  - Dependence among models

Limitations

- Methodology focuses on the model output, and the assessment of uncertainty is based on the perceived quality of the model.
- Does not present an explicit way of "deriving" the measure of model quality and credibility as a function of quality and credibility of its elements and sub-models.
- The method does not provide a way of propagating sub-model uncertainly to arrive at model uncertainty.
- Such propagation is naturally problem and context specific, and therefore more resistant to generalization and procedural formulation.

Limitations (cont)

- Many complex technical assessments involve multiple models, each possibility composed of sub-models covering different domains.
- This is exemplified in large multi-disciplinary assessments such as PRAs, which involve interface among many models (e.g., plant thermal -hydraulic response model, accident scenarios defined by event tress, and other physical and mathematical model of deterministic or stochastic behaviors of plant systems and operators).

Limitations (cont)

- The practical difficulty is carrying the results across models or sub-models that may be subject to additional constraints, requiring further assumptions or simplifications.
- Obviously this also introduces model uncertainty that cannot be simply viewed in a "model output" framework.
- Similarly it is difficult to "combine" the effects of modeling errors at conceptualization level with those arising during implementation.

Treatment of TH Uncertainties in PTS Risk Assessment

Ali Mosleh
Center for Technology Risk Studies
ACRS October 10, 2003

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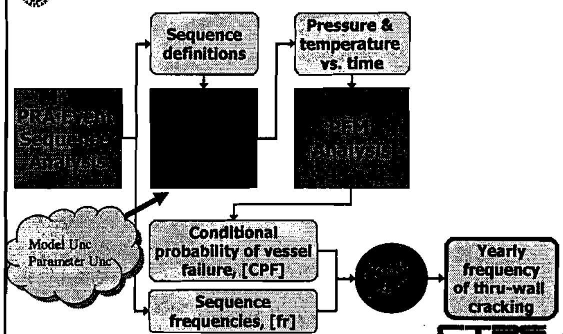
PTS Integrated Analysis



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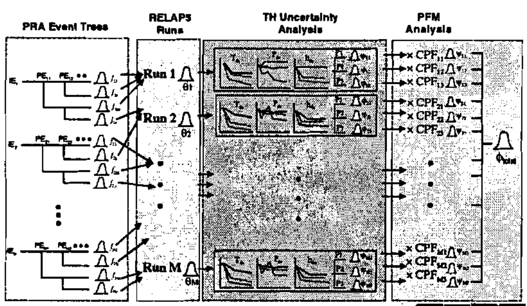
Conceptual Model



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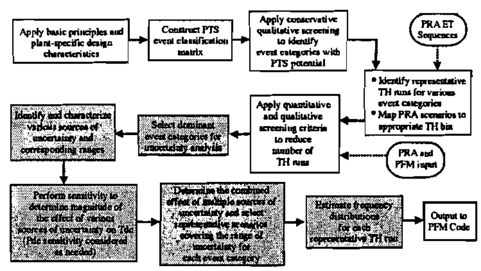
TH Uncertainty Assessment Process



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Practical Considerations

- Settle for less accurate method or solution in a sub-model in order to comply with interface requirements of other sub-models
- Accept that some uncertainties and variabilities of contributing factors are suppressed by grouping or aggregating them into "bins"
- Accept a somewhat uneven treatment of uncertainties among different modeling domains *[no model uncertainty in FTs]*

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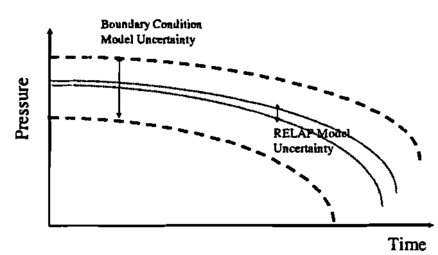
Context Dependency of Uncertainty Assessment



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Important TH Parameters

Temperature
- Heat Capacities
  - Primary and secondary system
- Heat Sources
  - Decay heat and RCPs
- Heat Sinks
  - Primary system breach, SGs, HPI, CFTs, and LPI
- RCS Coolant Flow Rate
  - RCPs state
- RPV Energy Distribution
  - Mixing of core water in downcomer phenomenon (RPV Vent Valves)
  - RCS flow interruption-and-resumption caused by vapor in candy cane
  - Boiling-condensation

Pressure
- RCS coolant mass change
  - Primary system breach
  - HPI
- RCS energy change
  - Heat sources
  - Heat sinks
- Short term rapid RCS steam condensation
  - Mixing of core water in downcomer phenomena
  - Boiling-condensation
  - PZR spray

7

Event Category Selected for TH Uncertainty Analysis

Primary Side State / Secondary Side State	Intact	Breached: Break Size <= 1.5" Breach flow could be compensated by HPI	Breached: Break Size > ~1.5" Breach flow cannot be compensated by HPI
Nominal			6.1e-4
			8.9e-4
One SG Breach		2.7e-7	
	3.7e-6	6.3e-5	
Two SGs Breach		2.1e-7	
	1.7e-5		
		4.9e-8	3.1e-6
		3.3e-6	1.2e-6
SG(s) Overfed			
SG(s) Breach + SG(s) Overfed			
	1.3e-6		

(1) HPI activated without being controlled
(2) HPI activated and controlled
(3) HPI is failed or not required
(4) HPI fails and is recovered

After screening out non-PTS risk sequences, 94% of the total sequence Frequencies fall in this cell;
TH uncertainty analysis focuses on this dominant cell

The cell is further divided into four categories for TH uncertainty analysis
1. PZR SRV stuck open and remains open with valve open area greater than 1.5-inch in diameter
2. PZR SRV stuck open and is reseated with valve open area greater than 1.5-inch in diameter
3. LOCA between ~ 1.5-inch and 4-inch in diameter
4. LOCA between 4-inch and 8-inch in diameter

8

Uncertainty Sources

- Model Uncertainty
  - Event Sequence Modeling and Mapping to TH Runs
    - Level of Details in Event Tree Models (e.g. explicit representation of component degraded states) *[Treated by adding needed details]*
    - Assignment of Event Tree Scenarios → TH Bins *[not treated, believe to be small]*
    - Assignment of Representative RELAP Runs → TH Bins *[Treated explicitly]*
  - Use of TH Code
    - RELAP5 Internal Modeling Uncertainties *[Several important factors treated explicitly]*
    - RELAP5 Input Deck Preparation(e.g., nodalization) *[not treated, believe to be small]*
- Parameter Uncertainty (all parameters associated with modeling steps, as well as those used within models) *[Important parameters treated explicitly]*

9

Known RELAP5 Limitations

- 1-D code
  - Included experimental and CFD results
  - Oregon State APEX program
- Volume averaged calculation
  - Included experimental and CFD results
- Empirical correlations
  - Perform uncertainty analyses and sensitivity studies
  - Several treated explicitly
- Nodalization choices
  - Used standard nodalization

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Characterization of Uncertainty Sources Treated

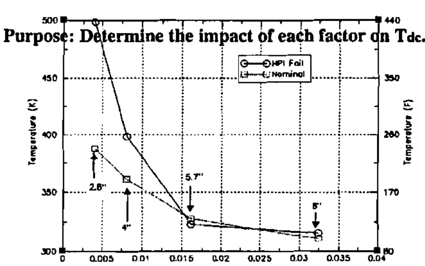
- **Parametric (Boundary Condition) Uncertainty**
  1. Primary Side Breach Size (1.5", 2", 2.8", 4", 5.7", 8" and 12" in diameter) *[Aleatory]*
  2. Primary System Breach Location (HL, CL, and PZR SRVs) *[Aleatory]*
  3. Decay Heat (Reactor trips at Infinite operation and Hot Zero Power) *[Aleatory]*
  4. Season (Fall/Spring, Winter, Summer - used different T values for SI and AFW) *[Aleatory]*
  5. HPI State (Success, ¼ Failed, ½ Failed, and Failed) *[Aleatory]*
  6. HPI Flow Rate (± 10%) *[Aleatory]*
  7. Core Flood Tank Pressure (± 50 psi) *[Aleatory]*
- **RELAP5 Code Model Uncertainty**
  1. RPV Vent Valves State (0%, 33%, 67%, and 100% Open) *[Epistemic]*
  2. Component Heat Transfer Coefficient (± 30%) *[Epistemic]*
  3. Flow Resistance (+100%) *[Epistemic]*
  4. Break Flow Rate (± 30% break area) *[Epistemic]*
  5. Numerical "Mixing" (removed by conservatively using a high cold leg reverse flow resistance)

11

Example of Sensitivity Study Results

Impact of HPI State

Purpose: Determine the impact of each factor on Tdc.



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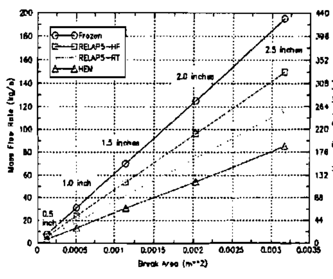
Treatment of Break Flow Rate Model Uncertainty

(Break Upstream Pressure: 7MPa/1028 psia)



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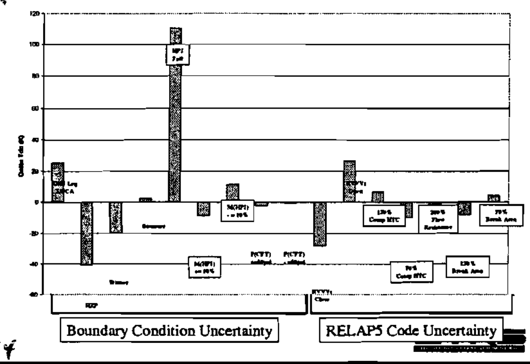
Impact of Various Sources of Uncertainty for Fixed Break Size

(2.8-inch LOCA)



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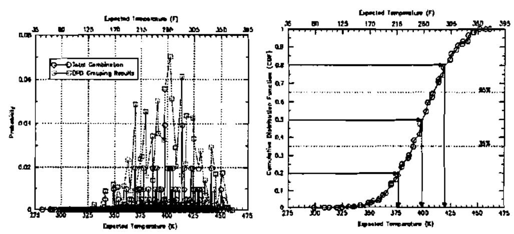
PZR SRV Stuck Open and Remains Open

PDF and CDF of Combined Effect of Multiple Uncertainty Variables

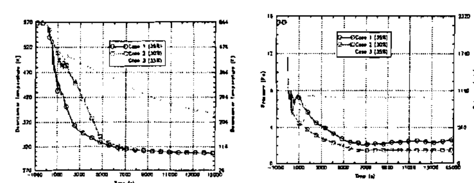


(992 combinations in total)

15

PZR SRV Stuck Open and Remains Open

T_{dc} and P_{dc} Trends for TH Runs Covering Uncertainty



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Observations on Treatment of Uncertainties in Complex Multi-Disciplinary Technical Assessments

Ali Mosleh
Center for Technology Risk Studies

ACRS, October 10, 2003

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Lessons Learned

- Uncertainty analysis cannot be done as an isolated task, run by "uncertainty specialists"
  - uncertainty analysis is an integral part of model development
  - as such uncertainty analysis should be everybody's business
- Integrated assessments using independently evolved disciplines, models, and tools, add to the complexity of
  - uncertainty assessment
  - uncertainty propagation
- Uncertainty assessment and "uncertainty management" become intertwined
- Technical and organizational coordination and communication are essential

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Lessons Learned (cont.)

- Initially we also adopted the common philosophy of most technical assessments that uncertainty analysis can be performed after "best estimate" analysis is completed
- This practice can easily result in not only an inadequate uncertainty analysis, but also incorrect "best estimate"
  - best estimate of the final result of a complex model is not necessarily achieved by combining best estimates of the sub-models

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Lessons Learned (cont.)

- One reason for delaying uncertainty analysis until after completing best estimate analysis is the prevailing belief that performing uncertainty analysis requires significantly more resources than point estimate analysis
- This is not necessarily true. In some cases concurrent uncertainty analysis can actually reduce the scope of issues to be considered

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Some Technical Issues

- At every step of the analysis a distinction needs to be made between *model structure* and *model parameter*
- Treatment of Model Uncertainty affects the structure of models (new event tree branches, additional top events)
- Characterization of uncertainty as *aleatory* or *epistemic* is also important as the former often impacts the structural of the model

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Potential Consequences of Inadequate Treatment

- Failure to account for dominant contributors to uncertainty
- Failure to properly characterize various types of uncertainty, possibly leading to incorrect method of uncertainty propagation
- Failure to properly carry uncertainties across sub-models and disciplines

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Treatment of Uncertainties in Complex TH Codes

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ACRS, October 10, 2003

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7

Objectives

- Development of a computational approach for propagation of uncertainties in complex models and codes
- Identification of various sources of uncertainty in predicting TH behavior with TH codes (RELAP 5) including
  - User specification of the computer model
  - Specification of initial and boundary conditions
  - Internal model and parameter uncertainties
- Methodology for characterization and quantification of identified uncertainty sources (experimental data, expert opinion)
- Test of methodology
- Suggestions on TH code modification to incorporate model and parameter uncertainties
- Implementation on TH Code (e.g., TRACE)

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8

An Evaluation of Existing Methodologies

N	General Characterization	AEAT	CSAU	ENUSA	GRS	IPSN	UMAE
1	Restriction on the number of input uncertain parameters	Y	Y	Y	N	N	NA
2	Deriving input uncertainty ranges	Y	Y	Y	Y	Y	N
3	Assigning subjective probability distributions	N	Y	Y	Y	Y	N
4	Use of Statistics	N	Y	Y	Y	Y	Y*
	Use of response surface technique	N	Y	N	N	N	N
5	Need of specific data for scaling	N	Y**	N	N	N	Y
6	Need of biases on the results	N	Y	N	N	N	Y
7	Determination of input uncertain parameters and related ranges	EX***	EX	EX	EX	EX	NA
8	Selection of uncertain parameter values within the determined ranges	EX	EX	RS	RS	RS	NA
9	Support to identification and ranking of input uncertain parameters	Y	Y	Y	N	N	N
10	Account for state of knowledge of input uncertain parameters	Y	Y-EX***	Y-EX	Y-EX	Y-EX	N
11	Number of code runs independent from number input and output parameters	N	N	Y	Y	Y	NA
12	Typical number of needed code runs	20-50	70	100	100	100	1-11
13	Typical number of uncertain input parameters	10	10	15	50	30	NA
14	Sensitivity measures of input parameters on output parameter	N	N	Y	Y	Y	N

* To a limited extent
** At a qualitative level during code validation
*** Expert judgment needed

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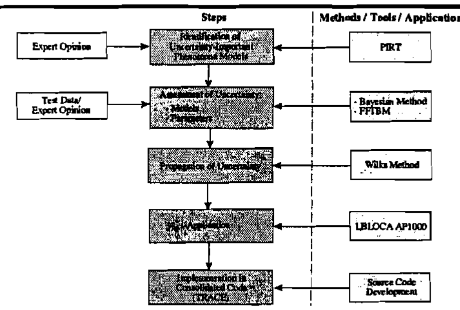
Major Steps and Methods



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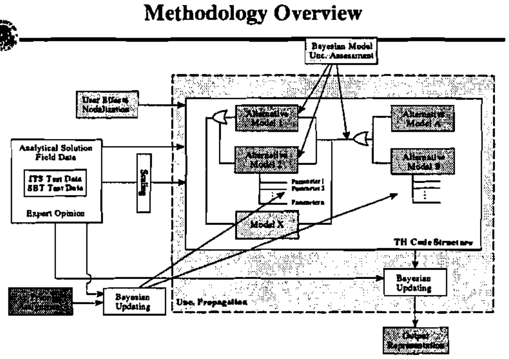
Methodology Overview



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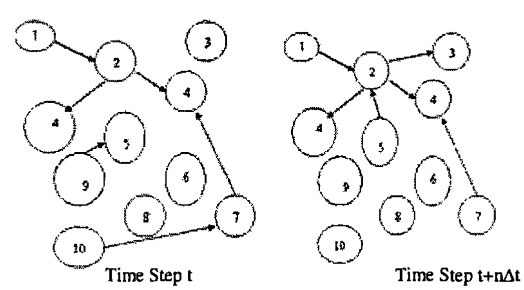
Dynamic Behavior of Complex Code



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Examples of Sub-model

- Chocked Flow-Relap5
  - –Sub-cooled
    - (Code Developer Alternative Models)
      - Burnell Model
      - Moody
      - Henry Fauske
  - Two-phase
    - One-Component
    - Two-Component
    - (Code Developer Alternative Models)
      - Trap and Ransom
      - Henry Fauske
  - Single-phase-vapor
- User selected models
  - –Abrupt Area Change
  - –Smooth Area Change

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Sub-models Uncertainty Examples
(Athlet Code - GRS)

- Heat transfer: model for single phase forced convection on vapor
  - Dittus-Boelter Correlation
  - McEligot Correlation
- Heat Transfer: Model for Choked Flow
  - Minimum Value
  - Hench-Levy Correlation
  - Biasi Correlation

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UMD Bayesian Approach to Uncertainty Quantification

- Incorporates
  - Experimental data
    - o Model performance
      - Separate Effect Tests (SETs) for sub-model
      - Integral Test facilities (ITFs)
    - o Measurement of input parameters
  - Expert judgment and qualitative information on
    - o Model credibility
    - o Model applicability
- Integrates the effects of model and parameter uncertainties

15

Sampling & Uncertainty Propagation
Wilks' Method

- A random sample of size N is drawn for each uncertain parameters
- Simple Random Sampling is used
- Number of samples is a function of desired confidence level and probability content

16

Test- Oconee1 PTS TH Uncertainty

- 100 runs using TH models of PTS for Oconee-1 NPP
- Same uncertain models and parameters as in UMD PTS TH Uncertainty Method (a total of 11)
- Same range of parameter variation
- 100 unique combinations were created to achieve 95% of probability content with 95% confidence
- Results are comparable with the result of uncertainty ranges calculated by UMD PTS in Oconee-1 PTS project

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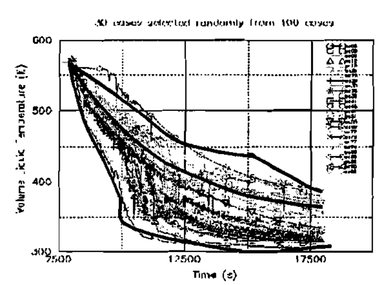
Results Compared with PTS TH Approach



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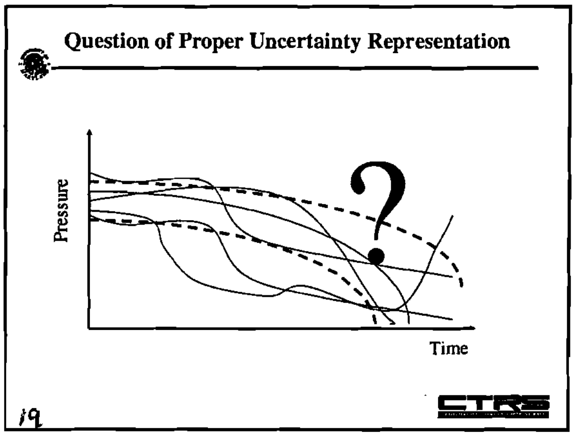


Question of Proper Uncertainty Representation
Pressure
?
Time
19

Reactor Vessel Fracture Uncertainty Characterization

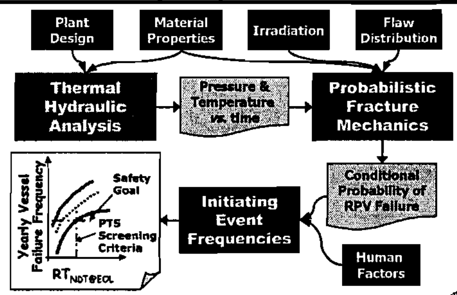
Mohammad Modarres

University of Maryland
Center for Technology Risk Studies

Presentation
To
Advisory Committee on Reactor Safeguards

October, 10, 2003

PRA-based evaluation of vessel failure frequency Due to PTS



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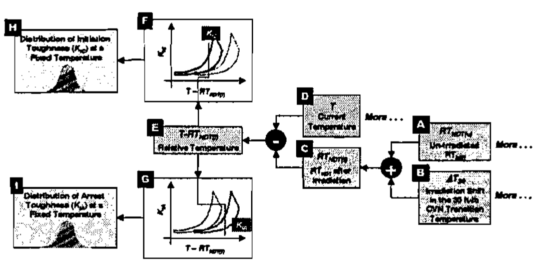
Sources of Uncertainty



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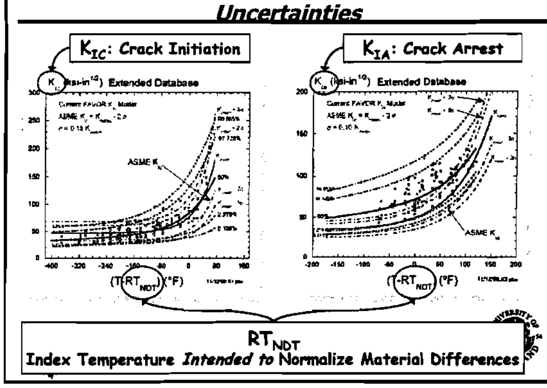
Fracture Toughness Modeling and Uncertainties



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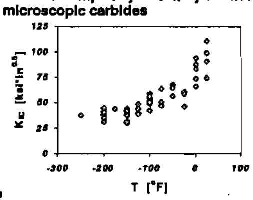
Uncertainty in Fracture Toughness

- Cleavage fracture in steels is well represented by the weakest link theory and microscopic size distribution of carbides leading to the variability in K_{Ic} at any fixed temperature
- K_{Ic} uncertainty can be assumed purely aleatory at a fixed temperature since K_{Ic} distribution is completely driven by the irreducible distribution of microscopic carbides



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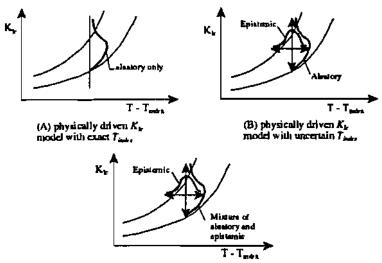
Indexing Temperature

- To account for heat-to-heat variability, an indexing temperature should be devised
- The indexing procedure introduces uncertainty since the indexing temperature can't be determined exactly in almost all cases
- Indexing temperature uncertainty is epistemic
- Depending on the approach used, the resulting K_{Ic} model involves added uncertainty

6

Recognize Three Possible Cases



(A) physically driven K_{Ir} model with exact T_{index}

(B) physically driven K_{Ir} model with uncertain T_{index}

(C) empirically driven K_{Ir} model with uncertain T_{index}

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Two Possible Approaches to Account for Uncertainties in K_{Ic}

1) **Master Curve model**

- Physically-based (assumes one universal indexing exists)
- K_{Ic} uncertainty would be a reflection of the weakest link model (assumed purely aleatory at a fixed temperature since K_{Ic} distribution is dictated by the irreducible distribution of microscopic carbides)
- The community accepts the weakest link and carbide fracture assumptions as an accurate model of fracture

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Two Possible Approaches to Account for Uncertainties in K_{Ic}

2) Empirical Model

- K_{Ic} model is based on actual observed data
- The procedure is well understood and compatible with NRC practices
- The resulting model is not purely aleatory but use of a temperature dependent adjustment of the LEFM data to correct for indexing conservatisms make aleatory distribution assumption possible
- Extrapolation beyond data points involves epistemic modeling uncertainties

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Procedures for Computing Fracture Toughness

- **Master Curve Procedure**
  - Sample distributions of RT_{NDT}, and RT_{NDT} bias relative to T_0
  - Compute adjusted RT_{NDT}
  - Obtain the Weibull distribution corresponding to T – adjusted RT_{NDT} (aleatory uncertainty)
- **Empirical Procedure (Modified Traditional ORNL Approach)**
  - Sample RT_{NDT} and RT_{NDT} bias based on lower-bounding model
  - Adjust the LEFM data (samples) and empirically generate a new "adjusted" K_{Ic} distribution that is fit into the data
  - Compute an adjusted RT_{NDT}
  - Obtain a Weibull distribution from a sample of the adjusted K_{Ic} distributions at (T – adjusted RT_{NDT})

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Probability Distribution Of RPV Fracture/Failure

- The probabilistic-based method shows marginal contribution of each flaw to the ***probability*** of RPV fracture/failure

$$\Pr[E(t)] = 1 - \sum_{i=1}^{n}\{1 - \Pr[E_i(t)]\}$$

where, Pr[E(t)] is the total vessel fracture/failure probability at time t, and $\Pr[E_i(t)]$ is the marginal probability contribution of the i^{th} flaw at time t to RPV fracture/failure.

- The deterministic-based method assumes that the most susceptible flaw among all of the multiple flaws causes failure of the vessel (i.e., weakest link view)

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Probability Distribution Of RPV Fracture/Failure (cont)

- Deterministically, we are interested in the flaw initiation at a give time during the transient given the computed K_I value: the flaw will initiate, if $K_I > K_{IC}$. Record the time t at which the flaw initiates. If m out of n (m < n) flaws initiate at different times t_j (j = 1, 2, …, m), according to the deterministic-based approach the time of vessel flaw initiation would be

$$t = \min(t_1, t_2, \ldots, t_m)$$

- Since K_{IC} value at each time is stochastic in nature it should be represented by its probability distribution (here a Weibull distribution)
- Use Monte Carlo simulation to randomly select a K_{IC} profile vs. time and calculate the time at which K_I exceeds

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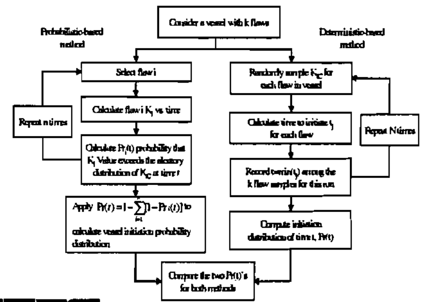
Summary Of The Approach



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Backups

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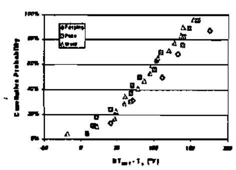
Proposed Procedure for the Use of Master Curve

1. Simulate a value of RT_{NDT} using either NB-2331, Generic, or MTEB 5.2 procedures
2. Estimate a bias correction value of RT_{NDT} - T_0 based on the CDF shown in the figure to the right
3. Estimate T_0 as $RT_{NDT} - \Delta RT$
4. T_0 from step 3, when combined with equations to the right define the aleatory uncertainty in K_{Ic}
5. Correct for the flaw size



$$K_0 = 28.2 + 70.1 \cdot \exp[0.0106(T - T_o)]$$

$$P_f = 1 - \exp\left\{-\left(\frac{K_{Ir} - 18.2}{K_0 - 18.2}\right)^4\right\}$$

$$K_{Ir}(xT) = 18.2 + [K_{Ir}(xT) - 18.2]($$

xT = thickness of x-inches for a straight crack front

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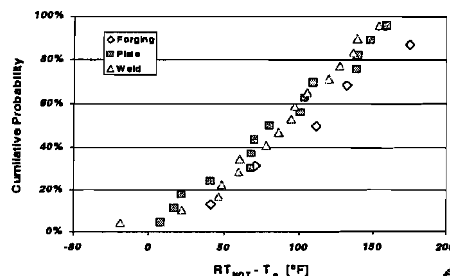
RT_{NDT} Bias Relative to T_0



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SAPHIRE PEER REVIEW

Daniel O'Neal
Reliability and Risk Engineer
RES

OVERVIEW

- SAPHIRE provides the capability to develop and run probabilistic safety assessment models

- Peer review was performed for the testing, verification, and validation (TV&V) of SAPHIRE

- Discuss the objectives of the review

- Discuss the SAPHIRE TV&V

- Discuss the review approach and the resultant insights and recommendations

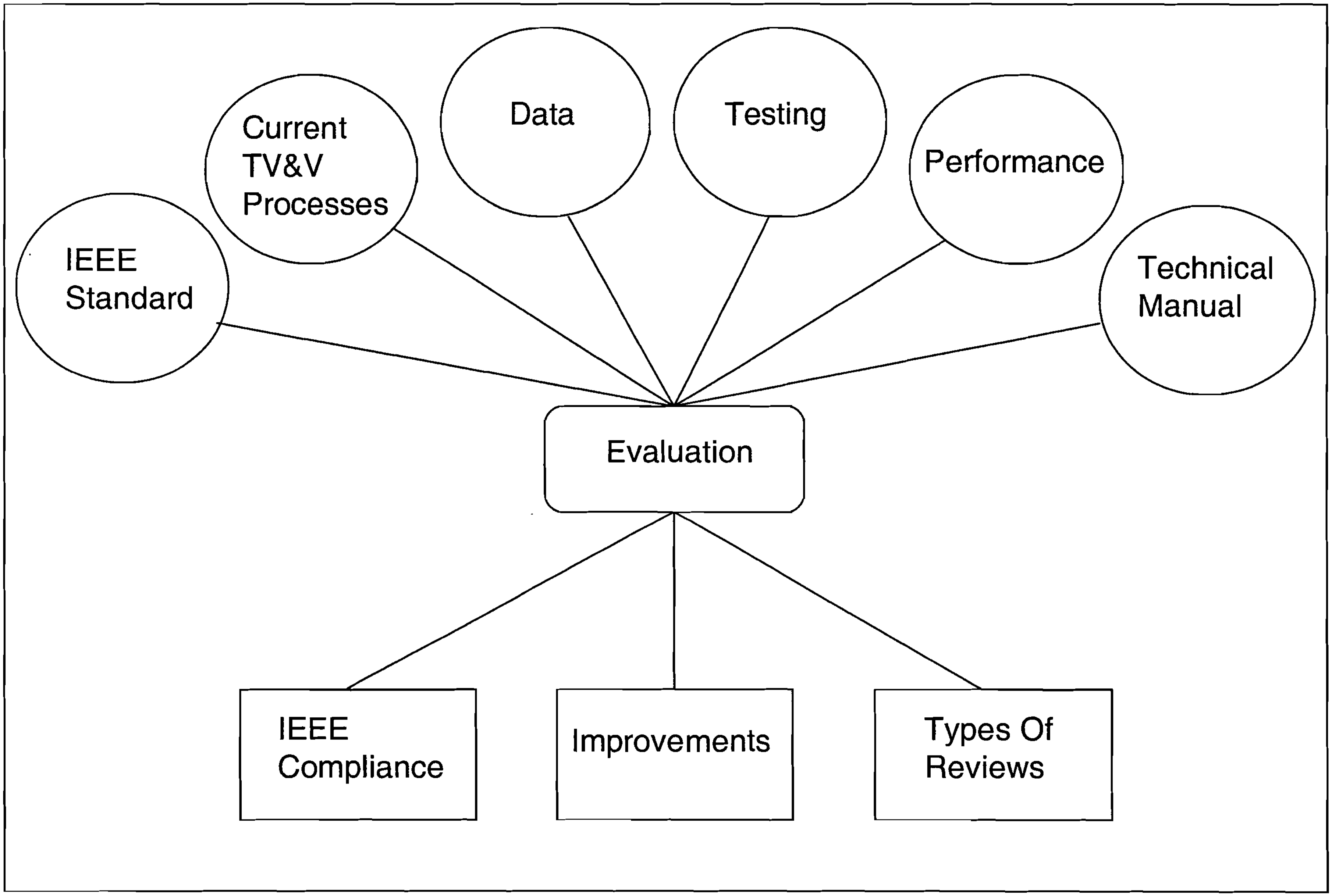
OBJECTIVES

- Identify potential TV&V improvements
- Provide recommendation on formal software standard compliance
- Consider types of reviews for SAPHIRE

SAPHIRE TV&V

- Automated TV&V process used for SAPHIRE versions 6 and 7
- Bases for TV&V provided in NUREG/CR-6688, “Testing, Verifying, and Validating SAPHIRE 6.0 and 7.0”, October 2000
- Change design and test procedure
  - Ensure the change meets the expected goal, identify interfaces and interactions with other SAPHIRE features, and optimize use
  - Users test the new features
  - Document the change
  - Update the test suite

REVIEW APPROACH



GENERAL INSIGHTS

- Process is formal for only some of the software life cycles
- Process relies upon continual release of new sub-versions
- A number of changes in the change logs reviewed were "significant" in that the change was related to a code error that affects the correct result for risk measures, importance measures, or uncertainty analysis and an error message does not appear to be generated to alert the model developer or code user
- Number of changes representing both non-significant and significant changes does not necessarily decrease with each newly released sub-version
- Insights support the need for improving the current TV&V process

RECOMMENDATIONS

- Process should be slowed down - more time up front spent on TV&V before issuing a new sub-version
- Current versions could benefit from formalizing some life cycle processes and implementing specific recommendations
- IEEE standard for software verification and validation compliance should be pursued for the future version 8
- Types of reviews that should be considered to improve the process are:
  - Acceptance reviews by the staff before general release
  - Periodic independent audits for the future version 8
- Proposed plan for implementation of recommendations follows a phased approach for specific and general recommendations

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FIRE RISK RESEARCH PROGRAM ACTIVITIES

- Fire protection SDP revision
- Circuit analysis
- Risk-informed, performance-based fire protection rulemaking (NFPA 805)
- ANS full power fire standard
- NRC/EPRI fire risk requantification studies
- Fire model benchmark / validation
- Hemyc and MT fire barrier testing
- International activities, e.g. circuits, fire event data

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RES/DRAA/PRAB Low Power And Shutdown Risk Research Activities

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RES/DRAA/PRAB

UNITED STATES NUCLEAR REGULATORY COMMISSION

LPSD PRA ACTIVITIES

- American Nuclear Society LPSD PRA Standard
  - Participation on the writing committee
  - Projected date for finalizing the standard is December, 2004
- Draft NUREG/CR-6595, Revision 1, "An Approach for Estimating The Frequencies of Various Containment Failure Modes and Bypass Events"
  - Provides a simplified method for estimating large early release frequency for LPSD conditions for different containment types
  - Is in public comment period

LPSD ACTIVITIES - CONTINUED

- LPSD fire analysis feasibility study
  - Determine the feasibility of expanding the scope of the "Fire Risk Re-quantification and Fire PRA Guide Upgrade Project" from full power operation to LPSD operation
- Reviewing LPSD events to obtain insights to support the worker fatigue rulemaking effort

INTERNATIONAL ACTIVITIES

- Participation in international activities on the study of LPSD risk to improve regulatory risk-informed decision making

- Cooperative PRA (COOPRA) LPSD Working Group

  - Working Group formed in 1997

- Committee on the Safety of Nuclear Installations (CSNI) LPSD Working Group

  - CSNI approved setting up a task group on LPSD PRA in 2000

COOPRA LPSD Working Group

- Initiating event topical report was written based on responses to a questionnaire
  - Objectives included an analysis of LPSD initiating events to gain insights on frequencies, data, and research needs
- Initiating event database is being developed
  - Provides a compilation of LPSD initiating events and a way to gain insights

CSNI LPSD Working Group

- Technical report on improving LPSD PRA methods and data to permit better risk comparison and trade-off decision-making is being written based on responses to a questionnaire

  - Scope of the effort includes all LPSD PRA modeling elements

  - Objectives are:

    (1) Identify differences between methods (and associated data) used in full power and LPSD PRAs that they preclude or substantially limit meaningful risk comparisons or trade-offs among these operational conditions

    (2) Define needed data collection or methods to overcome these differences