

Official Transcript of Proceedings ACKST-3252

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards  
Reliability and Probabilistic risk Assessment  
Subcommittee

Docket Number: (not applicable)

PROCESS USING ADAMS  
TEMPLATE: ACRS/ACNW-005

Location: Rockville, Maryland

Date: Friday, October 10, 2003

Work Order No.: NRC-1120

Pages 1-219

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UNITED STATES OF AMERICA  
NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)  
SUBCOMMITTEE ON RELIABILITY AND PROBABILISTIC RISK  
ASSESSMENT

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FRIDAY,  
OCTOBER 10, 2003

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ROCKVILLE, MARYLAND

The ACRS met at the Nuclear Regulatory Commission, Two White Flint North, room 2B3, 11545 Rockville Pike, at 8:30 a.m., Chairman George Apostolakis, presiding.

COMMITTEE MEMBERS:

GEORGE E. APOSTOLAKIS, Chairman

MARIO V. BONACA, Member

STEPHEN L. ROSEN, Member

WILLIAM J. SHACK, Member

ACRS STAFF PRESENT:

MICHAEL R. SNODDERLY, Designated Federal  
Official

MEDHAT EL-ZEFTAWY

1 ALSO PRESENT:  
2 JOHN FLACK  
3 KENT WELTER  
4 DON DUBE  
5 STU MAGRUNDER  
6 PAT O'REILLY  
7 DALE M. RASMUSON  
8 DON MARKSBERRY  
9 PATRICK BARANOWSKY  
10 BENNETT BRADY  
11 GARY DE MOSS  
12 W. ARCIEN  
13 B. COLAN  
14 SPYROS TRAIFOROS  
15 N. PRASAD KADAMBI  
16 MARK CUNNINGHAM  
17 MIKE CHEOK  
18 ALI MOSLEH  
19 MOHAMMAD MODARRES  
20 DANIEL O'NEAL  
21 J. S. HYSLOP  
22 ALAN RUBIN  
23 CURTIS SMITH  
24 ROY WOODS  
25

1	A-G-E-N-D-A		
2	I.	Opening Remarks, G. Apostolakis, ACRS ...	4
3	II.	Plan for Application of Formal Decision making	
4		Methods in Integrated Regulatory Decisions, J.	
5		Flack and N. Prasad Kadambi, RES .....	5
6	III.	Overview of the PRA Safety Research Program, M.	
7		Cunningham, RES .....	36
8	IV.	Program for Risk-Based Analysis of Reactor	
9		Operating Experience, P. Baranowsky, RES .	51
10	A.	ASP Program	
11	B.	Industry Trends Support	
12	C.	SPAR Model Development Program	
13	D.	Reply to ACRS Letter on Risk-Based	
14		Analysis of Reactor Operating Experience	
15	V.	Planned Activities in Development of PRA Methods	
16		and Standards, M. Cunningham .....	120
17	A.	Integrated Uncertainty Research	
18		A. Mosleh .....	122
19		M. Modarres .....	167
20	B.	SAPHIRE Peer Review, Dan O'Neal ..	183
21	C.	Fire Risk Research Program,	
22		J. S. Hyslop .....	196
23	D.	Low Power and Shutdown Risk,	
24		D. O'Neal .....	205
25			

P-R-O-C-E-E-D-I-N-G-S

8:31 a.m.

CHAIRMAN APOSTOLAKIS: The meeting will now come to order. This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Reliability and Probabilistic Risk Assessment. I am George Apostolakis, Chairman of the Subcommittee.

Subcommittee members in attendance are Mario Bonaca, Steve Rosen and William Shack. The purpose of this meeting is to discuss the status of the Probabilistic Risk Assessment Research Program with representatives of the Office of Nuclear Regulatory Research.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee. Michael Snodderly is the designated federal official for this meeting.

The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on October 1, 2003. A transcript of the meeting is being kept and will be made available as stated in the Federal Register notice.

It is requested the speakers first

1 identify themselves and speak with sufficient clarity  
2 and volume so that they can be readily heard. We have  
3 received no written comments or requests for time to  
4 make oral statements from members of the public  
5 regarding today's meeting. We will now proceed with  
6 the meeting and I call upon Mr. Prasad Kadambi of the  
7 Office of Research to begin.

8 MR. KADAMBI: Thank you very much, Mr.  
9 Chairman. I would like to ask the Branch Chief of the  
10 Regulatory Effectiveness and Human Factors Branch,  
11 John Flack, to perhaps come up.

12 CHAIRMAN APOSTOLAKIS: I'm sorry, John.

13 MR. FLACK: That's fine. Good morning.  
14 My name is John Flack, Branch Chief of Regulatory  
15 Effectiveness and Human Factors Branch. I just wanted  
16 to mention that this work actually evolved from  
17 recommendations from the ACRS about a year ago to use  
18 formal decision making in order to provide more  
19 transparency, reducibility, consistency, and  
20 traceability in light of the uncertainties basically.

21 What you will hear today is we will give  
22 you an overview of where we are on that effort and how  
23 we are moving forward in its application to other  
24 areas which we are constantly entertaining.

25 The key eventually would be to get to the

1 Commission with something and have them support this  
2 effort. One of the things I think is advantageous in  
3 the effort came up recently when we were just  
4 discussing on how to document knowledge and  
5 understanding in some formal way to be passed on to  
6 the next generation.

7 By applying methods like this you do leave  
8 that behind. People can understand better how  
9 decisions were made and what the basis of those  
10 decisions were. We are seeing this coming up again in  
11 another arena as another important area.  
12 Having said that, let me turn it over to Prasad who  
13 will walk you through.

14 CHAIRMAN APOSTOLAKIS: Very good.

15 MR. KADAMBI: Thank you very much, John.  
16 The outline of my presentation is basically just to  
17 introduce a document that we have prepared and  
18 introduce the Subcommittee to some ideas about how we  
19 can use the information in this document.

20 What this represents is the completion of  
21 the first phase of an activity that we undertook as  
22 the recommendation of ACRS. The second phase we see  
23 as the application to demonstrate the utility of these  
24 ideas. Then we have to get eventually Commission buy-  
25 in on this approach. That's what we are aiming

1 towards.

2 MR. ROSEN: I should acknowledge that was  
3 the wrong number, 6833.

4 MR. KADAMBI: Yes, I'm sorry. I was going  
5 to point that out. In some places I have interchanged  
6 the numbers and it should be 6833 of the NUREG/CR.

7 CHAIRMAN APOSTOLAKIS: You are the only  
8 one so far dealing with this issue? Obviously John  
9 knows what you're doing but you are the only one  
10 exploring this?

11 MR. KADAMBI: Our branch, I think, is  
12 really the one that is focusing on this.

13 MR. FLACK: Yes, we have the lead on it.  
14 Basically Prasad's work is doing the format. Now, we  
15 recognize that methods like this are being applied  
16 without recognizing --

17 CHAIRMAN APOSTOLAKIS: Sure. Sure.  
18 You've been making decisions since 1974.

19 MR. KADAMBI: Yeah. And I think we want  
20 definitely to acknowledge the role of the ACRS in  
21 bringing to our attention the merits of this approach.  
22 We did tell you back more than a year ago that we  
23 would be exploring the feasibility of applying these  
24 methods.

25 In order to provide the context for this,

1 I would like to find out, again, as John also pointed  
2 out, that the agency is really more than a lot of  
3 activities that have elements of formal methods.

4 What is seems these activities would  
5 benefit from is an overall structure and a predictable  
6 process that would at a higher level bring these  
7 concepts together so that we will have greater  
8 assurance of consistency, transparency, and a way to  
9 assess effectiveness and deficiency, I believe.

10 We got started on this really as part of  
11 the advanced reactor research plan when we were  
12 looking for different ways that we might prioritize  
13 the research that would become necessary if we started  
14 getting applications for advanced reactor concepts.

15 In addition to the phenomena  
16 identification and ranking table approach which has  
17 been sort of the standard way that we have pursued  
18 this, we wanted to see are there other ways of  
19 achieving some kind of prioritization so that's how we  
20 got started on it.

21 What we found is that really the  
22 methodologies have widespread applicability. Also  
23 what we found is that there are many ongoing  
24 activities such as the planning, budgeting, and  
25 performance management effort, the PBPM which is

1 central to a lot of things that the agency is doing.  
2 It is an effort that tries to consider the four  
3 performance goals of the agency.

4 In many ways it represents an application  
5 of multi-attribute utility. We would like to see if  
6 that and the PIRT process, and also I would like to  
7 find out the effort in performance based regulation  
8 which the Commission has identified as a strategic  
9 goal to improve risk informed and performance based  
10 regulatory approaches.

11 All these would benefit from a formal  
12 structuring of objectives. What I see is significant  
13 support for this whole effort is the success of the  
14 ROP which we would attribute substantially to this  
15 formal structuring of objectives.

16 CHAIRMAN APOSTOLAKIS: Which the ACRS also  
17 requested at the time and the staff performed  
18 beautifully.

19 MR. ROSEN: And quickly.

20 CHAIRMAN APOSTOLAKIS: So we all deserve  
21 credit for this. A lot of times people think of, you  
22 know, all the analysis and I have to have this and I  
23 have to have that. Sure there is a lot of effort  
24 going into that but simple things like structuring  
25 your objectives, thinking about them as are they

1 independent; am I double, triple counting; am I  
2 leaving anything out.

3 This is a great value. All formal  
4 mathematical theory is that they take you by the hand  
5 and they say, "Now my friend you have to think about  
6 this. The next step is to think about that." I think  
7 you really pointed out some of the great benefits even  
8 before you put any numbers in by just structuring your  
9 approach and saying, "This is what I really care  
10 about. I care about reactors. I care about this and  
11 I care about that."

12 Initiating events like the ROP does and in  
13 another context you have something else. That's  
14 already a major step because it forces you to think  
15 about what are the objectives of your analysis and  
16 some structure. I think the ROP has benefitted  
17 tremendously from it.

18 That simple diagram that shows the four  
19 top tiers is great. People look at it now and think  
20 this is what the NRC staff really cares about. They  
21 care about initiating events. They care about the  
22 primary human boundary. You know, this is wonderful.

23 MR. FLACK: And just to follow-up to that,  
24 we actually when we responded to the need to do  
25 advanced reactor research we followed that same logic

1 and it just carried us through.

2 CHAIRMAN APOSTOLAKIS: It structures  
3 everything. It has many, many applications so I'm  
4 really glad you guys are doing this.

5 MR. KADAMBI: Well, this particular  
6 NUREG/CR, in fact, does have a whole section devoted  
7 to the structuring of objectives. We use the reactor  
8 oversight process as an example that demonstrates some  
9 of these concepts and how they can be more widely  
10 applied.

11 The NUREG/CR itself, again, I point out at  
12 6833, is not a cookbook. What we try to do is after  
13 looking at this whole vast area of decision analysis  
14 try to identify certain important concepts and the  
15 literature in it. I have to point out our Chairman is  
16 responsible for a substantial part of the literature  
17 and we have benefitted considerably from it.

18 CHAIRMAN APOSTOLAKIS: Commissioner  
19 Modarres is doing all these things?

20 MR. KADAMBI: No, the Chairman of the  
21 Subcommittee right here. We have compiled this sort  
22 of catalog of tools and methods which we hope will  
23 make it easier for staff to get into it and to pursue  
24 it to the depth that they find necessary to apply it  
25 in any particular application because, of course, the

1 context determines a lot of exactly what actually  
2 happens in any application.

3 We did have a peer review of this NUREG/CR  
4 and it was very valuable to get the kind of feedback  
5 that we did from the other program offices. Everybody  
6 recognized the merits of a structured decision process  
7 and they also recognized how in their own work they  
8 see elements of these things.

9 But what did seem to throw everybody off  
10 was the unfamiliar terminology and the conceptual  
11 complexity of a lot of things in here. What we felt  
12 was this is something that needs to be addressed  
13 recognizing this as an important part of the feedback.

14 Again, it can be addressed by actually  
15 showing how it would work in specific cases using  
16 familiar examples. The bottom line is that the  
17 evidence from this work provides strong support to  
18 pursue these methods.

19 Again, it's 6833. What a staff member  
20 using this document would be introduced to a certain  
21 concept such as utility theory, value-of-information  
22 techniques, performance measures, something that I  
23 believe is quite key to this whole approach as to  
24 understand how qualitative objectives can be  
25 represented by appropriate performance measures and

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1 the concept of hypothesis testing which is, you know,  
2 a very familiar thing in science but quite often we  
3 don't really use it as much as we can in our work.

4 There is something called Receive  
5 Operation Characteristic that we devote quite a bit of  
6 time to in this document. I have to tell you that  
7 this is terminology that goes way back to the end of  
8 the second World War when they were developing radar  
9 techniques to differentiate between false and true  
10 signals. The way I use it in this work is basically  
11 a formal way of considering the probability of being  
12 right versus the probability of being wrong.

13 CHAIRMAN APOSTOLAKIS: False positive,  
14 false negative.

15 MR. KADAMBI: Right. Exactly. Also there  
16 is a section on objectives hierarchies which I think  
17 will help a great deal.

18 We have also tried to cover in this  
19 techniques that the staff is somewhat familiar with  
20 such as the analytic hierarchy process and CSAU, Code  
21 Scaling, Applicability and Uncertainty Evaluation.

22 CHAIRMAN APOSTOLAKIS: One comment here  
23 trying to help you avoid some of the pitfalls. If you  
24 mention the analytic hierarchy process to decision  
25 theorist, they will attack you because the AHP

1 unfortunately was presented as an alternative to  
2 decision theory.

3 But if you use it to support decision  
4 theory, in other words, you know, getting the  
5 utilities or eliciting information from experts but  
6 not making the decision using the AHP. Then it's a  
7 different story. It has its own problems.

8 I think it's similar to what happened with  
9 expert systems. They were oversold in the beginning  
10 that expert systems would solve everybody's problems  
11 and it turns out that they have not solved everybody's  
12 problems but they are very useful. Having interactive  
13 problems in the English language is great.

14 So this one is a tool that supports the  
15 decision theory and you probably know that already  
16 because it's like hold a red flag. If you mention  
17 this to people like Keene Neale or those guys it's  
18 something to be careful about.

19 MR. KADAMBI: I fully agree, Mr. Chairman,  
20 and I would say that something in my mind we want to  
21 be careful in the whole decision analysis area is we  
22 should not oversell it because it may really create  
23 unnecessary problems in the future.

24 CHAIRMAN APOSTOLAKIS: So the AHP is not  
25 an alternative. It's just another tool.

1 MR. KADAMBI: No. This is just to point  
2 out that --

3 CHAIRMAN APOSTOLAKIS: I understand.

4 MR. ROSEN: Come back to why you want to  
5 do this and you would like to have the agency use  
6 these techniques or recognize the aspects of the  
7 techniques and what they're now doing. Maybe expand  
8 the way they do business now to take on some more of  
9 the attributes of these techniques to make the  
10 decision processes even more formal and more  
11 transparent and that sort of thing.

12 So if you think of what your final  
13 objective will be which is to convince people to do  
14 something different, then the idea that you not make  
15 them mad in the process is very useful.

16 MR. KADAMBI: Exactly. That's the whole  
17 point of it.

18 CHAIRMAN APOSTOLAKIS: I really found it  
19 interesting that the reviewers complained that there  
20 was conception complexity. I thought conceptually the  
21 method is really simple. Implementing and applying it  
22 is a problem and I keep getting surprised myself.

23 For example, one of the latest problems  
24 we've had is how do you accommodate through teaming  
25 and maybe losses, economic losses from routine

1 failures, and the same problem with core damage which  
2 is huge. You have this tremendous difference. You go  
3 from a few thousand dollars to billions of dollars.

4 That creates a big problem in accessing  
5 utilities and all that. The implementation, if seems  
6 to me, is more complex and subtle than the conceptual  
7 frame work. But, you know, if people found it  
8 daunting, then what can you do? We have to educate,  
9 right?

10 MR. KADAMBI: We have to address the  
11 issue.

12 CHAIRMAN APOSTOLAKIS: Sure.

13 MR. KADAMBI: And hoping that is the sort  
14 of thing that we pursue.

15 MR. ROSEN: I may very well be that the  
16 way to introduce this is to talk about way decisions  
17 are made now. What aspects of what you do now are, in  
18 fact, parts of this which is talk about the way  
19 business is done now and say now the formal decision  
20 making theory would add this piece to that.

21 CHAIRMAN APOSTOLAKIS: Exactly. That  
22 would be a great way of doing it.

23 MR. ROSEN: Rather than top down and say  
24 these are all the things you have to do.

25 CHAIRMAN APOSTOLAKIS: Right. Use

1 something that people are already familiar with.

2 MR. ROSEN: And are doing.

3

4 CHAIRMAN APOSTOLAKIS: And putting in this  
5 form now you will have gotten extra help here.

6 MR. ROSEN: Yes.

7 MR. KADAMBI: In effect, that's exactly  
8 what I was trying to do by pointing out how the  
9 planning, budgeting, and performance management  
10 activity of the agency is really doing just that. I  
11 mean, if you look at what planning involves, it is  
12 really a careful identification of objectives and  
13 trying to structure it in such a way that you can, in  
14 fact, budget appropriately to the priorities.

15 MR. ROSEN: But, you see, even that is  
16 just a piece of a bigger structure which includes the  
17 agencies overall goals first and then down to the  
18 planning and budgeting. When you see an aspect of a  
19 budget come up, there's always the question how does  
20 this relate to the agency's goals so it's in this  
21 formal structure.

22 MR. KADAMBI: Exactly. That's the point  
23 I'm trying to make. And also I think it sort of  
24 encourages one to be more creative in identifying  
25 performance measures as you go through this effort and

1 identify the measures at the right level in this  
2 structure so that you don't get too deep into details  
3 and into the noise level of things and you focus on  
4 those things that are important as Dr. Apostolakis  
5 pointed out. It's a way to identify what is  
6 important.

7           Again, I go back to the success of the ROP  
8 and the Commission's emphasis on performance based  
9 regulation as offering opportunities to use formal  
10 decision methods. The PBPM process can be seen as a  
11 way to express multi-attribute utility theory. We are  
12 evaluating options to consider private projects and we  
13 certainly would like suggestions from the ACRS on  
14 this. What is key is that we do involve the other  
15 offices. I think we need to get more people involved  
16 from all the difference areas of agency activity.

17           We have to, I think, point out that the  
18 basic benefits that we see from this is a focus on  
19 structure, transparency, and treatment of uncertainty.  
20 Quite often that is where we, I think, can show  
21 improvement in our work. What we are suggesting is  
22 that there are some things that we can take from  
23 decision analysis to help us do that.

24           We have tried to identify a five-step  
25 process to do this. The first step would be to

1 construct utility function. Again, that sounds to  
2 some people, you know, like something complex but it's  
3 basically just identifying what is important for the  
4 decision maker to make sure that we incorporate in the  
5 things that we observe and that we try to measure  
6 those things that the decision maker and that depends,  
7 of course, on who it is.

8 Sometimes it's the Commission and  
9 sometimes it is the branch chief. It could be anyone  
10 in between, too. So, you know, we just formally go  
11 through this process and try to identify what the  
12 constraints are. Then the second step would be to  
13 have a way to think about alternatives.

14 Quite often what we end up doing is we  
15 identify an alternative and all the activity goes in  
16 either sort of proving success or failure of an  
17 alternative rather than spend more time and effort  
18 thinking about what are the different alternatives  
19 that will help us optimize the decision maker's  
20 preferences.

21 MR. ROSEN: Well, you hear about the  
22 President's decision making process. You always hear  
23 that he is presented with a slate of alternatives from  
24 do nothing to whatever. That is clearly evidence that  
25 down the street they are using it.

1 MR. KADAMBI: Right.

2 CHAIRMAN APOSTOLAKIS: One of the senior  
3 members of the Clinton administration, Secretary of  
4 the Treasury Robert Ruben, he said in an interview in  
5 the New York Times that every major decision to be  
6 made used this. They asked him, you know, if you have  
7 this big thing about the financial crisis in Korea and  
8 Japan and all that, the question was whether the  
9 United States should intervene and help them.

10 Congress was against it. He said he used  
11 the utility theory. They asked him, "How can you put  
12 probability to some of these things?" He said, well,  
13 he puts some numbers in and you do some sensitivity  
14 studies, the Secretary of the Treasury.

15 MR. ROSEN: You didn't call him up and  
16 lecture him on uncertainty, the fact that sensitivity  
17 studies are not substitutes for uncertainty analysis?

18 CHAIRMAN APOSTOLAKIS: I'm sure he knew  
19 that. He's a Harvard graduate. I was so impress. I  
20 should have kept that interview.

21 MR. ROSEN: He got it right and also the  
22 Vice Chairman of Citigroup.

23 CHAIRMAN APOSTOLAKIS: He said that  
24 throughout his career --

25 MR. ROSEN: He did have a job after

1 government.

2 CHAIRMAN APOSTOLAKIS: And even before.

3 MR. ROSEN: Before that he was with  
4 Goldman-Sachs.

5 CHAIRMAN APOSTOLAKIS: Yeah, and he said  
6 using this --

7 MR. ROSEN: He's done all right.

8 CHAIRMAN APOSTOLAKIS: He decided to help  
9 Mexico with their economic crisis. He said he had  
10 young people around him who understood these methods  
11 so they prepare alternatives using these and then he  
12 would make a decision. It was a very impressive  
13 interview.

14 MR. ROSEN: He's an impressive guy.

15 CHAIRMAN APOSTOLAKIS: You see, you don't  
16 have to be too occultant. I mean, if you follow the  
17 thought processes, it helps you.

18 MR. KADAMBI: Again, by way of how we  
19 would go about using this, we could generate expected  
20 utilities so that we could subject it to some kind of  
21 a testing process if we do implement it. We would use  
22 qualitative and quantitative factors. Quite often we  
23 get trapped into thinking that if you can't quantify  
24 it, then we should reject it.

25 What this approach would tell us at least

1 think about constructive measures that would be  
2 applicable to the qualitative aspects. We could look  
3 for figures of merit sometimes in very complex  
4 situations that may not be easy to do. In fact, it  
5 may turn out to be not just one figure of merit but a  
6 combination of them.

7           Again, depending on the context it may or  
8 may not be very complex. Also the key is to identify  
9 the decision rules to think about this. For example,  
10 when the option 2 effort, the risk categories are, in  
11 fact, decision rules that have been set up. If we  
12 look at it more formally, that way I think it may make  
13 it easier to implement some of these.

14           MR. ROSEN: If I were to think about the  
15 ROP in the context of these last few thoughts you  
16 offered, I would say that performance index are the  
17 performance indicators and the decision rules are the  
18 action makers. Am I correct?

19           MR. KADAMBI: Yes. That's how I would  
20 translate it, too.

21           MR. ROSEN: Because what we are trying to  
22 do with the ROP is decide where to apply agency  
23 resources.

24           CHAIRMAN APOSTOLAKIS: And the thought  
25 that the various colors should be consistent in the

1 parity of the colors comes from this theory that says  
2 when you say yellow here and yellow there, you have to  
3 mean the same thing in terms of preference.

4 MR. ROSEN: Otherwise --

5 CHAIRMAN APOSTOLAKIS: Otherwise you are  
6 arbitrary. That is an interesting input or insight  
7 from the theory that would have helped the developers  
8 of the matrix.

9 MR. ROSEN: But my point here is made to  
10 reinforce an earlier point I made which was that one  
11 needs to personify this for the agency. If you want  
12 to get your ultimate objective which is to get people  
13 to think more in terms and use it which is a valuable  
14 objective I support, then as you go along in these  
15 presentations, say, for example, in the ROP, here's  
16 how we did it.

17 We figured up performance index and these  
18 are our decision rules. We didn't call them those  
19 things at the time. We just used our good judgment  
20 and set it up that way. But, in fact, here are the  
21 pieces of formal decision method being embodied in the  
22 way we do business.

23 We just didn't know it so don't be too  
24 surprised if you find out that two-thirds of what we  
25 do follow these informal ways in thinking. It's just

1 a way of heuristically approaching the subject for  
2 your audience that I'm suggesting.

3 MR. KADAMBI: Yes, absolutely. I fully  
4 agree with what you said.

5 MR. BONACA: Among these steps you  
6 mentioned a number of times the treatment of  
7 uncertainty so it would be also part of this steps  
8 that you are describing here?

9 MR. KADAMBI: Yes. I think you would  
10 incorporate it at each step really because  
11 uncertainty, in fact, determines a lot of how you go  
12 from step to step and what you would consider as  
13 important and what you would pay more attention to and  
14 what you would pay less attention to.

15 I think it's sort of one of those  
16 background kinds of things that you have to keep in  
17 mind. My feeling is that as you start applying it you  
18 will be forced to think about it if you do it in a  
19 formal way.

20 MR. BONACA: So really probably the  
21 development of mortality is tied to it.

22 MR. KADAMBI: Yes, it is.

23 MR. ROSEN: And one alternative that is  
24 more preferable than another is one that is less  
25 uncertain.

1 CHAIRMAN APOSTOLAKIS: That's right.

2 Other things being equal.

3 MR. KADAMBI: Again, I don't know how it  
4 will work out in specific cases. There may be certain  
5 times when it doesn't quite work out that way but if  
6 it doesn't work out that way, I would submit you would  
7 at least know why it isn't and so you would know how  
8 to either confirm or deny your basic assumption.

9 MR. ROSEN: Well, I'm a control freak so  
10 I like alternatives that have less uncertainty rather  
11 than more. Maybe others would not follow that.  
12 That's one of my high priority items. I would like to  
13 get where I'm going, know where I'm going to start and  
14 get there with some reasonable assurance.

15 MR. KADAMBI: Sure. I understand.  
16 Anyway, these are the basic steps that we might think  
17 about using and how could we implement these. Again,  
18 I offer these as possibilities that we might pursue.  
19 What we will try to do along the lines of what Mr.  
20 Rosen pointed out is try to close the gap in  
21 terminology by pointing out similarities between a lot  
22 of what is already being done and what formal decision  
23 theory approach it really calls for.

24 One way of doing this might be to set up  
25 an interoffice working group which would provide a

1 focal point for these formal decision methods and  
2 develop a nucleolus of knowledgeable staff in this.  
3 We could identify case studies and apply them with  
4 internal stakeholder input, you know, involved in many  
5 of the steps where really having stakeholder input is  
6 quite critical.

7 Of course, at some point we would have to  
8 address the resource issues because all these things  
9 take resources and resources are always at a premium.  
10 We would have to work through these issues one by one.

11 CHAIRMAN APOSTOLAKIS: Have you found  
12 positive response from people when you talk about an  
13 interoffice working group?

14 MR. KADAMBI: Well, not yet. Maybe if the  
15 ACRS helps me, I will be able to get more positive --

16 MR. ROSEN: We could open up each meeting  
17 with a discussion what it appears and who is  
18 presenting it to us and what they know about formal  
19 decision methods and whether they are supporting the  
20 other agency.

21 MR. KADAMBI: I would go along with that.  
22 That would make you popular.

23 MR. ROSEN: We could start with our  
24 colleague Dana Powers.

25 MR. KADAMBI: What we would be looking for

1 is sort of a ripple effect of wider and wider  
2 participation in it and gradually have enough people  
3 that we can rely on to implement this. What I would  
4 foresee is that we prepare some kind of a NUREG report  
5 but it has to be something that we can go back to the  
6 Commission and say one way or another the staff has  
7 explored this approach, has demonstrated one thing or  
8 another, and then make sure that the Commission does  
9 support this activity.

10 MR. ROSEN: Do you have a training branch  
11 in this agency?

12 MR. KADAMBI: There is a whole -- you  
13 know, it's part of human resources. Training is a  
14 very important function.

15 CHAIRMAN APOSTOLAKIS: Short courses you  
16 mean?

17 MR. ROSEN: Well, we're talking about  
18 training. We're talking about training people to  
19 understand the value of formal decision methods.

20 CHAIRMAN APOSTOLAKIS: That's a good  
21 point. Maybe you can -- I don't know, maybe it's too  
22 soon now but after you've heard some of these case  
23 studies of where you demonstrate. You have it right  
24 there?

25 MR. KADAMBI: Well, no.

1 CHAIRMAN APOSTOLAKIS: I mean, it would be  
2 worthwhile having a two to three-day training short  
3 course as part of the agency's arsenal.

4 MR. ROSEN: I would start with a hour just  
5 to get the idea to people. Really, my point was that  
6 what you are really doing is -- research has looked  
7 into these methods and determined that they have value  
8 and suggest to the agency that they be used. It seems  
9 to me the rest of the job other than some advocacy  
10 from you is to support the training organization.

11 These are the kinds of things that are  
12 embedded in a culture, the agency's culture through  
13 management training, not through the research group  
14 trying to set up an interagency working group pushing  
15 on a rope. What you need to be doing is putting in  
16 your formal training program for managers so that the  
17 managers come to their jobs equipped understanding  
18 what FDM is and understanding how to -- where it's  
19 applied in the agency already.

20 When they set up a new project to take out  
21 their FDM methods and say, "Okay, let's make sure  
22 we're following through this." Otherwise, I feel  
23 research is the wrong person to do it and, secondly,  
24 pushing on a rope anyway.

25 MR. KADAMBI: Well, I think that is a

1 valuable suggestion and we ought to do something about  
2 it.

3 CHAIRMAN APOSTOLAKIS: You have to have  
4 case studies. You have to have case studies  
5 meaningful to the agency.

6 MR. ROSEN: You have to support training.  
7 You can't just tell training to do it but you would be  
8 the support for training. You would help them develop  
9 the methods. You would train their trainers. You  
10 would sit in on the sessions initially. It's a  
11 function of human resources to train managers,  
12 supervisors, and employees in general on techniques  
13 the agency wants to use.

14 MR. KADAMBI: It appears to me that could  
15 be the central message of a Commission paper as we go  
16 up to the Commission with the results of this case  
17 study and all the information.

18 CHAIRMAN APOSTOLAKIS: Are you doing any  
19 at all? I mean, what is the plan for this next year  
20 now?

21 MR. KADAMBI: Actually we haven't  
22 formulated a plan as such.

23 MR. FLACK: That's part of what we are  
24 here to discuss when Prasad was mentioning  
25 implementation and how to go about doing that and I

1 think the focus would be to try to get something to  
2 the Commission and draw out a pathway to get us there  
3 to demonstrate and to show that it works.

4 Then as part of that integrating it, I  
5 would think it's more a tool that you could integrate  
6 it into modules that may be already on the books where  
7 you would have a certain part of that in the context  
8 of that application and show how it works so there are  
9 different ways. Again, we are still trying to figure  
10 out in some way the next step in trying to get this  
11 laid out and that's what you're hearing today.

12 CHAIRMAN APOSTOLAKIS: So you are in the  
13 process then of thinking about what case studies to  
14 do?

15 MR. KADAMBI: Right. And how to go about  
16 doing that.

17 CHAIRMAN APOSTOLAKIS: Well, you can start  
18 by helping Mr. Thadani. I mean, he has to prioritize  
19 research efforts every year and I understand that's a  
20 contentious issue usually.

21 MR. FLACK: Well, that's not an easy one.

22 CHAIRMAN APOSTOLAKIS: It's not an easy  
23 one. Maybe you can pick a subset and ask yourself how  
24 would one go about it. You have a lot of these  
25 qualitative attributes there, of course, but if you

1 can convince him that this would make his life easier,  
2 then you made a major step forward I think and that  
3 doesn't have to be the only case.

4 MR. ROSEN: I think, George, you have a  
5 good idea. I think using the case studies is valuable  
6 and useful. The trouble is with them is they tend to  
7 feel like they are isolated. It's just a story for  
8 research. It's just a way for research to prioritize  
9 efforts. When, in fact, it should be viewed, I think,  
10 the other way.

11 The agency has core values or missions.  
12 It has a PBPM process, planning and budgeting process,  
13 which is structured around those missions. One of its  
14 missions is research which has to support the  
15 structure above it. And there is a case study here on  
16 how you can prioritize research using this. Don't see  
17 this as in isolation is my point.

18 See this as simply an embodiment of a  
19 structured formal decision making approach that the  
20 whole agency is really -- I mean, this is the most  
21 formal of agencies -- of enterprises compared to a mom  
22 and pop shop which may or may not have to do these  
23 things but, in fact, would be better off if they did.

24 The agency has a congressional act that  
25 establishes it, a set of regulations. This huge vast

1 structure which all you are really doing is saying,  
2 "Well, in this formal structure we are going to use  
3 formal decision tools." Case studies are important as  
4 anecdotal almost successes, but it should be seen as  
5 an overall embodiment of the formal structure you are  
6 operating in.

7 MR. KADAMBI: In fact, I would submit that  
8 if you look at our strategic plan you could actually  
9 build an objective hierarchy just from the way that is  
10 set up. If you go into the plan itself it defines  
11 very formally what is a regulatory framework and it  
12 defines it exactly the way you did which is it begins  
13 with the enabling legislation and comes all the way  
14 down to inspection procedures. That is the regulatory  
15 framework. I think it's all there.

16 CHAIRMAN APOSTOLAKIS: You have to be  
17 careful. It seems to me we have multiple objectives  
18 here. One objective is to do what you and Mr. Rosen  
19 have been discussing the last few minutes. But  
20 another objective is to build support. You need some  
21 influential people to support you.

22 That's why I said if you prove to Mr.  
23 Thadani that this can help you, then you have a  
24 powerful man behind you. If you only go up and say  
25 this is a good way of doing things, people will say,

1 "Gee, that's probably good," but you will not get the  
2 same kind of support.

3 The other thing regarding what you said  
4 about a strategic plan. It's not enough to say that  
5 what is in the strategic plan really conforms with  
6 this. Then you have to go an extra step and show how  
7 developing the plan would have been easier had they  
8 used this. Then people will come back and say, "Okay.  
9 We are already doing it." You have to demonstrate  
10 that there is some value to this.

11 That what you are doing already is not  
12 orthogonal to this but had you used this, you would  
13 have gotten something that is valuable that would have  
14 made your life easier, you know, some value. I think  
15 if you start doing these things you will see what will  
16 come.

17 MR. KADAMBI: I fully agree with you. The  
18 point I was also going to make was that we in the  
19 staff don't have really much by way of guidance on  
20 implementing this strategic plan, you know. This  
21 approach and if we sort of decide to use it could  
22 offer an easier way for staff which my experience is  
23 they sometimes have difficulty in thinking about the  
24 relationship between the strategic plan and their own  
25 work. This would be a way to help them, in fact,

1 align their activity.

2 MR. ROSEN: Let me give you an anecdote  
3 that supports, I think, very nicely your point, the  
4 one you're just making about the need to support the  
5 strategic plan and to understand it. In utilities  
6 that I have been associated with they have core values  
7 which is the kind of thing that the Commission has for  
8 its strategic goals.

9 When it's used appropriately and the staff  
10 of the utility understands it, those core values  
11 become important day-to-day things and I have  
12 experience with decision making groups within a  
13 utility asking each other whether or not certain  
14 actions of one group or one party is aligned with the  
15 core values or not.

16 In discussions about whether this was a  
17 good thing or a bad thing, the discussions brought up  
18 -- refer back to the core values and say these actions  
19 between these two groups are not consistent with this  
20 core value. You should see it in that light and  
21 whether I'm having a good discussion or I'm not, and  
22 correcting behavior and adjusting approaches.

23 This is the anecdote I wish to add and  
24 that is exactly the kind of thing I think you're  
25 suggesting is whether the staff here is working on

1 something and trying to make a decision between A and  
2 B. You can think about the formal structure he's  
3 operating in including the Commission's objectives and  
4 say better or worse this will align us better or worse  
5 with the core value, the structure.

6 CHAIRMAN APOSTOLAKIS: So the purpose of  
7 today's meeting was really not to call into the  
8 details of what you're doing. As you know, it's more  
9 like to familiarize ourselves with the various  
10 activities for the Office of Research. I take it this  
11 is a fairly low-level in the sense of funding  
12 activity. It's not into the hundreds of thousands of  
13 dollars.

14 Although I'm sure your salary would take  
15 care of it. But you will pursue it this year? You  
16 will try to identify some case? We will be happy to  
17 hear from you when you have some case studies and  
18 discuss them with you. Obviously the Subcommittee is  
19 interested. I think from the full committee you will  
20 have some skepticism but they will be willing to be  
21 convinced, I think.

22 MR. ROSEN: That's because the full  
23 committee is populated by structuralists rather than  
24 rationalists, or some structuralists who we are  
25 working on.

1 CHAIRMAN APOSTOLAKIS: No, you have to  
2 demonstrate value. You have to demonstrate value and  
3 case studies and perhaps the global approach that was  
4 discussed earlier.

5 Anything else from the members? Prasad,  
6 you want to say anything else?

7 MR. KADAMBI: No. I want to thank you for  
8 the opportunity to make this presentation.

9 CHAIRMAN APOSTOLAKIS: Thank you for  
10 coming. And John.

11 MR. FLACK: I appreciate it.

12 CHAIRMAN APOSTOLAKIS: Okay. Great.  
13 Thank you very much.

14 The next item is overview of the PRA  
15 Safety Research Program but the presenters are not  
16 here. We're take a few minutes. Oh, there's a break  
17 scheduled.

18 MR. ROSEN: You're right on schedule, Mr.  
19 Chairman, even though you're don't know it.

20 CHAIRMAN APOSTOLAKIS: Okay. We'll recess  
21 until 9:30.

22 (Whereupon, at 9:19 a.m. off the record  
23 until 9:33 a.m.)

24 CHAIRMAN APOSTOLAKIS: We're back in  
25 session. The next presentation is beginning the

1 overview of the PRA Safety Research Program, Mr.  
2 Cunningham.

3 MR. CUNNINGHAM: Yes, sir. I'm here. Mr.  
4 Newberry couldn't be here today because he had a  
5 wedding in the family that he decided was more  
6 important than this. What can I say?

7 CHAIRMAN APOSTOLAKIS: We'll remember  
8 that.

9 MR. CUNNINGHAM: I'm going to give you a  
10 real quick overview of what's going on in the division  
11 and then pat will come in and spend a good bit of the  
12 morning talking about the details of what's happening  
13 in one branch and then after lunch, I guess, we'll  
14 talk about the other branch, PRAB.

15 We're allocated in FY '04 to have 55 FTE  
16 in the division, 55 people, and a budget of about \$15  
17 million. You've heard many of the things that we do  
18 but it's basically we look at operating experience  
19 from a risk perspective. We look at some aspects of  
20 security.

21 MR. ROSEN: I hope you're not doing all  
22 the security work.

23 MR. CUNNINGHAM: No, sir. No, we're not.  
24 This doesn't include the security money. This is the  
25 non-homeland security.

1 MR. SHACK: Mark, the 55 FTE are staff  
2 here. The \$14 million is your contracted budget?

3 MR. CUNNINGHAM: Correct. Correct.  
4 That's right. It doesn't include the security. The  
5 security in FY '04 for the Office of Security Research  
6 budget in '04 is about \$8.5 million. That includes a  
7 wide variety of things, not just in PRAB, not just in  
8 DRAA.

9 CHAIRMAN APOSTOLAKIS: So what exactly is  
10 14.8?

11 MR. CUNNINGHAM: 14 is the budget for the  
12 PRA -- it's for these things except security.

13 CHAIRMAN APOSTOLAKIS: Okay.

14 MR. ROSEN: Contractor support.

15 MR. CUNNINGHAM: Contractor support. It's  
16 separate from the 55 FTE.

17 CHAIRMAN APOSTOLAKIS: Okay.

18 MR. CUNNINGHAM: Okay. Develop risk  
19 methods, perform risk analyses, develop standards,  
20 apply PRA to advanced reactor issues.

21 Within the Operating Experience Program we  
22 have the SPAR Model Development Program Analysis and  
23 the Accident Sequence Precursor Program, a new data  
24 system to look at basic events coming from the  
25 industry, Mitigating Systems Performance Indicator or

1 Index. Indicator? Index. Okay. I never get that  
2 right. Recommendations coming from the Davis Bessy  
3 Task Force and a series of things related to  
4 international cooperative efforts.

5 CHAIRMAN APOSTOLAKIS: Which task force is  
6 this?

7 MR. CUNNINGHAM: Davis Bessy Lessons  
8 Learned Task Force.

9 In the security area we've got basically  
10 the application of risk methods to certain security  
11 issues. We've got the development of guidance for  
12 using risk information and security decision making.  
13 We've got the lead for the office for integrating the  
14 research program supporting answer. Then we do a  
15 variety of briefings domestically and internationally  
16 to other government agencies, international  
17 organizations for foreign governments basically. That  
18 sort of thing.

19 MR. SHACK: Okay. And you have a separate  
20 contractor budget for this but the 55 FTEs covers the  
21 whole kit and caboodle.

22 MR. CUNNINGHAM: Correct. Correct. In  
23 terms of risk methods development I think I mentioned  
24 yesterday the big areas we tend to focus on, or have  
25 focused on for the last few years, are HRA and Fire

1 Risk Analysis. We heard about HRA yesterday. We'll  
2 talk a little about fire risk this afternoon after  
3 lunch, I guess. I guess we're not going to discuss  
4 materials and waste later but we are working with NMSS  
5 to develop risk analysis methods and decision  
6 criteria, safety goals, that sort of thing.

7 CHAIRMAN APOSTOLAKIS: So who is reviewing  
8 this, ACNW?

9 MR. CUNNINGHAM: ACNW, correct. The last  
10 part. We have talked to them several times I think.

11 CHAIRMAN APOSTOLAKIS: You have already  
12 done that?

13 MR. CUNNINGHAM: Yes.

14 CHAIRMAN APOSTOLAKIS: Or is it the joint  
15 subcommittee?

16 MR. CUNNINGHAM: It was just ACNW.

17 CHAIRMAN APOSTOLAKIS: So what is the  
18 purpose of the joint subcommittee? The whole idea was  
19 I thought to bring some perspective from the reactor  
20 where we have had experience with these things.

21 MR. CUNNINGHAM: That's a good idea for  
22 next year when we review the research programs maybe  
23 to have a joint meeting.

24 CHAIRMAN APOSTOLAKIS: Not just the  
25 research program but actually the research that they

1 are doing in establishing the safety goals for NMSS.  
2 Some perspective from the NMSS would have been useful.  
3 It just occurred to me I'm a member of that  
4 subcommittee so it's okay. You go to ACNW.

5 MR. CUNNINGHAM: ACNW, of course, is not  
6 bereft of risk analysis experience with Dr. Garrick on  
7 it as chairman.

8 CHAIRMAN APOSTOLAKIS: I never implied  
9 that. There is a certain perspective that the ACRS  
10 always brings having dealt with it for a long time.

11 MR. CUNNINGHAM: Okay. In terms of risk  
12 studies we have the lead in the office for  
13 investigating potentially risk-informed changes. 5044  
14 is basically done now. 50.46 is in the works.

15 CHAIRMAN APOSTOLAKIS: Were we briefed on  
16 50.46 recently, Bill, or has it been a while?

17 MR. SNODDERLY: It's been a while. We  
18 have one coming up. November 21st it has been  
19 tentatively scheduled.

20 CHAIRMAN APOSTOLAKIS: Already?

21 MR. SNODDERLY: Yeah, to be briefed on the  
22 expert elicitation and success.

23 CHAIRMAN APOSTOLAKIS: November? Am I  
24 invited to that?

25 MR. ROSEN: No. 50.69 is really an NRR

1 problem at the moment.

2 MR. CUNNINGHAM: 50.69. The technical  
3 work has been turned over to NRR. We are in the  
4 process of getting a peer review of our work, the  
5 research work. The first formal meeting of the peer  
6 review is sometime before Thanksgiving.

7 MR. ROSEN: When they pay attention, could  
8 you explain that to me?

9 CHAIRMAN APOSTOLAKIS: November 21st is  
10 valid. Is that set in concrete?

11 MR. SHACK: I thought we contacted George  
12 for an expert elicitation.

13 CHAIRMAN APOSTOLAKIS: Yeah, an expert  
14 elicitation. Nobody asked me if I can make it.

15 MR. SHACK: We'll talk.

16 CHAIRMAN APOSTOLAKIS: Can we change it?  
17 It's eight weeks from now. Six or eight weeks.

18 MR. SHACK: November 21st is when it's  
19 scheduled for?

20 CHAIRMAN APOSTOLAKIS: Yeah. Are you  
21 available?

22 MR. SHACK: Yeah. I'm okay with the 21st.

23 CHAIRMAN APOSTOLAKIS: Then the next week  
24 we have the ACRS 508 meeting, right? On the 2nd we  
25 have -- we're going to have to move here again.

1 MR. SHACK: Okay. What does your peer  
2 review involve now in the 50.69?

3 MR. CUNNINGHAM: I haven't been greatly  
4 involved in it but it's basically looking at, I  
5 believe, both the basic method that's been applied and  
6 getting into some of the nastier technical issues  
7 related to more the materials aspects of it, I  
8 believe. If I could, maybe when I'm back here after  
9 lunch I'll come back and give you a better answer.

10 MR. SHACK: Is there a document or a  
11 report? It's not Appendix T because that's been --

12 MR. CUNNINGHAM: That's correct. It's the  
13 technical basis report that research provided to NRR  
14 is the subject of the peer review.

15 CHAIRMAN APOSTOLAKIS: You're talking  
16 about which peer review?

17 MR. CUNNINGHAM: 50.69 PTS.

18 CHAIRMAN APOSTOLAKIS: That is a peer  
19 review group?

20 MR. CUNNINGHAM: Yes.

21 CHAIRMAN APOSTOLAKIS: Who are these  
22 people?

23 MR. CUNNINGHAM: I'll have to get you the  
24 names after lunch.

25 CHAIRMAN APOSTOLAKIS: Have we reviewed

1 the latest 50.69?

2 MR. CUNNINGHAM: No. We haven't seen the  
3 NEI Implementation Guide. That's the most important  
4 piece that we haven't seen.

5 MR. SNODDERLY: The next step is to have  
6 a briefing on resolution of the public comments.

7 MR. CUNNINGHAM: I'm saying 50.69. I  
8 don't mean 50.69. I mean PTS just to be clear.

9 MR. SNODDERLY: That sounds better.

10 CHAIRMAN APOSTOLAKIS: So there is a peer  
11 review on PTRS. Oh, yeah, sure. That was a huge  
12 effort.

13 MR. CUNNINGHAM: Yes. Okay.

14 MR. SNODDERLY: But 50.69 you have washed  
15 your hands of the whole affair?

16 MR. CUNNINGHAM: Research doesn't have  
17 much of a role in the implementation of 50.69.

18 CHAIRMAN APOSTOLAKIS: Is expert  
19 elicitation the only thing that's going on?

20 MR. CUNNINGHAM: No, no, but that's the  
21 biggest aspect of things right now.

22 CHAIRMAN APOSTOLAKIS: Is there a document  
23 I can read at least if I'm not here?

24 MR. CUNNINGHAM: There is a draft  
25 Commission paper in concurrence now that talks about

1 next steps of 50.46.

2 MR. SNODDERLY: On the 21st we plan to  
3 spend about four to six hours on the expert  
4 elicitation and then an hour and a half on the second  
5 that Mark just mentioned where they are going to -- it  
6 will be a negative consent paper that says, "Here is  
7 what we think we heard from your March 31st SRM and  
8 here's what we're doing. Unless we hear differently,  
9 we're going to provide you the following."

10 CHAIRMAN APOSTOLAKIS: So which  
11 subcommittee is meeting on the 21st?

12 MR. SNODDERLY: We call it a subcommittee  
13 but when you include Thermal Hydraulics, PRA, and Bill  
14 that's everyone.

15 MR. ROSEN: We're sort of fixated on the  
16 21st. Maybe the 20th you're thinking?

17 MR. SNODDERLY: The 20th was not an  
18 option. There were two dates that we considered.

19  
20 MR. ROSEN: What was the other one? Do  
21 you remember?

22 MR. SNODDERLY: The other one was very  
23 early in November but then there really wasn't -- the  
24 staff couldn't provide us with the results.

25 CHAIRMAN APOSTOLAKIS: How about Tuesday

1 of that week which is the 18th?

2 MR. SNODDERLY: Rob Tregoning is going to  
3 be away those first two days. He could do it Thursday  
4 or Friday. There's another meeting scheduled on  
5 Thursday so Friday was it.

6 MR. CUNNINGHAM: Okay. So we've looked at  
7 the risk associated with dry cask storage of fuel and  
8 that's being discussed with ACNW. We did the risk  
9 evaluation of GSI 191 on sump performance that I  
10 believe you saw fairly recently. We're doing a risk  
11 evaluation of accident induced steam generator tube  
12 ruptures.

13 You've seen DG 1122 and heard a lot about  
14 it. The ANS external events standards, to my  
15 understanding, is just going to publication here  
16 within the next week or two so that is basically done  
17 for now. We supported the development of that. We  
18 are supporting the development of the ANS low power  
19 and shutdown standard.

20 In January there's a multi-  
21 organizationally sponsored workshop in Vienna on PRA  
22 equality. IAEA and a number of others, NEA and  
23 ourselves are sponsoring this workshop and we are --

24 CHAIRMAN APOSTOLAKIS: What is the purpose  
25 of it?

1 MR. CUNNINGHAM: To look for  
2 commonalities, I believe, across countries and  
3 organizations about what we can do to get to the --  
4 where do we want to be and what is needed to get there  
5 is my understanding.

6 CHAIRMAN APOSTOLAKIS: What happened to  
7 sensitivity?

8 MR. CUNNINGHAM: We are going to be  
9 developing another guide that covers those specific  
10 issues.

11 CHAIRMAN APOSTOLAKIS: This is what Mary  
12 mentioned when she was here.

13 MR. CUNNINGHAM: Correct. For advanced  
14 reactors we're helping NOR and the reviews of some of  
15 the reactor types, developing some basic tools to  
16 support those reviews. We are also trying to work  
17 with what we call the technology neutral framework.  
18 I'm not sure if the Committee has seen that or not.

19 CHAIRMAN APOSTOLAKIS: Is there still  
20 activity going on there? That's based on Option 3, is  
21 it not?

22 MR. CUNNINGHAM: Yes. Take Option 3 and  
23 overlay it onto advanced reactor design.

24 CHAIRMAN APOSTOLAKIS: There is some  
25 activity or is it very low level?

1 MR. CUNNINGHAM: It's moderate level I  
2 would say.

3 MR. SNODDERLY: Next month, George, Mary  
4 is going to be down with Tom King to present the  
5 framework to us.

6 CHAIRMAN APOSTOLAKIS: We have selected  
7 the date again, Michael?

8 MR. SNODDERLY: No, it's to the full  
9 committee.

10 CHAIRMAN APOSTOLAKIS: To the full  
11 committee?

12 MR. SNODDERLY: To the full committee.

13 CHAIRMAN APOSTOLAKIS: Those dates have  
14 been selected. So my question was meaningful.

15 MR. ROSEN: And we hope you will attend,  
16 George.

17 CHAIRMAN APOSTOLAKIS: What a low blow.

18 MR. ROSEN: It's no fun without you.  
19 Could you go back to that one?

20 MR. CUNNINGHAM: Yes, sir.

21 MR. ROSEN: Could you tell me where ACR-  
22 700 is? I'm lost on it entirely.

23 CHAIRMAN APOSTOLAKIS: It's Canadian.

24 MR. ROSEN: Is this still active? My  
25 notice in the research plan is there's a kazillion

1 efforts on it. I'm surprised by that.

2 CHAIRMAN APOSTOLAKIS: What does ACR stand  
3 for?

4 MR. SHACK: Advanced Canadian Reactor.

5 MR. ROSEN: Something like that.

6 MR. CUNNINGHAM: My understanding is, yes,  
7 it's still one of the active ones.

8 MR. ROSEN: That means the Canadians are  
9 going to come down here and make presentations and  
10 ultimately apply for certification.

11 MR. CUNNINGHAM: Correct.

12 CHAIRMAN APOSTOLAKIS: So it will be  
13 handled the same way as AP-1000.

14 MR. CUNNINGHAM: Yes, that's correct.  
15 Because it's a different design it introduces  
16 different issues.

17 MR. ROSEN: And they have done the same  
18 thing in Britain, I think. The British may decide to  
19 do something different than this agency might and  
20 that's difficult. It causes difficulty

21 MR. CUNNINGHAM: It makes life more  
22 complicated. Yes, it does.

23 MR. ROSEN: Okay. I'm asking that in the  
24 context of research decisions we have to say we like  
25 or don't. One of the puzzling things about the plan

1 that I saw now is the amount of effort that's going  
2 into ACR-700.

3 CHAIRMAN APOSTOLAKIS: What about passive  
4 equipment? What's going on there?

5 MR. CUNNINGHAM: I'm sorry?

6 CHAIRMAN APOSTOLAKIS: You have a program  
7 on PRA passive equipment or processes? Phenomenon?

8 MR. CUNNINGHAM: Phenomenon. It's more  
9 phenomenon.

10 CHAIRMAN APOSTOLAKIS: It's not passive.

11 MR. CUNNINGHAM: That's right. It's how  
12 do you model the reliability of functions.

13 CHAIRMAN APOSTOLAKIS: Does anyone have  
14 any idea how to do that or you are searching for  
15 ideas?

16 MR. CUNNINGHAM: We are searching for  
17 ideas at this point.

18 MR. ROSEN: This is like reactor vessel  
19 heads?

20 MR. CUNNINGHAM: This is like passive ECCS  
21 systems. Passive ECCS systems.

22 MR. ROSEN: Oh, okay.

23 MR. CUNNINGHAM: That sort of thing.

24 CHAIRMAN APOSTOLAKIS: Yeah. So, you  
25 know, the AP-1000 is inside the containment at high

1 elevation so gravity works right.

2 MR. ROSEN: We hope.

3 CHAIRMAN APOSTOLAKIS: But nobody has come  
4 up with any potential failure modes as far as I know.  
5 People are skeptical but it says this might happen.

6 MR. CUNNINGHAM: That's my understanding,  
7 too.

8 CHAIRMAN APOSTOLAKIS: How can we build  
9 something that cannot fail? It goes against our  
10 nature.

11 MR. CUNNINGHAM: I don't know.

12 CHAIRMAN APOSTOLAKIS: Okay.

13 MR. CUNNINGHAM: The division provides  
14 support to a number of different things. We are  
15 responsible for updating the implementation plan for  
16 managing the PRA steering committee, the internal  
17 committee.

18 CHAIRMAN APOSTOLAKIS: How do you  
19 pronounce the second acronym?

20 MR. CUNNINGHAM: RIRIP. Or IP for short.

21 CHAIRMAN APOSTOLAKIS: Now you're  
22 shortening acronyms. And the other one is RILP? The  
23 third one?

24 MR. CUNNINGHAM: I'm sorry? The other one  
25 is already taken by international programs I'm afraid.

1 CHAIRMAN APOSTOLAKIS: Okay.

2 MR. CUNNINGHAM: Okay. So that's kind of  
3 the overview.

4 CHAIRMAN APOSTOLAKIS: So all of these are  
5 active programs?

6 MR. CUNNINGHAM: Correct.

7 CHAIRMAN APOSTOLAKIS: Okay.

8 MR. CUNNINGHAM: Active in '04, if you  
9 will. Some of these things may not be very far along  
10 but they are active. With that, Pat Baranowsky and  
11 Company will present the program in the Operating  
12 Events Risk Analysis Branch.

13 CHAIRMAN APOSTOLAKIS: We're moving now to  
14 our advanced technology.

15 MR. BARANOWSKY: We're now moving to the  
16 real world. Not things that could possibly occur but  
17 things that have occurred.

18 CHAIRMAN APOSTOLAKIS: You're going  
19 backwards. You're using transparencies.

20 MR. BARANOWSKY: Every time I bring a  
21 PowerPoint presentation that doesn't work.

22 MR. ROSEN: This is why operating  
23 experience is your job because you know from operating  
24 experience that this works.

25 MR. BARANOWSKY: Briefing experience, yes.

1 MR. ROSEN: And you have a backup bulb in  
2 there in case it blows.

3 MR. BARANOWSKY: If need be, we'll go up  
4 and get a little cartridge and stick in and add the  
5 PowerPoint.

6 MR. ROSEN: You could also, if need be,  
7 come over here and hold it up in front of us.

8 MR. BARANOWSKY: We do have hard copies,  
9 I'm sure. I have some people here that should be  
10 coming up and sitting down around the table. I  
11 thought this would be more of a sort of roundtable  
12 discussion.

13 I guess I'd better introduce myself for  
14 the record. Patrick Baranowsky, Chief of the  
15 Operating Experience Risk Analysis Branch. I brought  
16 a few people from my branch here that are responsible  
17 and involved in the key areas. I'll just start from  
18 this side.

19 Don Marksberry who has been doing program  
20 management work for the Accident Sequence Precursor  
21 Program for the last couple of years at least. Dr.  
22 Pat O'Reilly who is heading up the SPAR development  
23 work, Dale Rasmuson who is working on both Data  
24 Systems and Industry Trends Program, and Dr. Don Dube  
25 who is working on support for performance indicator

1 development for the Reactor Oversight Process.

2 We have other folks, Mike Cheek who is the  
3 Assistant Branch Chief, Gary DeMoss who is pretty much  
4 our Senior Risk Analyst for ASP events, and Dr.  
5 Bennett Brady who is a key person working on data  
6 systems and interfaces with INPO also available here.

7 So, what we are going to cover are pretty  
8 much programs I've just identified. I'll give a  
9 little introduction to how the branch is organized and  
10 what we're about. Then we'll cover data collection  
11 analysis, the Accident Sequence Precursor Program,  
12 industry trending, SPAR work, and then Mitigating  
13 System Performance Index.

14 Introduction. Just a quick overview of  
15 these things. The Accident Sequence Precursor Program  
16 is used not only to have a resource that gives us  
17 information on significant events over a period of  
18 time but now also becoming part of what the agency  
19 uses in their report to Congress to identify how well  
20 we're doing.

21 It's sort of an NRC and industry report,  
22 if you will. We look at both significant events. If  
23 there are certain numbers of them, they would be  
24 getting reported to Congress. And whether or not the  
25 trends in Accident Sequence Precursors are degrading

1 in some way.

2 The other thing I would mention about the  
3 Accident Sequence Precursor Program, which has been  
4 going on for quite awhile, is that it does provide an  
5 independent assessment by the Office of Research apart  
6 from licensing types of analyses. We try and be  
7 realistic without any consideration of whether we are  
8 trying to license a plant and have some conservatism  
9 or not in there. Sometimes it gives a little bit  
10 different spin but usually not too much from what  
11 we're seeing in the regulatory area.

12 In the oversight process we have a couple  
13 of activities ongoing. The first is to support the  
14 Industry Trends Program which I'll discuss. And also  
15 to develop performance indicators, the most recent of  
16 which is the Mitigating System Performance Index. In  
17 both of those things we have briefed the ACRS on  
18 before. I'll say a little bit about it but if there  
19 are any updated types of questions that you would like  
20 to ask, we are prepared for that.

21 We have done quite a bit of work on our  
22 data collection and analysis to streamline that. It  
23 was sort of all over the place in terms of how we were  
24 collecting and staring and coding and we really  
25 compressed it into a fairly efficient operation.

1           Now we have a lot of work going on in the  
2           SPAR model development area. It's kind of stretched  
3           us to the limit on resources. I'll go over the  
4           various things there but it's full power, low-power  
5           shutdown, LERF, and even some consideration of  
6           external events. That's the full scope of what we do  
7           in this branch.

8           The next chart is meant to show how some  
9           of this is organized. It's organized so that there is  
10          a good interaction between the activities or else we  
11          wouldn't be able to do this with a relatively small  
12          staff.

13          Just looking from the bottom up the way  
14          our work is organized we have identified a number of  
15          databases or sources, if you will, of operating  
16          experience information that we process into the  
17          databases or that we share with others like INPO, for  
18          instance and their EPIX data.

19          Then you'll see also in this lower tier  
20          here reliability and availability data system. That's  
21          sort of our common way of treating the information so  
22          that we don't have one project with a slightly  
23          different approach to calculating parameters or  
24          whatever. It's all done in a fairly consistent way.

25          This information gets fed into a number of

1 analytic activities that used to be done independently  
2 when we were first studying initiating events and  
3 components to see how we might look at industry trends  
4 and get some what I would call industry average or  
5 generic insights on these things.

6 We actually published a number of reports  
7 which we presented before the ACRS several years ago.  
8 Now what we have done instead of updating the reports  
9 as we had one time planned, because that's just way  
10 too costly, we have taken what I will call algorithms,  
11 if you will, that we developed to do the analyses and  
12 the standard approach for collecting the data and the  
13 standard approach for displaying the important  
14 contributors and insights.

15 That's all going into a web-based system  
16 so that for 10 or 20 percent of the cost we can do all  
17 this not only for all the different aspects but we can  
18 update it much more rapidly because publishing NUREGs  
19 is just a time-consuming process.

20 The only thing that we would want to be  
21 careful about is if we modify our methods and  
22 approaches we would want to have an interaction with  
23 peers before we incorporate that into our methodology  
24 because every one of these reports had pretty  
25 widespread review inside of NRC with ACRS and with

1 external entities like INPO, EPRI, and owner's groups.

2 MR. SHACK: Now, how do you handle that  
3 with the web base? Do you put up a private site  
4 somewhere and people discuss it?

5 MR. BARANOWSKY: No. The way it works is  
6 if we've already had the methodology and the process  
7 peer reviewed, then we just carry it out as a routine  
8 production activity. All we're worried about then is  
9 QA and that's where we are on this.

10 But if there is a new element to this  
11 that's added, then it has to go through a much more  
12 rigorous process, most likely with NUREG production  
13 and the usual peer review activity. If we were to  
14 expand the items that you see on this list here but  
15 suppose we said external event issues, we would do a  
16 study that would go through the usual process of  
17 development, peer review, resolution of comments,  
18 finalizing the methodology and then it would get  
19 incorporated into what I would call a production sort  
20 of mode.

21 MR. SHACK: Just on the SPAR, too, when  
22 people are using SPAR for SDP that's done by NRR, do  
23 you support that or you support it only to the extent  
24 that you just hand them a SPAR bottle?

25 MR. BARANOWSKY: No, we are available for

1       consultation and we are actually working on a more  
2       integrated approach for us to deal with SPAR analysis,  
3       SDP and ASP analyses so that we can all use a common  
4       set of tools and procedures.

5               I think just the tools alone are not  
6       enough. My experience has been that if we don't have  
7       a process and procedures to use the tools in a  
8       consistent way, we can use them anyway we want and get  
9       anything we want and it's not trustworthy as a  
10      production activity.

11              Once we get to the point where we think we  
12      know how to do certain types of analyses, we should  
13      have ingrained in the process an approach that in most  
14      cases gets us to a result we can believe in without  
15      having to go back and reinvent the wheel on whether we  
16      know how to do an analysis of the reactor coolant pump  
17      seal type of accident.

18              That does lead us up to the next level  
19      which is the plant specific analyses and there we have  
20      both the SPAR models get developed to support that and  
21      the Accident Sequence Precursor Program which takes  
22      information from the lower tiers.

23              You will notice I have also added another  
24      little item under the Accident Sequence Precursor  
25      Program, inspection reports, because at one time we

1 were just analyzing what came in from LERs I'm going  
2 to say about five or six years ago, maybe it was more.  
3 More? Okay.

4 Well, we decided that a precursor is a  
5 precursor no matter where it comes from. Even if the  
6 LER format isn't set up to capture it, perhaps there  
7 are other things such as two or three inspections  
8 might uncover problems that don't get reported in a  
9 single LER so we wouldn't want to miss that if it was  
10 significant.

11 Now, I don't know that we've run into any  
12 like that but I think a few years ago there were some  
13 concerns so that gives us some comfort to know that  
14 we're not being blinded by just the format and  
15 restrictions associated with LER reporting. Then  
16 we've taken this information from --

17 MR. ROSEN: Have you been impacted by the  
18 rather sparse nature of recent inspection reports?  
19 The ROP seems to have caused inspection reports to be  
20 less descriptive perhaps than earlier inspection  
21 reports of performance.

22 MR. BARANOWSKY: The ones that we worked  
23 with on the more significant events I think are pretty  
24 detailed. Maybe you can help me out here, Don  
25 Marksberry.

1 MR. MARKSBERRY: Yeah. Most conditions  
2 which are identified in inspection finding usually  
3 results in LER so that's our first go is we read the  
4 inspection report and the associated LER. If we need  
5 additional information we call the inspector up. We  
6 call the SRA in the region to get additional  
7 information.

8 MR. ROSEN: So the kind of things that  
9 reach your program are important enough to ultimately  
10 generate an LER and you maybe get a clue of it in  
11 inspection report. And the kind of thing I'm talking  
12 about is there used to be a lot of flowery descriptive  
13 language in inspection reports before the ROP.  
14 Inspectors were wax poetic about performance at the  
15 plants and you could get all kinds of insights from  
16 that. Now with the ROP they're a lot more  
17 constrained.

18 Even though they do many of the same  
19 things they don't write them all in the reports so  
20 there is less peripheral, as we call it, information  
21 in these reports than there used to be. But since  
22 you're working on the mainline, I can see how that  
23 probably hasn't impacted you much.

24 MR. BARANOWSKY: And plus we follow up  
25 informally on many of these things. That's what takes

1 a lot of time sometimes is interacting with the  
2 regional inspectors and/or the licensee to get some of  
3 that additional information that's not in either the  
4 inspection report or the LER.

5 MR. ROSEN: But you're really talking  
6 about something that rises to some level of  
7 importance.

8 MR. ROSEN: But you would have an SDP to  
9 work from, wouldn't you?

10 MR. BARANOWSKY: Not necessarily. I'm not  
11 sure of the numbers but I think about 60 percent of  
12 the Accident Sequence Precursors have an overlap with  
13 the SDP and about 40 percent don't. Remember, the SDP  
14 will look at performance deficiencies per their  
15 definition. What we're looking at is what is the risk  
16 out there. I don't care whether it's because you  
17 intended it or didn't intend it. It is what it is.  
18 Our scope is broader in that respect.

19 We also look for overlapping conditions  
20 even if they might be related to different aspects of  
21 performance, whereas the SDP says we look at this  
22 performance issue once and then we go and look at  
23 another performance issue. What we're looking for is  
24 how is the risk building up as a result of  
25 combinations of things or individual items so it's

1 really a different perspective.

2 The top of the chart here everything sort  
3 of feeds up to our ability to develop risk-based  
4 performance indicators. We did a study a couple of  
5 years ago on risk-based performance indicators which  
6 was reviewed by the ACRS. Then since then we did a  
7 spin off activity working at NRR and the industry on  
8 adapting some of that for the mitigating systems  
9 cornerstone. We'll talk about that a little bit  
10 toward the end of the discussion.

11 CHAIRMAN APOSTOLAKIS: Question. One of  
12 the problems, Mark, as you know associated with this  
13 work is dissemination of the information we generate  
14 and even, you know, Carl Fleming's report points out  
15 that some from the staff meaning that 20 percent of  
16 the events that you identify don't find their way into  
17 the PRAs, which is something that is debatable.

18 This is really -- I mean, there is a lot  
19 of useful work that comes out of these precursor  
20 studies and other studies that your branch is doing.  
21 By in large that is not informing the work that the  
22 industry is doing on PRAs. Are we making any progress  
23 at all?

24 MR. BARANOWSKY: You make a good  
25 point. I can't say we have made progress but I think  
it's being addressed finally. The Davis Bessy Lessons

1 Learned Task Force resulted in a follow-on activity  
2 called the Operating Experience Task Force, I think.

3 I think one of the issues that comes out  
4 of that is the dissemination of operating experience,  
5 information, and insights. It just so happens one of  
6 my key staffers, Don Marksberry, was on that task  
7 force. The report is in draft and I'm sure it will  
8 come to the ACRS.

9 MR. MARKSBERRY: I think we're scheduled  
10 to brief you in a couple of weeks or so. A couple  
11 three weeks.

12 CHAIRMAN APOSTOLAKIS: A day I cannot  
13 come?

14 MR. BARANOWSKY: That's the way we  
15 schedule it.

16 CHAIRMAN APOSTOLAKIS: Full committee.  
17 Does my colleague here want to make a comment?

18 MR. ROSEN: I don't like it when he misses  
19 full committee meetings. Neither does the chairman of  
20 the Commission. I would like to point out that some  
21 of your colleagues were here yesterday, John Flack and  
22 J. Persensky, talking about the Human Factors Research  
23 Program.

24 They gave us three slides on potential  
25 performance indicators for the Corrective Action

1 Program, safety conscious work environment, and human  
2 performance. Those were thrilling to me because, you  
3 know, we've complained that the ROP needs to have  
4 indicators of cross-cutting the issues. Are you the  
5 guy that was supposed to do that?

6 MR. BARANOWSKY: I don't know. If I am,  
7 I need to have the resources.

8 MR. ROSEN: Here they are.

9 MR. BARANOWSKY: I need to have the  
10 resources to do the work.

11 CHAIRMAN APOSTOLAKIS: As a dean of my  
12 school once said, if there is such a set available,  
13 anybody can do it.

14 MR. ROSEN: Exactly. And he was right.  
15 You don't need to be smart or determined. I recommend  
16 to you if you haven't seen this to get hold of  
17 Persensky and Flack's presentation to the ACRS  
18 yesterday, to the Subcommittee on the 9th, and to look  
19 at the last three charts in their presentation which  
20 are potential performance indicators in the areas of  
21 the cross-cutting issues.

22 MR. BARANOWSKY: Okay. I appreciate that.  
23 So that's sort of an overview of how we are organized.  
24 I guess the one point is that things sort of fit  
25 together and if we didn't have some of these things

1 going on, we would actually not be able to operate  
2 with the small group and the kind of budget size that  
3 we have. We take advantage quite a bit of forming  
4 small interactive teams to work up and down this chart  
5 and it seems to be working out.

6 CHAIRMAN APOSTOLAKIS: This is really what  
7 happens. This is data. This is real data. We have  
8 a course at MIT every June for mid-level managers for  
9 utilities on risk formulation. We run it twice now.  
10 This is one of the most popular talks. People really  
11 appreciate. When you start talking about data people  
12 really get excited. It has always been a very  
13 successful popular talk.

14 MR. BARANOWSKY: Okay. Thanks. So let me  
15 now just cover the data collection and analysis. This  
16 last fiscal year we made significant progress on our  
17 integrated data collection and coding system. What we  
18 do is we have identified the types of factors and  
19 information that we want to extract for all the kinds  
20 of studies or risk parameters that we want to  
21 generate.

22 Then in a coding book we have that laid  
23 out so that we can take an individual coder and train  
24 them and have one person -- or, I should say, do it  
25 one time because there may be a couple of people

1 involved -- go through, say, an LER and extract  
2 information that feeds into a lot of analytics, if you  
3 will. Many of the charts and parameter type  
4 estimations that were in all of our system studies are  
5 now just together in one activity and we have the  
6 algorithms to do the calculations.

7 We've also worked pretty closely with INPO  
8 so that we can extract information out of the EPIX  
9 system which is becoming a more and more quality  
10 system. Now, it doesn't have the kind of rigor and  
11 perfection to it that some folks in licensing  
12 applications like to see.

13 What that means is there is an occasional  
14 failure event that is either not include or that is  
15 included when called a failure that we might not call  
16 a failure which one has to be aware of on a plant  
17 specific basis because the numbers of failures to key  
18 components on a specific plant are relatively small.

19 But across the industry if you want to  
20 look at, say, certain types of valves or pumps or  
21 whatever, there's a pretty good data base there.  
22 Let's say there's 100 failures per year of certain  
23 types of valves and we're probably getting 98 of  
24 those. That's pretty good.

25 MR. ROSEN: Is it true that EPIX also

1 collects runtime data for operating equipment and  
2 successful tests?

3 MR. BARANOWSKY: They collect some of  
4 that. Dale, can you? Dale Rasmuson.

5 MR. RASMUSON: They collect information on  
6 a quarterly basis for some of the systems such as  
7 runtimes and demands and that. In others they  
8 estimate it. They should have collected information  
9 over like the past year or two years and then they put  
10 in an estimate of what the runtime would be for that  
11 time.

12 MR. ROSEN: Well, this is the famous  
13 denominator problem that we've talked about. Right?

14 MR. RASMUSON: Right.

15 MR. ROSEN: Which EPIX really takes a shot  
16 at.

17 MR. RASMUSON: Which it really does.

18 MR. ROSEN: Which is a whole lot better  
19 than nothing.

20 MR. BONACA: Now, we asked questions about  
21 EPIX three years ago. We actually recommended that  
22 everybody would report so I talked to INPO about that.  
23 Is everybody reporting?

24 MR. BARANOWSKY: Everybody is reporting  
25 and, in general, they are doing pretty good. If you

1 want a better characterization, I would have to ask  
2 Dale.

3 MR. RASMUSON: Most utilities are doing a  
4 good job of reporting on the components that we're  
5 interested in. We haven't taken a look at all the  
6 things. What we want is just a small subset of all  
7 the components there. There are some utilities that  
8 report but not real well. I would say like 90 or 95  
9 percent of them are really doing a good job.

10 MR. ROSEN: Isn't it true, Dale, that INPO  
11 checks that?

12 MR. RASMUSON: They have.

13 MR. ROSEN: Somebody actually goes to the  
14 plant as part of the evaluation and has a look at what  
15 they're doing and make sure they are at least getting  
16 the main report.

17 MR. RASMUSON: I don't think that happens  
18 but they do have what they call right now -- Bennett,  
19 correct me on this if I make a mistake here but right  
20 now they have moved to a new data system where they  
21 are submitting their data on the Internet. That comes  
22 in. They have developed programs to check the data to  
23 make sure that the data is coded and that errors are  
24 not in there. Like, for instance, negative values for  
25 demands or things.

1                   As we have been getting a submittal from  
2                   INPO and we load it, we have our checks in there and  
3                   we are finding that -- well, this time we just got one  
4                   yesterday and I sent it out to Idaho and they loaded  
5                   the data into RADs and there were no negative values  
6                   in the thing. We've had them before. Just a few.  
7                   The quality of the data is increasing and we have good  
8                   data now. We can do some good analyses and come up  
9                   with some good estimates.

10                   MR. BONACA: I see the LERs looking for  
11                   comatose failures so you are looking under EPIX. You  
12                   find consistency in those assessments that you get  
13                   from them. I'm asking more about the quality of the  
14                   information you are getting and if it is, in fact,  
15                   consistent or if it gives you signs that there are  
16                   some problems to the reporting.

17                   MR. RASMUSON: Basically I think EPIX is  
18                   a great improvement over NPRDS.

19                   MR. BARANOWSKY: NPRD.

20                   MR. RASMUSON: Over NPRDS. Sorry. Over  
21                   NPRDS. We get a lot more narrative in EPIX where in  
22                   NPRDS you were limited to like three fields of 240  
23                   character. Now we have lots and lots of text that  
24                   goes in there.

25                   MR. ROSEN: You have to remember it was

1 done in an era when you had to name a file with no  
2 more than eight characters.

3 MR. RASMUSON: Right. I know.

4 MR. BONACA: My question is more  
5 directional. In the past we relied heavily on LERs  
6 for identification of common cause failures but they  
7 are a limited set of information coming in. Now you  
8 get EPIX. Does the information coming from EPIX  
9 confirm what you had?

10 MR. RASMUSON: Yes. In our database  
11 before -- our common cause database before about 60  
12 percent of our common cause failures were coming from  
13 NPRDS where we actually were building up the failures.

14 MR. BARANOWSKY: So we have more  
15 confidence in EPIX to provide the raw information than  
16 we did from NPRDS, plus we've got the LERs. We can  
17 cross compare and we have done that to make sure.

18 MR. BONACA: Common cause is a bad example  
19 because, of course, I mean they look at those and they  
20 would be in LERs anyway. What about component  
21 reliability? Do you get really different information  
22 or do you look at the two sources?

23 MR. RASMUSON: We are just getting to  
24 where we can really do some comparisons in that. The  
25 system studies had not been updated for quite a while

1 and we have that now. We have just posted on our  
2 webpage new system results and now we're working on  
3 getting down at the segment train level where we can  
4 actually do some comparisons. Some of the comparisons  
5 that we did for auxiliary feed water pump, just a real  
6 quick spot check, EPIX in our system studies gave very  
7 good results.

8 MR. ROSEN: I would be remiss if I didn't  
9 ask a question about fire events. The question I have  
10 is fire events that last more than 15 minutes are  
11 reportable, I think, under LER, but those fires are --  
12 all fires are important from a risk analysis point of  
13 view because little fires become big fires.

14 Even short duration fires ultimately  
15 become big fires if you don't do something about them.  
16 My question is are the fire events in EPIX only the  
17 reportable fire event or is there some lower  
18 categorization of fire?

19 MR. RASMUSON: There's some lower  
20 categorization of fires also and our fire events are  
21 also supplemented with information from Neal, the fire  
22 insurer.

23 MR. ROSEN: So you are getting some robust  
24 fire database or analysis?

25 MR. BARANOWSKY: Yes, I think we have a

1 pretty extensive fire database down to smoke events  
2 and don't have fires.

3 CHAIRMAN APOSTOLAKIS: Interesting.

4 MR. ROSEN: This is very important, of  
5 course, because the importance of fire in the overall  
6 risk perspective.

7 MR. BARANOWSKY: That really covers the  
8 consolidated data. I would just mention what the  
9 status is on this because we did have to do a fire  
10 amount of software work so we've gone through the  
11 development and trial testing in August and we have a  
12 webpage now that we put together that allows some  
13 access for NRC staff. I presume that means ACRS  
14 members, too.

15 We're testing this out and modifying it to  
16 see if the information that's conveyed when someone  
17 queries the system is useful or could change.  
18 Eventually we are going to have this set up so it can  
19 be available externally but we have some additional  
20 work to do to make that happen.

21 MR. SHACK: Does that mean somebody can  
22 download the Excel database?

23 MR. BARANOWSKY: I think we want to let  
24 them have access to raw information but I don't  
25 believe they will be able to download a database.

1 MR. SHACK: On the internal webpage?

2 MR. BARANOWSKY: I don't think so.

3 MR. RASMUSON: No, not really. Not at  
4 this time. Right now we're working our way -- we've  
5 got some phases outlined here.

6 MR. BARANOWSKY: Let me just show this  
7 picture. This will show you the kind of things that  
8 you can find on the website. In other words, all the  
9 analysis work that I talked about, we're trying to  
10 figure out how to get that out to folks because now we  
11 have it available here. We need to not only make it  
12 available on the website but then the next step is to  
13 make sure that those who use this information would be  
14 aware of it.

15 Activities along that line are going on  
16 now. In fact, I think we have a communication plan  
17 that we put together. I noticed recently that NRR is  
18 giving a briefing on how to get access to operating  
19 experience events, information which includes this  
20 website. We have the ability on the left-hand side  
21 here to do some word searches from reports. Right now  
22 it's LER but that can be expanded to whatever anybody  
23 wants to put in there.

24 Then we have the kind of raw data and what  
25 I'll call processed data that we've collected which

1 feeds into the charts, tables, etc., that are related  
2 to initiating events, components, and so forth.  
3 That's the bulk of it, by the way. Then on the far  
4 right we do also support the --

5 MR. ROSEN: Which right? Your right or  
6 our right?

7 MR. BARANOWSKY: Your right.

8 MR. ROSEN: Okay.

9 MR. BARANOWSKY: On the far right we have  
10 some work that we're doing to make available, for  
11 instance, ASP program results and insights as opposed  
12 to having someone go and use a special database which  
13 is also available but maybe not quite as readily known  
14 and accessible.

15 MR. ROSEN: What I'm taking away from this  
16 is that I could go in and look at the fire event  
17 database today if I wanted to if I was at my computer.

18 MR. BARANOWSKY: You can go in and look at  
19 the output of the fire event database. I don't know  
20 if you could go in and yank the whole database out.  
21 Eventually we are going to let you be able to query  
22 the database.

23 The first step was we've collected  
24 information on all kinds of fire events, put them into  
25 bins, and we have numbers and so forth and some

1 parameters that we calculated and that kind of thing  
2 is being put into -- is either in or being put into  
3 the website now.

4 MR. RASMUSON: Right. That's on the  
5 website now.

6 MR. ROSEN: What kind of things? Do you  
7 mean like fire event databases in bins like fires that  
8 lasted longer than five minutes, 10 minutes in  
9 duration?

10 MR. BARANOWSKY: It could be duration. It  
11 could be location. It could be damage. I don't  
12 remember what all is stored in there. The idea is to  
13 get someone like you or another interested person to  
14 go in and say, "I couldn't find this that I was  
15 looking for," and then as we collect that, what folks  
16 are actually trying to extract out of the database we  
17 can adjust it to be able to do that.

18 It's not set up so that anybody can do  
19 anything. That's way, way too costly for us to do.  
20 Ultimately you'll get to the point where you can query  
21 the database to some extent but we've got to put the  
22 tags and flags in there and we can't tag and flag  
23 every single possibility. We are trying to flag and  
24 tag them based on how they are used in risk analysis  
25 but we are open to other ideas, too. I would ask

1 anybody who's interested to go in and take a look.

2 The next item is the action sequence,  
3 precursor analyses. This project has been going on  
4 for 20 something years. I don't think the objectives  
5 have changed very much in terms of systematically  
6 analyzing operating experience events to understand  
7 their risk implications.

8 The methodology and sophistication has  
9 actually changed and it's sophisticated enough, I  
10 think, that we can use it to understand where there  
11 might be some areas in PRAs that we would want to  
12 improve the capability not necessarily so much because  
13 the total risk might be significantly underestimated  
14 but if you want to get down into details where you  
15 want to make changes in regulations or plant specific  
16 things, you need to know more than the overall risk.

17 I think we've got a pretty good handle on  
18 the overall core damage frequency but when we get down  
19 to the lower levels that we make decisions on tech  
20 specs or licensing amendments or even changing  
21 regulations, that's another story.

22 MR. ROSEN: This webpage that you talk  
23 about in the prior slide, that's accessed through  
24 NRC.gov?

25 MR. BARANOWSKY: Yeah. We should have

1 given you the -- it's not on here. We should have  
2 given you -- does anyone here know the website?

3 MR. RASMUSON: I will see that you get the  
4 URL for it. It's on our internal webpage right now  
5 and you can get to it through the RES webpage but I'll  
6 get you the address.

7 CHAIRMAN APOSTOLAKIS: If a graduate  
8 student wants to get some curves for the failure rate  
9 of a particular component, they can do it?

10 MR. RASMUSON: Yes.

11 MR. ROSEN: Well, he has to get to the  
12 internal webpage.

13 MR. BARANOWSKY: Oh, yeah. He has to have  
14 access to internal. Because of security we haven't  
15 been able to get the external one working.

16 CHAIRMAN APOSTOLAKIS: But how could -- so  
17 that means it's not accessible.

18 MR. BARANOWSKY: Well, it's not accessible  
19 if you're not considered an internal cleared person.

20 MR. ROSEN: So it's not off NRC.gov.

21 MR. SHACK: It's internal .NRC.gov.

22 MR. BARANOWSKY: And we just rolled this  
23 out a couple of months ago, by the way, so it's like  
24 a beta test version.

25 CHAIRMAN APOSTOLAKIS: And then what

1 happens? We can do that?

2 MR. BARANOWSKY: If Citrix happens to be  
3 working that day.

4 MR. ROSEN: It doesn't work on Government  
5 holidays.

6 MR. BARANOWSKY: Within a year I think we  
7 would like to have this thing well accessible and  
8 improved to provide information so it's something to  
9 think about.

10 So the accident sequence precursors, let's  
11 give you a little picture here of what we've been  
12 seeing. Normally we trend the accident sequence  
13 precursors over about an eight to 10-year period and  
14 we have been trending now for the 1993 events. If you  
15 trend that batch of events there, you can't come up  
16 with an increasing or decreasing trend with any  
17 statistical competence.

18 But if you look at '97 on, you'll see that  
19 we've seen more events. You know some of the big ones  
20 as well as us. We've been actually swamped with  
21 trying to analyze some of these pretty significant  
22 events. They are important to us and they are  
23 important to licensees because many of them go into  
24 the SDP so there's really a lot of attention to how  
25 the analysis is done.

1           Simple assumptions that used to make it  
2 quick and dirty get within a factor of 2 or 3 that I'm  
3 happy with are not acceptable anymore. People are  
4 concerned about whether the best estimate is  $8 \times 10^{-7}$   
5 or  $1 \times 10^{-6}$ .

6           MR. ROSEN: Well, it might only be a  
7 liberal distinction to that whether or not it goes  
8 from white to yellow. That's the thing. Most of  
9 these are on the edge when you start arguing about  
10 what should be in the model and how the model should  
11 be adjusted.

12           One thing that we have been doing is  
13 spending a lot of time looking at model uncertainties  
14 and parametric uncertainties. I don't think anybody  
15 is systematically incorporating insights from model  
16 and parameter uncertainties into their thinking about  
17 what does this all mean. They are all taking the  
18 point estimates and running with them.

19           For instance, I've seen  $9.7 \times 10^{-6}$  called  
20 something that's in the  $10^{-6}$  range. If I draw a  
21 distribution about that and I show you the modeling  
22 uncertainties that go along with the parametric  
23 uncertainties, over half of what we're worried about  
24 is up over the --

25           CHAIRMAN APOSTOLAKIS: We try not to

1 sensitize people to the importance of modeling  
2 uncertainties. In a couple of years you're going to  
3 see some results.

4 MR. BARANOWSKY: Decisions in light of  
5 uncertainty is not something that we're taking on.  
6 What we are trying to do, though, is bring the  
7 uncertainty out. Don, you had some examples here that  
8 maybe I can show. These are backups. Let me show  
9 these.

10 Let me start with this one. This was a  
11 low service water flow incident to the diesel  
12 generator coolers at the Cook plant. This chart shows  
13 the end result of our analysis which included both  
14 model and parameter uncertainties. If I can read  
15 this, you can see -- I don't know what the point  
16 estimate is but -- what are these two marks here, Don?

17 MR. MARKSBERRY: The licensee.

18 MR. BARANOWSKY: Oh, licensee doing an  
19 estimate. This one? Sorry. This one is the  
20 licensee's estimate. This one is --

21 MR. MARKSBERRY: The STP.

22 MR. BARANOWSKY: The STP estimate. This  
23 range represents our best estimate including both  
24 model and parameter uncertainties. Then we had sort  
25 of a low and a high model result. This is the high

1 end of model uncertainties and the low end. We don't  
2 know how to put these --

3 CHAIRMAN APOSTOLAKIS: I wonder how you  
4 did that. Do you have a report?

5 MR. BARANOWSKY: We have a report. Here  
6 was the key modeling uncertainty that had to do with  
7 debris in the forebay and how that impacted the diesel  
8 generator cooling system.

9 CHAIRMAN APOSTOLAKIS: Boy, this is --

10 MR. BARANOWSKY: This is a routine ASP  
11 event.

12 CHAIRMAN APOSTOLAKIS: This is an aria to  
13 my ears. We are making a note here that we will get  
14 the written document from you guys?

15 MR. BARANOWSKY: Yes. You can get it. I  
16 need to let you know that it's classified sensitive  
17 because of the PRA information in general meets a  
18 condition and guideline that was set out almost two  
19 years ago. We're trying to get that changed so it can  
20 be released to the public because I don't personally  
21 think there's any security information in the ASP  
22 analyses that we have to worry about.

23 But, in theory, one could use precursor  
24 analysis with location and vulnerability information  
25 to identify security issues. We pretty much scrubbed

1 this so you don't have that in there and we're trying  
2 to get the criteria changed. But certainly internally  
3 ACRS you can see this so just be aware that will  
4 have --

5 CHAIRMAN APOSTOLAKIS: The model  
6 uncertainty, I mean, I don't know if you've seen the  
7 last letter from the ACRS on this.

8 MR. CHEOK: This is Mike Cheok. I have a  
9 comment on the Cook analysis. That's draft right now.  
10 We will put the file out in about a month so we might  
11 want to wait until a month from now before we sent out  
12 the final analysis.

13 CHAIRMAN APOSTOLAKIS: Do you have any  
14 other examples?

15 MR. CHEOK: We have several other  
16 examples.

17 MR. BARANOWSKY: We can send you probably  
18 three or four.

19 CHAIRMAN APOSTOLAKIS: If you can. I'm  
20 not interested in just Cook.

21 MR. SHACK: Now, that SDP, that was a SPAR  
22 analysis point estimate or that's a notebook analysis?

23 MR. BARANOWSKY: No, no. Oh, who knows?

24 DR. O'REILLY: It was -- this is Pat  
25 O'Reilly. I believe it was a Phase 3 analysis and it

1 was not necessarily using a SPAR model. It was kind  
2 of a hybrid type of analysis.

3 MR. SHACK: We're supposed to get  
4 conservative results. Right?

5 MR. BARANOWSKY: Well, normally you are  
6 supposed to but when you read the report on Cook you  
7 will the level of sophistication that went into our  
8 analysis. I doubt that the SDP at this point can  
9 afford to move up to that standard. The question is  
10 whether or not what they did is adequate for  
11 identifying performance issues that should be followed  
12 up on as opposed to whether they got the risk number  
13 right to within a factor of 10.

14 MR. SHACK: What does right mean?

15 MR. BARANOWSKY: The thing about the  
16 accident sequence precursors is we apply this standard  
17 basically to all of our work so you can compare and  
18 add A and B together and not have apples and oranges  
19 if you want to get some notion of whether we're  
20 looking at the really significant ones or not.

21 I think from the SDP point of view they  
22 are identifying things that we ought to follow up on  
23 in inspections and that is what they are supposed to  
24 do. Hard to explain to the public sometimes why they  
25 are different but that's the thing.

1           George, you had mentioned that we had some  
2 insights. These are what I would call pretty high-  
3 level insights. What we haven't done is gone and  
4 really scrubbed the ASP work to see if there are more  
5 profound things than just saying 20 percent of the  
6 incidents have some unique characteristics to them  
7 that are not usually captured in PRAs.

8           If you are making decisions at that level  
9 in the PRA, you might have some problems drawing the  
10 right conclusion if these things weren't incorporated  
11 in there. There are reports on each of these. There  
12 was one that was an RCS blowdown into the refueling  
13 water storage tank at hot shutdown which was a fairly  
14 high risk contributor. A couple of strange things  
15 happened when the reactor tripped and loss of surface  
16 water.

17           CHAIRMAN APOSTOLAKIS: So the question is  
18 if I go now to the PRA, which is done for hot  
19 shutdown, am I going to see a failure mode like this?

20           MR. SHACK: I don't think so.

21           CHAIRMAN APOSTOLAKIS: That's the thing  
22 that we need to spread the word and make them more  
23 realistic.

24           MR. SHACK: Yeah. This is something like  
25 an event B sequence but not exactly. It's an

1 interesting way that it got there. There weren't  
2 dials that failed or anything. This was an operator  
3 made a mistake or got confused.

4 DR. O'REILLY: They had conflicting  
5 operations going on at the same time, George, and  
6 neither of the two were in communication with the  
7 other.

8 CHAIRMAN APOSTOLAKIS: Okay. So the  
9 industry doesn't know this but do our own guys know  
10 these things? When they receive a PRA or a piece of  
11 a PRA in support of a risk informed decision do our  
12 own guys know about these things?

13 MR. BARANOWSKY: Well, the information is  
14 available and, as I said, it's not always so easy to  
15 go to so they may not go to it. One of the insights  
16 from the operating experience task force is we need to  
17 make this easy to get to.

18 CHAIRMAN APOSTOLAKIS: If a reviewer from  
19 NRR is dealing with shutdown modes, is there anyway he  
20 or she can press a couple of buttons and get all these  
21 insights regarding these modes? Do we have that yet?

22 MR. BARANOWSKY: No.

23 CHAIRMAN APOSTOLAKIS: Think about it.  
24 Maybe that's what we need.

25 MR. BARANOWSKY: You are right. As I

1 said, if we had the resources we would go through and  
2 put together a little better package that would allow  
3 you to dig down. Start off with high-level  
4 considerations and then lead you down to the details  
5 so you could use it appropriately.

6 Right now the way it is is you would have  
7 to just go in and scroll through all the ASP events  
8 and be able to figure out which ones you want to look  
9 at. We don't have them categorized and classified.

10 CHAIRMAN APOSTOLAKIS: They're never going  
11 to do that.

12 MR. BARANOWSKY: They aren't going to do  
13 that. You're right.

14 CHAIRMAN APOSTOLAKIS: Unless it's easy  
15 access, they're not going to do it. They have so many  
16 other pressures. I mean, it's not because they are  
17 bad guys. They have lots of things to do.

18 MR. BARANOWSKY: I'm trying to get Don  
19 Marksberry to work Sundays -- he's already got  
20 Saturday booked -- to do this but he just says he's  
21 got to have a day off.

22 CHAIRMAN APOSTOLAKIS: I don't know about  
23 that.

24 MR. BARANOWSKY: This is an identified  
25 issue.

1 I'm not going to say too much about the  
2 Industry Trends Program because we had a briefing --  
3 how long ago was that, Dale?

4 MR. RASMUSON: Just a month ago.

5 MR. BARANOWSKY: Two months maybe. Let's  
6 talk a little bit about it for the benefit of anyone  
7 who either wasn't there or some update things. I'll  
8 let Dale do some updating, too.

9 The Industry Trends Program is a  
10 complement to the reactor oversight process. It's not  
11 actually a part of it.

12 CHAIRMAN APOSTOLAKIS: You guys want to  
13 take a five-minute break?

14 MR. BARANOWSKY: That's fine.

15 CHAIRMAN APOSTOLAKIS: Okay. Back in five  
16 minutes.

17 (Whereupon, at 10:42 a.m. off the record  
18 until 10:50 a.m.)

19 MR. BARANOWSKY: Okay. Just briefly on  
20 the Industry Trends Program, it focuses primarily on  
21 industry-wide implications of things and trends so it  
22 complements some of the more generic activities that  
23 the NRC does. What we are doing is supporting NRR on  
24 this project and they are using a lot of the  
25 information that we have in our initiating event and

1 systems studies that trend the performance of  
2 equipment or initiators over time.

3 If there is a significant deviation in  
4 time for this integrated look, then that should spur  
5 us on to look more closely at whether or not there is  
6 a generic issue here. Then we could take either the  
7 lack of such conditions or their existence and report  
8 them to Congress as part of the NRC's performance and  
9 accountability requirements. That is one of the major  
10 things that pushes this project.

11 There is a process, and this is really an  
12 NRR process but I just wanted to show it, in which  
13 data is fed into the process and we analyze it and  
14 looks for trends on specific things. The items that  
15 are going to be trended are not just any old thing.  
16 We go through a process of picking what's going to be  
17 trended, what the scope is and so forth.

18 For instance, I think we picked six  
19 specific initiating event categories with specific  
20 definitions and the counts for those things are sort  
21 of rigorously defined so that we don't have  
22 differences every year that's based on the way people  
23 count things or do their work and we wouldn't be able  
24 to get a reasonable trend.

25 That goes into the process, as I said, in

1 which we, meaning the agency, looks to see if there is  
2 something evolving here. If there is a significant  
3 degradation, then the senior managers have their  
4 meeting once a year and talk to the Commission and it  
5 could be identified there and discussed in terms of  
6 agency response activities which normally would be  
7 underway by that time.

8 And if it meets certain criteria, it can  
9 actually get report up to Congress where it's a  
10 deviation in performance that's degrading to the point  
11 we think we have to go and tell Congress that there is  
12 a problem evolving here. That's the process.

13 What we've been working on lately is an  
14 integrated indicator in which we can take most of the  
15 risk significant, if not all the risk significant,  
16 events which have different risk importances and  
17 weight them accordingly and come up with a single  
18 indicator more for the reporting to Congress than  
19 anything else.

20 We still have the information  
21 disaggregated down into the 10 or 15 types of  
22 indicators and we use that as safety engineers at the  
23 NRC. But how do we report trends on 15 or 20  
24 initiating events with different risk significance.  
25 And if this ever gets expanded into the other

1 cornerstones, we could have literally 100 indicators  
2 and that wouldn't make any sense. The idea was to  
3 come up with a way of rolling this up.

4 Currently what happens is they're just  
5 counted. A large break LOCA would be counted the same  
6 as an innocuous reactor trip, turbin trip, in which  
7 the plant started up a few hours later. That's not  
8 the way this is set up. It goes into the risk  
9 importance measure and it weights it and its potential  
10 impact on core damage frequency for the specific plant  
11 that had the incident and we used the SPAR models for  
12 this.

13 Then we collect the information for a year  
14 and then year by year we can put it together and show  
15 the trend. That's what we presented at the last ACRS  
16 meeting. The point that we got to now is we finished  
17 the initial development at work and we're sending it  
18 over to NRR shortly and a decision needs to be made as  
19 to whether or not they want to do some trial and  
20 specific implementation kinds of activities while we  
21 fine tune things. You know, make sure it has QA.  
22 Make sure it's a production thing instead of a  
23 research activity. That's pretty much where we are on  
24 that.

25 The next item is the SPAR model

1 development program. I'll go through this in the  
2 order that we identified types of SPAR models that we  
3 are developing. First thing is the so-called level 1  
4 Revision 3 models which are the full power SPAR models  
5 and we now have 72 of these models developed which  
6 represent all the operating reactor configurations.

7 A couple of them are close enough that we  
8 can use virtually the same model but we can make as-  
9 necessary adjustments on, say, performance data or  
10 even some recovery factors. Are there any other  
11 things we would change?

12 We're done the on-site QA reviews for all  
13 of these which actually was an ACRS recommendation two  
14 years ago. We went out to every site. We gave our  
15 model to the licensees, we got theirs, and we compared  
16 them and we saw where there were differences. Where  
17 we had the designation "i" means we haven't addressed  
18 those differences yet so there's quite a few of them  
19 that we haven't been able to address the differences  
20 yet. When we do address them, then we just call them  
21 3.

22 DR. O'REILLY: We have about 25 models  
23 left to complete the follow-up on those on-site QA  
24 reviews.

25 MR. ROSEN: I'm delighted to hear that.

1 I think I was one of the people who sort of suggested  
2 that. In fact, I went further. I suggested why don't  
3 you just throw these away and get an agreement with  
4 the licensee to use their model.

5 I think I understand the reasons you don't  
6 do that now, but clearly you didn't want to be in the  
7 situation you're in where your model was just plain  
8 wrong and the licensee would tell you that the first  
9 time you tried to use it. You wanted to find out your  
10 model was wrong and not up to date before you tried to  
11 use it in some contentious proceeding.

12 DR. O'REILLY: Well, you should be aware  
13 that there are some cases in which we have agreed to  
14 disagree with the licensee's PRA.

15 MR. ROSEN: As long as you know that the  
16 plant has three of these and not two.

17 DR. O'REILLY: Correct. That was the main  
18 purpose of these on-site QA reviews which, by the way,  
19 we did in conjunction with NRR's benchmarking of the  
20 SDP notebook for the plant.

21 MR. ROSEN: And more than just three of  
22 these, not two, that there's a connection between here  
23 and here which is modeled that they can take credit  
24 for in their analysis. You ought to understand that,  
25 too.

1 DR. O'REILLY: Yes.

2 MR. BARANOWSKY: We have a good  
3 understanding now of the physical plant as operated  
4 which we're trying to incorporate into the models at  
5 the level of detail that we work with. We also went  
6 one step further and that's this third bullet here as  
7 part of our Mitigating System Performance Index.

8 There were 20 plants that were part of the  
9 pilot program and we did what I call an enhanced SPAR  
10 model which now goes down to the level necessary to  
11 model the plant for the key systems in the Mitigating  
12 System Performance Index, support systems and all  
13 their interconnections some of which were put in as  
14 undeveloped events in our simpler models.

15 This work has been getting pretty high  
16 marks from folks that we worked with because we are  
17 really understand where there are any differences and  
18 what those differences are between what an NRC model  
19 and standard set of assumptions might give versus  
20 licenses. I believe we have a very good agreement in  
21 many cases.

22 We have identified a few issues which  
23 while we have our standard of approach might be to,  
24 say, use a RELAP generated success criteria and a  
25 licensee might be using MAP. We're just saying those

1 are differences which should be resolved and we're  
2 looking at how that might happen over the next year or  
3 so.

4 At least we're aware of it. We are aware  
5 if their risk number is a little bit different than  
6 ours, we understand it's because of slightly different  
7 success criteria. We can now focus in on the things  
8 that are driving those success criteria and hopefully  
9 get to a much closer result.

10 Don Dube gave a presentation to -- I don't  
11 remember which subcommittee it was but we had some  
12 extremely close calculations and core damage frequency  
13 and importance measures. These are our own models.  
14 We did them ourselves and all we wanted to know is how  
15 is the plant designed and operated. We didn't use  
16 their model.

17 MR. ROSEN: What do you mean by close?

18 MR. BARANOWSKY: Close to the core damage  
19 frequency.

20 MR. ROSEN: Close to the licensee's  
21 estimate.

22 MR. BARANOWSKY: The licensee's estimate  
23 and then if it was different we could say exactly why  
24 it was different. What we are trying to come up with  
25 is a list of items that we can work in some form.

1 We're not sure how. Possibly through the ASME  
2 standard activity to resolve these things so that we  
3 don't argue about those kind of modeling things on  
4 regulatory applications. We argue about other things  
5 like thresholds and risk philosophy and whatever.

6 MR. BONACA: This is level 1, no external  
7 events at power?

8 MR. BARANOWSKY: Yes. We've done a lot of  
9 work at the at power. I think we either have very  
10 good models or where there are limitations, we  
11 understand what we're missing in the models.

12 In fact, we're planning on putting I'll  
13 call it a warning of some sort or an advisal up front  
14 in our SPAR models indicating the specific limitations  
15 for their use so that when those folks who didn't  
16 develop them go out and use them, they will know that  
17 they have to be concerned about the level of detail,  
18 say, in the service water across connect model and  
19 you've got to use accordingly. Supposedly these  
20 things are to be used by skilled practitioner stuff,  
21 just push button.

22 I'm going to skip the next one. Let's go  
23 to low-power shutdown. With low-power shutdown I  
24 think we had a briefing on this.

25 DR. O'REILLY: A year ago.

1 MR. BARANOWSKY: Okay. We have completed  
2 the BWR and PWR templates. We have some SPAR models.  
3 This low-power shutdown is a little bit different  
4 because plants don't go through the same exact  
5 evolutionary characteristics or process every time  
6 they shutdown so it's not a push-button model by any  
7 stretch of the imagination. It's more of a model with  
8 procedure for making it fit what you have actually  
9 observed.

10 MR. ROSEN: And the difference is  
11 enormous.

12 MR. BARANOWSKY: Yes.

13 MR. ROSEN: For instance, if a PWR does a  
14 hot early mid LOOP or doesn't, the risk number for  
15 that shutdown will be enormously different. Wildly  
16 heterogeneous in time and enormously different from  
17 outage to outage.

18 MR. BARANOWSKY: I mean, more so than for  
19 sure the normal operating condition plants you have to  
20 have an analyst who can work with these models.

21 DR. O'REILLY: Because of that, we are  
22 concentrating on an approach that does plant  
23 categories versus trying to have a low-power shutdown  
24 for each individual plant.

25 MR. BARANOWSKY: So it would be sort of a

1 general model, if you will, that you have to make  
2 adjustments for some guidelines.

3 DR. O'REILLY: Correct.

4 MR. ROSEN: So when you advertise this to  
5 the agency and say here is the standard outage for  
6 PWR, let's say, and put a risk number on it, you will  
7 be making a mistake. You're going to have to say here  
8 is a range of outages.

9 Someone is going to ask you ultimately and  
10 you're going to have to say something like, "Well, it  
11 depends what you do. Here's a range of outages.  
12 Here's one that is pretty low risk and here's one  
13 that's pretty high risk and you'll notice the  
14 differences."

15 DR. O'REILLY: Right. We've tried to  
16 capture the several most risk important configurations  
17 for low-power shutdown but you're right. A particular  
18 plant one of those might not be quite as risky.

19 MR. ROSEN: Or you can do it at a  
20 different time during the outage when decay heat is  
21 down and it will change the structure again. Not only  
22 whether you do it but when you do it will be  
23 important.

24 DR. O'REILLY: That's right.

25 MR. BONACA: You could blow the whole

1 core.

2 MR. ROSEN: Right.

3 MR. BONACA: I mean, so you have no mid  
4 LOCA concern.

5 MR. ROSEN: Right. Sometimes it's zero

6 MR. BARANOWSKY: You'd have to go back and  
7 look at their past history of what they did and I can  
8 only tell you what their risk exposure was. Or if  
9 they will tell us what they are going to do in the  
10 future, then we can do that, too.

11 MR. ROSEN: They won't do that because  
12 they don't know.

13 MR. BARANOWSKY: So that's the limitation.  
14 You're going to have to be an analyst that can work  
15 this thing as you go through it.

16 So we'll be conducting QA reviews and we  
17 have a couple of more, what do you call these, these  
18 standard models or whatever.

19 DR. O'REILLY: Lead plant models.

20 MR. SHACK: Now, is this built on top of  
21 the enhanced SPAR or is this a 3 or 3i?

22 MR. BARANOWSKY: It's different.

23 DR. O'REILLY: I'll tell you what will  
24 happen is enhancing the Revision 3 SPAR models can  
25 result in enhancements to the low-power shutdown

1 models because we pull in the fault trees from the  
2 Rev. 3 models into the low-power shutdown  
3 configuration.

4 MR. SHACK: Okay. But in the event  
5 diagram this all overlaps. There are low-power  
6 shutdowns on enhanced models and on non-enhanced  
7 models.

8 DR. O'REILLY: It could happen that way,  
9 yes.

10 MR. ROSEN: So this fiction that's being  
11 perpetrated that there's no risk analysis for shutdown  
12 is clearly demonstrated to be wrong here.

13 DR. O'REILLY: We hope so.

14 MR. ROSEN: You need to contest the people  
15 who come up with this fiction now and then that plants  
16 only know yellow, red, and orange. There are lots of  
17 plants that do better than that.

18 DR. O'REILLY: There are a few. We are  
19 finding out there aren't a majority but there are some  
20 out there, yes.

21 MR. SHACK: Have you computed some  
22 comparisons with yellow, red, and orange?

23 DR. O'REILLY: We've only gotten one on-  
24 site QA review of low-power shutdown model completed  
25 because most of the ones that we have models for are

1 also participating in this MSPI comparison exercise  
2 and we did not want to put additional burden on the  
3 licensee's PRA staff so we had to delay the rest of  
4 those.

5 We reported to the subcommittee last  
6 October about the results of the one on-site QA we did  
7 at the Surrey plant. As I said before, we got mixed  
8 results out of that. Part of the problem was the lack  
9 of knowledge on the part of the licensee's PRA staff  
10 about their low-power shutdown model. They had it  
11 done by a contractor and were no longer working with  
12 that contractor at the time.

13 MR. BARANOWSKY: Okay. The next thing  
14 that we're doing is we are developing the large early  
15 release frequency models. We've done some development  
16 work here that we completed including the bridge trees  
17 and containment of entries. The bridge trees bridge  
18 from the level 1 models basically to the core damage  
19 states and containment failure states. We have  
20 incorporated peer reviews. Who was involved in that  
21 peer review? Can you remember?

22 DR. O'REILLY: It was an internal peer  
23 review but I do believe that the reports came to the  
24 ACRS.

25 MR. BARANOWSKY: I don't know that we have

1 briefed the ACRS on this. Have we?

2 DR. O'REILLY: No. We talked to you about  
3 this last year but you couldn't fit it on your  
4 schedule.

5 MR. BARANOWSKY: So let us know. We would  
6 like to hear more about it. There's not a lot of  
7 ability to do LERF analysis without going through  
8 extremely detailed and time consuming and costly  
9 process like the NUREG 1150 type of things. Or just  
10 pulling things out of the air saying, "I think that's  
11 going to be a big release and an early one," and just  
12 calling it that.

13 This gives us some capability in between  
14 there. It's not perfect but based on what we  
15 understand to be important in talking to folks who are  
16 doing the more sophisticated developmental activity,  
17 we are incorporating those features that seem to have  
18 the biggest drive in here. Again, it's another one of  
19 these things that is going to have to have procedures  
20 for its application.

21 DR. O'REILLY: Yes.

22 MR. BARANOWSKY: More than just the level  
23 1 core damage frequency models.

24 MR. CHEOK: Let me say something about  
25 that, Pat. Remember when we were talking when you

1 were developing the 174 reg guide and we had this  
2 NUREG on LERF, a lot of the small LERF models starts  
3 up with that NUREG where we can convert from CDF to  
4 LERF.

5 MR. BARANOWSKY: So we'll continue to  
6 develop these models for lead plants and if it seems  
7 appropriate, we would be glad to brief the committee.

8 I'll also mention that we haven't started  
9 yet but have future plans to do external event models.  
10 Again, we don't know exactly whether they would be  
11 more of a procedure and process approach or a hard  
12 model that is mostly push button. We would have to  
13 come up with a scheme.

14 MR. ROSEN: I think you know you're going  
15 to treat fires as an external event. Right?

16 MR. BARANOWSKY: Fire, flood, seismic, and  
17 external winds.

18 MR. ROSEN: High winds.

19 MR. BARANOWSKY: High winds. And they are  
20 all different enough in the way you are going to  
21 analyze them that it's not just a simple matter. We  
22 put that off to the end, but there is a crying need  
23 for us to have that, in particular, in the  
24 significance determination process.

25 When we did it for the power states, we

1 had fairly detailed PRAs and lots of them that we  
2 could work back from including our own. I mean,  
3 licensees and PRAs. You go to the external events and  
4 there's just a few studies and a few PRAs.

5 MR. ROSEN: If I asked you what happened  
6 during Hurricane Isabel to certain plants that  
7 tripped, you know, what was the risk, do an ASP  
8 analysis?

9 MR. BARANOWSKY: We could do the analysis  
10 but it would cost.

11 DR. O'REILLY: We would have to create our  
12 own custom model.

13 MR. BARANOWSKY: We've done that.

14 MR. ROSEN: Those plants tripped because  
15 of salting on the insulators because there was a lot  
16 of high winds and they are seacoast sites and there  
17 was no rain to wash the insulators. How do you model  
18 that, the high winds?

19 MR. BARANOWSKY: Actually it becomes  
20 easier to model something that has already failed and  
21 just what the consequential situation is and we  
22 predicted just that.

23 MR. ROSEN: But I'm not interested in just  
24 that. I'm interested in how likely was the event.

25 MR. BARANOWSKY: That's different. That's

1 what we would have to spend some time on.

2 The last item is the Mitigating System  
3 Performance Index which we briefed the committee on a  
4 few months I guess. I think I mentioned that this did  
5 evolve from some work that we did on risk-based  
6 performance indicators.

7 It was put together in response to a  
8 request to promptly address some problems associated  
9 with the current performance indicators. It's what we  
10 call highly risk informed but there are a number of  
11 things that are done that make it not risk based per  
12 se but it's highly risk informed.

13 It accounts for unavailability and  
14 unreliability consistent with PRAs which gives us a  
15 nice connection there. It's more plant specific by  
16 far than the current set of indicators, it eliminates  
17 the fault exposure time problem, eliminates the  
18 cascade of cooling system support system failures onto  
19 front line system issue.

20 MR. ROSEN: In other words, it treats it  
21 properly.

22 MR. BARANOWSKY: Well, treats it properly.  
23 And the thresholds are consistent with the current  
24 performance indicators.

25 MR. ROSEN: And it's DOA, I understand.

1 MR. BARANOWSKY: And it's DOA. No, it's  
2 not DOA.

3 MR. ROSEN: Good. Why isn't it dead on  
4 arrival?

5 MR. BARANOWSKY: I'm going to explain  
6 that, I hope.

7 MR. ROSEN: I hope it's not dead on  
8 arrival.

9 MR. BARANOWSKY: Let me just finish this  
10 and I'll address that and then we'll see if it's DOA.  
11 We did do a pilot program on this. Did we report the  
12 pilot program the last time we came here?

13 SUBCOMMITTEE MEMBER: No.

14 MR. BARANOWSKY: Okay. And we are  
15 planning, by the way, a future ACRS briefing to follow  
16 up the last one plus the new stuff that happened.  
17 Don, when did we have that approximately scheduled?

18 MR. DUBE: I think probably early January  
19 or sometime.

20 MR. BARANOWSKY: And in December we are  
21 shooting to release the draft report that analyzes all  
22 the issues that evolved from the pilot program and how  
23 we came to a conclusion as to how they could be  
24 addressed technically. So the pilot program went  
25 through an exercise, the original version of what the

1 Mitigating System Performance Index was.

2           Until you try something out you never know  
3 what kind of bugs are in there and whatever. And then  
4 we found things that needed to be fixed up and we did.  
5 I'm not going to go through the details but this was  
6 part of our validation and verification effort because  
7 the licensees were the ones who were actually trying  
8 out the performance index and we were just doing some  
9 double checking validation verification work.

10           That included the need for us to upgrade  
11 the SPAR models which I described earlier in order for  
12 us to do that. We couldn't even do it with the  
13 original SPAR models. They weren't detailed enough or  
14 accurate enough.

15           They were good enough to get the overall  
16 core damage frequency and some key sequences but you  
17 have to go down into a level where the importance of  
18 key components is really fairly close if you are going  
19 to be making decisions that may change and performance  
20 pushes you over a threshold with a delta CDF  $10^{-6}$   
21 which is basically in the second or third decimal  
22 place of your overall knowledge on the core damage  
23 frequency.

24           MR. ROSEN: It turns out when you go out  
25 to plant, systems they are made of components.

1 MR. BARANOWSKY: You do what?

2 MR. ROSEN: It turns out when you go out  
3 to plants and put your hands on the equipment, systems  
4 are made of components together.

5 MR. BARANOWSKY: Right.

6 MR. ROSEN: It's a nasty fact of life.

7 MR. BARANOWSKY: It is. We came up with  
8 a neat little approach to incorporate components into  
9 the system in whatever levels allow us to work with a  
10 performance threshold that is based on what was  
11 promulgated in SECY 99007 when we did the reactor  
12 oversight process which is these  $10^{-6}$  levels that get  
13 you from the green to white to yellow to red and so  
14 forth.

15 Okay. So what's the status now? We've  
16 had several meetings to go over technical issues. Of  
17 concern are whether or not we will be getting false  
18 positive or false negative indications of degradation  
19 and performance and equipment that is highly risk  
20 significant.

21 It only takes a few failures if you are  
22 looking at a short period of time to call a failure  
23 rate high, let's say, when normally you would collect  
24 data over a longer period of time. That's an issue  
25 and we have come up with schemes for dealing with that

1 which we did not present to the ACRS.

2 Why don't you give a summary of a couple  
3 of the key items that we resolved and then we're just  
4 going to come and talk to you again.

5 MR. ROSEN: Put your last slide back on  
6 just so I don't have to look at that white background.

7 MR. DUBE: This is Don Dube. There were  
8 a number of issues identified but there were really  
9 six major issues. Of those we presented proposed  
10 solutions in the July 23rd meeting and had some go  
11 arounds. Industry has concurred with five out of the  
12 six resolutions that we have proposed.

13 These have to do with invalid indicators  
14 where there is only one failure -- one failure results  
15 in a white indication. Or, at the other extreme,  
16 insensitive indicators where it takes dozens and  
17 dozens of failures to reach a white indication. What  
18 we have proposed is putting a front stop and a back  
19 stop to address both sides of the issue.

20 They have agreed on those approaches  
21 pretty whole heartedly. The only outstanding issue is  
22 the extent to which we include the contribution of  
23 common cause failures to the importance measures and  
24 whether that should be part of the MSPI methodology.  
25 Really there's only one outstanding issue and I think

1 we can come up with a resolution on that.

2 MR. ROSEN: So it's not that other arm.

3 The minds have been greatly exaggerated.

4 MR. DUBE: No.

5 MR. BARANOWSKY: Let's talk about some of  
6 the things that have come out. You might have even  
7 read about these in Inside NRC. There are issues  
8 related to whether or not we can use licensees, PRAs  
9 as they exist to do the Mitigating System Performance  
10 Index calculation mainly because of the concern about  
11 PRA quality and what that means.

12 What we have done is try to identify the  
13 specific aspects of the PRAs that if you make a  
14 different assumption such as using the success  
15 criteria from RELAP versus the MAP code, what impact  
16 that has on calculating the MSPI values.

17 Because we are putting in these  
18 performance based approaches with front stops and back  
19 stops, it becomes less sensitive to the precision of  
20 the PRA. We need to run some simulations to verify  
21 how sensitive any of those issues are. We haven't  
22 done that yet.

23 MR. DUBE: Well, we've started. In fact,  
24 one interesting result is that at the July meeting I  
25 presented to you and I said that one particular plant

1 has a difference in success criteria than what we  
2 assume in the SPAR model. They said their success  
3 criteria is one out of two PORC for feed and bleed and  
4 many plants of that design have two of two PORC as a  
5 success criteria. We know the change in core damage  
6 frequency.

7 Now what we're doing is our MSPI  
8 sensitivity studies and looking at how differences in  
9 the PRA models and outputs affect the MSPI results.  
10 In this particular case depending on which assumption  
11 you use you may either get a white indication because  
12 of some failures of feed water pumps or a yellow  
13 indication. It's extremely sensitive. But other  
14 cases what we found is there are differences in let's  
15 say failure rates between the SPAR model and industry  
16 PRA. Some people are saying those are unacceptable.  
17 What we've done is rolled all the differences and  
18 doing sensitivities on those and we find, hey, it  
19 doesn't even affect the results to more than a factor  
20 of 1.5 or 2.

21 We are doing these sensitivity studies and  
22 getting a feeling for how sensitive is the output,  
23 which is the MSPI result, to the input. As you do  
24 enough of these you start to see an interesting trend.

25 CHAIRMAN APOSTOLAKIS: Mr. Cunningham

1 mentioned it today but Mary also a month or two ago.  
2 The stuff is developing a regulatory guide on how to  
3 do sensitivity and uncertainty analysis. It's all  
4 within the bigger context of PRA quality and PRA  
5 standards and so on. I think it will benefit a lot  
6 from the insights that you gentleman have collected  
7 over the years.

8 In particular how sensitive certain things  
9 are to assumptions because this is one of the  
10 requirements in the PRA standard, the ASME standard,  
11 that you have to identify the key assumptions that  
12 affect your results. The regulatory guide will deal  
13 with how to do that. I think you have to talk to  
14 them. Are you in contact with them at all or shall we  
15 intervene?

16 MR. BARANOWSKY: No, the PRA quality issue  
17 needs to be resolved in a manner that is consistent  
18 with what they're doing. We're testing some things  
19 out. In theory, they are going to learn from what  
20 we're doing.

21 CHAIRMAN APOSTOLAKIS: No, but this issue  
22 of two PORCs versus one and so on, these are examples  
23 they have to be aware of. These are key assumptions.

24 MR. BARANOWSKY: We are feeding this into  
25 them. The feed is from us to them. We have the

1 actual experience of doing the analyses.

2 CHAIRMAN APOSTOLAKIS: That's what I'm  
3 asking. There is a connection?

4 MR. BARANOWSKY: Yeah, and we are trying  
5 to feed that in.

6 CHAIRMAN APOSTOLAKIS: But they never tell  
7 you what they do, right? It's only one way?

8 MR. BARANOWSKY: Well, the concern that I  
9 have is we are working with specifics and then when  
10 you start getting into generalities of what PRA  
11 quality is, it becomes a discussion of philosophy as  
12 opposed to -- what I'm interested in is can I get a  
13 reasonably close analytic result so that when I apply  
14 it in a quantitative situation I don't get two  
15 potentially different decisions. That's all I care  
16 about.

17 CHAIRMAN APOSTOLAKIS: But this regulatory  
18 guide is not really dealing with the big issue of  
19 quality. It's dealing with the specific issue of what  
20 does it mean to do sensitivity analysis and what does  
21 it mean to do uncertainty analysis and how should I do  
22 these two things.

23 Obviously they have to be fully aware of  
24 some of the key assumptions that you guys are  
25 identifying. Anybody can talk about success criteria

1 that are important but here is an example where it  
2 does make a difference what kind of success criteria  
3 you assume. That's all I'm saying. And this is  
4 happening.

5 MR. BARANOWSKY: I think I can give  
6 accident sequence precursor cases where we did the  
7 same thing. We would run through point analysis. We  
8 had like 20 issues raised. We went through 19 of them  
9 that had no impact but it took a lot of effort to go  
10 through them. We said only one causes the bottom line  
11 to change. The others are peripheral.

12 CHAIRMAN APOSTOLAKIS: I would like to get  
13 some of this information for my own benefit.

14 MR. BARANOWSKY: We're going to get you  
15 some of these accident sequence precursor things.

16 MR. ROSEN: So tell us the bottom line on  
17 MSPI.

18 MR. BARANOWSKY: Okay. The bottom line is  
19 we think we can resolve all the technical issues and  
20 there are still issues related to its acceptability as  
21 a replacement for the current process which involves  
22 a performance indicator and/or a significance  
23 determination evaluation on single component failures.  
24 I think that's about the bottom line.

25 Some people want to do SDPs on single

1 component failures and our position is that is best  
2 done through reliability analysis because of the  
3 context of false positives and false negatives if you  
4 don't look at it in that regard. We factored that  
5 into the front and back stop issues that Don has  
6 talked about.

7 MR. ROSEN: Why doesn't that resolve the  
8 issue? Now you have an MSPI that recognizes that you  
9 ought to not make broad generalizations based on one  
10 event. You use the back stops and front stops to make  
11 sure that you don't and now you move the MSPI into the  
12 ROP replacing those other outdated -- let's say those  
13 other partial indicators which I began developing in  
14 the '80s with something that is much more robust. I  
15 think you're doing great. Don't give up early.

16 MR. BARANOWSKY: We're going through the  
17 process and we're trying to address issues that people  
18 are raising about why they like to do it one way or  
19 another. I think we're slowly just making progress.  
20 It's a little bit more difficult than we thought it  
21 would be. I don't think we can just say it's our  
22 opinion you --

23 MR. ROSEN: Not necessarily disabling.  
24 Things that are difficult sometimes turn out to be  
25 good things. I think working with the industry is

1 great but at some point you can declare victory and go  
2 ahead and make a recommendation to the agency that you  
3 move the ROP along. We didn't ever expect ROP to be  
4 the way it was on day zero forever.

5 MR. BARANOWSKY: I think we need to  
6 recognize that what we're proposing is not the perfect  
7 fix to performance indicators but a pretty good  
8 improvement that gives us a good handle on where we  
9 should spend our inspection resources.

10 MR. ROSEN: Look at the chart behind you,  
11 the one I had you put up. It just so happens to be  
12 that those bullets that you list, unavailability and  
13 unreliability are consistent with the PRA. It  
14 accounts for plant specific design and performance  
15 data which was one of ACRS' big complaints about it.

16 It eliminates fault exposure time which  
17 the industry complained about. It cascades properly  
18 the support systems, especially the cooling support  
19 system, and so on. Those are very significant  
20 advantages and I don't want to lose them. I think  
21 they are valuable. The longer we wait to accrue those  
22 advantages, that's lost opportunity.

23 MR. BARANOWSKY: One last point on that  
24 also is that this is new and different from the way  
25 anybody has done detailed performance indicator

1 calculations and so there is a concern about what  
2 effort will be involved in implementing this.

3 We think we figured out how to handle the  
4 industry side and I think the industry folks are  
5 comfortable with it but there is a concern about how  
6 much inspection activity is appropriate and would be  
7 required. Do they have to inspect the PRAs? Do they  
8 have to inspect all the interpretations of data?

9 MR. ROSEN: Got it across the line into  
10 the agency, the concerns, which is wonderful because  
11 we could help you with that. This is the right  
12 direction for the ROP and I support it. You've  
13 presented me with a target rich environment so I'll  
14 confine my comments besides MSPI to just two others.

15 These PIs for the cross-cutting issues  
16 that we have been looking for and worried about, you  
17 gave me a troubling answer to what I said before when  
18 I said, "Look, you need to look at Persensky's and  
19 Flack's presentation from the other day and look in  
20 the potential performance indicators that he proposed  
21 on Safety Conscious Work Environment Corrective Action  
22 Program and Human Performance."

23 You said, "I don't know if I'm the right  
24 guy." Well, I'll hold you responsible. I don't know  
25 if you are either but I see you. It's troubling to me

1 to have an agency person of your caliber and elevation  
2 in the agency to say, "I don't know who's in charge of  
3 this," because, you know, somebody has to be and  
4 you're as good a target as anybody.

5 This is important. Very important, Pat.  
6 We need to get this resolved. We brought it up in  
7 letters from ACRS to the Commission that here is an  
8 avenue. Please, between you and Flack and Persensky  
9 and whoever else, would you take the lead to say,  
10 "Okay, here's a way to go forward. Let's at least  
11 look at it." I'm not saying do it. I'm just saying  
12 here is a suggestion.

13 CHAIRMAN APOSTOLAKIS: Maybe we can say  
14 something in our research board about this because he  
15 needs help with that. He cannot take the lead.

16 MR. ROSEN: I know. I'm just troubled by  
17 somebody like him saying, "I don't know who's in  
18 charge."

19 CHAIRMAN APOSTOLAKIS: We'll make sure we  
20 raise that when we write the appropriate report  
21 because then I think some people may pay attention.

22 MR. ROSEN: I'll try. I'll try. Okay.

23 CHAIRMAN APOSTOLAKIS: We'll turn you into  
24 a psychologist.

25 MR. BARANOWSKY: Well, I'm sure you'll get

1 me in trouble, but okay.

2 MR. ROSEN: I'm trying to get you in  
3 trouble.

4 CHAIRMAN APOSTOLAKIS: Because you don't  
5 get into trouble on your own.

6 MR. ROSEN: I want to get you into trouble  
7 and then out of it as a hero.

8 MR. BARANOWSKY: All right.

9 MR. ROSEN: All right. One more. On your  
10 slide 18, this was on integrated initiating event  
11 indicated development, you talked about rolling up the  
12 indicators and collect communications to Congress and  
13 other stakeholders. It seems to me that you've gone  
14 a long way to make some very important integrations of  
15 this information. This is just for initiating events,  
16 right?

17 MR. BARANOWSKY: Um-hum.

18 MR. ROSEN: But, at least, it says from a  
19 perspective of the industry and over time now as you  
20 trend this stuff you're going to be able to say  
21 whether this really is meaningfully going up or down.  
22 I think that's a very big value of it. In other  
23 words, it doesn't say how well the events were handled  
24 but it says whether they are occurring or not.

25 I think you can say over time that it has

1 a lot to do with how well the industry is maintaining  
2 the plants and other things like grid reliability.  
3 It's a very important statistic to be watching over  
4 time now. It becomes valuable because of the things  
5 you've done with thinking about risk. For example, as  
6 you've quantified, don't just add numbers and send  
7 them to Congress.

8 My God, what could be worse than handing  
9 those guys loaded guns. They could shot them any  
10 place. They could shoot themselves with it. I think  
11 it's a very valuable thing and over time I think it  
12 could become even more valuable as long as we trend it  
13 properly and draw appropriate risk-based conclusions,  
14 risk-informed conclusions. Thank you.

15 CHAIRMAN APOSTOLAKIS: Any other comments  
16 by any members? You want to make any comments?

17 MR. BARANOWSKY: No, but we appreciate the  
18 briefing.

19 CHAIRMAN APOSTOLAKIS: Thank you very much  
20 for coming. This has been excellent as usual.  
21 Appreciate it. Thank you.

22 Okay. We will recess until 12:30.

23 (Whereupon, at 11:32 a.m. off the record  
24 for lunch to reconvene at 12:30 p.m.)

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12:34 p.m.

CHAIRMAN APOSTOLAKIS: The next item is  
Planned Activities in Development of PRA Methods and  
Standards. Mark Cunningham will open it up.

MR. CUNNINGHAM: Yes, sir. Thank you. We  
have four speakers this afternoon in addition to  
myself.

CHAIRMAN APOSTOLAKIS: We have to finish  
by 2:30.

MR. CUNNINGHAM: No problem.

CHAIRMAN APOSTOLAKIS: If you don't  
finish, we're gone.

MR. CUNNINGHAM: We'll be done by 2:30.  
We're talking in the broad category of things about  
SAPHIRE peer review. We've talked in the past about  
two aspects of it. One is how do you review and try  
to improve the basic models that are in PRAs that show  
up in codes like SAPHIRE.

Then there is also how do we test the

1 code, if you will, itself to ensure that it's  
2 representing the models correctly and that sort of  
3 thing. You'll hear a little bit about both this  
4 afternoon. Our friends from the University of  
5 Maryland are here, Dr. Modarres and Dr. Mosleh, and  
6 they will be talking about improvements and how we  
7 model things in PRAs.

8           Following them we'll have a brief  
9 discussion on the work we're doing in fire risk  
10 analysis from J. S. Hyslop of the staff. That's one  
11 slide, I believe. Then we'll talk some more about the  
12 technical review, the DMB review of SAPHIRE. And  
13 we'll talk a bit about what we're doing in low-power  
14 and shut-down risk analysis. Both of those could be  
15 very short if we are pressed for time.

16           CHAIRMAN APOSTOLAKIS: Geez, are you going  
17 to go through all of these?

18           MR. CUNNINGHAM: No.

19           MR. ROSEN: But look at the subject,  
20 George. This is what you've been bugging us about.

21           CHAIRMAN APOSTOLAKIS: Not on a Friday  
22 afternoon. Not on Friday afternoon.

23           MR. ROSEN: Now they deliver it and you're  
24 in a hurry.

25           MR. CUNNINGHAM: Is every other slide a

1 good move?

2 CHAIRMAN APOSTOLAKIS: Yeah, every other  
3 slide would be good.

4 DR. MOSLEH: I should probably start with  
5 some introduction.

6 CHAIRMAN APOSTOLAKIS: Sure. Tell us who  
7 you are first of all for the record.

8 DR. MOSLEH: I am Ali Mosleh. I'm the  
9 Professor of the University of Maryland in Reliability  
10 Engineering. We have had a number of research  
11 projects with the Office of Research in the general  
12 area of uncertainty and various applications. We were  
13 informed of the desire to have a presentation on some  
14 of our work and progress.

15 It was short notice, Wednesday morning, so  
16 we tried to put together something that is  
17 representative of what we have done and what we are  
18 currently working on. About four separate topics  
19 under the broad topic of uncertainty treatment and we  
20 will try to cover as much of those and as many of the  
21 details as possible.

22 In fact, if it is preferred, we can take  
23 one of the several topics and spend more time on it.  
24 These are the topics that we have plans for  
25 presentation. These are a subset of several topics

1 under the topic of uncertainty. The first one was a  
2 project that we had like about four years ago or five  
3 years ago. It was kind of a two-year project under  
4 the collaborative agreement that we have between NRC  
5 and CTRS, Center for Technology Risk Studies.

6 The second one is topics that we have  
7 addressed and those that are kind of subject of  
8 ongoing research. I'm here with my colleague  
9 Professor Mohammad Modarres. We are kind of the co-  
10 project principal investigators in this activity. And  
11 one of our graduate students Mr. Paul Copahanna.

12 I plan to start with the first topic, the  
13 integrated model and parameter uncertainty with the  
14 stated objectives of developing a conceptual unified  
15 framework and methodology for treating model  
16 uncertainty, model and parameter uncertainty.

17 To provide guidance for practical  
18 applications. That was kind of a key requirement.  
19 And apply the method and techniques to representative  
20 cases from fire risk models. Later we extend that and  
21 expand that to other applications including thermal-  
22 hydraulic model uncertainty.

23 The results can be summarized in this  
24 viewgraph where we develop the Bayesian framework for  
25 treating model uncertainty in which the Bayesian

1 framework treats model as a source of evidence and  
2 information concerning the unknown of interest.

3 Demonstrated that many popular methods  
4 such as model averaging can be demonstrated to be a  
5 special case of the general Bayesian framework so as  
6 a general framework that's a good property to look  
7 for.

8 Formulated solutions for several important  
9 classes of model uncertainty problems encountered in  
10 PRA, namely the types of evidence that we have the  
11 types of models which we try to address a good subset  
12 of those in terms of developing methods and algorithms  
13 within the general Bayesian framework. And  
14 demonstrated that the method, you know, could be  
15 applied in two cases involving fire models.

16 One case was COMBRN model uncertainty,  
17 kind of a remake and reassessment of the work that was  
18 done several years back using a variation of the same  
19 general principles. Another one is the line fire  
20 temperature model uncertainty in two applications  
21 within the fire risk discipline.

22 What we mean by model uncertainty,  
23 essentially we're talking about capturing the  
24 difference between reality and model that we develop  
25 for various applications. That delta, which is the

1 difference between reality and M meaning the model  
2 representation of that reality, whatever the source of  
3 that delta or that difference might be we try to  
4 capture that in our model uncertainty framework.

5 We view models as at least having these  
6 key components. They rely on certain input from  
7 reflecting characteristics of the environment and  
8 other parts of the boiler system. They provide an  
9 output function or product. In the middle you have a  
10 model that is based on some concept, the conceptual  
11 design and implementation.

12 Both of these could result in uncertainty.  
13 Certainly uncertainty in the input. Certainly  
14 uncertainty in conceptually capturing aspects of  
15 reality and how you formulate that model implemented  
16 in whatever language, numerical methods or analytical  
17 equations and the like, that all these could be  
18 subject or sources of uncertainty.

19 We tried to clarify a kind of subject or  
20 terms that people have used in this context, form  
21 versus parameter. We realize that parameter and form  
22 distinction is kind of arbitrary and it's a context  
23 and level of tecal dependent. For instance, something  
24 that at one level is a parameter is a structured  
25 element of a model.

1                   In this case you're looking at a gradual  
2 degradation or elaboration of a conceptual model for  
3 heat release rate recognized as a function of time.  
4 Then when you go down to kind of the next level you  
5 have two structural kind of models. One is linear and  
6 the other one is exponential. In each of these two  
7 models you have a set of parameters.

8                   Now, the moment you specify these  
9 parameters they become structure properties of them  
10 all. In the left-hand side if alpha is one it's a  
11 linear model. If alpha is two, it becomes a nonlinear  
12 model. There is no solid line between parameter and  
13 model and that is something that one needs to be  
14 careful when we talk about model uncertainty  
15 propagation and parameter uncertainty propagation.

16                   MR. ROSEN: Let me complain at the outset  
17 and maybe Mike and you can fix it. When you put six  
18 of these on one slide -- on one page, as you have, I  
19 can't read them.

20                   DR. MOSLEH: It's useless. I agree.

21                   MR. ROSEN: Would you see if you can't get  
22 them two on a page so I can read the terminology?

23                   MR. WOODS: This is Roy Woods. I'm sorry.  
24 I did that. I got those about a half hour ago and I  
25 thought you would probably complain if I killed a tree

1 with all these slides so I did it that way.

2 MR. ROSEN: If you could get them two on  
3 a page, I could at least study them later.

4 MR. SHACK: Or send us a pdf file.

5 MR. WOODS: I can do that, too.

6 DR. MOSLEH: These are available in  
7 electronic format. One of the points is that  
8 effectively a case of successful treatment of model  
9 uncertainty is a case where you can state with  
10 certainty if you have confidence that you think the  
11 true value falls in the range that you expressed.

12 Obviously we know from history of science  
13 and engineering that a lot of cases non-negligible  
14 probability that the true value would fall outside the  
15 models that you use to make a prediction.

16 This is kind of represented in this  
17 picture where we have -- the question here is which  
18 question here are we trying to answer? The first  
19 question, the ideal case, is the case where you have  
20 the true value captured within the uncertainty range,  
21 the best representation.

22 The other case is something that is a  
23 little more practically achievable, although falls  
24 short of addressing the fundamental question in the  
25 broadest possible sense, and that is what can I say

1 about the unknown of interest if I have input and  
2 information from various models so unknown interest  
3 being X and there's no guarantee that obviously the  
4 true value would fall within range and there needs to  
5 be some modification and correction in this second  
6 representation on the lower right to bring it back to  
7 the types of representation that we have on the upper  
8 left.

9 We took in the first round at this and at  
10 the point we closed this project under the NRC  
11 collaborative agreement we addressed the lower right.  
12 We said what can we say about the unknown interest  
13 given IM and IM being information from models and  
14 information about models.

15 If you state the problem this way,  
16 remember one of the issues we wanted to wrestle is  
17 there a framework, a rational, logical framework for  
18 addressing the question of model uncertainty. The  
19 moment you phrase the question this way, in other  
20 words, what can you say about the unknown X given IM  
21 information from and about model.

22 Then based here is really the natural  
23 choice as a framework because exactly mathematically  
24 based theorem tries to answer that question. Given a  
25 piece of information what can you say about the

1 unknown of interest.

2 This is a familiar equation form to the  
3 Committee. Again, symbolically we have a posterior  
4 distribution given the information from the  
5 singular model.

6 CHAIRMAN APOSTOLAKIS: There are a lot of  
7 slides. Can you skip the mathematical details?

8 DR. MOSLEH: Sure. Okay. I think maybe  
9 --

10 CHAIRMAN APOSTOLAKIS: Maybe an example or  
11 something.

12 DR. MOSLEH: Yes. The key step we took  
13 is, of course, in the base theorem the key question we  
14 need to address is the construction of the likelihood  
15 function fundamentally. One of the first steps we  
16 took was the information on models would go into the  
17 structure of the likelihood function. Information  
18 about models from models will go as a condition just  
19 as given a piece inside the likelihood function. This  
20 is how we capture both types of information.

21 In constructing the likelihood function in  
22 terms of capturing information about models, we use a  
23 parametric representation. In other words, you  
24 structure the likelihood function in such a way that  
25 the parameters of the likelihood would represent

1 information about the models of interest.

2 CHAIRMAN APOSTOLAKIS: The fundamental  
3 issue here is really -- I don't know how familiar the  
4 members are with the likelihood function but the  
5 likelihood function is essentially the probability  
6 that if you knew the true answer, the model would be  
7 closed in qualitative terms which is really a judgment  
8 about how good the model is.

9 In other words, if you had infinite  
10 confidence in the model, it would be a dental  
11 function. If you know the true value, then it gives  
12 you the true value. When you start having doubts  
13 about the model, then you have a distribution.

14 You know, if the true value is here,  
15 there's a probability that the model will give me  
16 something over there. This is where you have to  
17 evaluate the credibility of the model predictions.  
18 How are you doing that? I mean, in qualitative terms.  
19 What inputs do you use?

20 DR. MOSLEH: I have a couple of examples.  
21 For instance, here on the second bullet, information  
22 about models, performance data is a piece of evidence  
23 like you have experimental measures and then  
24 prediction of the model. Assessment, this is now a  
25 qualitative or quantitative judgment, subjective

1 judgment about quality and applicability of the model.

2 Not only the quality or credibility of the  
3 model within its domain application as it was intended  
4 and designed for, but also sometimes you use models in  
5 other domains of applications so applicability is  
6 another question.

7 Taking this information from model and  
8 this combination of performance data or other  
9 subjective assessment about the quality of the model  
10 would be the two pieces of information that would go  
11 into the likelihood function, the second going into  
12 parameters you define to capture this type of  
13 information.

14 So, for instance, in the case of when you  
15 have performance data, a set of numbers from  
16 experiment, that's E1 through En measurements, then  
17 you can use a simple error, model which we have used  
18 in other applications such as expert opinion modeling,  
19 to basically relate the prediction of the model and  
20 the actual data.

21 CHAIRMAN APOSTOLAKIS: But this is where  
22 your judgment comes into the picture, right?

23 DR. MOSLEH: Right. Including the choice  
24 of the error model.

25 CHAIRMAN APOSTOLAKIS: Have you developed

1 any guidance as to how I'm going to do that? I mean,  
2 the formulation is fine, and it's the right  
3 formulation, of course, but when it comes to saying  
4 something, let's say, I have one model and somehow I  
5 have to decide how credible the results are. You have  
6 an example, I think. Maybe you can speak in terms of  
7 an example because we don't have much time.

8 DR. MOSLEH: Here is a case where you have  
9 data so I think the question of using data to see how  
10 good the model has performed with respect to the data  
11 is a simpler problem. You have the actual data to  
12 tell you the magnitude of error. For that you use the  
13 error model.

14 CHAIRMAN APOSTOLAKIS: Let's look at this.

15 DR. MOSLEH: I think another one is better  
16 because this one talks about use of data, performance  
17 data. Here is a case where we have a prediction of  
18 point source model, fire models. Then we are dealing  
19 with the line fire like the cable along the length as  
20 a fire. If you are using a code designed for one  
21 application, how do you now take it for a different  
22 application.

23 Here we are assessing applicability which  
24 is now reduced into one parameter, one number between  
25 zero and one. That number would be used to adjust the

1 likelihood function. You can raise the likelihood  
2 function to a number between zero and one and you  
3 would change that number.

4 The strength of the likelihood function,  
5 therefore, data representation of your confidence in  
6 your model would change going from a flat distribution  
7 to fully, as Dr. Apostolakis mentioned, delta function  
8 that represents the full confidence in a model.

9 Now, who do you estimate such quantities  
10 in a number, a credibility factor, or applicability  
11 factor? We use a simple method of decomposition of  
12 attributes of a model. You have a context alpha. The  
13 model is designed for context alpha and you are using  
14 it for context beta.

15 You list the attributes within context  
16 alpha that are important in context alpha and you list  
17 the attributes, the physical models, the aspects of  
18 the physical process, for instance, that you need to  
19 address, and a number of other things that go deeply  
20 inside the specifics of the model.

21 So you list those and you go through this  
22 comparison of what I have in context A and the way  
23 that the model is treating those. To what extent in  
24 that particular case, say in the case of attribute E  
25 how well is it addressing the question. Do I need,

1 for instance, to introduce a bias term. Do I need to  
2 introduce like take it totally as being applicable.

3 Do I need broaden my uncertainty range  
4 because this thing would give the answer but with kind  
5 of a bigger error. That kind of a one-to-one  
6 assessment is the method we use to take a comparison  
7 between the two context and the model attributes  
8 within the two context, and reduce them to a single  
9 number. We use something like AHP in that area.  
10 That's analytic hierarchy type process.

11 At the end you get a number that is an  
12 overall qualitative assessment of applicability of a  
13 model alpha to context beta.

14 CHAIRMAN APOSTOLAKIS: So essentially you  
15 are structuring the judgment process.

16 DR. MOSLEH: Exactly. Right. In the area  
17 of confidence in the model in its context, also  
18 context alpha, we use the same type of approach. Here  
19 is the specific case that you work with an expert in  
20 the fire phenomenology looking at the point source  
21 fire model and a line fire model and looked at  
22 different attributed in the terms of geometry,  
23 ventilation, fire characteristics, plume  
24 characteristics, and the attributes of each of these  
25 categories.

1                   They will judge one by one once. Then at  
2 the end the expert, in this case there were two  
3 experts, collectively look at the number that was just  
4 a single number as a result of this process, and  
5 essentially to converge to kind of one number to be  
6 used.

7                   CHAIRMAN APOSTOLAKIS: In this particular  
8 case, though, wouldn't you make also a point -- I  
9 mean, it is a model uncertainty issue but you are  
10 really trying to take a model that was developed for  
11 one physical situation applied to another from a point  
12 source to a line source. The question is why don't  
13 you go straight and develop a line source model.

14                   Do you have any examples where for the  
15 same physical situation there were more than one  
16 models? In other words, people have made different  
17 assumptions. Like in the human reliability you are  
18 familiar with the benchmark exercise. Have you dealt  
19 with any problems like that?

20                   DR. MOSLEH: Not in a real application in  
21 the example I can give you. There is another project  
22 that we have and and that's the software reliability  
23 where you use the exact same thing but on multiple  
24 models.

25                   The process of judging -- according to the

1 procedure that we've been following in every case  
2 there are judgments in terms of comparing models in  
3 terms of their relative strength and weaknesses. We  
4 look at the structure and the details of the model.  
5 But we have not made an attempt in terms of covering  
6 the unknown or nonexistent model. In other words, the  
7 issue of completeness.

8 CHAIRMAN APOSTOLAKIS: But you have dealt  
9 with a situation where I can say six models attempting  
10 to do the same thing but they are using different  
11 assumptions and different methods. Again, it's a  
12 matter of structuring the judgment process that will  
13 tell you eventually I believe the model is biased or  
14 I believe this and that.

15 DR. MOSLEH: Precisely.

16 CHAIRMAN APOSTOLAKIS: I mean, there is  
17 no -- ultimately you have to rely on experts.  
18 Anything else you want to tell us?

19 DR. MOSLEH: That's basically -- I wanted  
20 to say --

21 CHAIRMAN APOSTOLAKIS: The thermal  
22 hydraulic uncertainties, you want to do that?

23 DR. MOSLEH: If I may add one point in  
24 terms of limitations of this thing, this methodology  
25 has focused on model output and if it's a model output

1 methodology. When you deal with more complex systems  
2 such as thermal hydraulic models and you need to  
3 really go inside and then construct model uncertainty  
4 from looking at model uncertainty with these submodels  
5 you need to do a lot more obviously.

6 That's the type of thing that we're  
7 dealing with in the model uncertainty application to  
8 thermal hydraulics. Dealing with complex situations  
9 where you have --

10 CHAIRMAN APOSTOLAKIS: I remember in the  
11 PTS a couple of years ago it was either you or  
12 Mohammad who told us that the various boxes there in  
13 the big diagram there is model uncertainty and had to  
14 do with materials.

15 DR. MOSLEH: Yes.

16 CHAIRMAN APOSTOLAKIS: Have you done that?

17 DR. MOSLEH: Yes.

18 CHAIRMAN APOSTOLAKIS: Okay. So you're  
19 going to talk about it?

20 DR. MOSLEH: After I'm done, Mohammad  
21 will. I do need to leave about 10 minutes before 2:00  
22 for a conference and then I think you have until 2:30  
23 to cover that material.

24 I need to go back to the other  
25 presentation. This is -- I have two presentations on

1 thermal hydraulic uncertainty. One is the work we did  
2 under the PTS risk assessment. The other one is a  
3 more general uncertainty for thermal hydraulic codes.  
4 I make a few comments on this one and then try to  
5 focus on the other one in the interest of time.

6 In this case we were in the middle of many  
7 activities and disciplines. As you can see, there was  
8 a PRA event sequence analysis, thermal hydraulic  
9 analysis, and PFM analysis. Initially we started just  
10 focusing on thermal hydraulic and uncertainty analysis  
11 and immediately realized that it's just almost  
12 impossible. In the middle of an integrated assessment  
13 you have to be involved pretty much in all --

14 MR. ROSEN: Not impossible. It's not  
15 irrelevant.

16 DR. MOSLEH: Yes.

17 MR. ROSEN: What would be the good of  
18 doing a good thermal hydraulic analysis and  
19 uncertainty analysis in the midst of a sea of other  
20 uncertainties that are unquantified?

21 DR. MOSLEH: You have to really look at  
22 the context you're doing the uncertainty.

23 MR. ROSEN: You've got to do the whole  
24 thing if you're going to do it at all.

25 DR. MOSLEH: Yes. We should have known

1 that maybe by taking two minutes but we jumped in  
2 thinking it was going to be a small task but we ended  
3 up being involved pretty much in all the activities of  
4 PTS just to address the uncertainty.

5 So there were kind of genetic lessons that  
6 we drew from this experience and became kind of the  
7 motive for another task or activity to see if you are  
8 addressing a complex technical assessment how do you  
9 address the uncertainties, what would be the  
10 procedures, techniques, and tools. That's kind of a  
11 more recent activity.

12 In this project some of the things that we  
13 had to address obviously other than -- you know, we  
14 have an overall process to follow. Namely, you have  
15 uncertainties from the PRA side event sequences in  
16 terms of frequencies. You go through a process of  
17 reduction in terms of the number of sequences that you  
18 want to carry, grouping and classifying.

19 You have to wrestle with the limits and  
20 the number of RELAP runs you could run. Then  
21 ultimately you have interface constraints. In other  
22 words, the PFM analysis code would take an input in a  
23 particular format of representation. These establish  
24 certain constraints over what we could do.

25 . MR. ROSEN: Would you go click on the

1 model so we can expand this?

2 DR. MOSLEH: Yes. So there is this  
3 discipline, this discipline, the connection, and then  
4 we have to do through the binning and representation  
5 of the uncertainty of the three key parameters, many  
6 of those, and the PFM analysis. But the point that I  
7 wanted to make is that in context when you do  
8 uncertainty analysis you have now additional concerns  
9 that are imposed on you and that changes the nature of  
10 the methodology or tools that apply.

11 In this case we have to almost kind of  
12 completely rely on a diskatized version of the  
13 universe by treating uncertainties in bins, in groups,  
14 in categories and go through the systematic and force  
15 reduction of number. A 100 or 200 thermal hydraulic  
16 runs reduce to 50 or so runs that would go ultimately  
17 to PFM analysis. The runs were supposed to represent  
18 the range of uncertainty that you have for each of the  
19 groups or categories, namely the ones in the middle  
20 right here. Three curves per set of --

21 CHAIRMAN APOSTOLAKIS: The age of  
22 uncertainty, the aleatory uncertain so now you have --

23 DR. MOSLEH: This is a one scenario class  
24 and then you're talking about epistemic uncertainty.

25 CHAIRMAN APOSTOLAKIS: You had 50 runs for

1 one scenario and these 50 are presented different from  
2 the measures of the parameters that appear in the  
3 scenario.

4 DR. MOSLEH: Yes.

5 CHAIRMAN APOSTOLAKIS: Another scenario  
6 you had another 50.

7 DR. MOSLEH: That's right, 50  
8 combinations. The lines that you see represent the  
9 epistemic uncertainty of the parameters in an  
10 interesting way. Then when I go to the other one, I  
11 will comment on this because this is something that is  
12 a common mistake on many people who are doing thermal  
13 hydraulic uncertainty and maybe physical phenomenon.

14 CHAIRMAN APOSTOLAKIS: Okay. So this is  
15 making mistakes?

16 DR. MOSLEH: It's not the thermal  
17 hydraulic expert who makes the mistake but those who  
18 try to do uncertainty.

19 CHAIRMAN APOSTOLAKIS: That was a very  
20 good way of getting out of it, Ali. Have you seen any  
21 numbers from the PFM analysis that are higher than  
22  $10^{-8}$ ?

23 DR. MOSLEH: Oh, yes.

24 CHAIRMAN APOSTOLAKIS: They are capable of  
25 doing this?

1 DR. MOSLEH: Absolutely, after a lot of  
2 complaints.

3 CHAIRMAN APOSTOLAKIS: I have yet to see  
4 a PFM calculation that is more than  $10^{-6}$ .

5 MR. SHACK: I have.

6 CHAIRMAN APOSTOLAKIS: You have?

7 MR. SHACK: Oh, yeah. I can pop nozzles  
8 off the SRDM housings.

9 CHAIRMAN APOSTOLAKIS: I have never seen  
10 that. I would like to see that just as a new  
11 experience in life.

12 Okay. Go ahead.

13 DR. MOSLEH: So in this process given the  
14 constraints obviously one thing that really these  
15 constraints or context really helped us is that  
16 sometime the boundary condition uncertainties were  
17 dominant so you change the boundaries that were kind  
18 of well defined physical --

19 CHAIRMAN APOSTOLAKIS: What do you mean  
20 boundary conditions?

21 DR. MOSLEH: Such as the temperature and  
22 the season. Seasonal change in the temperature as a  
23 boundary condition. Then it was the judgment of the  
24 RELAP and the thermal hydraulic experts that some of  
25 the uncertainties and the actual code calculations

1 were much smaller in those cases compared to the  
2 variation in input parameters. That helped us kind of  
3 escape and skip some of the more difficult TH  
4 uncertainty issues we were not kind of equipped or  
5 prepared or had the time to address in that project.

6 MR. SHACK: You're not addressing the  
7 uncertainties in RELAP itself.

8 DR. MOSLEH: That's right, yeah. It's the  
9 uncertainty in the boundary conditions or the way of  
10 developing the boundary conditions that the aleatory  
11 part now takes over.

12 CHAIRMAN APOSTOLAKIS: Some of the  
13 boundary conditions are aleatory, right?

14 DR. MOSLEH: They are, mostly.

15 CHAIRMAN APOSTOLAKIS: Oh, mostly.

16 DR. MOSLEH: The ones that don't vary.  
17 Not all.

18 MR. SHACK: Aren't they really epistemic?  
19 I mean, if you knew when the event was going to take  
20 place at the time of year --

21 CHAIRMAN APOSTOLAKIS: Then you would  
22 know.

23 MR. SHACK: -- then you would know.

24 MR. ROSEN: If we knew when the event was  
25 going to take place, we would know a lot more about it

1 and we would make sure the event didn't occur.

2 DR. MOSLEH: On philosophical grounds  
3 there's only one type of uncertainty. They are all  
4 epistemic, right? But, you know, in terms of how much  
5 control we have on those, we have a line that puts  
6 some of them in the aleatory domain and other in the  
7 epistemic but it's an arbitrary line depending on  
8 analysis resources and knowledge.

9 CHAIRMAN APOSTOLAKIS: It's not arbitrary.  
10 It's convenient.

11

12 DR. MOSLEH: It's convenient.

13 CHAIRMAN APOSTOLAKIS: It's not arbitrary.  
14 People are not doing it capriciously.

15 DR. MOSLEH: No.

16 CHAIRMAN APOSTOLAKIS: That's a nice word.

17 DR. MOSLEH: I think in a sense the  
18 philosophers would say, "Look, this is a minor point.  
19 If you want to draw the line here and there, you need  
20 certain criteria but fundamentally it's the same  
21 uncertainty. Uncertainty is uncertainty.

22 CHAIRMAN APOSTOLAKIS: So when you say  
23 RELAP model uncertainty there, what do you mean?

24 DR. MOSLEH: Meaning you have two  
25 submodels that you kind of invoke one versus another

1 or two numerical conversation criteria. When you  
2 invoke one versus another you get a difference in the  
3 results.

4 CHAIRMAN APOSTOLAKIS: Didn't you just  
5 answer that the uncertainty RELAP itself is not --

6 DR. MOSLEH: In those cases we didn't need  
7 to address the RELAP uncertainty that we uncovered.

8 MR. SHACK: If I only know the temperature  
9 within plus or minus 70 degrees but I don't know what  
10 time of year it is, it doesn't matter that when I  
11 specify the temperature exactly RELAP has an  
12 uncertainty in the calculation because I get such a  
13 wide variation because I don't know the --

14 CHAIRMAN APOSTOLAKIS: But that presumes  
15 that they have some idea what the RELAP uncertainty  
16 is.

17 MR. SHACK: Yes. It is an implicit  
18 assumption.

19 CHAIRMAN APOSTOLAKIS: And you know that.

20 MR. SHACK: Yeah.

21 DR. MOSLEH: These were looked at case by  
22 case and examined in context, specifically what case  
23 you're talking and what sources of uncertainty in  
24 RELAP exist, whether those are covered or not. So  
25 it's not a general statement or generic statement.

1 That was something that helped us again doing  
2 analysis.

3 CHAIRMAN APOSTOLAKIS: Let me understand  
4 this. How did you find out that the boundary  
5 condition had such an impact? Somebody told you or  
6 you found out?

7 DR. MOSLEH: No, we would run. We would  
8 actually run the cases.

9 CHAIRMAN APOSTOLAKIS: So you filed  
10 through simulations?

11 DR. MOSLEH: Absolutely. In order to zoom  
12 in on important parameters, the numbers that we need  
13 to run, we ran about 1,000 RELAP cases to kind of get  
14 a feel for it.

15 CHAIRMAN APOSTOLAKIS: But one could  
16 conceivably have a formal sensitivity analysis to  
17 guide you.

18 DR. MOSLEH: Yes.

19 CHAIRMAN APOSTOLAKIS: This is important  
20 by the way, Mark, to the regulatory guide that you  
21 guys are thinking of developing now in sensitivity and  
22 uncertainty.

23 MR. CUNNINGHAM: Certainly.

24 CHAIRMAN APOSTOLAKIS: It would be nice to  
25 have a method that guides you to do the sensitivity

1 analyses that will uncover cases like that rather than  
2 relying on the expertise of the analyst who bury  
3 things. I think that is one of the most important  
4 things.

5 DR. MOSLEH: I think I agree in the sense  
6 that the way we have to kind of develop our own  
7 procedure because how many and which particles we  
8 change and then modify so we develop kind of an  
9 internal set of guidelines to help us minimize the  
10 number of runs we have to make until we get the  
11 insights that we need.

12 CHAIRMAN APOSTOLAKIS: Very good.

13  
14 DR. MOSLEH: Some of those were summarized  
15 and shared with ACRS before in the PTS presentation  
16 but also some of them are here. Here is a quick list  
17 of uncertainty sources that we looked at and tried to  
18 address. This is the entire process of uncertainty  
19 propagation from the PRA side all the way to the input  
20 to the PFM fracture mechanics code input.

21 Model uncertainty, of course, sequence  
22 modeling and grouping and mapping those thermal  
23 hydraulic runs is a source of uncertainty. The way we  
24 treated them sometimes by recognizing that we needed  
25 to add more details or further rebin things to address

1 things properly. In some cases they were not treated  
2 because they were judged to be small.

3 MR. SHACK: You mean, you did the  
4 rebinning basically to reduce your uncertainty, right?  
5 If you left the bins the original way you would have  
6 just been left with huge uncertainty bands.

7 DR. MOSLEH: To reduce the uncertainties  
8 like binning is uncertainty management in a way. Some  
9 of it was dictated not by a desire to reduce or manage  
10 uncertainty but just basically input/output  
11 requirement from the parts of the analysis, from the  
12 PRA side all the way to PFM.

13 For instance, in the PFM we have to  
14 produce 30 sets of uncertainty curves, 30 times 3, 90  
15 inputs to the code. We have to kind of compress  
16 things into fewer bins defined by that requirement.

17 So one is how you structure the model in  
18 terms of its interface with the rest of the model.  
19 The other aspect of uncertainty we tried to capture  
20 obviously was use of the TH code itself, internal  
21 model uncertainties, and input model uncertainties.  
22 Then the caliber of parameter uncertainty --

23 CHAIRMAN APOSTOLAKIS: Aren't the input  
24 parameter -- input uncertainties parameter  
25 uncertainties?

1 DR. MOSLEH: By input deck preparation is  
2 the structure aspect of it. You know, nodalization,  
3 how many nodes do you use.

4 CHAIRMAN APOSTOLAKIS: Oh. Did you find  
5 the parameter uncertainty was not important?

6 DR. MOSLEH: I can't say that because  
7 actually we have aleatory uncertainties. We also call  
8 them parameters of the model such as temperature  
9 variations or state of components, degradation and all  
10 that. We really didn't do the separation.

11 CHAIRMAN APOSTOLAKIS: In PRAs there's a  
12 growing belief that the so-called parameter insurance  
13 which is failure rates and initiating figures. I  
14 really found that useful because the results of the  
15 PRA are not affected.

16 MR. ROSEN: Just in the PRAs but, of  
17 course, this was bigger. We had talked about physical  
18 phenomena and parameter uncertainties can be very  
19 large.

20 CHAIRMAN APOSTOLAKIS: But even in the  
21 PRAs when we say parameter uncertainty, we really mean  
22 initiating event frequency and failure rate.

23 MR. SHACK: We end up treating everything  
24 as a parameter uncertainty.

25 CHAIRMAN APOSTOLAKIS: Eventually

1 everything is a parameter uncertainty.

2 MR. SHACK: In the context that you're  
3 meaning parameters.

4 CHAIRMAN APOSTOLAKIS: Yes. So we have to  
5 be careful.

6 MR. ROSEN: You used a lot of crackgos in  
7 your stuff and it can never be small.

8 CHAIRMAN APOSTOLAKIS: Well, you can  
9 always model the acceptance rate for potential  
10 parameters. Then those parameters are important.

11 Okay. Great. Let's keep going.

12 DR. MOSLEH: Certainly I believe --

13 CHAIRMAN APOSTOLAKIS: So your message  
14 here is there isn't one thing that can be called model  
15 uncertainty. Depending on the problem there are lots  
16 of things --

17 DR. MOSLEH: It's very context dependent.  
18 There are certain principles that you can share that  
19 draw from these things and then share and develop as  
20 kind of a procedural method. In application it's very  
21 context dependent in terms of even, you know,  
22 obviously the types of tools that you use, the  
23 attention you pay to one aspect versus another.

24 In the fire case the focus was on, for  
25 instance, the relevance of the data to the application

1 so there's a lot of detailed statistical modeling. In  
2 this case a lot of decisions is about the quality, the  
3 interface, the logic model.

4 CHAIRMAN APOSTOLAKIS: If we want to  
5 sensitize people in general without referring to  
6 specific context, to sensitize people to the issue of  
7 model uncertainty as opposed to parameter uncertainty,  
8 first of all, we have to make sure we understand what  
9 parameter uncertainty means because, as we just said,  
10 there are certain instances where that's important.

11 I guess what people tend to ignore is, for  
12 example, the possibility that you may use more than  
13 one model to model the same thing. The possibility  
14 that certain things that you are doing like the nodal  
15 skin themselves introduce uncertainty so we will have  
16 to sensitize them to that.

17 I don't know, there are things that you  
18 mentioned like formal inputs and so on, things that  
19 are not obvious, in other words, but I doubt there is  
20 a generic approach to these things. I mean, there is  
21 a philosophical approach but --

22 DR. MOSLEH: I think -- I'm sorry?

23 CHAIRMAN APOSTOLAKIS: Mathematical  
24 approach?

25 DR. MOSLEH: No, not mathematical. That's

1 why I mentioned the fact that the statistical  
2 procedure is insufficient in terms of the full  
3 spectrum of issues that you need to deal with in model  
4 uncertainty.

5 But in the other areas as well, I think  
6 there are common characteristics that you can kind of  
7 abstract out of these various experiments and  
8 exercises and applications that is quite promising.  
9 For instance, I mentioned, I think -- let me see.  
10 This is a case where we have to generate three curves  
11 and the meaning of these curves.

12 There are three actual traces of thermal  
13 hydraulic power which is pressure and temperature.  
14 Each has an assigned probability that is the result of  
15 our binning, reduction, and probability manipulation,  
16 parameter, and propagation of uncertainty.

17 The reason that this particular  
18 representation had to be the way it is is not only  
19 because of the input requirements for another part of  
20 the analysis required this type of thing, but also it  
21 goes back to a fundamental question that if you have  
22 a physical coat that generates results on behavior of  
23 the physical system in time. You change the input  
24 parameters or the model parameters and all that and  
25 you get a spaghetti of results.

1 CHAIRMAN APOSTOLAKIS: Explain what these  
2 curves are.

3 DR. MOSLEH: Say that this one is the  
4 downcomer temperature as a function of time and then  
5 you have three curves that are, say, in this case this  
6 one is the result of a RELAP run for a specific  
7 combination of parameter values, input values. The  
8 red one is also for another one and the green.

9 These were selected as representatives of  
10 many, many combinations that you get out of varying  
11 the parameters which on the left-hand side you see a  
12 density function and when you vary 11 parameters, each  
13 would require a thermal hydraulic RELAP run.

14 You get many, many results, of course,  
15 1,000 combinations, and we have to select three out of  
16 these to represent the whole spectrum. And for each  
17 of these combinations we'll have probability -- out of  
18 900 combinations you have the probability that add up  
19 to one so you're talking about the density function.

20 You kind of collapse these into three --  
21 you go through kind of three possible combinations in  
22 terms of expected average temperature here and there.  
23 If I run a case that comes close to this area, that  
24 covers this range of probability like about 30  
25 percent. This is another 30 percent and another 30

1 percent.

2 All this range of output or thermal  
3 hydraulic cases are now going to be represented by  
4 just a single run carrying the probability of that  
5 range. It's a characterization of the spaghetti up of  
6 distributions, a continuum. At the end then you end  
7 up with these three curves each of which has maybe 30  
8 percent or 35 percent probability.

9 When you go to the PFM analysis, you take  
10 the green curve and the probability of that green  
11 curve is the probability of the initiating event that  
12 led to that thermal hydraulic condition multiplied by  
13 .35 which is the probability that --

14 MR. ROSEN: The events that class will  
15 have.

16 DR. MOSLEH: That class will have.

17 CHAIRMAN APOSTOLAKIS: So you have  
18 significant uncertainty there. I mean, if you look at  
19 5,000 seconds, you can go anywhere from 320 all the  
20 way to 470 on the left. Right?

21 DR. MOSLEH: Yeah.

22 CHAIRMAN APOSTOLAKIS: By the way, you  
23 said you would finish at 1:50. No, you have until  
24 2:30 because you have the SAPHIRE discussion.

25 MR. CUNNINGHAM: That's correct. We can

1 shorten that depending on what you would like to hear  
2 more of.

3 DR. MOSLEH: Tell me how much time I have.  
4 Ten minutes?

5 CHAIRMAN APOSTOLAKIS: I would say so.

6 DR. MOSLEH: Okay.

7 CHAIRMAN APOSTOLAKIS: Then Mohammad will  
8 need what?

9 DR. MODARRES: Ten or 15 minutes will do.

10 DR. MOSLEH: Maybe I go to the other  
11 presentation that is kind of the general thermal  
12 hydraulic uncertainty because there's a few things  
13 that I want to mention there.

14 Initially in the SAD there is observations  
15 from the PTS experiment or experience. Some of the  
16 generic lessons are there. These are important  
17 insights but we are working on those to see if we can  
18 get more of these lessons learned.

19 Treatment of uncertainties in complex TH  
20 codes. These are our objectives. We are currently  
21 working on these so it's a computational approach for  
22 propagation of uncertainty in the complex models and  
23 codes, identification of various sources of  
24 uncertainty, and methodology for characterizing and  
25 quantifying the uncertainties and the impact of those

1           uncertainties.

2                       Then hopefully at the end suggesting some  
3           says of modifying the code that it will be a layer  
4           over the typical TH code that would kind of guide it  
5           to do uncertainty.

6                       We looked at initially a number of  
7           methods, what GRS is doing, University of Pisa is  
8           doing, and a number of other known methods like at  
9           CSAU in terms of assessment and characterization of  
10          uncertainty. If you look at these methods, they look  
11          at one aspect or the other put none of them in a  
12          comprehensive way as in terms of our desired  
13          objectives. We are addressing a number of dimensions.

14                      For instance, one methodology focuses on  
15          the propagation of uncertainty using multi-color maps.  
16          Another approach tries to modify and adjust the final  
17          results of codes based on experimental data, test  
18          facility, and special effects to test the facility  
19          data to adjust and modify.

20                      But our objectives go beyond that. We  
21          want to have kind of a comprehensive coverage. The  
22          major steps of the methodology is evolving now and  
23          involved a number of -- combining some of the best  
24          features of various methods that they have seen and  
25          then some of the techniques that we are introducing

1 under a broader umbrella.

2 You can see the steps, identification of  
3 uncertainty, important phenomena models, something  
4 that PIRT could initially obviously help there;  
5 assessment of uncertainty, model and parameter,  
6 propagation and application.

7 In each case I think we have pretty much  
8 have a framework. In some cases we have decided and  
9 settled and tested the methodology and we know that it  
10 works.

11 CHAIRMAN APOSTOLAKIS: What is Wilks  
12 method?

13 DR. MOSLEH: It's a statistical method of  
14 kind of reducing the number of samples that you want  
15 to run a complex code with. As you can imagine, you  
16 have so many parameters and how many samples do you  
17 need to ensure certain coverage.

18 CHAIRMAN APOSTOLAKIS: So why not use  
19 latin pipes?

20 DR. MOSLEH: This, I am told by the  
21 experts including our student, that this is by far  
22 more efficient. It's really good if -- I mean, have  
23 you tested that?

24 CHAIRMAN APOSTOLAKIS: I think Graham's  
25 paper.

1 DR. MOSLEH: Yes.

2 CHAIRMAN APOSTOLAKIS: What did you see?

3 DR. MOSLEH: It was exchanged within Dr.  
4 Wallis and --

5 CHAIRMAN APOSTOLAKIS: Right, but now  
6 there is a new paper from Graham Wallis and William  
7 Knot.

8 MR. SHACK: Which hasn't appeared yet.

9 CHAIRMAN APOSTOLAKIS: No. That's why I  
10 was surprised.

11 DR. MOSLEH: Yeah.

12 MR. SHACK: The original exchange.

13 CHAIRMAN APOSTOLAKIS: Yeah, the original  
14 exchange.

15 DR. MOSLEH: I view this purely and  
16 strictly as kind of a statistical, numerical method.  
17 We found it, we tested it. GRS uses in their code  
18 uncertainty assessment and they are happy.

19 CHAIRMAN APOSTOLAKIS: Something is  
20 replacing latin hypertism.

21 DR. MOSLEH: In this case, yeah. There is  
22 a lot to be said obviously about the differences and  
23 merits and all that but all I can say at this point  
24 given the time is that it works based on the tests  
25 that we have done which have been the smallest test

1 and the largest test, namely testing with RELAP.

2 Here is an overview of the types of things  
3 that we are trying to adjust and how we adjust them.  
4 If we end with this viewgraph I'm happy because I can  
5 comment about a lot of the attributes and  
6 characteristics of the methodology we are developing.  
7 One is obviously we need to do --

8 CHAIRMAN APOSTOLAKIS: Where do you start  
9 in this figure, from the left?

10 DR. MOSLEH: Where do I start? I start  
11 with the biggest box here in the background. That  
12 kind of takes care of an obvious thing, that one needs  
13 to do uncertainty propagation. How is the question.  
14 The other thing is internally you need to invest model  
15 uncertainties internal, structural model uncertainties  
16 inside the code. That's this box.

17 Then you have certain types of evidence  
18 information. That's in this box here. Analytical  
19 solutions, field data, test data, and expert opinion.  
20 That's kind of your base information. You see a  
21 number of modifiers or processes or procedures. One  
22 is that obviously there is a scaling that needs to be  
23 done in some cases from test facility or modifications  
24 and adjustments that should go into kind of an  
25 assessment of the model uncertainty. That's the

1 meaning of this box.

2           You have input to the power process which  
3 is the user affects or nodalization as an example.  
4 And you see a number of places where we say Bayesian  
5 model uncertainty. Here is a Bayesian uncertainty on  
6 input to the model so, if you remember, you have a  
7 soft model of parameters.

8           You see a Bayesian updating using a  
9 standard procedure. The Bayesian model uncertainty  
10 trying to adjust the structural as well as parametric  
11 aspects of submodels and the overall model refers to  
12 the methodology that I presented in the first  
13 presentation and the extensions of that.

14           There are a couple of places where we do  
15 Bayesian updating with the evidence. One is here any  
16 evidence that they have in terms of empirical  
17 correlations or test data that would help us  
18 understand the credibility, the nature and accuracy of  
19 specific models within the code. That's one.

20           Another one is at the end if you have,  
21 say, integrated test results and something that points  
22 to the performance, the entire code, we do another  
23 Bayesian updating of modifying the code results with  
24 whatever evidence we have from test and experience so  
25 that's another one.

1                   And there's another issue of code, the  
2                   output representation which is very context dependent.  
3                   A couple of points. One is when you're looking at  
4                   propagation of uncertainty, for instance, inside the  
5                   code, it is not a straightforward process of taking  
6                   samples and running those through.

7                   There are important points to consider  
8                   such as if I have alternative models one and two, and  
9                   suppose I use a methodology that would enable me to  
10                  kind of look at the credibility of this model and this  
11                  model or even a compact assessment of those, one  
12                  question that one needs to address is that does it  
13                  make sense to, for instance, mix these models in some  
14                  weighted average or procedure like that or any other  
15                  numerical mixing and then proceed.

16                  In some cases yes and in some cases no  
17                  because the mix may not be physically meaningful and  
18                  the mix may not max with the rest of the procedure or  
19                  process that you will encounter. Going from this  
20                  point to this point maybe this model matches this  
21                  model.

22                  MR. ROSEN: Like a plant where you have  
23                  three feed water pumps in one cases and two in another  
24                  and the model is either two are running or three are  
25                  running and somebody wants to say two and a half are

1 running.

2 DR. MOSLEH: Yes.

3 MR. ROSEN: Well, you can't have that.  
4 That doesn't sound reasonable.

5 DR. MOSLEH: In some cases it makes sense  
6 and in some cases it doesn't make sense. The  
7 procedure for propagation of uncertainty, you trace it  
8 inside the code, would be different obviously. We  
9 have a number of structural characteristics that we  
10 have identified that we need to address in developing  
11 the procedure for uncertainty propagation. That is  
12 beyond just the assessment within individual blocks  
13 and boxes.

14 Another feature is the dynamic nature of  
15 such codes. You have in one time step you're invoking  
16 submodel 2 and then you go to 4 but not 2. In another  
17 time step you go from submodel 2 you go to 3 and 4  
18 maybe. So as you exercise the model the structure of  
19 the model changes and you're uncertainty tracking  
20 overlay needs to track these things, needs to be  
21 sensitive to these.

22 It's almost running risk scenarios or  
23 probabilistic scenarios inside the code. In other  
24 words, you need to do uncertainty as it relates to the  
25 specific cases or path through the computational

1 process. I have examples of these. What I wanted to  
2 say about this thing was that this is the result of  
3 applying the sampling method using the PTS uncertainty  
4 data involving 11 parameters.

5 All the color curves that you see are  
6 actual PH runs based on Wilks sampling method so you  
7 get 100 runs. That gives you a spectrum of variation.  
8 Just for fun or just to see how well we perform in the  
9 PTS case, we look at the PTS uncertainty bounds we  
10 selected based on our own procedure and they nicely  
11 fit.

12 Gives us a little bit more confidence  
13 about the performance of the Wilks uncertainty  
14 propagation and also a little bit of verification of  
15 what we did in the previous one. The Wilks  
16 methodology works in terms of generating the spaghetti  
17 of distribution.

18 The question is actually what do you take  
19 out of that spaghetti as a representative uncertainty  
20 found in the lower box. The comment I made earlier  
21 about the thermal hydraulic uncertainty procedures  
22 that we have seen, some of them -- couple of them, the  
23 prominent ones, make a mistake that you can actually  
24 trace the upper bound of these curves just right over  
25 the top of this spaghetti or right under using a

1 certain counting procedure like, you know, the number  
2 of curves that fall within or the percentile of the  
3 statistical distribution at the specific time windows  
4 and call those upper bound and lower bound. Obviously  
5 these are not physical. The upper bound is not a  
6 physical representative.

7 CHAIRMAN APOSTOLAKIS: This is the same in  
8 the waste depositories where they calculate the dose  
9 and they report the results with a 90 percentile  
10 curve. These curves are not actual runs. They are  
11 the 90 percentile of many, many curves underneath  
12 which are the actual runs.

13 MR. ROSEN: And they end up with a human  
14 receptor who eats so much that he would explode if he  
15 ate that.

16 DR. MOSLEH: That's the same thing.  
17 Exactly.

18 CHAIRMAN APOSTOLAKIS: So it's a bunch  
19 over 90 percentile but it's not one run.

20 MR. SHACK: But sometimes it's the right  
21 way to do it.

22 DR. MOSLEH: And sometimes it's not. I  
23 would say that in the cases we had, the TH runs we  
24 were dealing with in all that, to me, and obviously to  
25 everybody else also, they did not accept. That's why

1 we went through an elaborate process of selecting  
2 three curve representative and it confused a lot of  
3 people. But the point was this, that you can't just  
4 go to upper bound and lower.

5 MR. SHACK: But, you know, just taking  
6 this case, I mean, why wouldn't looking at the 90th  
7 percentile -- if you wanted to look at the 90th  
8 percentile of the temperatures and pressure that the  
9 vessel would see, I mean, you're not using it to  
10 really judge the thermal hydraulic model but you want  
11 to know what's the whole range of temperatures and  
12 pressures that the vessel would see.

13 DR. MOSLEH: If you just want to see at  
14 any moment what would be the maximum pressure or  
15 temperature that the vessel would see, yes. But  
16 connecting those points of design is not a physical  
17 trace. Basically the system will not experience that.

18 CHAIRMAN APOSTOLAKIS: For communication  
19 purposes it's good but if you want to use it as an  
20 input --

21 MR. SHACK: If you were looking for a  
22 state dependent thing that wasn't history dependent,  
23 then it would be reasonable.

24 DR. MOSLEH: Exactly.

25 MR. SHACK: But if it's history dependent

1 then --

2 CHAIRMAN APOSTOLAKIS: Or just  
3 communication.

4 DR. MOSLEH: Just communication. And I  
5 think, unfortunately, misleading. It's really amazing  
6 that people came with physics and hydraulics  
7 background would just accept this even though it is  
8 the type of thing that should get a kind of rapid  
9 quick negative reaction from that perspective. These  
10 are not physical places. I'm giving you a sample of  
11 a number of issues that you're addressing.

12 CHAIRMAN APOSTOLAKIS: Okay. Great. Is  
13 this work continuing now or is it over?

14 MR. CUNNINGHAM: It will continue.

15 CHAIRMAN APOSTOLAKIS: Are you done?

16 MR. CUNNINGHAM: Or a follow-up to it or  
17 something.

18 CHAIRMAN APOSTOLAKIS: Thank you very  
19 much. Professor Modarres.

20 MR. ROSEN: I would comment while  
21 Professor Modarres is coming up that the presentation  
22 that you skipped, the one on observations of treatment  
23 of uncertainties and complex multi-disciplinary  
24 technical assessments is very useful for common  
25 understanding of why doing uncertainty analysis is

1 important and also when to do uncertainty analysis and  
2 who should do it and how it should be done. I think  
3 it has some useful insights so thank you.

4 CHAIRMAN APOSTOLAKIS: Let me ask what  
5 would it take for these methods to become usable  
6 routinely by people other than Modarres and Mosleh?

7 DR. MOSLEH: Are you asking me?

8 CHAIRMAN APOSTOLAKIS: I mean, should the  
9 agency always come to you? That would be nice for  
10 you.

11 DR. MODARRES: Good afternoon. Let me  
12 introduce myself. I'm Mohammad Modarres from  
13 University of Maryland. I'm also a professor of  
14 nuclear engineering and also reliability engineering.  
15 The answer to Dr. Apostolakis' question is that  
16 actually one of the objectives of this research is to  
17 bring at the end the lessons that we learned into the  
18 code development.

19 There is a task at the end to put some  
20 procedure of the analysis that will be perhaps we are  
21 thinking of a P process or kind of a thing before a  
22 RELAP or trace which is being done now which then the  
23 analyst would look at the aspects of the uncertainty  
24 analysis that should be considered before actually  
25 embarking on the calculation. We haven't started

1 thinking about it but ultimately the idea is to bring  
2 it down to something that everyone can use it. That  
3 was the original idea and still is.

4 CHAIRMAN APOSTOLAKIS: Okay. Go ahead.

5 DR. MODARRES: Okay. What I wanted to  
6 talk about here is an aspect of the fracture mechanic  
7 uncertainty analysis that we were involved some three  
8 or four years ago we started and ended about two years  
9 ago. I actually originally borrowed this from a  
10 previous presentation made by Mark Kirk but this kind  
11 of captures the totality of the aspects of what the  
12 PTS analysis is involved that be used as fracture  
13 mechanic uncertainty as part of it.

14 Basically the focus was on the  
15 probabilistic fracture mechanics box which is the --  
16 Ali talked about the thermal hydraulic analysis  
17 uncertainty aspects also here. That box was  
18 traditionally analyzed prior to the PTS analysis as  
19 primarily deterministic.

20 Essentially the stresses were calculated  
21 at a given scenario and the strength was used using a  
22 redesigned curve of deterministically and then if the  
23 two crossed each other it was assumed that the vessel  
24 will fail and if it doesn't, they don't fail.

25 Basically they will go through the

1 variations and distribution of flaws and then test  
2 this for every flaw there and then find out the  
3 likelihood that the vessel would fail because of the  
4 variability and the number of flaws.

5 We took that and we said, okay, what about  
6 the uncertainties which are involved in actually the  
7 models representing the strength of the vessel and  
8 also the measurement of the stress which applies to  
9 the vessel given a scenario occurs. The focus was  
10 basically on the fracture mechanics here.

11 The first steps that we got involved, of  
12 course, we were PRA analyst and tried to actually  
13 understand the physical phenomena which was the  
14 underlined physical phenomena which goes here. We  
15 have to break down the elements here down to the  
16 individual contributors to the uncertainty to  
17 understand that.

18 First the stress, the box H on the top  
19 left basically describes what we are trying to  
20 calculate ultimately which is the toughness of the  
21 vessel. You can think of it as the strength of the  
22 vessel. Then that changes over the -- there are two  
23 factors that are affecting this.

24 One is the temperature that is applied on  
25 the vessel, and the second one is, of course, is the

1 embrittlement which over the time changes this  
2 characteristic. So we wanted to see how to calculate  
3 that. Of course, this is the value that was  
4 considered as a fixed number prior to us entering and  
5 we wanted to bring this distribution into it.

6 We wanted to see what actually contributes  
7 to this so we can represent it by distribution. By  
8 going through this it was realized that actually there  
9 are two kinds of uncertainties here. One is the  
10 uncertainty associated with the basic variability into  
11 the vessel to vessel variabilities and the material  
12 variabilities that exist in the vessel which gives  
13 rise to this distribution.

14 The second one is, of course, this  
15 temperature shift, what is called a temperature shift  
16 which is a product of the vessel being irradiated over  
17 the time. In order for the NRC to take care of this  
18 temperature shift, there was a measure called  $RT_{NDT}$   
19 which was calculated based on -- I'm sure Dr. Shack  
20 knows far better than me how the history of this came  
21 up.

22 Technically this  $RT_{NDT}$  came from  
23 calculations of the current temperature and some other  
24 irradiation here which was calculated from another  
25 parameter,  $\Delta T_{30}$  which involved, again, a number

1 of other assumptions.

2 There were quite a bit of uncertainties  
3 here was coming actually to the picture of how this  
4  $RT_{NDT}$  itself was calculated. There were uncertainties  
5 as to the measurement of the X axis and there were  
6 uncertainties to the value of the Y axis both here.  
7 The question was how to characterize and compute this.

8 Of course, there is the lower box here is  
9 a toughness uncertainty and that is that once a crack  
10 starts to grow, it's possible to be arrested and then  
11 this is the arrest toughness is how that can be  
12 stopped from actually growing and going through the  
13 vessel wall completely and then causing a failure of  
14 the vessel.

15 So here if you're looking at actually by  
16 going through the history of this, we found out  
17 actually that if you're looking at it there were about  
18 200 or so data points which are shown on the left box  
19 here to calculate this  $K_{1c}$  which is the strength  
20 distribution. Then a model by assumption of viable  
21 model was forced into it to see how actually a Weibull  
22 model fits into it.

23 Originally this is the ASME curve which  
24 NRC used. Someone at AME sat and basically drew a  
25 language in the bottom of all of these to say this is

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1 the most conservative line I can get. Therefore, it  
2 encompasses everything. Of course, this doesn't  
3 include all this variability you see in the data, as  
4 you can see here.

5 Of course, one process was to go through  
6 these data and either use this Weibull distribution  
7 which is a function of the temperature here, or use  
8 some other -- use this deterministic. Of course, our  
9 standing was that you should capture somehow this  
10 variability.

11 But by going to a more careful evaluation  
12 of this, we wanted to see what part of this is  
13 aleatory in nature and what part of it is epistemic in  
14 nature. When we went through the data here and looked  
15 at the data very carefully looking at this  
16 temperature, we found actually that this variability  
17 here comes because of a cleavage fracture in the  
18 steel.

19 This cleavage fracture comes because of a  
20 break basically on the weakest link of the carbides.  
21 In other words, it was very dependent on the carbide  
22 distribution itself. In fact, the weakest link and  
23 the distribution of carbide gave rise to the Weibull  
24 distribution.

25 In fact, if you take this weakest link

1 model and try to find a weakest link with the sizes of  
2 these carbides and combine the two together, you can  
3 derive, in fact, a Weibull distribution. That is how  
4 originally Weibull distribution came about to begin  
5 with.

6 This was very well described by an  
7 aleatory distribution because the carbides then -- the  
8 size of the carbides distribute themselves in an  
9 aleatory way and, therefore, the Weibull distribution  
10 is actually an inherent physical characteristic  
11 representing that kind of a distribution. That was  
12 the first thing.

13 We said, okay, this must be treated and  
14 must be treated as an aleatory representation in this  
15 case of the  $K_{1c}$ . We went back and said, okay, one way  
16 is to, of course, take the data and use the fitted  
17 Weibull distribution that you have. The second one  
18 was actually another method which is a common talk and  
19 we learned about it.

20 The other thing that we had to deal with  
21 was that indexing temperature which brought in -- we  
22 have to understand what kind of uncertainty involves  
23 in that indexing. The indexing, as I earlier noted,  
24 comes about because of the embrittlement and because  
25 of the temperature variation that comes in because of

1 the cooling scenario of the reactor vessel it.

2 So this indexing temperature is also very  
3 important to bring the heat-to-heat variability  
4 between the vessels and also the embrittlement  
5 aspects. But it causes actually a significant  
6 uncertainty into the result that you would get  
7 ultimately. We looked at this in three ways.

8 We said, "Okay, you can look at it and the  
9 first graph represents a case that we said earlier a  
10 Weibull distribution of  $K_{1c}$  as it's shown for a given  
11 temperature is basically an aleatory distribution.  
12 Then the indexing could be precisely measured is one  
13 way to looking at it.

14 In fact, this is what is done currently  
15 with a method called Master Curve. This was actually  
16 standardized and, therefore, this reference  
17 temperature can be measured exactly for a given vessel  
18 and, therefore, there would be no variability here  
19 given that you know exactly the embrittlement in the  
20 vessel.

21 Therefore, this would be the case that you  
22 have only an aleatory distribution. Or you have  
23 uncertainty about this indexing temperature and,  
24 therefore, you would have a distribution here but that  
25 distribution is epistemic in nature because you can't

1 really determine if there is a real temperature of  
2 indexing.

3           Finally, originally Oak Ridge came with  
4 some kind of the mixing of the two so we tried to  
5 actually separate and that was a third way of  
6 analyzing. This is the Master Curve that I was  
7 talking about. This is actually the trend and NRC had  
8 some reservations at the time to use it because of the  
9 newness and there were some issues to be addressed at  
10 that time. It actually is the cleanest and more  
11 physically based model that could be used and it would  
12 lead into, if I go to the previous graph, it would  
13 really represent this situation.

14           The second way was to use basically an  
15 empirical model of the  $K_{1c}$ . That is, to use the data,  
16 fit a Weibull distribution to the data, and then come  
17 up with an indexing temperature which is appropriate  
18 which is systemic in nature and that's what we came up  
19 with.

20           Because of the fact that actually NRC had  
21 a reservation on the use of the Master Curve  
22 originally because of a number of factors involved we  
23 came up with a procedure here, an empirical procedure,  
24 for Oak Ridge to use and, therefore, to calculate the  
25  $RT_{NDT}$  and bring in only the epistemic aspects of this

1 calculation.

2 Note that these data, in order to  
3 calculate these data, these particular data points to  
4 plot them, you have to use this  $RT_{NDT}$  to actually come  
5 up with the Weibull distribution originally. To  
6 separate them we have to go through this procedure.

7 In other words, you have to go through  
8 this procedure to actually come up with the  
9 distribution itself by going through and finding how  
10 much bias this has with the original model of the --  
11 if I go actually to my backup here.

12 If you go through the data here, the  $RT_{NDT}$   
13 and  $T_0$  which is exact temperature has a bias here. It  
14 has a consistent bias. We came up with a methodology  
15 to sample from this distribution so that you can find  
16 the corresponding  $RT_{NDT}$  and then correct the data for  
17 that.

18 Once you correct the data, then what you  
19 would be left with is just the aleatory distribution  
20 and then you can really plot the empirical  
21 distribution here and using this adjustment.

22 So the idea was here to go and represent  
23 the -- if I go is to this case. This was ultimately  
24 what we set out to be used at the code which Oak Ridge  
25 is developing, favor code, and this is the model that

1 they are now using. Basically the  $RT_{NDT}$  is calculated  
2 and is an epistemic distribution and that procedure  
3 was developed so that the sampling is done properly.

4 That is, for instance, a sample of  $RT_{NDT}$   
5 was taken and this whole area of distribution was  
6 actually propagated for the calculation of the  
7 probability of the vessel fracture all the way  
8 through. Consistent with this procedure was developed  
9 that ultimately then Oak Ridge used for that. So the  
10 message here is that -- I think going back to your  
11 question earlier, Dr. Apostolakis, the  $10^{-6}$  there are,  
12 indeed  $10^{-2}$  and so on. It just depends on the  
13 temperature.

14 CHAIRMAN APOSTOLAKIS: That was done in  
15 jest.

16 DR. MODARRES: Okay.

17 CHAIRMAN APOSTOLAKIS: From my colleague  
18 on my left.

19 DR. MODARRES: Okay. But there are some  
20 of that. There were a number of other uncertainties.  
21 For instance, one issue was the treatment of multiple  
22 flaws in a vessel. Originally we proposed the use of  
23 this model that the probability of each flaw failing  
24 due to a given trace or a given scenario is  
25 probability is given by this, then the total vessel

1 failure probability would be calculated from that.

2 Favor used that and later the industry had  
3 reservations about this because they couldn't  
4 understand why probability comes like that. In other  
5 words, there was a difficulty understanding what is  
6 the marginal contribution of each flaw to the total  
7 probability of the whole vessel.

8 Then we had to go through, for instance,  
9 an exercise to show that, indeed, this is exactly the  
10 same as saying that because the question was that  
11 there is only one bad flaw which is the worse flaw and  
12 then that's the flaw that actually ultimately causes  
13 the vessel to fail so why not only calculating for  
14 that one flaw this probability and that's the one.

15 Then we showed from the fact that if you  
16 go through and calculating the minimum that if you  
17 calculate the time that each of these flaws would  
18 ultimately go to failure if this scenario will  
19 continue that the minimum of that time is really the  
20 one you are interested because that is the first flaw  
21 that ultimately will break.

22 This would yield exactly the same answer.  
23 We have to go through mathematical proof that this  
24 actually comes exactly the same as the previous model.  
25 Ultimately we settled on a simpler approach which is

1 this approach. These were kinds of things that we had  
2 also go through the process of coming up in the  
3 analysis of uncertainties.

4 Again, the experience here is that  
5 bringing probability into the physical analysis is  
6 kind of you come to these kinds of issues that are on  
7 the surface quite obvious for us but from the people  
8 who are only mechanistic analysis is not too obvious.  
9 We have to go through some learning curves here of how  
10 to communicate with each other in a way because these  
11 two models are exactly the same, in fact.

12 MR. SHACK: Why isn't that a product  
13 rather than a sum?

14 DR. MODARRES: Sorry. This is a mistake  
15 here. Sorry. This is last minute. Sorry. This  
16 should be product. You're right.

17 CHAIRMAN APOSTOLAKIS: Well, they're all  
18 Greek letters.

19 DR. MODARRES: They are all Greek letters.  
20 This should be a product. This is last minute that we  
21 put together.

22 CHAIRMAN APOSTOLAKIS: That's it?

23 DR. MODARRES: Yeah.

24 CHAIRMAN APOSTOLAKIS: Okay.

25 MR. SHACK: You missed some of this,

1 George, but this was a very interesting case where it  
2 was very important to track between the epistemic and  
3 the aleatory. It made a real difference in the way  
4 that you did the calculation.

5 CHAIRMAN APOSTOLAKIS: Yeah, sure.

6 DR. MODARRES: You could find the answers  
7 by several of these factors. I wouldn't say order of  
8 magnitude but several factors different if you are  
9 taking samples differently. This made a big  
10 difference.

11 CHAIRMAN APOSTOLAKIS: Very good.

12 MR. ROSEN: You know, I pointed out when  
13 Ali was still here that this presentation that he  
14 skipped on treatment of uncertainties and complex  
15 multi-disciplinary technical assessments was very  
16 valuable. It's only six slides. It seems like the  
17 most important one and the easiest one to grasp to the  
18 staff.

19 Certain things like the fact that  
20 uncertainty analysis is not an isolated task that  
21 could be done by uncertainty specialists. It's  
22 integrated into the analysis. It's something that the  
23 analysts need to understand and do as they develop the  
24 models and use as part of what they are doing. There  
25 is such a thing as uncertainty management when you are

1 using models.

2 You can use models that create uncertainty  
3 and, therefore, cast ultimate doubt on your answers or  
4 you can use models that are less uncertain and  
5 contribute to better acceptance of your models. And  
6 that technical and organizational coordination and  
7 communication are essential during the process of  
8 analysis to reduce uncertainty.

9 Those are just a couple I read off the  
10 first slide. I think this is a particularly useful  
11 presentation and might be useful to us in discussing  
12 uncertainty in the future. I wish he had actually  
13 spent a little time with this.

14 CHAIRMAN APOSTOLAKIS: Maybe I gave you  
15 the wrong impression, Mark, when we spoke on the phone  
16 but this is really something that should be discussed  
17 in a separate meeting on the subject of uncertainty.

18 MR. CUNNINGHAM: Certainly.

19 CHAIRMAN APOSTOLAKIS: Today really we're  
20 trying to figure out what the problem is, where it's  
21 going. But it was good you guys gave us these  
22 presentations because I don't think we've had -- I  
23 mean, we've had pieces in the past but from the  
24 perspective of uncertainty we haven't had. I hope you  
25 are going to go out and present these in conferences.

1 DR. MODARRES: Yeah, we have --

2 CHAIRMAN APOSTOLAKIS: The problem is in  
3 order to appreciate the subtle points there is so much  
4 else you have to learn that the local people are not  
5 willing to learn. I mean, how much would the average  
6 attendee be willing to learn about PTS and all that in  
7 order to reach the point where he would appreciate  
8 calling something aleatory or epistemic. It's really  
9 a major problem.

10 MR. ROSEN: You might disconnect from PTS  
11 and just talk about in general.

12 CHAIRMAN APOSTOLAKIS: But can you do it,  
13 though, in general without the context of PTS?

14 MR. ROSEN: Take a look at this point. It  
15 says here, "Initially we adopted the philosophy that  
16 uncertainty analysis can be performed after the best  
17 estimate analysis is produced." This is the standard  
18 practice. When you get someone to do uncertainty,  
19 they do a best estimate and then they think about  
20 uncertainty and the answer.

21 The insight here is that this practice can  
22 easily resolve not only inadequate uncertainty  
23 analysis but also an incorrect best estimate. In  
24 other words, you have to imbed the uncertainty  
25 analysis in what you do as you develop your best

1 estimate, not later.

2 MR. SHACK: It took somebody's ingenuity  
3 to figure out how to come up with that uncertainty in  
4 the  $RT_{NDT}$  the way that they did so they can break that  
5 thing out. I'm not sure who the clever guy was that  
6 came up with the scheme but it was a good idea and it  
7 sort of made the whole thing possible because  
8 otherwise you were left with an intractable kind of a  
9 problem.

10 CHAIRMAN APOSTOLAKIS: I suspect part of  
11 the reluctance on the part of some of the industry  
12 groups to do uncertainty analysis is precisely because  
13 they have not integrated it into analysis and they  
14 don't appreciate the value of uncertainty analysis.  
15 We have seen many times people say that you don't need  
16 to do it.

17 MR. ROSEN: Well, I think you pointed out  
18 in the past, Dr. Apostolakis, that's because people  
19 have equated uncertainty analysis in general with  
20 parameter uncertainties. They struggle through a  
21 parameter of uncertainty analysis and come out with 9  
22 percent uncertainty and they say, "Compared to what I  
23 know I have never claimed it was better than a factor  
24 of 2 or maybe 5 away from the real answer. Here is 9  
25 percent and you're beating me up about 9 percent so

1 this is irrelevant."

2 Of course, that wasn't the point. The  
3 point wasn't just to do parameter uncertainty. It was  
4 to do uncertainty which includes model uncertainty in  
5 the way you're treating the data and all these other  
6 things, not just the parameter.

7 CHAIRMAN APOSTOLAKIS: Very good. Very  
8 good. Now, given that we are rapidly running out of  
9 time, we will thank you. Thank you, Mohammad.

10 Who is next, Mark?

11 MR. CUNNINGHAM: Dan O'Neal from the staff  
12 is next.

13 CHAIRMAN APOSTOLAKIS: Okay. How much  
14 time do you need? Are you coming?

15 MR. O'NEAL: I'm on the way.

16 MR. CUNNINGHAM: Dan will need no more  
17 than 27 minutes.

18 CHAIRMAN APOSTOLAKIS: For this?

19 MR. CUNNINGHAM: Yes. And we'll just --

20 CHAIRMAN APOSTOLAKIS: How about SAPHIRE?

21 MR. CUNNINGHAM: That's in this.

22 CHAIRMAN APOSTOLAKIS: Oh, that's in  
23 there?

24 MR. CUNNINGHAM: Yes. Dan is covering two  
25 subjects, SAPHIRE, low power and shutdown.

1 CHAIRMAN APOSTOLAKIS: Oh. Peer review.  
2 Didn't we ask for it two years ago?

3 MR. CUNNINGHAM: Yes.

4 MR. O'NEAL: Good afternoon. I'm Dan  
5 O'Neal. I'm the man for SAPHIRE. I would like to  
6 discuss the peer review that we did.

7 CHAIRMAN APOSTOLAKIS: We're developing a  
8 pattern here, you know. A pattern. You propose  
9 something, the staff says no, and two years later it's  
10 done.

11 MR. ROSEN: So we could save a lot of time  
12 by not saying no up front.

13 CHAIRMAN APOSTOLAKIS: Go ahead.

14 MR. O'NEAL: We earlier this year did a  
15 peer review for SAPHIRE.

16 CHAIRMAN APOSTOLAKIS: Do we have a  
17 handout of this?

18 MR. O'NEAL: It's over on the chair over  
19 there.

20 CHAIRMAN APOSTOLAKIS: On the chair.  
21 These?

22 MR. ROSEN: As long as it's not six to a  
23 page.

24 CHAIRMAN APOSTOLAKIS: SAPHIRE 7. If I go  
25 now to the website this is what I download?

1 MR. O'NEAL: You can download both version  
2 6 and version 7. Actually, version 7 is the current  
3 least model. As I'll talk about, we also have in the  
4 concept stage version 8.

5 What we did earlier this year was form a  
6 peer review of the SAPHIRE verification and validation  
7 process. I just wanted to say very quickly SAPHIRE  
8 itself is the code which helps develop and run the  
9 probabilistic safety assessment models. What we did  
10 was we actually did the TV&V for the code.

11 TV&V is testing, verification, and  
12 validation. It's the process basically which ensures  
13 that the underlying code is performing correctly to  
14 its requirements. There's a pretty detailed  
15 verification validation process set up at the  
16 laboratory where SAPHIRE is maintained and developed.

17 MR. ROSEN: Which is?

18 MR. O'NEAL: Which is the Idaho National  
19 Environmental Laboratory.

20 MR. ROSEN: I've heard of it.

21 MR. O'NEAL: What I would like to do today  
22 is to discuss what were the objectives of the review  
23 and a little --

24 CHAIRMAN APOSTOLAKIS: Who were the  
25 reviewers? Can I ask who the reviewers were?

1 MR. O'NEAL: Yes. We put together an  
2 internal team of risk analysts and a TV&V expert. It  
3 was basically an internal team review.

4 CHAIRMAN APOSTOLAKIS: By internal you  
5 mean internal to what?

6 MR. O'NEAL: NRC team review of SAPHIRE.

7 CHAIRMAN APOSTOLAKIS: Did you get anybody  
8 from other national laboratories?

9 MR. O'NEAL: No. Actually the team was  
10 just NRC personnel. There are other users of SAPHIRE  
11 but they weren't involved in the review of this.

12 CHAIRMAN APOSTOLAKIS: Okay.

13 MR. O'NEAL: And so the objective  
14 basically, you know, we're going to take a look and  
15 see how does the cold -- how does the verification  
16 validation meet what we expect it to do for the NRC.  
17 That's basically how we are gearing this review  
18 towards, to determine what type of improvements might  
19 be needed, if any. I'll talk a little bit about all  
20 those objectives.  
21 I would also like to give a brief discussion of what  
22 is the TV&V currently. Finally, I'll talk about our  
23 insights and recommendations.

24 We took a look to see if any improvements  
25 were actually needed based upon whether or not we felt

1 it might be -- whether or not it might be applicable  
2 to staff applications. For example, if the current  
3 TV&V process if there were any specific or general  
4 recommendations that we might have developed based  
5 upon our review, that we would put together a proposed  
6 plan which I can talk about a little bit later, too.

7 In addition, we felt it might be useful to  
8 consider the possibility of taking a look at what we  
9 viewed, what we saw from the results of our review in  
10 determining if there was a need to have a compliance  
11 with a formal software standard for verification and  
12 validation. Also we tried to cover a broad area,  
13 whether or not the types of reviews that were being  
14 done for SAPPHIRE code was sufficient or if it needed  
15 to be improved.

16 Currently there's the automated testing  
17 verification and validation process. It's a  
18 beneficial process since it's very quick. It relies  
19 upon -- basically it takes a look at a change or a new  
20 feature and it runs the tests for that change or new  
21 feature. There's a large data base of test suites  
22 that can be run. The automated process is a useful  
23 feature but it also has some boundaries which we  
24 considered in our review.

25 The bases for the current process is

1 documented in that NUREG. It considers the IEEE  
2 standard for software verification of validation, as  
3 well as the NRC's software procedure guidance,  
4 software quality assurance procedure guidance, in  
5 determining the current TV&V. Those two documents or  
6 verification of validation were considered in  
7 determining for the current TV&V what type of actions  
8 might actually improve the process.

9 This document, of course, as you see, is  
10 for the year 2000. It looked at -- it has the bases  
11 for what has occurred prior to 2000. Since this  
12 publication we have provided additional -- we have  
13 provided additional, I guess, structure to the design  
14 and testing process by establishing a procedure for  
15 testing, for evaluating a change and documenting it.

16 It looks at the change to ensure that it  
17 meets the expected goal. It also looks at the  
18 interactions of SAPHIREs features that might be  
19 affected by the change. Also trying to look at the --  
20 make the change in the most useful way. For example,  
21 if you want to make a specific change because of a  
22 specific request, make that change in the most general  
23 way that would be most useful. Of course, we have  
24 documentation and we want to update the test suite.

25 Was all this satisfactory for the current

1 NRC applications? This is the approach that we looked  
2 at that we used to evaluate the current testing, the  
3 verification of validation process. It involved  
4 looking at the processes that are in place at the  
5 laboratory, looking at the changes that were made over  
6 the time period as the subversions of the SAPHIRE code  
7 were changed to account for various errors or new  
8 features or new requirements. We took a look at --

9 MR. SHACK: Who developed the test suite?

10 MR. O'NEAL: The test suite is developed  
11 by the Idaho National Laboratory. That was one thing  
12 we considered here, whether or not the test suite, for  
13 example, has an adequate -- is it complete enough.  
14 Are the test acceptance criteria adequate for what we  
15 expect for staff applications. The TV&V process has  
16 to be maintained consistent and synchronized with the  
17 applications that the staff uses SAPHIRE for. That  
18 was another aspect to be considered.

19 In particular we had two supporting  
20 activities. One was to see how the current TV&V  
21 process matched up with the IEEE standard for software  
22 verification validation. There's various life cycle  
23 processes that a software project goes through so we  
24 took a look to see if what we're doing now matches up  
25 with the formal standard.

1           We also made a database for the number of  
2 changes that were made and we analyzed the database.  
3 For example, we looked at whether or not the change in  
4 the change log for the SAPHIRE code was related to a  
5 vital feature of the SAPHIRE code or a vital feature  
6 of something which would affect the PRA results.

7           We would also take a look at whether or  
8 not the change was repetitive, for example. Whether  
9 or not it was related to a risk measure, importance  
10 measure, uncertainty analyses, and whether or not it  
11 was significant. We had a pretty large database of  
12 which we could analyze the changes and, in fact, there  
13 were about 500 changes that we looked at. Those were  
14 over version 6 and version 7.

15           We wanted to determine of the verification  
16 validation process was okay or if we needed to make  
17 some improvements, specific or general, and whether or  
18 not there was enough -- if there were insights that  
19 would support or suggest that compliance with a more  
20 formal standard, a more formal approach than what is  
21 currently being done is warranted.

22           Of course, we also wanted to ensure that  
23 the SAPHIRE V&V and the underlying code for the PSA  
24 models are receiving the types of reviews that they  
25 should be receiving. Our general insights --

1                   CHAIRMAN APOSTOLAKIS: That's where you  
2 lose me. It seems to me you are reviewing the review  
3 process. I don't see anything here that has to do  
4 with SAPHIRE. Are you talking about the process? You  
5 found it to be formal? The process this or the  
6 process that? Where are your findings regarding  
7 SAPHIRE itself? Is the code usable? Is it useful?  
8 Does it have problems?

9                   MR. O'NEAL: The SAPHIRE code, as I  
10 mentioned, is subjected to the process. When I say  
11 the process, it means it's subjected to a series of  
12 tests which test the vital features of the code. Does  
13 it calculate risk measures?

14                   CHAIRMAN APOSTOLAKIS: So what are you  
15 findings? The third bullet seems to touch upon those.  
16 The other bullets refer to the process itself. That  
17 may be useful but it doesn't tell me about SAPHIRE.

18                   MR. O'NEAL: That's right. As I pointed  
19 out, we did an assessment of the performance of the  
20 code by an analysis of the change log, for example.  
21 And we also looked at what are those findings telling  
22 us.

23                   CHAIRMAN APOSTOLAKIS: So what are they  
24 telling us? What are they telling us about the code?

25                   MR. O'NEAL: Okay.

1 CHAIRMAN APOSTOLAKIS: You say a number of  
2 changes in the change logs they viewed were  
3 significant. "Code error that affects the correct  
4 result for risk measures." What does that mean? That  
5 the results of SAPHIRE was produced but not right or  
6 what?

7 MR. O'NEAL: What it means is in the  
8 change log which documents the changes over the  
9 versions 6 and 7, it means that when the change was  
10 made, it was made for a reason. We evaluated whether  
11 or not the change could affect the correct result for  
12 these types of considerations.

13 If it does, what it means is that it puts  
14 a lot of emphasis on the user to understand that there  
15 was an error in the code and to detect it himself.  
16 The TV&V process is the process which is set up to  
17 detect the errors in the code.

18 CHAIRMAN APOSTOLAKIS: Fine. So you did  
19 find an error then. That's what you're saying.

20 MR. ROSEN: Significant errors.

21 CHAIRMAN APOSTOLAKIS: Did you find  
22 significant errors?

23 MR. O'NEAL: Yes. Well, this is what I  
24 meant by significant was that when we looked at the  
25 changes, did the change result in an error. I mean,

1 was it related to an error in the code which could  
2 affect the correct numerical results but it does not  
3 alert you if you are a model developer.

4 CHAIRMAN APOSTOLAKIS: Oh, so you didn't  
5 get the error fixed. You just identified it.

6 MR. O'NEAL: These were fixed. Once they  
7 are identified, of course, they are fixed.

8 CHAIRMAN APOSTOLAKIS: So there is no  
9 reason to alert the user because the user doesn't  
10 know.

11 MR. O'NEAL: It becomes important if it  
12 bypasses the TV&V process and the user, for example,  
13 is using a model with the underlying code that still  
14 has the error in it.

15 MR. ROSEN: Do you alert past users who  
16 may have used it for importance to 6 or 7 or whatever  
17 and you later found an error in the code? Do you have  
18 a method to alert the users as to what was found and  
19 what the importance might be?

20 MR. O'NEAL: Well, we do have a website  
21 which has the change logs on it so anytime that there  
22 is an error or a change made to the log because of  
23 something that was found it's posted but that is a  
24 very recent feature.

25 CHAIRMAN APOSTOLAKIS: NASA, for example,

1 is using this to do a major PRA. Are they using the  
2 version that has the error? Shouldn't you let them  
3 know? I don't think that they are going back to the  
4 website every week to check whether there were errors  
5 found. The code has wide use.

6 MR. O'NEAL: There's going to be errors in  
7 almost every PRA computer code. There has to be a  
8 process to alert anybody who needs to know that.

9 MR. ROSEN: There's a user's group I'm  
10 sure.

11 MR. O'NEAL: There is a SAPHIRE's users  
12 group.

13 MR. ROSEN: They can alert and they talk  
14 to each other.

15 MR. O'NEAL: The NRC has meetings for both  
16 the SAPHIRE and SPAR model users group so there are  
17 mechanisms to relay these things.

18 CHAIRMAN APOSTOLAKIS: I hope that at some  
19 point there would be no major errors.

20 MR. O'NEAL: That's what we were looking  
21 at when we looked at the database. Are there errors  
22 that we might have -- are we seeing anything in the  
23 database which could have bypassed TV&V process. That  
24 was one of the objectives to see if we were  
25 comfortable with the number of changes that might

1 represent this type of condition.

2 CHAIRMAN APOSTOLAKIS: So the bullet  
3 before last is kind of ominous. "The number of  
4 changes representing both non-significant and  
5 significant changes." What does that mean? You mean  
6 errors. Somewhere there should be errors.

7 MR. O'NEAL: There are errors that are  
8 changes in the change log corrected. Once they're  
9 corrected, they are updated in a new subversion so  
10 that's why there's the second bullet. It shows that  
11 every time --

12 MR. SHACK: This is indicating these  
13 errors were found by users rather than by the TV&V  
14 process.

15 MR. O'NEAL: Well, actually, I think it  
16 was a mixed bag. The documentation was not very clear  
17 on who found it, whether it was a TV&V, whether it was  
18 users. But I am aware that there have been users that  
19 have found significant change errors in the code and  
20 those get fed back to us and we provide it to the  
21 laboratory. The laboratory corrects it and puts up a  
22 new subversion. What we also wanted to see by our  
23 review were things getting better. As you released a  
24 new subversion are you improving the reliability?

25 CHAIRMAN APOSTOLAKIS: There is one last

1 question. Are these changes controlled? One of the  
2 complaints I heard from people outside is that  
3 somebody picks up the phone, calls and says, "Hey, I  
4 found this error." The guy on the phone goes and  
5 fixes it and that's it. There is no formal mechanism  
6 evidently for actually evaluating the error or fixing  
7 it and announcing to the world. Has that been fixed  
8 now?

9 MR. O'NEAL: There is a formal process for  
10 making the changes and I discussed that earlier.

11 CHAIRMAN APOSTOLAKIS: This guy you talk  
12 to him and he goes and changes the code. That's too  
13 sloppy.

14 MR. O'NEAL: Well, there's many, many  
15 users of SAPHIRE and the person who is using it may  
16 come from a national laboratory, may be an NRC user or  
17 somebody else. The mechanism is --

18 CHAIRMAN APOSTOLAKIS: He can change his  
19 own version but the center one shouldn't change that  
20 way. Anyway, we are running out of time so I guess  
21 we're going to have another opportunity to talk about  
22 it sometime. Do we need to give some time to J.S.?

23 MR. CUNNINGHAM: We have two options at  
24 this point in the remaining time. We can talk about  
25 low power and shutdown, we could talk about fire risk.

1 MR. ROSEN: Yes. Let's get fire up here  
2 and then low power and shutdown right after that.

3 CHAIRMAN APOSTOLAKIS: It's only one  
4 slide.

5 MR. HYSLOP: My name is J. S. Hyslop. I  
6 have one slide that I imagine was put in back for the  
7 presentation. I'm in the PRA branch of the Office of  
8 Research and I'm the project manager for the Fire Risk  
9 Research Program.

10 I have a general remark. We have a plan  
11 for the Fire Risk Research Program which is being  
12 updated for 2004 to 2006. We're in that process. I  
13 think you'll see from my slide that the program is  
14 continuing to provide critical support to regulatory  
15 activities for nuclear power plants.

16 MR. ROSEN: Is that plan a NUREG or  
17 something like that?

18 MR. HYSLOP: At this time it's not  
19 publicly available. We've received some internal  
20 comments and we're updating it. I would have to talk  
21 to my management to find out what's been done in the  
22 past.

23 MR. ROSEN: Typically it's an internal  
24 document, a memorandum from somebody to somebody not  
25 published as a NUREG.

1 MR. HYSLOP: I'll go ahead and start  
2 because you've got the slide.

3 MR. ROSEN: Go ahead.

4 MR. HYSLOP: There's about eight  
5 activities on the slide for the Fire Risk Research  
6 Program. The first is the fire protection SDP  
7 revision. The fire protection SDP is to evaluate the  
8 risk significance of fire protection inspection  
9 findings.

10 Research is playing a large role. We  
11 developed a time based framework. We are leading a  
12 task group to resolve issues on frequency and  
13 database, providing support in other areas like the  
14 fire scenario group and circuit analysis.

15 We are also writing the revision with  
16 inputs from task groups. I guess you guys if you're  
17 not familiar with this revision process there are many  
18 task groups have been developed to address technical  
19 issues consisting of NOR, research, industry, and EPRI  
20 playing a role also.

21 MR. ROSEN: That's on the SDP?

22 MR. HYSLOP: That's on the fire protection  
23 SDP revision alone. The next topic is circuit  
24 analysis. About a month ago in front of the fire  
25 protection subcommittee I present research activities

1 and circuit analysis. Basically from the history of  
2 research we supplemented the Omega Point Test to  
3 identify the probability of spurious operations and  
4 supported the expert elicitation for the  
5 interpretation of that data.

6 More recently we supported public  
7 meetings. We helped to identify important circuit  
8 analysis features for planned resumption of associated  
9 circuit inspections. We just published a NUREG which  
10 I'm sure you're on the distribution list for, NUREG  
11 CR-6834 entitled Circuit Analysis, Failure Mode, and  
12 Likelihood Analysis.

13 We're supporting NOR and development of a  
14 NUREG particularly for associated circuits. We've  
15 recently accepted a user's need from NOR. We will  
16 determine if there are any additional circuit features  
17 beyond those identified in that meeting that should be  
18 added when the associated circuit inspections begin.

19 The third bullet, we are providing review  
20 guidance for NOR specialist to support changes which  
21 would occur during the risk informed performance based  
22 rulemaking which endorses 805. In particular we're  
23 providing guidance to enable people to evaluate fire  
24 models.

25 To do that we're performing a V&V on a set

1 of fire models from simple to sophisticated fire  
2 models running from empirical zone to CFD. We will be  
3 using an ASTM standard 135597 which is specifically  
4 developed for fire model V&V. We'll also be providing  
5 guidance to help reviewers evaluate the worthiness of  
6 inputs to fire models, in particular heat release  
7 rates.

8 Heat release rates have been one of the  
9 more interesting areas because you need to make sure  
10 you covered it all. You need to make sure you cover  
11 those low-probability potentially high-consequence  
12 fires. Of course, lastly we're going to be providing  
13 review guidance for FRA methods tools and data.

14 The next bullet, the ANS full power fire  
15 standard. That standard will eventually provide a  
16 bases for changes under 805 and Research is providing  
17 two writing members to the standard committee.

18 MR. ROSEN: Do you know if they are  
19 addressing fire in the low-power shutdown model?

20 MR. HYSLOP: No, they're not. The  
21 standard is not. However, later in my talk I will  
22 talk to you about a little something we're going to be  
23 doing.

24 MR. ROSEN: I'm worried about fire,  
25 especially during shutdown because of the number of

1 people and activities increases so much over  
2 operation.

3 MR. HYSLOP: Right. This is a full-power  
4 standard.

5 MR. ROSEN: You need to do more for the  
6 low-power standard.

7 CHAIRMAN APOSTOLAKIS: The database  
8 mostly.

9 MR. ROSEN: Right. I think he knows that  
10 and I'm reinforcing the point.

11 MR. HYSLOP: I'll talk a little bit more  
12 about that later in my presentation. The next topic  
13 is the NRC/EPRI fire risk requantification studies.  
14 These studies are being performed under a joint  
15 memorandum of understanding between NRC and EPRI. The  
16 goal there is to provide state of the art guidance for  
17 the conduct of FRA.

18 In that program there is debate between  
19 EPRI and NRC specialists and that debate is based upon  
20 our existing research programs. The results will have  
21 broad application to regulatory activities and issues.  
22 It's impacting the SCP revision.

23 It's going to be providing a support for  
24 technical bases on the manual actions rulemaking.  
25 It's going to be assisting the ANS fire risk standard.

1 And it will assist in review guidance, as I said, for  
2 the 805 rulemaking. Also it will provide guidance for  
3 licensees who are developing applications.

4 MR. ROSEN: The fire risk requantification  
5 studies debate between you and this EPRI? Is that the  
6 word you used, debate?

7 MR. HYSLOP: Yes. Deliberation and  
8 debate. Yes, because there are two parties.  
9 Obviously we have research programs and we are  
10 debating with the goal of developing consensus. We've  
11 been very successful in that endeavor so far.

12 CHAIRMAN APOSTOLAKIS: Do you disagree in  
13 some areas?

14 MR. HYSLOP: At this point we have come to  
15 resolution on all areas.

16 CHAIRMAN APOSTOLAKIS: Very good.

17 MR. HYSLOP: Now, we've gone further in  
18 some areas than others. The HRA in particular. We  
19 haven't gotten as far in that area as some of the  
20 others and naturally it's a harder area. The research  
21 programs aren't as far developed as you might be for  
22 circuit analysis where we put several years in fire  
23 induced circuits.

24 Now regarding your comment on low-power  
25 and shutdown, net week we're going to have a meeting

1 with EPRI and a licensee about looking at doing a low  
2 power and shutdown requantification study. This  
3 meeting is the first part of a couple of meetings to  
4 evaluate the feasibility of doing that.

5 We are hopeful. We've had good  
6 experiences in the low power. We've got a range of  
7 players who can sit around the table and make  
8 decisions about where we need to go and what the  
9 challenges are. It's a feasibility study and we  
10 haven't agreed to do it yet.

11 MR. ROSEN: Okay. Good. You're working  
12 on it.

13 MR. HYSLOP: Working on it. Now, the next  
14 bullet is the FAR model benchmarking and validation.  
15 My days leading this activity and we've performed some  
16 analytical exercises on cable tray fires and fires in  
17 turbo halls. This has been a part of a fairly large  
18 international collaboration called the International  
19 Benchmark Studies.

20 We completed a fire test at NIST and we  
21 are currently analyzing the data on that test. We  
22 have additional test planned. The tests at NIST which  
23 are planned are to be determined. However, we are  
24 planning test with the French at the DIVA facility and  
25 those particularly tests are for multi-compartment

1 effects.

2 The next to the last bullet is a planned  
3 activity. This is Hemyc and MT fire barrier testing.  
4 This has been tested before. However, these formal  
5 tests have come into question so NOR has developed a  
6 test plan which identifies configurations to be  
7 tested, includes public comment.

8 Research is going to perform that test  
9 plan. We are also considering developing a model to  
10 extrapolate the results of the test beyond the test  
11 configurations. We are going to assess if any  
12 additional testing is appropriate.

13 Last comment or bullet is international  
14 activities. The international activities besides the  
15 fire modeling support circuit analysis and fire event  
16 data. The circuit analysis there's a group called  
17 FIDEC under the Cooper Working Group. FIDEC stands  
18 for the Fire Induced Damage to Electrical cables and  
19 circuits and they are performing some tests. The  
20 Germans will perform some tests in November and  
21 December on that.

22 The last activity, fire event data, that's  
23 being done in the auspices of the OECD. They are  
24 developing an international fire events database and  
25 we are participating in -- it's my understanding from

1 talking to the people running that that we are  
2 supplying LER data.

3 That's it. I hope I haven't gone too fast  
4 but I was aware that we were trying to get through  
5 this quickly.

6 MR. ROSEN: Well, I'm sorry to have to ask  
7 you to come here because you know I'm the Fire  
8 Protection Subcommittee Chairman and have heard most  
9 of this before but I think the reliability of the PRA  
10 subcommittee players who were here and needed to hear  
11 some of this. At least it's on the record and they  
12 did hear it. Thanks very much, J.S.

13 MR. HYSLOP: You're welcome.

14 MR. CUNNINGHAM: One last topic would be  
15 low power and shutdown.

16 MR. ROSEN: Right.

17 MR. CUNNINGHAM: Dan, if you want to go  
18 ahead and do that.

19 As Dan is getting up, I'll remind the  
20 Committee members that this is a topic where we have  
21 been somewhat constrained in what we can do in the  
22 area of low power and shutdown risk analysis by some  
23 Commission decisions on budget and that sort of thing.

24 You don't see as robust a program in low  
25 power and shutdown risk as you do, for example, as in

1 fire risk analysis. Dan will kind of talk about most  
2 of the work that we're doing is supporting the  
3 development of standards for low power and shutdown  
4 PRAs.

5 MR. O'NEAL: I'll quickly talk about the  
6 other activities that we've been doing. I think you  
7 heard earlier about the SPAR models. There's a number  
8 of other activities going on. First and foremost, we  
9 are actively supporting development of low power  
10 shutdown standard which is being written by the  
11 American Nuclear Society.

12 We're on the writing committee so we are  
13 actively involved in writing those standards. The  
14 standard itself is projected to be completed around  
15 December 2004. Just recently work started again on it  
16 back in the early spring of this year so there's been  
17 a little bit of delay.

18 MR. SHACK: When is a draft going to be  
19 available?

20 MR. O'NEAL: That's usually -- I would  
21 project around summertime next year. It's usually  
22 available about six months before.

23 The supporting work that we're doing for  
24 the ANS low power shutdown standard is a revision to  
25 our NUREG/CR-6595 which provides a simplified method

1 for evaluating larger release frequencies. We've  
2 added a chapter specific to shutdown conditions, how  
3 to estimate larger release frequency for low power and  
4 shutdown conditions. That's in our draft NUREG which  
5 is actually out for public comment right now. The  
6 public comment period ends the end of October. In  
7 addition to low power shutdown standards work --

8 MR. ROSEN: Do you have these review  
9 graphs for us to take home and think about?

10 MR. O'NEAL: Yes, they are back on the  
11 chairs over there.

12 MR. SNODDERLY: In the SAPHIRE packet?

13 MR. O'NEAL: It's separate. We're also  
14 taking a look at expanding the scope for the fire  
15 requantification project from full power to low power  
16 shutdown. We are going to be doing a feasibility  
17 study for that which is actually underway right now so  
18 there's not much right now to talk about but maybe  
19 later.

20 In addition, we are supporting the worker  
21 fatigue rule effort by looking at low power shutdown  
22 events, reviewing the LERs to see what type of  
23 insights we may gain and provide that to the staff  
24 that's working on the rulemaking.

25 Another important topic is our activities

1 in the international community for trying to learn  
2 about the low power shutdown risk. We actively  
3 participate in the international meetings for a couple  
4 of the international low power shutdown groups. One  
5 is called the Cooperative PRA Working Group for low  
6 power shutdown. The other one is CSNI, or the  
7 Committee on the Safety of Nuclear Installation.

8 Both of these organizations have something  
9 in common in terms of wanting to improve the  
10 regulatory decision-making process by sharing the  
11 information on low power shutdown PRAs, the different  
12 approaches that have been taken, the different  
13 insights, different types of data and methods that are  
14 available. It's a learning process and we are  
15 actively participating in those.

16 A little bit more about what we're doing  
17 for COOPRA group. The United States had the lead for  
18 writing a topical report on initiating events. That  
19 was based upon responses to a questionnaire from the  
20 various member countries taking a look at what can we  
21 learn from initiating events in terms of the  
22 uniqueness of the low power shutdown initiating  
23 events, the types of, I would say, data that's not  
24 there and the types of data that might have to be  
25 obtained to improve the insights.

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1 MR. ROSEN: Well, there's a lot of data  
2 there. Right? For instance, RHR flow interruptions  
3 during shutdown.

4 MR. O'NEAL: That was one of the things.  
5 One of the objectives was to see. For example, what  
6 is based upon operational experience and what is not.  
7 Those types of initiating event questions have been  
8 asked in that questionnaire to help gain some  
9 insights. What is the completeness, you know. Do we  
10 have enough data to look at the initiating event  
11 frequency. Do we have enough data.

12 MR. ROSEN: Let me see if maybe the  
13 regulatory guys. If you're in shutdown mode and  
14 you're on RHR and you have a flow interruption that  
15 last long enough to actually get some heat up, is not  
16 that an event that is reportable, LER reportable?

17 MR. CUNNINGHAM: I believe the answer is  
18 yes it is.

19 MR. ROSEN: So you have data. You have  
20 some data, at least.

21 MR. O'NEAL: Yes.

22 MR. ROSEN: The presumption always is that  
23 reportable events are reported.

24 MR. O'NEAL: Right, but this is for the  
25 COOPRA group itself so it's not only the United States

1 but other countries.

2 MR. ROSEN: Well, we will eventually  
3 include the foreign data but just the domestic  
4 database so that you have some view of ability to at  
5 least attempt to calculate the reliability of residual  
6 heat removal. Given that, you also have the ability  
7 to study the events that happened and fortunately none  
8 of them has resulted in really serious problems.

9 But if you have an initiating event  
10 frequency, you can then understand that there are  
11 periods when you are eight to 10 minutes away from  
12 boiling, a maximum reduced inventory situation and PWR  
13 at mid LOOP for a hot early mid LOOP.

14 Then you can make some estimates of how  
15 likely it would have been to get into a really  
16 significant bind. It's only a matter of  
17 probabilities. The point is there have been these  
18 interrupts. They just haven't happened at the worse  
19 possible time yet.

20 MR. O'NEAL: Yes. That data is out there  
21 and we have incorporated it into the models that we  
22 are developing. I think there are also issues about  
23 human induced initiating events so that's another --

24 MR. ROSEN: Well, loss of RHR could be  
25 human induced. I don't care how it's induced.

1 There's lots of different ways but the point is the  
2 first output of something like this might be some  
3 people are feeling about the global risk of loss of  
4 RHR in terms of frequency consequences. We know  
5 something about frequency more than you seem to imply  
6 but I think when you study it, you'll see that it's  
7 there.

8 MR. CUNNINGHAM: There's a document that  
9 was completed a year or two ago by this same COOPRA  
10 group that got into what are the perspectives globally  
11 about the risk associated with low power and shutdown.  
12 That report got to just what you're saying, it can be  
13 significant and it's this type of scenario and that  
14 sort of thing so there is an initial report.

15 It led to two or three reports being  
16 developed one of which was this. Given that we see  
17 that general pattern, what are the things as technical  
18 people we could work on to improve the quality of them  
19 and getting an initiating event frequencies was a key  
20 piece that people thought needed to be standardized,  
21 if you will.

22 MR. ROSEN: There are some in this agency  
23 who think that the risk of low power and shutdown is  
24 negligible and I beg to differ. I think some data  
25 analysis and evaluation might be helpful. There is an

1 answer. It either is or it isn't or it is under  
2 certain circumstances perhaps. I think it would be a  
3 useful contribution to put some data rather than just  
4 intuition on the table.

5 MR. O'NEAL: I think that's what the  
6 second activity where we are developing a database for  
7 initiating events might help out with since we're  
8 going to maintain a database and keep it updated with  
9 initiating events frequencies for a particular plan  
10 operational status.

11 MR. ROSEN: Also it's going to lead you  
12 right into the shutdown risk SDP.

13 MR. O'NEAL: Yes. And I think the  
14 initiating events for DSDP have already taken into  
15 account the updating of RHR.

16 MR. ROSEN: I don't know if it's already  
17 happened but sooner or later someone will have an  
18 event during shutdown under the ROP and then there  
19 will be a big debate about whether it was white or red  
20 or yellow or what and it would be helpful to have a  
21 better database.

22 MR. O'NEAL: We are also developing the  
23 models for low power shutdown. Office of Research is  
24 developing the low power shutdown models. Updating  
25 the frequencies in those models is being done. There

1 is some updating going on for those models.

2 The other international activity that  
3 we've been participating in the CSNI low power  
4 shutdown working group. The work here is broader than  
5 what we've been doing for COOPRA. It covers the major  
6 elements for a low power shutdown PSA anywhere from a  
7 cooling initiating event to definitions of plant  
8 operational states to the consequence to how low power  
9 shutdown PSA is being used, and identifying areas of  
10 research.

11 A major product for this group is to  
12 produce a technical report based upon the results of  
13 a questionnaire. What can we learn from what other  
14 countries are doing with their low power shutdown  
15 studies. What type of methods and data are out there  
16 to help us.

17 For example, if you see the objectives  
18 there to improve risk tradeoff decision making between  
19 full power operation and low power shutdown operation.  
20 Once we identify what are the significant areas that  
21 have to be addressed, how will those areas be  
22 addressed. The report that we're putting together is  
23 a summary of the responses and what we've learned from  
24 those responses.

25 It takes a look at what types of methods

1 and data are being used and what else do we have to  
2 learn. What are the areas of interest for further  
3 research. We expect to learn a lot from this effort.  
4 An example of something that might be useful or  
5 further useful to look into is, for example, HRA  
6 during low power shutdown.

7 HRA would benefit for simulator type of  
8 data which is a noted limit for low power shutdown  
9 studies is a lack of that type of data where you might  
10 have simulator data for full power types of scenarios.  
11 There's some information on what other countries have  
12 done in that area so that is one example. We are  
13 continuing to work on this report and expect to be  
14 able to learn a lot and share information.

15 MR. ROSEN: When do you think this report  
16 will be done? Do they have a schedule?

17 MR. O'NEAL: Well, let's see. We're going  
18 to -- we just recently had a meeting over in Paris and  
19 it was decided at that meeting to allow further  
20 information to be presented for completion of the  
21 report so it's not a really definite time right now  
22 but at least we are going to be updating our report  
23 later on. Those countries who want to update their  
24 input can do it and they will provide information to  
25 us by the end of the year.

1 MR. ROSEN: The end of this year?

2 MR. O'NEAL: Yes. And the report itself  
3 is actually -- I haven't heard a completion date for  
4 that report but we will have another meeting discuss  
5 it. The various member countries will look at it and  
6 have another chance to discuss it. There is a final  
7 draft. That's going to take place some time after we  
8 get some updated responses to the questionnaire.

9 The format of the report is actually going  
10 to be combined with what we are doing for the COOPRA  
11 effort so we are going to take the work for COOPRA  
12 which is more than the initiating report which I  
13 presented. We are going to take what COOPRA is doing  
14 as well as what CSNI is doing and combine it to one  
15 report and have a couple of appendices. I don't have  
16 a time scale for that yet.

17 MR. ROSEN: Any guess? This is important  
18 work and it sounds to me it's drifting without someone  
19 saying when we're going to get to the finish line.

20 MR. CUNNINGHAM: The answer is probably  
21 within six to nine months.

22 MR. ROSEN: You think next year sometime?

23 MR. CUNNINGHAM: Yes.

24 MR. ROSEN: Okay. This would be fairly  
25 useful. This thing you introduced there with your

1 bullet No. 1, the differences between methods used and  
2 tradeoffs is something we call cycle risk  
3 optimization. That is, you can do -- you have to do  
4 something to maintain a component of importance. The  
5 question is when you do. Do you do it online which  
6 may be possible under certain sets of tech specs or do  
7 you wait until shutdown?

8 It may turn out for equipment that's of  
9 particular use during shutdown like electrical power  
10 equipment. It may be less risk in terms of overall  
11 cycle risk optimization to do it during operating  
12 periods rather than during shutdown and clearly vice  
13 versa. The important thing to a risk analyst is not  
14 when you do but what is the overall cycle risk from  
15 breaker to breaker and breaker to breaker.

16 When does the strategy that reduces  
17 overall cycle risk. In other words, the interval of  
18 risk over time. That is the important parameter, not  
19 we're using risk during operation and then shutting  
20 down and having a whole lot more risk during shutdown  
21 and the overall risk is higher than you would have  
22 been if you did it during shutdown. Cycle risk  
23 optimization is an important point.

24 A lot of people are doing it implicitly,  
25 I think, and getting the wrong answer. They are doing

1 it the way we always used to. A lot of people are  
2 doing it while they are shutdown when really they are  
3 probably better off doing it when they are running for  
4 equipment that's important for risk control during  
5 shutdown. I also think there is some of the reverse.

6 If once we could have a shutdown risk  
7 calculation method that is, as you suggest here, that  
8 would allow meaningful risk comparisons or tradeoffs  
9 among these operational conditions we would be in much  
10 better shape. I think this is a worthwhile effort and  
11 I think you can do whatever you can to try to move it  
12 along.

13 MR. O'NEAL: Okay.

14 MR. ROSEN: If there are no further  
15 comments from my colleagues? I doubt there will be  
16 any. Or from members of the staff? I'm not as sure  
17 there wouldn't be any. Members of the public?  
18 Members of ACRS staff? Okay. We'll stand adjourned.

19 (Whereupon, at 2:59 p.m. the meeting was  
20 adjourned.)

21

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25

CERTIFICATE

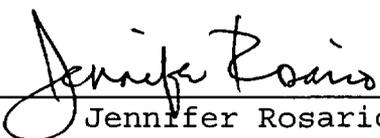
This is to certify that the attached proceedings  
before the United States Nuclear Regulatory Commission  
in the matter of:

Name of Proceeding: Advisory Committee on  
Reactor Safeguards  
Reliability and Probabilistic  
Risk Assessment Subcommittee

Docket Number: n/a

Location: Rockville, MD

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**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**

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## 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.

# 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



# **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

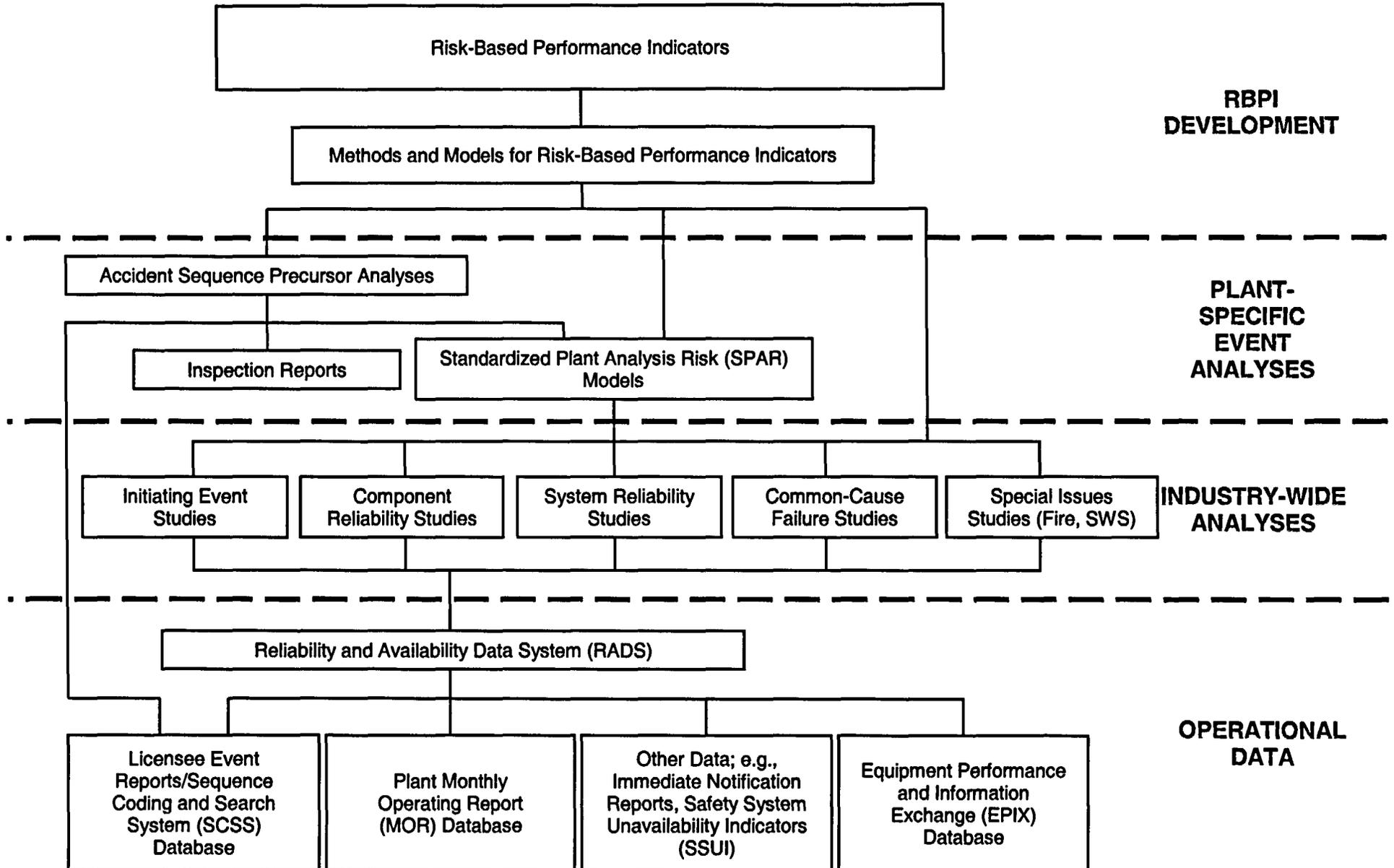
1. Introduction
2. Data Collection and Analysis
3. Accident Sequence Precursor (ASP) Program
4. Industry Trends Program
5. Standardized Plant Analysis Risk (SPAR) Model Development Program
6. Mitigating Systems Performance Index (MSPI)

# 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

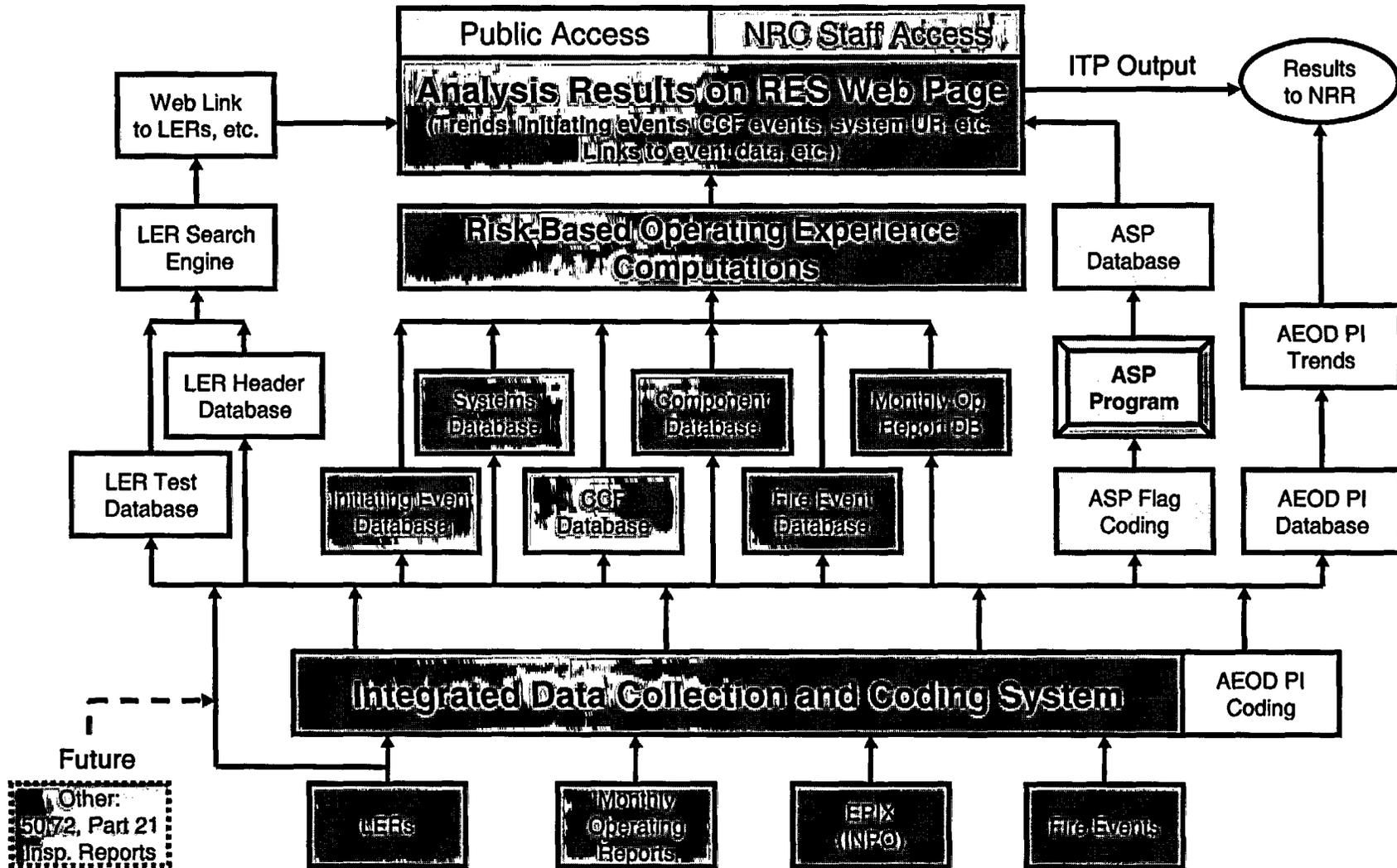
# CONSOLIDATED DATA COLLECTION AND ANALYSIS

- 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



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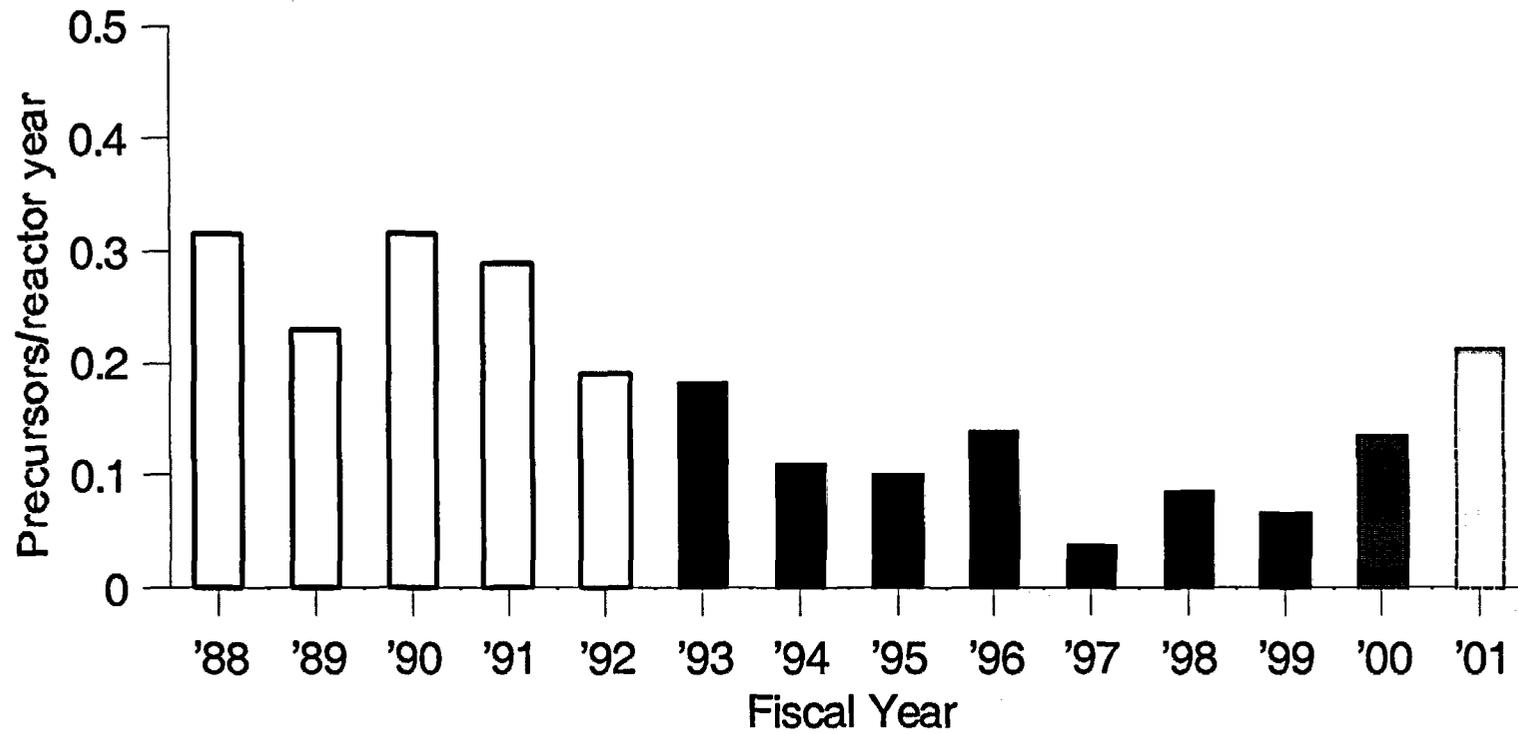
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# **Accident Sequence Precursor (ASP) Program**

# 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  $\Delta CCDP \geq 1 \times 10^{-3}$ ) 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

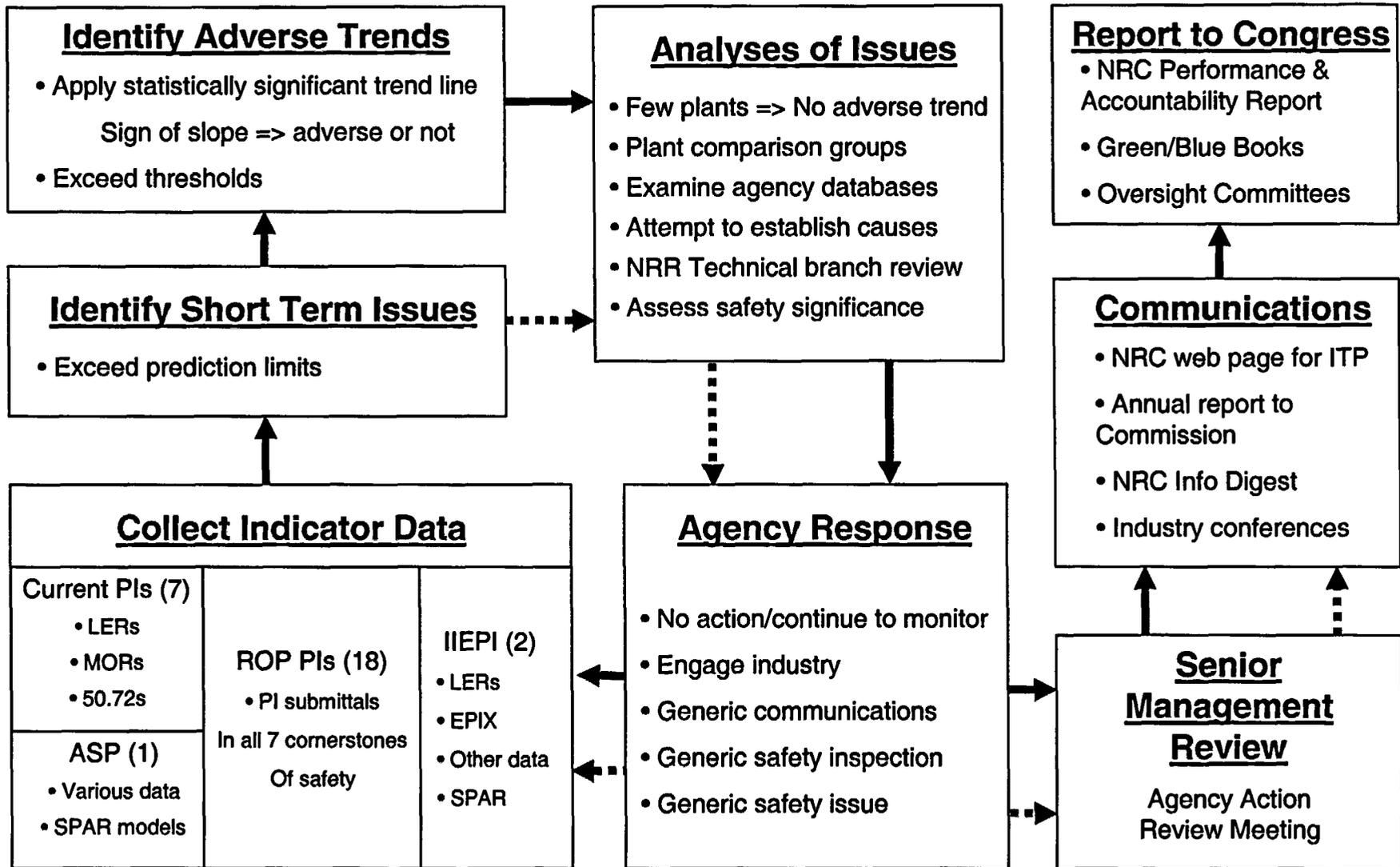
# Industry Trends Program (ITP)

- 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



# 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.

# 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

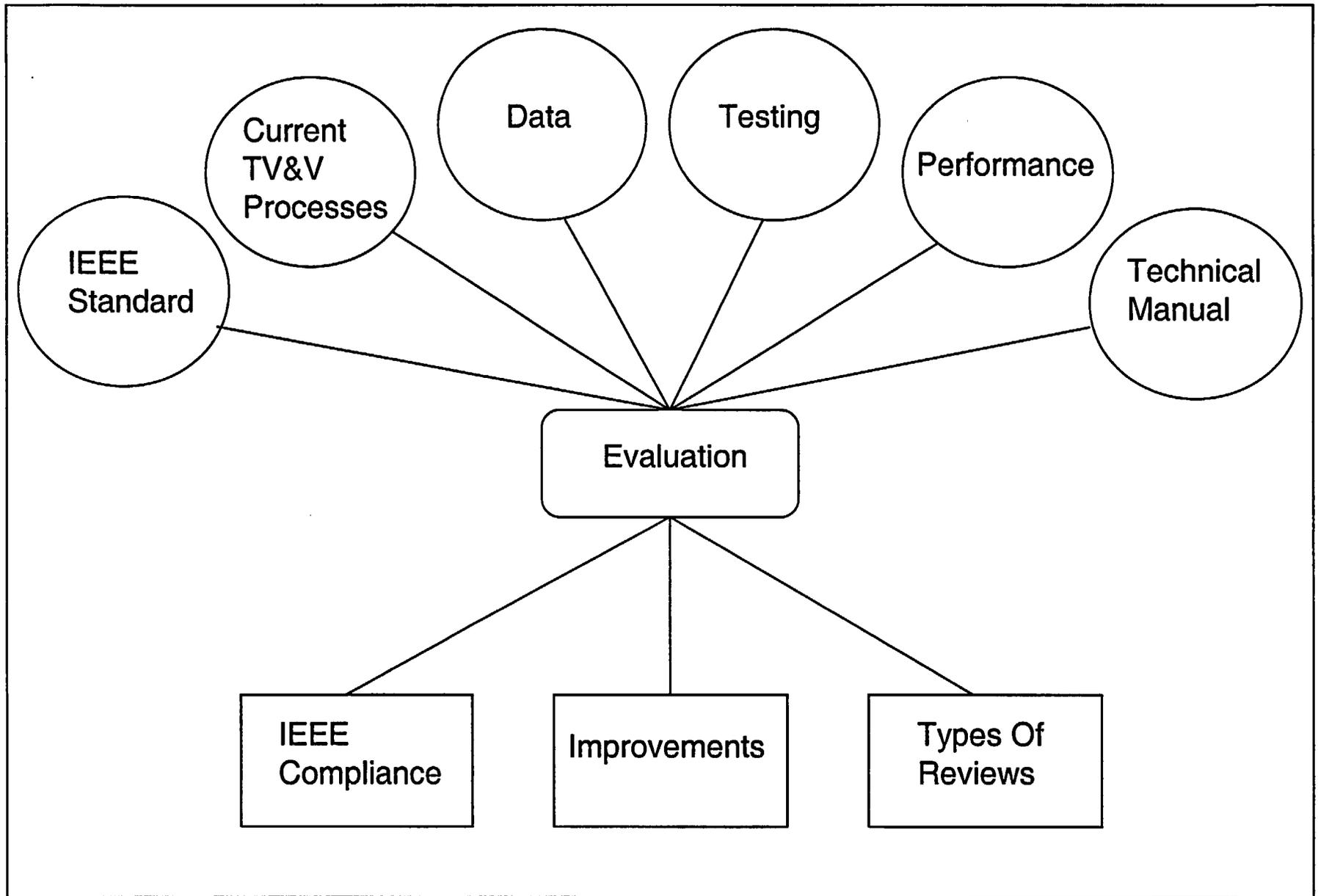
# OBJECTIVES

- 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

# 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

# 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



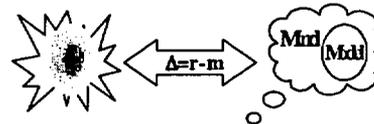
## Results

- 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)

5



## Model Uncertainty

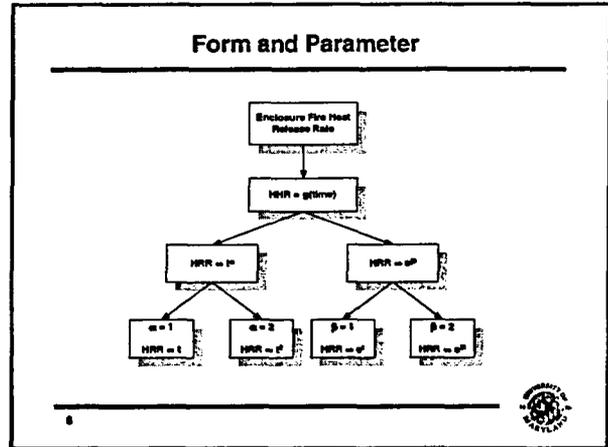
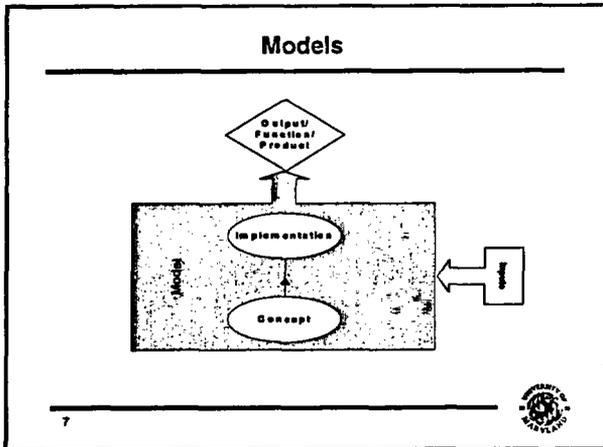


### Examples of Sources of Model Uncertainty:

- Conceptualization of a reality aspect
- Implementation into a particular form
- Several plausible models reflecting different interpretations of reality

6

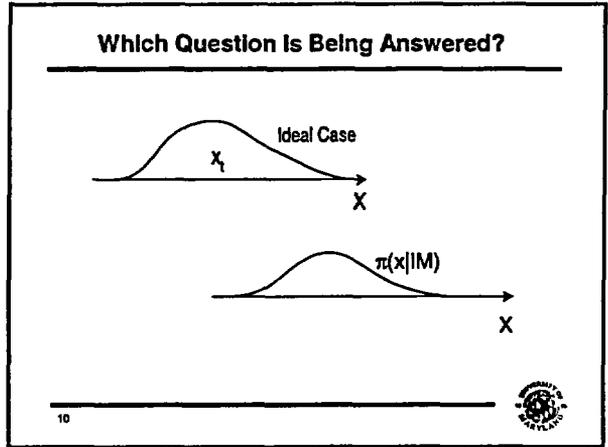




### Model Uncertainty

- 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

9



### 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  $X$

11

### Bayesian Framework

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

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

where

- $\pi(x|IM)$ : uncertainty distribution of  $X$  given information  $IM$
- $\pi_0(x)$ : the distribution for  $X$  before the evidence  $IM$  is available
- $L(IM|x)$ : (likelihood function) the probability of observing evidence  $IM$  when the true value is  $x$

12

### Characterization of IM

> The evidence, IM, can be grouped into two major categories:

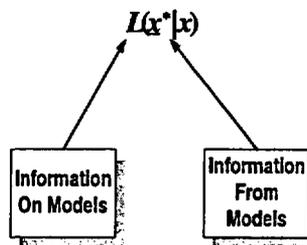
- Information from models ( $\underline{x}^*$ , an estimate of X):
  - o Point estimate
  - o Probability distribution
  - o Bounds for the unknown X, such as  $x_1 \leq x \leq x_2$
  - o A statement concerning X, such as "X is high"
- Information about models (D):
  - o Performance data
  - o Assessment of the quality and applicability of the model

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

13



### Constructing The Likelihood Function



14



### Constructing the Likelihood Function (Parameterization Strategy)

$$\int_{\theta} L(\underline{x}^* | \theta, x) \pi(\theta | D) d\theta$$

15



### Likelihood Function: An Example

> Information about the model:  $D = D^p, D^a$

- $D^p = \{E_1, \dots, E_n\}$ : Performance data
- $D^a$ : Qualitative information on model quality and applicability

> Corresponding parameters in the likelihood:  $\theta = \{\theta^p, \theta^a\}$

> An example is the Error Model:

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

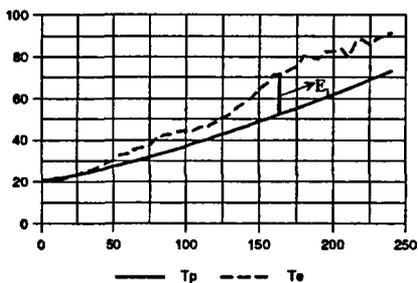
where

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

16



### Likelihood Function: An Example (cont)



17



### 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:

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

18



### 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 ?

19



### Example: Cable Jacket Temperature Prediction

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

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

20



### 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:

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

21



### Construction of the Likelihood (Homogeneous Performance Data)

> Updating model predictive capabilities:

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

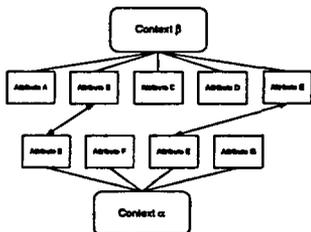
> Assumption: ( $E_1, \dots, E_6$ ) are independent and each  $E_i$  is distributed according to a Lognormal distribution:

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

22



### Applicability of Models



23



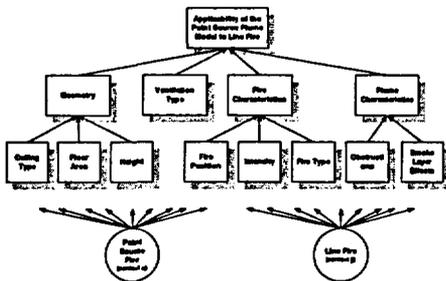
### Applicability of Models (cont)

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

24



### Example: Line Fire Plume Temperature



25



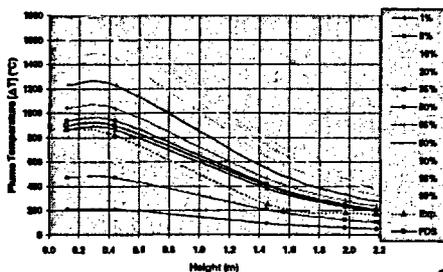
### Example: Line Fire Plume Temperature

- 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

26



### Posterior Uncertainty Distribution



27



### 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

28



### 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

29



### 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 uncertainty to arrive at model uncertainty.
- Such propagation is naturally problem and context specific, and therefore more resistant to generalization and procedural formulation.

30



### Limitations (cont)

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- 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 trees, and other physical and mathematical model of deterministic or stochastic behaviors of plant systems and operators).

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31



### Limitations (cont)

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- 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.

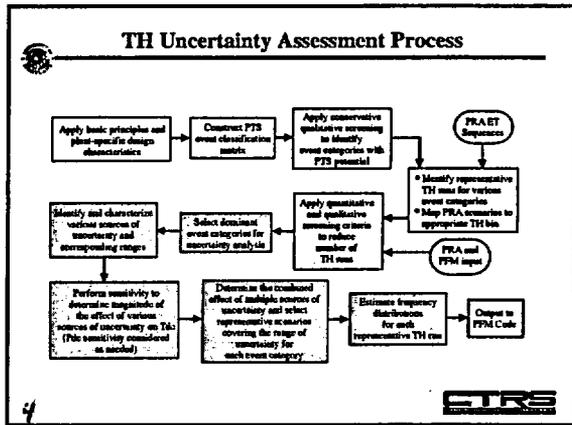
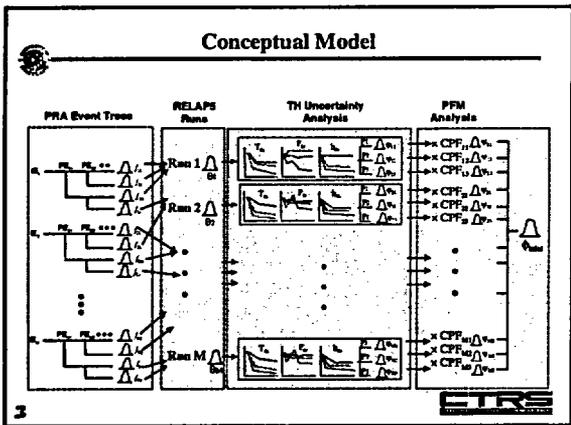
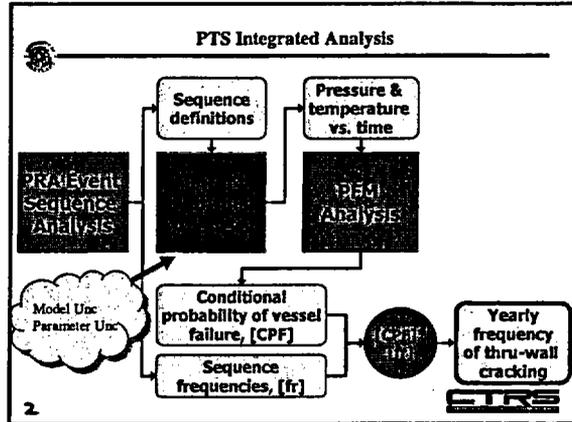
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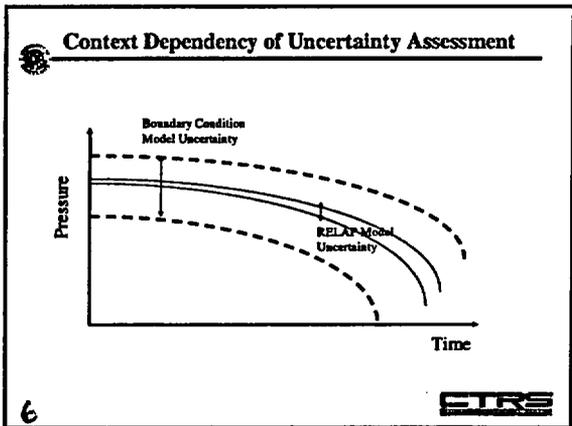


## Treatment of TH Uncertainties in PTS Risk Assessment

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

- ### 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]
- 5
- 



### 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 LP1
- 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

### Event Category Selected for TH Uncertainty Analysis

Primary Side Secondary Side Event	Event	Breach	
		Breach Size = LP Breach Area used to compensated by SFT	Breach Size = LP Breach Area used to compensated by SFT
Success		8.1e-4	8.2e-4
One SRV Success	2.7e-4	3.7e-7	6.2e-8
Two SRV Success	3.7e-8	3.8e-7	1.2e-4
Three SRV Success		4.9e-8	2.3e-4
Core Flooding Success			
Core Flooding Core Damaged	1.3e-5		

(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 assessing 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:

- FZR SRV stuck open and remains open with valve open area greater than 1.5-inch in diameter
- FZR SRV stuck open and is restricted with valve open area greater than 1.5-inch in diameter
- LOCA between 1.5-inch and 4-inch in diameter
- LOCA between 4-inch and 8-inch in diameter

### Uncertainty Sources

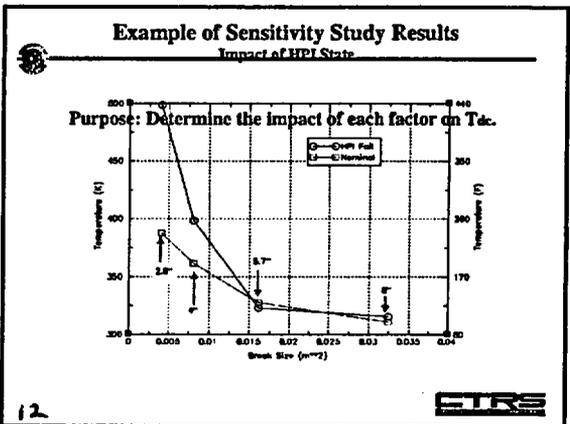
- Model Uncertainty
  - Event Sequence Modeling and Mapping to TH Runs
    - Level of Details in Event Tree Models (e.g., explicit representation of component degraded states) [Treated by adding needed details]
    - Assignment of Event Tree Scenarios → TH Bins [not treated, believe to be small]
    - 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]

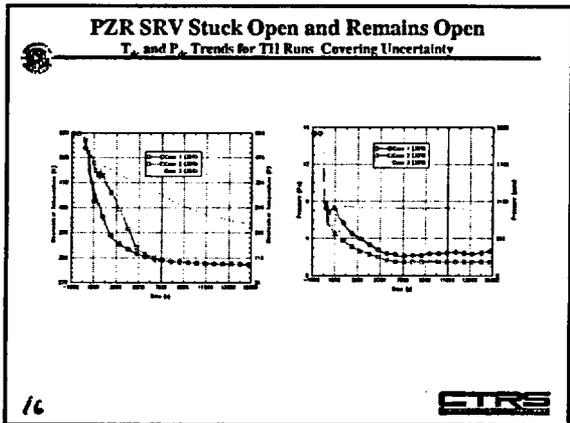
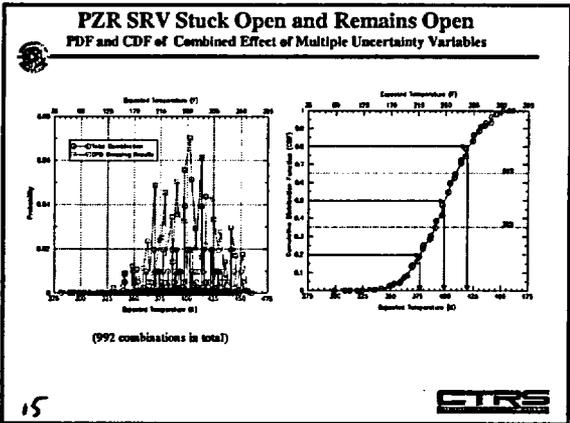
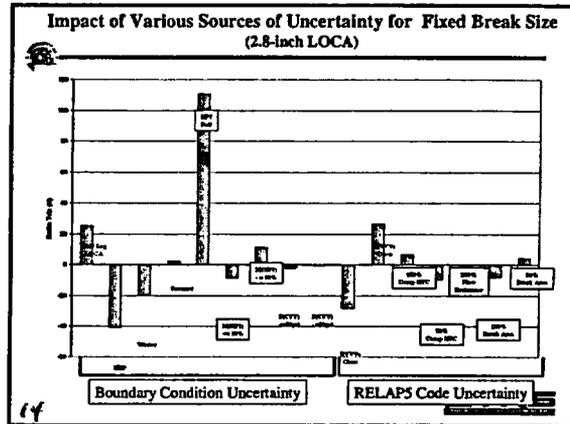
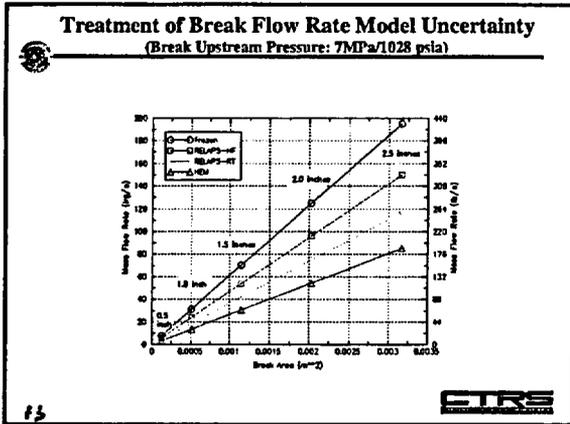
### Known RELAP5 Limitations

- 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

### Characterization of Uncertainty Sources Treated

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





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

Ali Mosleh  
Center for Technology Risk Studies

ACRS, October 10, 2003



**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

2



**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

3



**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

4



**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

5



**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

6



# Treatment of Uncertainties in Complex TH Codes

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ACRS, October 10, 2003

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)

8 

## An Evaluation of Existing Methodologies

#	General Characteristics	AAAT	CRUI	EPURA	GM	SPH	UNAE
1	Based on the number of input variables propagation	Y	Y	Y	H	H	NA
2	Building upon uncertainty ranges	Y	Y	Y	Y	Y	H
3	Assigning subjective probability	H	Y	Y	Y	Y	H
4	User P-Values	H	Y	Y	Y	Y	Y*
5	Use of response surface technique	H	Y	H	H	H	H
6	Need of specific data for testing	H	Y**	H	H	H	Y
7	Effect of errors on the results	H	Y	H	H	H	Y
8	Dimensionality of input variables parameters and output ranges	NA**	NA	NA	NA	NA	NA
9	Reduction of complete parameter values within the designated range	NA	NA	NA	NA	NA	NA
10	Support to identification and ranking of input variables propagation	Y	Y	Y	H	H	H
11	Amount for state of knowledge of input variables propagation	Y	Y-LS	Y-LS	Y-LS	Y-LS	H
12	Number of sub-step independent from within input and output	H	H	H	Y	Y	NA
13	Typical number of variables input	20-30	30	100	100	100	1-11
14	Typical number of variables output	10	10	10	10	10	NA
15	Amount for error propagation	H	H	Y	Y	Y	H

\* Y = YES  
 \*\* NA = NOT APPLICABLE  
 - All a qualitative level during code validation  
 - Expert judgment needed

9 

## Major Steps and Methods

10 

## Methodology Overview

11 

## Dynamic Behavior of Complex Code

12 

### Examples of Sub-model

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

**ETRS**

### 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

**ETRS**

### UMD Bayesian Approach to Uncertainty Quantification

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

**ETRS**

### 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

**ETRS**

### Test- Oconee1 PTS TH Uncertainty

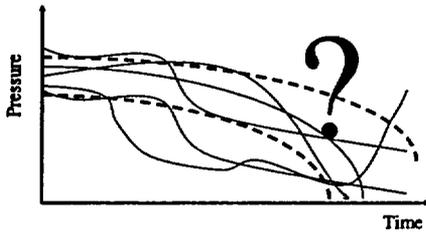
- 100 runs using TH models of PTS for Oconee-1 NPP
- Same uncertain models and parameters as in UMD PTS TH Uncertainty Method (a total of 11)
- Same range of parameter variation
- 100 unique combinations were created to achieve 95% of probability content with 95% confidence
- Results are comparable with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

**ETRS**

### Results Compared with PTS TH Approach

**ETRS**

Question of Proper Uncertainty Representation



19

ETRS

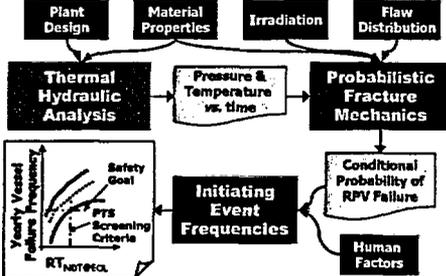
**CTRS**  
CENTER FOR TECHNOLOGY RISK STUDIES

### 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

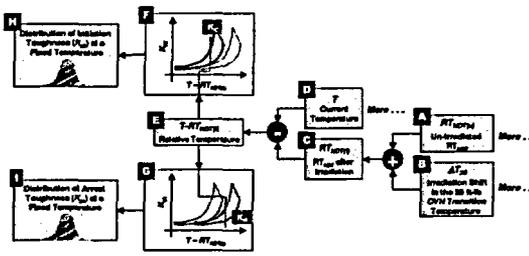


### PRA-based evaluation of vessel failure frequency Due to PTS



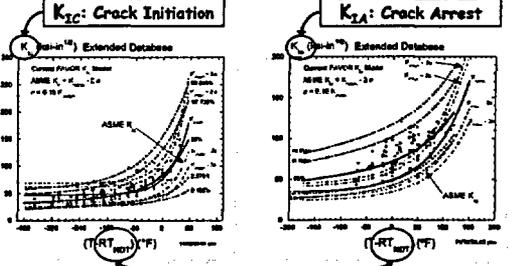
**CTRS**

### Sources of Uncertainty



**CTRS**

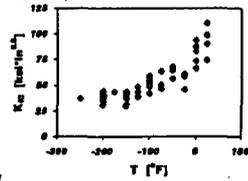
### Fracture Toughness Modeling and Uncertainties



**CTRS**

### 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



**CTRS**

### 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

**CTRS**

### Recognize Three Possible Cases

(A) physically driven  $K_{Ic}$  model with exact  $T_{0,ref}$

(B) physically driven  $K_{Ic}$  model with uncertain  $T_{0,ref}$

(C) empirically driven  $K_{Ic}$  model with uncertain  $T_{0,ref}$

CTRS

### 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

CTRS

### 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

CTRS

### 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  $T - \text{adjusted } RT_{NDT}$  (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  $(T - \text{adjusted } RT_{NDT})$

CTRS

### Probability Distribution Of RPV Fracture/Failure

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

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

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  $i^{\text{th}}$  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)

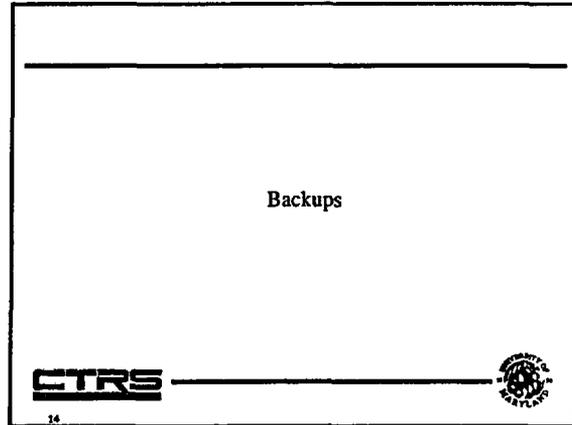
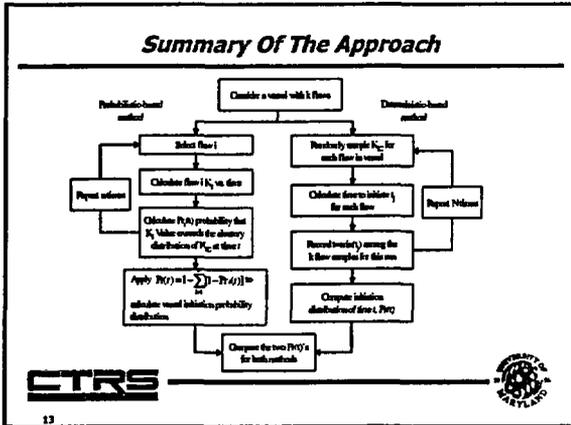
> Deterministically, we are interested in the flaw initiation at a give time during the transient given the computed  $K_I$  value: the flaw will initiate, if  $K_I > K_{Ic}$ . Record the time  $t$  at which the flaw initiates. If  $m$  out of  $n$  ( $m < n$ ) flaws initiate at different times  $t_j$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

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

> 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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### 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  $K_{fc}$
5. Correct for the flaw size

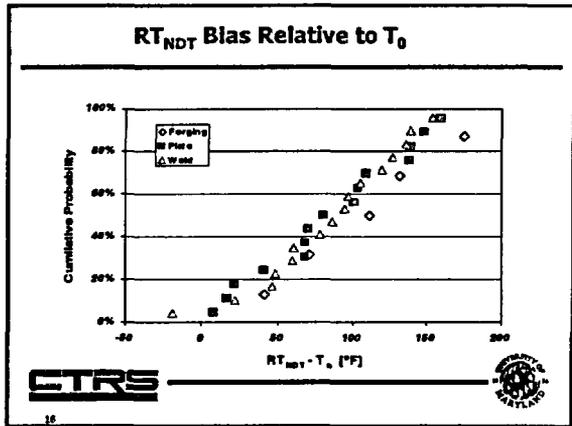
$$K_{fc} = 28.2 + 70.1 \cdot \exp\{0.0106(T - T_0)\}$$

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

$$K_{fc}(xT) = 18.2 + [K_{fc}(xT) - 18.2]^{1/4}$$

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

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

Daniel O'Neal  
Reliability And Risk Engineer  
RES/DRAA/PRAB



# LPSD PRA ACTIVITIES

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- 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**

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- 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

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- 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

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- 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

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- 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