UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

October 18, 2011

MEMORANDUM TO: ACRS Members

FROM: John Lai, Senior Staff Engineer /RA/
Technical Support Branch
Advisory Committee on Reactor Safeguards

SUBJECT: CERTIFICATION OF THE MINUTES OF THE ACRS SUBCOMMITTEE ON RELIABILITY AND PRA REGARDING HUMAN RELIABILITY ANALYSIS (HRA) METHODS AND FIRE HRA GUIDELINES ON APRIL 20, 2011, IN ROCKVILLE, MARYLAND

The minutes for the subject meeting were certified on September 7, 2011. Along with the transcripts and presentation materials, this is the official record of the proceedings of that meeting. A copy of the certified minutes is attached.

Attachment: As stated

cc w/o Attachment: E. Hackett
C. Santos

cc w/ Attachment: ACRS Members

UNITED STATES
NUCLEAR REGULATORY COMMISSION
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WASHINGTON, DC 20555 - 0001

MEMORANDUM TO: John Lai, Senior Staff Engineer
Technical Support Branch
Advisory Committee on Reactor Safeguards

FROM: John W. Stetkar, Chairman
Subcommittee on Reliability and PRA

SUBJECT: CERTIFICATION OF THE MINUTES OF THE MEETING OF THE SUBCOMMITTEE OF RELIABILITY AND PRA ON HUMAN RELIABILITY ANALYSIS METHODS AND FIRE HRA GUIDELINES ON APRIL 20, 2011, IN ROCKVILLE, MARYLAND

I hereby certify, to the best of my knowledge and belief, that the minutes of the subject meeting on April 20, 2011, are an accurate record of the proceedings for that meeting.

/RA/ Date 9/7/11
John W. Stetkar, Chairman
Subcommittee on Reliability and PRA

Certified By: John W. Stetkar
Certified on September 7, 2011

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
MINUTES OF THE MEETING OF THE SUBCOMMITTEE ON RELIABILITY AND PRA ON HUMAN RELIABILITY ANALYSIS METHODS AND FIRE HRA GUIDELINES ON APRIL 20, 2011, IN ROCKVILLE, MARYLAND

INTRODUCTION

On April 20, 2011, the ACRS Subcommittee on Reliability and PRA held a meeting in Room T-2B3, 11545 Rockville Pike, Rockville, Maryland. The purpose of the meeting was to discuss progress on the development of human reliability analysis methods in response to Staff Requirements Memorandum SRM-M061020 and fire HRA guidelines in NUREG-1921. Mr. John Lai was the designated federal official for this meeting. The subcommittee received no request from the public to make oral statements. The entire meeting was open to the public. The subcommittee chairman convened the meeting at 8:30am and adjourned at 5:29pm.

ATTENDEES

ACRS Members
John Stetkar, Subcommittee Chairman
Dennis Bley, Member
Said Abdel-Khalik, Member
William Shack, Member

ACRS Staff
John Lai, Designated Federal Official

NRC Staff
Erasmia Lois, RES/DRA
Richard Correia, RES/DRA
Susan E. Cooper, RES/DRA
Sean Peters, RES/DRA
Kendra Hill, RES/DRA
Jing Xing, RES/DRA
Julie Marble, RES/DRA
Mark Henry Salley, RES/DRA
Steven Laur, NRR/DRA
Samson Lee, NRR/DRA
Ray Gallucci, NRR/DRA
Hanh Phan, NRO/DSRA

Others
Jeff Julius, Scientech
John Forester, SNL
Stuart Lewis, EPRI
Ali Mosleh, University of Maryland
Erin Collins, SAIC

Gareth Parry, ERIN
April Whaley, INL
Kaydee Kohlhepp, Scientech
Stacey Hendrickson, SNL

SUMMARY OF THE MEETING

Major Issues discussed during the meeting are described in the following Table.

Table 1. Major Issues Discussed During the Meeting

Major Issues Discussed	
Issue	Reference Pages in Transcript
Erasmia Lois of NRC stated that the meeting today is to discuss the literature search, how it is performed and how it is being used. The development of a quantification scheme will also be discussed.	7-11
Stuart Lewis of EPRI stated that EPRI has developed a tool called “HRA Calculator” in the past to help facilitate performing a human reliability analysis and EPRI is trying to do what they can to improve the HRA methods.	12-19
Chairman Stetkar asked if the HRA calculator has been benchmarked against any operating experience, either from the nuclear industry or from other industries. Stuart responded that they have not tried to do any sort of benchmarking.	14
Member Shack stated that the recent Point Beach EPU project used the EPRI HRA Calculator with a new human dependencies model to calculate the changes in reliability associated with the power uprate. There were rather dramatic changes in some human error probabilities. Stuart stated that he was not aware of the results but he realized that dependencies were treated in a very simplistic fashion in the old IPE study.	19
April Whaley of INL discussed the literature review process. She stated that the process was examined by an internal peer review and it was recommended to include additional depth. She discussed the concepts of macrocognitive functions, proximate causes (PCs), and performance influencing factors (PIFs).	22-78
Chairman Stetkar asked if the macrocognition “framework” replaced the Information-Decision-Action (IDA) framework that the staff discussed at the previous Subcommittee meeting. April replied that for human cognition, it replaced IDA.	27-28
Chairman Stetkar asked why a relatively large number of proximate causes need to be considered for the "failure to act" macrocognitive function (slide 16), compared with other complex cognitive functions. April Whaley of INL and John Forester of SNL stated that the staff is still refining the final list of proximate causes for each macrocognitive function. They will consider the comment that the current list may place too much emphasis on details for the "failure to act" function.	33-35

Members and NRC contractors discussed the list of PIFs (slide 18) including safety culture, morale, and motivation. The list is preliminary in nature and the staff is still working to identify the relevant items.	38-52
Chairman Stetkar asked how the situation performance influencing factor accounts for the preceding human behavior in the scenario. April Whaley stated that it is part of the task of the qualitative analysis and the crew response tree. It will be discussed later.	53-54
Chairman Stetkar asked if the schedule concerns may hinder the development of other literature research areas such as sensemaking/understanding, coordinate/communicate. Staff responded that they will take that as a consideration.	74-77
Gareth Parry of ERIN Engineering and John Forester of SNL discussed Crew Failure Modes (CFMs) and Crew Response Trees (CRTs) and showed an example of how the trees were constructed using the results from the framework developed by INL.	79-159
Chairman Stetkar asked if the framework would apply to conditions other than internal events. Gareth and John replied that it would.	87-91
Chairman Stetkar commented that the decision points in the CRTs now are focused on procedures. One may also need to consider actions beyond procedure-related events. Gareth stated that sequences of decisions or steps which lead to failures will be considered in the CRTs. Member Bley also commented that these should be decision points in the CRTs.	97-103
Chairman Stetkar asked if the PIFs only make the analyst aware of important factors that affect the specific CFM or if they are actually quantitative branch points. Gareth Parry replied that they are not quantitative branch points. They are really designed to help the analyst determine whether the particular PIF category is applicable for the Human Failure Event (HFE).	107-108
Member Bley commented that in showing the process of associating PCs with CFMs, the process looks like a search mechanism to find a number of HFEs. Gareth Parry agreed with that observation.	130-131
Member Bley commented that there is no mention of operator or crew variability in the study. Gareth Parry stated that the CRT does not address this variability. He thinks that the expert panel may be able to address this issue.	158-159
Member Bley asked if the methodology can be applied to new reactors, passive reactors, and small modular reactors. Erasmia Lois replied that the overall framework should be adaptable.	159-160
Chairman Stetkar commented that he had some concerns about whether or not all the literature reviews can be brought together in the timeframe that staff has presented. For example, regarding the qualitative and quantitative assessment of uncertainty, he believes that there is still quite a bit of development which needs to be considered.	162-163
Susan Cooper of RES stated the purpose of the Fire HRA presentation and briefly discussed the topics for the presentation.	170-196

Member Bley asked if this methodology (Fire HRA) will be consistent with the framework discussed in the generic HRA presentation. Chairman Stetkar commented that this project is primarily a schedule-driven effort to support the fire analyses for transition to NFPA-805, while the other project is a more comprehensive evaluation of the overall HRA process.	175-176
Erin Collins of SAIC stated that they certainly implemented some of the HRA guidelines in their fire PRA work. There were eight plants at this point in time that have used some elements in the document.	182-184
Jeff Julius of Scientech and Erin Collins of SAIC summarized the reviews, tests, public comments, and changes in the fire HRA guidelines.	196-250
Chairman Stetkar stated that the guidelines reference the ANS/ASME fire PRA standard and specific sections of NUREG/CR-6850 but do not reference Reg. Guide 1.205, NEI 04-02, or NEI 00-01. These documents especially provide guidance in the area of treating fire-induced multiple spurious operations.	199
Chairman Stetkar stated that the fire HRA guidelines indicate that one, and only one, spurious instrument signal needs to be considered to meet Capability Category II of the ASME PRA standard. However, NEI 04-02 and NEI 00-01 don't have limits on the number of simultaneous spurious operations. How does the staff reconcile this situation?	240-249
John Forester of SNL and Erin Collins of SAIC described the qualitative analysis.	251-271
Chairman Stetkar stated that the integration of safety (e.g., fire damage) and security (e.g., operator access) should be considered in the HRA. Staff stated that this has been incorporated as an example in the training course and it should be added in the guidance document.	259-261
Chairman Stetkar asked why Appendix D for self-induced SBO is necessary. Staff stated that it was carried over from the previous version.	272-280
Stacey Hendrickson of SNL presented the scoping quantification approach.	281-325
Chairman Stetkar asked why in the guidance one can basically ignore other things that are happening in the control room (e.g., fire effects on non-safety related SSC's) as long as they are not directly related to the specific HFE that is being evaluated. John Forester replied that there is a multiplier used in this situation.	287-289
Chairman Stetkar stated that the guidance document does not mention the treatment of uncertainties in the available time margin. Stuart Lewis of EPRI stated that there may be other things to consider besides the uncertainties.	297-304
Chairman Stetkar discussed with the presenters how one models control room abandonment. Staff and NRC contractors explained that the basic concepts are in the scoping analysis of the guidance document.	310-325

Jeff Julius of Scientech discussed the EPRI approach for detailed fire HRA methods.	326-334
Member Bley mentioned that control room manning is assumed at the minimum but the guidance was not clear. Member Shack confirmed that statement in Table B-16.	330
Erin Collins discussed the subject of recovery, dependency, and uncertainty analysis.	337
Chairman Stetkar and the presenters discussed different kinds of recovery actions in the context of NFPA-805 and PRA. Staff will consider adding a discussion of recovery back into the guidance document.	338-343
Chairman Stetkar asked how human dependency is identified in the cutsets. Erin Collins said if one would artificially set the failure probability to a high number (e.g., 0.9), the dependencies will show up.	344-349

Table 2. Action Items

ACTION ITEMS	
Action Item	Reference Pages in Transcript
Periodically update the status of HRA methodology development with the PRA Subcommittee in December 2011	164
Fire HRA team may consider another subcommittee meeting before meeting with the full committee.	363-364

BACKGROUND MATERIALS PROVIDED TO THE SUBCOMMITTEE

1. Erasmia Lois, et al, ”Building a Psychological Foundation for Human Reliability Analysis,” March 2011(ML110830445)
2. “Updates to EPRI/NRC-RES Fire HRA Guidelines”, Presentation to PSA2011, March 2011 (ML110830624, ML110680224)
3. Revised Draft NUREG-1921,”EPRI/NRC-RES Fire Human Reliability Analysis Guidelines”, March 2011(ML110960175).

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NOTE:
Additional details of this meeting can be obtained from a transcript of this meeting available in the NRC Public Document Room, One White Flint North, 11555 Rockville Pike, Rockville, MD, (301) 415-7000, downloading or view on the Internet at http://www.nrc.gov/reading-rm/doc-collections/acrs/ or it can be purchased from Neal R. Gross and Co., 1323 Rhode Island Avenue, NW, Washington, D.C. 20005, (202) 234-4433 (voice), (202) 387-7330 (fax), nrgross@nealgross.com (e-mail).

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Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

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Docket Number: (n/a)

Location: Rockville, Maryland

Date: Wednesday, April 20, 2011

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UNITED STATES NUCLEAR REGULATORY COMMISSION'S ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, as reported herein, is a record of the discussions recorded at the meeting.

This transcript has not been reviewed, corrected, and edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARD

(ACRS)

+ + + + +

RELIABILITY AND PRA SUBCOMMITTEE

+ + + + +

WEDNESDAY

APRIL 20, 2011

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ROCKVILLE, MARYLAND

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The Subcommittee met, at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., John Stetkar, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

JOHN W. STETKAR, Chair

SAID ABDEL-KHALIK

DENNIS C. BLEY

WILLIAM J. SHACK

NRC STAFF PRESENT:

ERASMIA LOIS

SEAN PETERS

MARK SALLEY

SUSAN COOPER

RAY GALLUCCI

THERON BROWN

ALSO PRESENT:

STUART LEWIS

APRIL WHALEY

JOHN FORESTER

ERIN COLLINS

JEFF JULIUS

STACEY HENDRICKSON

C-O-N-T-E-N-T-S

C-O-N-T-E-N-T-S (CONTINUED)

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

8:39 a.m.

CHAIR STETKAR: (presiding) The meeting will now come to order.

This is a meeting of the Reliability and PRA Subcommittee. I am John Stetkar, Chairman of this Subcommittee meeting.

ACRS members in attendance are Dennis Bley, William Shack, and Said Abdel-Khalik. John Lai of the ACRS staff is the Designated Federal Official for this meeting.

The Subcommittee will discuss the development of human reliability analysis methods as well as the revised Human Reliability Analysis Guidelines in NUREG-1921. We will hear presentations from the NRC staff, EPRI, and NRC contractors.

There will be a phone bridge line. To preclude interruption of the meeting, the phone will be placed in a listen-in mode during the presentations and Committee discussions.

We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting. The entire meeting will be open to public attendance.

The Subcommittee will gather information, analyze relevant issues and facts, and formulate

proposed positions and actions as appropriate for deliberation by the full Committee.

The rules for participation in today's meeting have been announced as part of this notice of this meeting previously published in The Federal Register.

A transcript of the meeting is being kept and will be made available as stated in The Federal Register notice. Therefore, we request that participants in this meeting use the microphones located throughout the meeting room when addressing the Subcommittee. The participants should first identify themselves and speak with sufficient clarity and volume so that they may be readily heard.

We will now proceed with the meeting, and I call upon Dr. Erasmia Lois of the NRC staff to begin.

Erasmia?

MS. LOIS: Thank you.

I believe that Sean Peters, my Branch Chief, has some opening remarks.

MR. PETERS: Yes. I am Sean Peters. I am the Branch Chief for the Human Factors and Reliability Branch and the Office of Nuclear Regulatory Research, Division of Risk Analysis.

I would like to wish everybody a good morning. I would like to thank everybody here in attendance.

As we understand, this is our attempt to answer SRM-M061020 which told the ACRS and the staff to work together to identify either a single model for the agency to use or a set of models to use in specific circumstances pertaining to reliability analysis.

The team I would like to thank for persevering through this difficult task. I would like to thank the NRC staff, our contractors, Idaho, Sandia, the University of Maryland. And I would also like to thank our members from the Electric Power Research Institute who also are supporting this project.

I would also like to thank the ACRS for its participation and advice and consent. We hope to use the feedback that the ACRS gets to develop the best possible approach to answering the SRM.

And with that, I would like to pass it over to Erasmia.

MS. LOIS: Thank you.

My intro slides are also going to be kind of flashcards because I just reminding the Committee

members of some of why we are here and what we are doing.

I would like to note that we have changed the agenda a little bit. We had originally on the agenda Dr. Mosleh from the University of Maryland to present an overview of the methodology. But last week at Sandia we decided that, for the sake of time, we don't need the review, and, then, we proceeded without the overview from Dr. Mosleh.

So, I am going to cover background, what we tried to achieve, what is our current scope and focus, the interactions we have with the ACRS, what we are trying to achieve today. I will cover milestones and, then, what are the anticipated users.

This is SRM. I don't need to read it to you again.

RES has the initiative to address the SRM. We decided, since this is an SRM to ACRS, we are going to have input from the ACRS through periodic meetings. And it is an effort which is done collaboratively with EPRI.

We believe that the SRM is directing the staff to develop a single method, if possible, and if not, it should be justified why not, why more than one, what method should be used when, and, then,

provide implementation guidance for each one of the particular methods for the application. And, also, the SRM expresses desirability for convergence of NRC and industry methodology.

Our aim is to establish a consensus approach by developing a single high-level method and structure that ensures consistency throughout the analysis process, to be of sufficient generality to support application for the different domains, recognizing that the specific domain's needs could be addressed by modifying or expanding the methodology for the specific applications. And also, one of the aims of this work is to be developed by gaining acceptance by both PRA, HRA, and human factors experts and practitioners.

We started by developing the method for a detailed internal event analysis at power, and collaboratively with EPRI, we hope that that will be an approach that is going to be adopted by both the NRC and the industry.

And also, as part of this project, also, there is an aim and emphasis for adapting the methodology on event evaluations to support significant determination process or other risk-informed applications related to event evaluations.

In the future, we will expand to other reactor hazards and the new reactors.

We have periodic meetings with the PRA Subcommittee. Now we met twice last year, and this is the first this year.

In the October meeting, we presented a basis and the rationale for what we call a hybrid approach which we are pursuing. The basic features of the hybrid was an updated technical basis by performing a cognitive psychology literature review, the use of explicit links of the literature review findings to create underlying frameworks to model human performance through those explicit connections, and, then, develop a quantification scheme that reflects the improved qualitative analysis and guidance.

The Subcommittee requested for the next, which is today's meeting, a briefing that provides a clearer picture of the literature review, a discussion of the breadth and depth of the literature search, and, also, the discussion of how the literature search results are incorporated in the hybrid method being developed.

So, then, with that, what we are going to do today is to discuss the literature search, how it

was performed, the findings, and how it is being used, because its use is going to be incorporated by presenting the quantification scheme being developed. And therefore, we are going to present an example or an outcome of thoughts of incorporating the literature research results in the quantification.

We would like to have feedback from the Subcommittee and, also, plan for the next meeting.

This slide covers the milestones presented in quarters. I think the first five bullets indicate that we would like to have the technical work being done by the December of 2011. Then, next year, in 2012, go through the testing and trial applications and, also, extend a review and feedback. Then, in 2013, go through the publication -- I'm sorry -- public review period and publication efforts.

The anticipated uses of this work is to support NRC. It is confirmed activities. Some of those are guidance for review and risk-informed licensee requests, event evaluations, and new PRAs. We anticipate that the methodology is going to be used by the industry as well for similar applications.

With that, I will let Stuart Lewis, who is representing EPRI, to have some introductory words, unless there are any questions.

MR. LEWIS: Good morning.

My name is Stuart Lewis. I manage the risk and safety management program at the Electric Power Research Institute. I just want to take a couple of moments to very briefly update you on our perspective as to what I guess is the external stakeholder movement the staff is directed to work with on this project, and remind you why it is we are participating and what it is we hope that we will gain from our involvement.

Just very briefly, to summary from our perspective the state of HRA as it exists within the industry. Most of the nuclear industry currently uses HRA methods that were developed by EPRI back in the late 1980s and early 1990s. Since that time, we haven't spent much time actually developing new methods. We have put a lot of effort into developing guidance to use those methods, but primarily what we have out there are two complementary approaches with respect to -- and these only address the assessment of human failure events in the cognitive phase for post-initiator events. So, in other words, they don't address things like leaving equipment unavailable due to errors in maintenance or testing. And again, this is analogous to the scope of the work we are doing

within the SRM response.

We have two approaches. One is a time-based correlation that has the awkward title of human cognitive reliability with operator reliability experiments. The other one is a complement to that is a caused-based decision tree approach that attempts to identify the reasons the operators might fail to take some action, and especially when those reasons don't have much to do with the amount of time available.

These methods, as well as some other methods, are incorporated into a piece of software that we call the HRA Calculator that is very widely used in the industry.

The primary intent behind developing the HRA Calculator in the first place was to improve the level of consistency among different analysts. It has always been the case I think in human reliability analysis that, if you put five HRA analysts in a room and ask them to attack a problem, you would get at least five different answers.

One of the main objectives of using the Calculator was to eliminate some of the variability that comes from using some of the approaches that are out there now.

We have also done some limited methods

development work, particularly in the area of treating dependencies among human failure events that are relevant following an initiating event. That is an area that hadn't been studied very extensively in the past, and we have developed models that are based primarily on engineering judgment and, then, a logical assessment of the situation and appear to do a reasonable job of treating dependencies, given the state of the methods we have got to work with right now.

CHAIR STETKAR: Stuart, when you say "do a reasonable job", are you trying to benchmark it against any operating experience, either from the nuclear industry, which is rather thin in terms of dealing with complex, evolving-type scenarios, but from other industries, you know, that have experience from highly-trained professionals dealing with accidents?

MR. LEWIS: We have not tried to do any sort of benchmarking like that. I think that there is, obviously, more extensive experience in other fields. It is not quite as widely reported as the experience in the nuclear industry, which, as you point out, doesn't provide a lot of data on an overall basis for benchmarking.

So, again, it comes down to whether we believe that the results we are getting appear to be reasonable reflections of the scenario, but, obviously, that is something we would love to do if we had the opportunity to collect that kind of data.

Since our own project will have the same issue, we will to deal with the same sorts of dependency considerations. We think that, as you will eventually hear, we have some concepts in there that will make the dependencies more straightforward and more objective than they might be now. But, like everything else, we are doing the best we can with what we have got, I guess.

MEMBER BLEY: Stuart, I have a followup on that. But before I do, Mr. Chairman, I forgot to mention at the beginning I have no organizational conflict of interest, but I do have a technical conflict of interest on some of the items that will be discussed today. I will not participate in our discussions on those issues.

But on your last comment, are not some of the methods you have described here involved in the international empirical study, which is a benchmarking kind of exercise?

MR. LEWIS: It is, but up to this point at

least it really hasn't looked very much at dependencies, the treatment of dependencies in human failure events. There may have been a limited look at the experiment s done in Halden, but I don't think it provides very much to allow us to benchmark how we look at a broad range of potentially-dependent nuclear failure events.

MEMBER BLEY: I think that is an important point. That is good to remember. Thanks.

MR. LEWIS: I want to point out that currently the HRA Calculator is in use at every utility in the U.S. and several outside the United States. We think at this point that, through the training we have done, we offer at least two opportunities every year for utility engineers, and recently we have had quite a bit of involvement from NRC staff as well in our training to understand how the tools and methods should be used.

We think that they are used effectively in performing PRAs and risk applications, but we recognize, as I said, that the methods themselves are 20 years or more old at this point. And even when they were developed, there was an expectation that that wouldn't be the last word, that there would be additional work time. We may be a little longer

getting around to that than we have visioned when those reports were written back in the late eighties and early nineties, but I guess there is not much we can do about that at this point. So, we are trying to do what we can to improve what we have got.

I would point out that one of the activities we have been involved in in terms of the developmental project has been the development of the fire HRA guidance that you will hear about this afternoon. That has been a fairly extensive effort on our part over the last five years or so, before my time at EPRI. It has been going on quite a while.

So, why are we interested as an external stakeholder in participating in this project? Essentially, what we would like to do is take advantage of the significant resources the NRC has put into the project and take advantage to the extent that we can in approving the way we do business.

I think in participation or through our participation we have seen an effort to move more and more toward a practical at least interim solution to this issue that was posed by the SRM, something that we can incorporate into current PRAs without fundamentally restructuring the way we do PRA, which may ultimately be the right thing to do, but it is

probably not feasible in the next few years, given the number of applications and the widening range of uses people make currently in PRAs. But we do think that, as you will hear, we are using some of the basic concepts through the cause-based decision trees in modeling what is going into this project, merging that with concepts from ATHEANA and other projects, to try to provide a more comprehensive model for HRA.

We think that the work that has been done in support of the SRM provides a stronger underpinning from the cognitive psychology world than we have in at least the methods we have used in the past, and in a way that we can, I think, use in a practical approach.

And we will update the way we do the quantification process, as you will hear later on when Gareth and John Forester talk.

So, we want to take advantage of this work to the extent we can to update our methods. We also think there is a benefit to the industry being engaged with the NRC in developing methods that you are going to use. So, we think that that is to everybody's benefit if we are on the same page, understand how the methods are formulated, where their weak points might be, and how they might be used in risk-informed applications, and in things like the significance

determination process going forward. So, we think there are benefits in both areas for us. That is primarily why we are engaged to the extent that we are.

I will, just to wrap up, say that I think that right now we are on a track that we think depends on proven methods, incorporates some useful concepts, and puts it ahead toward a very useful product going forward, one that will help us understand better not only the basis for the numbers that we generate, but the causes for the events that we evaluate.

So, with that, if you have any questions, I would be happy to try to answer them.

CHAIR STETKAR: Thank you.

MEMBER SHACK: Just one. We saw an EPU recently for Point Beach in which they used EPRI Calculator with the new human dependencies models to calculate the changes in reliability associated with the power uprate. They had some rather dramatic changes in reliability due to the way that the dependencies shifted.

I just wondered if you had looked at those results and those seemed what you had intended from the Calculator?

MR. LEWIS: I haven't seen the Point Beach

results. So, I can't comment on those specifically. I know that in the IPE days most plants submitted PRAs that treated dependencies in a very simplistic fashion. Sometimes they ignored them altogether.

(Laughter.)

CHAIR STETKAR: Yes, that was sort of the baseline.

(Laughter.)

MR. LEWIS: In other cases, they might have assumed, for example, in particular scenario they would take credit for only one human failure event or human action and assume everything else was completely dependent. That was less common, but there were some IPEs that did that. So, this has been kind of an evolving story since that time.

So, I don't know what their results are dramatically different from, what the baseline they were comparing to might be. But, even if these were in one of those first two camps, they could look a lot different now using our dependency approach than they would have before.

CHAIR STETKAR: You know, it may be a case -- and I don't know, I didn't look at the EPU -- it may be a case of going, as Stuart said, from limited treatment using subjective --

MEMBER SHACK: That was changing the methods.

CHAIR STETKAR: Yes.

MR. LEWIS: That was probably the case then.

CHAIR STETKAR: It might be both changing the methods and, because of the power uprate, reducing times and increasing whatever --

MEMBER SHACK: The big change seemed to come from the dependencies.

CHAIR STETKAR: In the dependencies?

MS. LOIS: Wait a minute. Let me find it.

CHAIR STETKAR: It could be from zero or minimal treatment to some treatment.

MR. LEWIS: Right. Most of the other EPU PRAs I have seen, the change in timing has a relatively small impact, but if you change overall approaches, that could certainly happen, significant impact on the results.

CHAIR STETKAR: Why don't we go offline here while you guys try to fix the problem, so we don't have all of the peripheral discussions on the record?

(Whereupon, the foregoing matter went off the record at 9:03 a.m. and went back on the record at

9:07 a.m.)

CHAIR STETKAR: Okay. We are back in session.

I guess, April, you are up.

MS. WHALEY: Good morning.

My name is April Whaley. I work in the Manufacturers' Controls and Statistics Department at Idaho National Laboratory.

I am going to be presenting on the literature review work that we have been doing in support of this project.

Basically, what I am going to cover today is I am just going to do a quick overview of the literature review process that we have used. I am going to overview the concept of macrocognition and why we have included that in our methodology. I am going to discuss how we structured the results of our literature review. Then, I am going to go into some specific details on the results from the detect/notice portion of our literature review. Then, I will just cover the wrapup, conclusions.

So, this literature review process that we have been doing, it has been a long process.

(Laughter.)

Literature reviews could go on forever.

But what we are doing, we are trying to provide a psychological basis for the hybrid methodology that we are developing and incorporating current understanding of human performance in the methodology. A lot of the psychology that is involved in HRA methods to date is 1980s or older psychological theory. So, we wanted to bring things up-to-date.

And this process is also producing a tool, a cognitive framework that helps identify errors, human errors, causes for those errors, and linking those to performance-influencing factors, or PIFs.

MEMBER SHACK: Which are different from performance-shaping factors, PSFs.

MS. WHALEY: Yes. Yes, and the difference is that PIFs take into account situational and plant status and influencing factors rather than just only things that affect human performance, such as stress or fatigue. It is a little broader, a broader net.

And the results of the literature review are being used to inform the development of the qualitative and the quantitative approach.

So, the process that we have been using has gone through two major stages. The first one, the first stage was an initial literature review in which we took this kind of a bottom-up approach where we

went to see, what is the literature going to tell us? Rather than having a particular model in mind, we just went to see what the literature would tell us and let the information percolate up from there. And we were looking for psychological processes of mechanisms that can lead to failure.

Once we reached a point where we felt we had made adequate progress at that, we stopped and we did a lot of work developing this cognitive framework. And we incorporated macrocognition. We did a lot of structuring and organizing of the results and developed the proximate causes of human failure.

This process, then, went through an internal peer review where we had internal NRC and INL stakeholders review our literature review to see had we covered the right areas. The results of that literature review said, yes, you have covered the right areas, but you need more depth. You need a little more diversity within those areas to support the framework that we had developed.

So, we commenced stage two. This stage we did a targeted review to support the cognitive framework that we have developed.

This is an excerpt of the areas that we have looked at. This is a very, very broad and

comprehensive literature review. Any one of these areas could be the topic of a dissertation. So, this is pretty broad-sweeping.

We have covered areas, research on macrocognition, sensation perception, attention, situation awareness, crew coordination, decisionmaking, and, then, human performance errors such as slips and lapses and errors of commission, and other related concepts.

CHAIR STETKAR: April?

MS. WHALEY: Yes?

CHAIR STETKAR: Be careful with the microphone there.

MS. WHALEY: Yes.

CHAIR STETKAR: I was trying to look forward, ahead in your slides. I know you are going to spend some time on the detect/notice function because that is the furthest along in your work. Are you going to talk about the other four basic functions at all?

MS. WHALEY: I will highlight them and just explain kind of what they are. But I am not going into any depth on the results from those because the results are still in progress.

CHAIR STETKAR: Let me ask the question

now, then, as I read through the material, I know that you added the failure-to-act function or on this slide the action function --

MS. WHALEY: Yes.

CHAIR STETKAR: -- as something that didn't derive directly from your literature search, is that true?

MS. WHALEY: That is true.

CHAIR STETKAR: Okay.

MS. WHALEY: Yes, and I have slides to this point later on.

CHAIR STETKAR: You do? Okay.

MS. WHALEY: Yes.

CHAIR STETKAR: I will wait then. Thanks. I didn't see them. So, continue. Thanks.

MS. WHALEY: Okay. Yes. Okay.

All right. So, now I am going to just overview macrocognition and why we have incorporated it into our model. Macrocognition is originally a term coined to describe cognition in real-world settings rather than in research laboratories.

A lot of the psychological research is done in universities with college students in research labs with very tightly-controlled variables. That type of research has been coined microcognitive

because it is looking at very targeted, narrow aspects of human cognition.

Macrocognition, on the other hand, looks at what do people do in real life? What people do in real-world settings, and how does human cognition play out there? It is a broader scale.

So, in macrocognition, decisions are often complex. They have to be made quickly. They are being done by domain experts or well-trained personnel rather than novices for the most part in situations that have real consequences.

So, the macrocognitive functions are the high-level activities that must be successfully accomplished to perform a task or achieve a goal in this naturalistic environment.

And the reason why we included macrocognition in our methodology is that it provides us a useful structure for organizing the literature review process and the output. And it is more suited to the nuclear domain than trying to assemble all of these very small models that are focused on only one narrow aspect of cognition. So, we are incorporating it because it is useful.

CHAIR STETKAR: And this framework, if I can call it a framework, essentially replaces the IDA

framework that we heard about in previous briefings?

MS. WHALEY: Yes. For human cognition, yes, it replaces the IDA. We are still using IDA when we are talking about types of tasks in terms of a task decomposition. But when we are looking at the actual cognitive framework, we are using the macrocognitive because of the assumptions that are a part of the macrocognitive framework versus IDA. IDA assumes a linear process; macrocognition dose not.

CHAIR STETKAR: I know not in your presentation, but I will ask Stuart, since he is the only one up there I can ask, in the later discussion about the quantitative approach, are we going to hear anything about how these concepts are merged or replaced or whatever?

MR. LEWIS: Yes.

CHAIR STETKAR: Okay. Thank you.

MR. LEWIS: Gareth Parry and John Forester will both go interactively --

CHAIR STETKAR: Okay. Because, as I was reading through the discussion on the macrocognitive sort of framework, I was trying to think about, does this mean sort of throw out IDA and replace with this, and how is that done? So, I am glad we are going to hear a little bit about that because that is sort of

the practical end of how it is going to work.

Thank you.

MS. LOIS: So, the other team members, Dr. Mosleh, Dr. Forester, and Dr. Parry could also answer some questions.

CHAIR STETKAR: Okay. Good. We will hold those until we hear that part of the presentation.

MS. WHALEY: Okay. There are a number of different models of macrocognition. The reason this is the case is because neurocognition is a continuous process. Different researchers divide that spectrum of human cognition up slightly differently. There is not one agreed-upon or official list of macrocognitive functions.

But, in speaking with some macrocognitive researchers, there is a general consensus at a very high level that key generic macrocognitive functions include detecting or noticing problems, making sense or understanding what those problems mean, making plans and adapting and making decisions about how to respond to this situation, and, then, communicating and coordinating with other people.

So, various different macrocognitive researchers might quibble about some of the details and exactly where you draw the line, but most of them

would agree kind of at a high level these are the key macrocognitive functions.

It is important to note that these macrocognitive functions are not assumed to be orthogonal or dependent. They are not linear or serial. They kind of function in a continuous loop. And people typically have to accomplish all of these at the same time, all or most of these functions at the same. So, it is not something that is very easily chopped up into boxes.

The macrocognitive functions and the models that we reviewed were not developed for the nuclear power plant domain. A number of the models were developed based on research with NASA and space shuttle missions or work with firefighters and policemen or military applications.

And there are aspects of the nuclear environment hat are unique. There is the highly-proceduralized environment. The procedures provide predefined goals and plans, so there may be less planning and trying to figure out what to do about an event when you have the procedures to tell you.

And HRA has been concerned with errors in action implementation, among other things. But, traditionally, yes, HRA wants to know what is the

probability that people are going to push the wrong button. This is not something that macrocognitive functions have been doing research on or macrocognitive researchers have been research on. They are focused more on the internal cognition.

But for HRA purposes, we still need to address this because this is a question that is relevant. So, because we need to kind of tailor the macrocognitive research to the nuclear domain, that is why we added action.

And there is some research out there about human performance errors. It is a slightly different type than a lot of the cognitive research, but we are working on integrating that into our model.

We also condense planning into decisionmaking, and not because we don't think planning is not important or relevant, but because of the highly-proceduralized nature of nuclear power plant operations, that seems to be a smaller area and can be more easily collapsed into decisionmaking.

So, these macrocognitive functions serve to guide and structure the output of the literature review and to structure the cognitive framework that we built from the literature review results.

CHAIR STETKAR: Now I am going to ask the

question.

MS. WHALEY: Okay.

CHAIR STETKAR: As you know, historically, human reliability analysis has focused rather heavily, if we go back to Swain and Guttman and the early guidance, on the manipulation of pieces of equipment; is this is a round knob versus a square button; is it a horizontal display versus a vertical display. It has not done very well in evaluating cognition --

MS. WHALEY: Yes.

CHAIR STETKAR: -- which is why we are sitting here.

You have added this action because of the historical focus of nuclear power plant PRA on the push-a-button, turn-a-handwheel-type activities. I guess I sort of understand that, but when I look at the list of your five functions, and I step down to he next level where I look at your delineation of proximate causes for each of those functions, which is something that I, as an analyst, need to start thinking about, I notice that the failure to detect function lists three proximate causes; the failure of sense-making understanding lists two; the decisionmaking lists four; the failure to coordinate lists three, although you admit that that is not

1 necessarily quite complete yet. But the failure to
2 act lists five.
3 MS. WHALEY: Yes.
4 CHAIR STETKAR: More approximate causes
5 are listed for that failure to act than anything else,
6 which means to me I need to pay more attention to that
7 than anything else. Could you explain why? Given the
8 fact hat I have gone through this horrendous process
9 to determine what I need to do, why do I need to spend
10 so much time determining whether or not I push the
11 right button, that what I call implementation of that
12 decision process?
13 MS. WHALEY: Yes, that --
14 CHAIR STETKAR: It seems a bit unbalanced
15 to me.
16 MS. WHALEY: And that is a very fair
17 question. The short answer to that is that we are
18 still working on that section.
19 CHAIR STETKAR: Okay.
20 MS. WHALEY: And I would not surprised if
21 there are some additional revisions there. I would
22 agree with the sentiment that the cognition is more
23 important in terms of where the errors most often
24 happen, and the errors that are unrecoverable happen
25 when people have wrong understandings of what is going

on.

So, I expect that the sense-making understanding is probably going to expand.

CHAIR STETKAR: I was just looking at that relative balance in the sense of analysts, what type of guidance are we giving to analysts in terms of where they spend their resources in terms of value-added for their limited time and money and things like that.

MS. WHALEY: Yes.

CHAIR STETKAR: And it just seemed a bit unbalanced. Now it doesn't necessarily mean that we need to expand the number of proximate causes in the other areas to 10 or 12 --

MS. WHALEY: Oh, yes.

CHAIR STETKAR: -- because that also has a distinct effect on the poor analysts who are trying to do this.

MS. WHALEY: Yes, that is a very fair comment.

CHAIR STETKAR: You may want to consider that.

MS. WHALEY: Yes, we will consider that as we continue our revisions on this.

MS. LOIS: John Forester would like to --

CHAIR STETKAR: I'm sorry. John, you're quiet.

MR. FORESTER: This is John Forester from Sandia Labs. I would just like to comment that the proximate causes that come out of the literature review, you know, they identify these cognitive mechanisms that we see that under certain conditions could lead to failure. Well, when you begin to look at those for the different type of macrocognitive functions, the proximate causes are sort of given by the nature of the cognitive mechanisms. They suggest what the consequences of the failure of those mechanisms would be or how that behavior, the cognitive behavior would become manifest in the environment.

So, what the literature gives us tells us these are the ways that the failure could occur. That doesn't mean all those ways are necessarily important or that, with some thought, you can't collapse some of those and address several of them in one set of questions.

So, again, that is what the literature gave them. Our next step, then, is to use that information in a way that is practical and gets at the right questions and answers, but doesn't necessarily

have to address each and every one.

CHAIR STETKAR: Okay. Thanks.

MR. FORESTER: Sure.

MS. WHALEY: So, moving on, we had this very extensive literature review that produced hundreds of psychological mechanisms, and we need to do something with that to organize it or structure it in a way that this is useful.

So, some of the terms that we are using in organizing our literature review are the macrocognitive failure mode, which is failure of the macrocognitive function, which can lead to human failure; the proximate cause, which is the contributing cause of that failure mode, the macrocognitive failure mode; the psychological mechanism that leads to failure when activated by contextual factors, and, then, those contextual factors, including the plant factors, that influence the likelihood of failure.

It is important to note that the failure of the macrocognitive function does not necessarily mean failure of the HFE. These terms are kind of part of our cognitive framework, which is used to inform the qualitative and quantitative analysis. But, at this level, we are not assuming that failure of the

macrocognitive function equals failure of the HFE. That may be the case in some instances, but we are not making that assumption.

The quantification approach, they are the crew failure modes that John and Gareth will be speaking about later. They do make that assumption about their crew failure modes because they do take into account the plant.

The macrocognitive functions only really focus on human cognition, and they don't incorporate plant performance so much. So, I just wanted to clarify that failure of the macrocognitive function does not mean failure of the HFE necessarily.

So, the literature review identified hundreds of psychological mechanisms or processes that can lead to human failure. The process we went through in sorting these, this very long list of mechanisms, was that we asked, what are the consequences of this failure? The consequences tended to cluster into categories. And these categories became the proximate causes of the failure of the macrocognitive functions. And therefore, they are sorted by the macrocognitive function.

This is an example of the process. I think you may have seen this slide before. The

Endsley situation awareness model was one of the few models that actually focused on specific types of errors. In this example, she states that one of the types of situation awareness errors occurs when people incorrectly sample information. Well, what is the consequence of people having an inaccurate sampling strategy? Well, they could not perceive a relevant piece of information. They could not attend to it or they could misperceive it. And these became the proximate causes. And we went through this process with every piece of information we extracted from the literature.

This is our current list of proximate causes, subject to revision, as we just spoke about a moment ago. We expect additional proximate causes probably for failure to coordinate, and I would not be surprised if we had some revisions on failure to act as well.

CHAIR STETKAR: I am woefully out of my realm of understanding here, but failure to understand is coalesced into two what I would consider rather simplistic proximate causes. Either I can't understand it or a misunderstand it.

MS. WHALEY: Yes.

CHAIR STETKAR: Is it really that simple?

MS. WHALEY: It is really not that simple.

CHAIR STETKAR: I mean, again, if I look at the relative level of detail under some of the other functions --

MS. WHALEY: Yes, on the failure to understand or the sense-making understanding macrocognitive function, we originally had a larger number of proximate causes, such as having an incorrect mental model or data that doesn't match the mental model. And they all seemed to kind of boil down to one of these two.

CHAIR STETKAR: I mean I understand this at a very high level.

MS. WHALEY: Yes.

CHAIR STETKAR: But I was curious whether that same sort of coalescing process apparently was done --

MS. WHALEY: Yes.

CHAIR STETKAR: -- for all of the other functions.

MS. WHALEY: Yes.

CHAIR STETKAR: Or is currently in progress.

MS. WHALEY: Yes, it is currently in progress.

CHAIR STETKAR: Okay.

MS. WHALEY: And we have a number of people working on this. I am working on the sense-making understanding portion right now, and I am hoping to be able to flesh out the proximate causes a little better than what they are right now. Because I agree with you that just saying incorrect understanding or inability to develop an understanding, that to me seems a little too high level. We haven't worked out exactly how to cluster the mechanisms that we have in a way that doesn't overly complicate things.

CHAIR STETKAR: Yes, I was trying to get a sense of whether the list that we see in front of us right now -- obviously, from what you have said, it is still a bit in a state of flux -- whether there was strong incentives to try to coalesce some of the other details or whether the direction you are heading is actually to provide more detail where things may be too high level.

MS. WHALEY: Yes. We certainly want to keep in mind practicality and ease of implementation of this. So, we are trying to keep our list of proximate causes at a manageable level. We don't want to be too overly simplistic. We don't want to be too

detailed. Right now, I think that the failure to understand may be a little too simplistic. So, we are still working on that. I would say I have been asked a number of times by different project members where are we in terms of how complete is our list, and I would say we are probably 80 to 90 percent complete.

CHAIR STETKAR: Yes, I mean a little bit of what I am hearing in the meeting this morning is a little bit different perception than what I received reading through the document. Because it was fairly clear that the coordination function is still evolving. I didn't realize that some of the other ones were still somewhat fluid anyway.

MS. WHALEY: Yes, the coordination macrocognitive function is a little bit of a different beast because it deals with things at a group level. Most of the other macrocognitive functions are on an individual level, and we are not trying to figure out, well, how do we deal with one versus many.

MR. FORESTER: I would like to comment, if I could.

CHAIR STETKAR: Sure.

MR. FORESTER: John Forester, Sandia Labs.

I think at some level the more important aspect, I mean those two, they talk about

understanding and diagnosis. And you're right, that is at a pretty high level. The important thing is to capture the cognitive mechanisms that could lead to these types of things and the factors that would lead to those cognitive mechanisms, to the cognitive failure mechanisms.

So, it is not so important, I don't think as to what exactly is the proximate cause or how you represent it, as long as you have kind of a functional way to do it. But you want to make sure that you are capturing the cognitive mechanisms that could lead to that and the factors that would cause it.

CHAIR STETKAR: Okay. Thanks.

MS. WHALEY: That is a very good point, John.

This is an illustration of kind of the cognitive framework that we have been developing. This basically is a graphical illustration of how we are trying to connect the macrocognitive functions shown in the purple box to the proximate causes, and, then, the proximate causes connected to the various mechanisms that can lead to that particular cause of failure, and then linking those to the PIFs.

And it may be the case that for the sense-making understanding proximate cause we have, a lot

more of the mechanisms -- more mechanisms, fewer proximate causes. So, we definitely want to make sure that we are adequately representing that, the level of complexity there.

But this cognitive framework is being used by the parts of the team who are working on the qualitative analysis and the quantification approach. They are using this to inform their work and the development of the crew failure modes and the structure and the questions for the decision trees used for quantification. They will speak to that in their presentations a little bit later.

One of the purposes of developing this cognitive framework is to identify the relevant PIFs for the proximate causes. This is the PIF structure that we are using. I don't know if you can read it very well.

But this is taken from Katrina Groth dissertation research in which she analyzed PIF information from a number of different sources, performed some factor analyses, and came up with this set of definitionally orthogonal in the PIF taxonomy.

CHAIR STETKAR: I think we are okay on time. Stop me when I delve into too many details.

I actually looked at this list, and I had

a few questions about specific PSFs and their definition or my understanding of what they might mean.

For example, under organizational PSFs, the fourth bullet down says, "Safety culture". Could you tell me what safety culture is and how I can evaluate the goodness or badness of that for a particular organization for a particular activity?

MS. WHALEY: I would have to look up the definition that Katrina used in her dissertation to answer that very explicitly. But it has to do with the culture in an organization and how well they put safety as a value --

CHAIR STETKAR: I understand that, but I also listened to Garrison Keillor where Lake Woebegone, all the women are strong, all the men are good-looking, and all the children are above average. It strikes me that most people who evaluate their own safety culture will evaluate themselves as equal to or better than average because it is a rather nebulous concept.

The point is, compared to other performance-influencing factors that, indeed, do seem to measure objective type pieces of information -- and that is why, given the fact that analysts will need to

somehow or another, and I know we will hear about this later, evaluate each of these performance-shaping factors, the question is, are we defining some performance, I'm sorry, performance-influencing factors, although it does say PSFs, I notice on your slide there.

MS. WHALEY: The metrics?

CHAIR STETKAR: Uh-Hum.

MS. WHALEY: The metrics, you mean?

CHAIR STETKAR: The metrics.

MS. WHALEY: Yes.

CHAIR STETKAR: Metrics would be a good term. The question is, do we have items in there that are either extremely difficult to evaluate or functionally irrelevant because everyone will evaluate them as average or better than average, and we just sort of know that?

MS. WHALEY: That is a good question. I know that Katrina did list metrics of her various PIFs in her dissertation. I haven't read that in the last four months. So, I don't remember off the top of my head what those metrics are.

MR. FORESTER: I would like to comment, if I could.

CHAIR STETKAR: Sure.

MR. FORESTER: John Forester, Sandia Labs.

This is just a list of the performance-influencing factors of PSFs that Katrina identified in her dissertation.

CHAIR STETKAR: Okay.

MR. FORESTER: There is no assumption that we are going to cover every bit of this in our methodology.

CHAIR STETKAR: Okay.

MR. FORESTER: We are going to use this as a guide to help us examine things that we think we can measure in some realistic way in the context of applying the HRA. Some of this will be useful. Other things we are just not going to be able to measure.

CHAIR STETKAR: Okay.

MR. FORESTER: And unless we can identify that it can have a huge impact in some way, we are probably not going to address it explicitly.

With respect to safety culture, obviously, it is a huge problem. There are a lot of different influences going on.

You know, there may be some things like maybe crews being resistant to take certain actions because of the impact on the plant. So, they might trade off safety for -- you know, I mean that kind of

notion. You can look for kind of specific things that might be related to safety culture, if you think it might be important.

So, again, that is more of a guide of the kind of things we will look at, but we are not going to capture all that, not in any kind of realistic way.

CHAIR STETKAR: Okay. Okay. That helps a little bit because it sort of explains the fact that this also is still evolving a bit.

Let me ask you one other one, put you on the spot. Under personal PSFs, the third bullet down, there is something called moral, motivation, and attitude. I think a bit of what John just mentioned regarding safety culture can translate into that, although this is actually under an individual rather than a crew. So, the organizational effect would be at a higher level.

Under that bullet, I think I understand problem-solving style, information use, and compliance as elements that would be affected by my own personal attitudes. I am not quite sure about prioritization within the context of a particular event scenario. That sort of sub-bullet jumped out at me as something that didn't quite seem consistent with some of those other thought processes.

I was curious how it belongs in there, if it does, or whether it merits a separation evaluation, basically.

MS. WHALEY: That is a good question. I believe that the reason why this is in this structure, that it is trying to get at the issue of people putting maybe personal goals over plant goals or, say, it is more important that I save face and look like I know what I am doing rather than admitting that I make a mistake and, therefore, I am going to do something to address that issue rather than what the procedure tells me I should do, that type of you have personal conflicting goals that --

CHAIR STETKAR: Okay.

MS. WHALEY: -- can lead to an incorrect prioritization of a task.

So, that would just be one example off the top of my head of what that is trying to get at.

CHAIR STETKAR: Okay. I guess I understand it in that. I was thinking more in terms of if I actually have options in the plant, for example, taking an action that might mitigate damage to some fairly expensive piece of equipment versus taking an action that put me on a trajectory to mitigate an evolving accident scenario. That is a

1 different type of prioritization. I tended to think
2 of it in that way.
3 MS. WHALEY: Well, that could possibly
4 also be another example of this type of prioritization
5 error --
6 CHAIR STETKAR: And that tends more toward
7 the safety culture --
8 MS. WHALEY: Yes.
9 CHAIR STETKAR: -- of the organization.
10 Okay. Thanks.
11 MEMBER ABDEL-KHALIK: So, staying with the
12 same bullet, the fourth sub-bullet, compliance, I
13 assume that includes procedure adherence.
14 MS. WHALEY: Uh-hum.
15 MEMBER ABDEL-KHALIK: How would you
16 measure that?
17 MS. WHALEY: That is a good question.
18 There is probably a number of ways you could get at
19 it, all subject to various different caveats and
20 limitations. You could question the operators. You
21 could observe simulator performance.
22 I believe, like I said before, that
23 Katrina included possible metrics for all of these in
24 her dissertation. We could review that to see what
25 kind of metrics would be involved in assessing that.

But, like John said, we are using this kind of as a guide, but we may not be able to get at every single one of these.

MEMBER ABDEL-KHALIK: I mean this is another one that is tightly coupled to a safety culture.

MS. WHALEY: Uh-hum. Yes. Yes, these are not assumed to be independent.

MEMBER ABDEL-KHALIK: Right.

MS. LOIS: One aspect of code and code compliance is the plant philosophy, for example. We have seen that in Holden where we assumed that some crews were allowed to deliberately go to the step of the procedure that they assumed what they are dealing with versus some other crews that were adhering to each step of the procedure. So, that is one aspect of compliance, how do you deal -- once you recognize what you are dealing with, do you sit back and you go through the process or not? There is tremendous variety from crew to crew and plant to plant.

So, these are very general terms. Actually, we need to provide or the document should provide the definitions and the metrics, so that it characterizes exactly what we mean under each one of those. And definitely we are not going to use or

every HRA is not going to use all of these PSFs, but it is the general picture of where PSFs come from.

MEMBER BLEY: Let me jump in on this a little. This is one where I am conflicted, but just as a point of information. I have changed sides here.

(Laughter.)

CHAIR STETKAR: So, you're sitting upfront for this one?

MEMBER BLEY: Yes, for just this question anyway. Because I am really intertwined on this, I am not going to talk much, but people have hit a what goes on.

In fact, in a number of analyses that have been done, and John has participated in some of these as well, you need to get into the plant. You need to see how people do this. You need to look at their admin procedures. You need to look at their history, where things have gone wrong. You need to observe them operating day to day.

And actually, I think in the one of the older ATHEANA documents we spoke of characterizing the crew and actually identifying the kind of things you raise, not by data, but by observation and discussion, and, then, incorporating that somehow into the model.

I think you don't want to pass by here

easily because this can have a major impact, especially in the cognitively-challenging cases. So, I think they have a framework for it, and I think it is in some of the earlier documents that back this up.

MS. WHALEY: Now we -- go ahead.

CHAIR STETKAR: No, no, go on.

MS. WHALEY: Okay. When we began working on this project on the literature review, we came to a point of what PIFs are we going to use; what PIFs are we going to use in our method. Katrina had just finished this dissertation, and it was the most thorough work on PIFs done to date. So, we said we will adopt her taxonomy for now as a guide, and, then, we can adapt it as we need to down the road as we develop things.

CHAIR STETKAR: One more before you hit the button.

MS. WHALEY: Okay.

CHAIR STETKAR: Again, as I was looking through these things, under situation PSFs, there's quite a list there. I noticed you have hardware and software condition in events. This is a prelude to a bit of a concern that I have, and Stuart mentioned it earlier in the context of dependencies, human dependencies in particular.

The framework, and, indeed, what I have seen of the guidance, seems to focus exclusively on my ability to perform a particularly well-defined action in the context of a scenario that is defined by some combination of hardware successes and failures.

How does this situation performance-influencing factors account for my preceding behavior in this scenario? I use the example of the fact that I have been really stupid for the last 45 minutes during the evolution of this scenario because I failed to do this; I did this wrong; I took this action that I shouldn't have taken. And now you are suddenly asking me to do the fourth action in isolation, and I'm smart because I have got good cues for the action, this particular one, good procedures, a lot of time available.

What suddenly made me smart? How am I not influenced by my preceding behavior during this scenario? I don't see that situation factor.

MS. WHALEY: The answer is that of course you are affected by your previous performance. The way that this method attempts to get at that exact issue, you know, your performance across time, you can't look at each HFE in isolation.

That is part of the task of the

qualitative analysis, the crew response tree. You know, we are trying to get at it there and in the decision trees. I believe John and Gareth can speak to that.

CHAIR STETKAR: Okay. I will wait until they come up. I get it.

MS. WHALEY: But, yes, we agree that that is an issue and we need to make sure that we assess it somewhere in the process.

CHAIR STETKAR: Okay. Somewhere somehow. I mean that sort of starts to address that it is the whole issue of treatment of dependencies, too. Part of it is just identifying them and making sure that an analyst recognizes that they need to really think about that in the same context as all of these other items that are on the list.

Okay. Now I will let you push the button.

MS. WHALEY: Okay.

MEMBER ABDEL-KHALIK: No. Sorry. Equipment reliability varies significantly from plant to plant.

MS. WHALEY: Uh-hum.

MEMBER ABDEL-KHALIK: Now where does that fall on your list here?

MS. WHALEY: On this particular list, that

could be -- let's see, the equipment reliability will be handled, I think, in a number of different -- it could be incorporated into our method in the quantification. And I really can't speak to that part since that is not my focus.

But if we are looking at where that would fit on the PIFs, that would be in the hardware and software conditioning events, which I believe has to do with the history of an instrument or a piece of equipment being unreliable or known to give falsifications. I believe that is where that is assessed.

And also, in the input or output or the ambiguity of the system response is where some of the questions of equipment performance can be assessed in this particular structure. But I believe that we also attempt to get at that in the CFMs and the career response training.

CHAIR STETKAR: Said, are you talking about equipment reliability as it leads into a particular challenge for the operator or are you talking about equipment reliability as it affects the operator's decision process going forward?

MEMBER ABDEL-KHALIK: Both, and, also, equipment reliability in terms of availability of

equipment or unavailability of equipment that may actually complicate the scenario beyond what --

CHAIR STETKAR: But that stuff is the rest of the PRA model. So, we can sort that out because you should have two different scenarios, depending on whether something is working or not there.

But equipment availability, if I can step in, and I am not conflicted here, if I look at personal PSFs, for example, if I have an option of using Plan A for mitigating a certain scenario or Plan B, and Plan A involves equipment that I know because of my experience doesn't work very well, now I might be wrong about that, but I know that because of my knowledge, experience, familiarity with the situation, previous bias, or whatever.

I will in that case, if I know Plan A involves using equipment that I don't have a confidence in, I will invoke Plan B. So, indeed, equipment reliability or perceived equipment reliability does affect my decision going forward.

And, then, the PRA would, if I choose Plan A or if I choose Plan B, the PRA models for the hardware should sort out whether or not I was right, basically. So, it does; perceptions about equipment reliability going forward do affect people.

Okay.

MS. WHALEY: Okay. Now that I have provided an overview of the process and the structure that we have developed, I wanted to go into a little bit more detail on some of the specific results from the tech notice portion of the review.

So, what does the tech notice encompass? It represents essentially the physical process of sensing in the early stages of object recognition. As more meaning is associated with perception, the process of sense-making and understanding kicks in.

So, sensation is physiological. It is light hitting the rods and cones. It is sound waves hitting the eardrum.

That produces electrical impulses, which are translated into sensory cortex in the brain. And there, some very unconscious, instinctual meaning is applied, such as the light is red or the sound heard is an H sound. The more information that is assigned to this electrical impulse, the more it moves over into sense-making understanding.

So, knowing that a red light means that there is an alarm on a piece of equipment, and that equipment is malfunctioning, that would be sense-making or understanding.

You know, in the example on the slide, interpreting the sound of "shh" to mean quiet is more sense-making than perception. But, you know, the boundaries are very fuzzy.

So, the literature review conducted on the tech notice, we conducted a card-sort of all the literature in which we sorted the literature into categories with kind of broad similarity. There is some overlap and there is room for other categorizations of the literature, but this is what our card-sort reveals. We are not positing this as the only solution, just a framework that made sense to us, and it helps us cluster the literature.

So, we have these five types or these five categories of microcognitive models that can be viewed perhaps as requirements for detection. We need to know about, there are models about the cue content. What is the type, the availability, quality, context of the information? This can greatly affect detection.

An operator's ability to be vigilant as they are monitoring things, and this is affected over time by fatigue, workload, and stress.

Change detection refers to an operator's ability to detect change. This can be affected by

change blindness or inattentional blindness.

Expectations have a role as well. I mean people are primed by their experience and their training. They know what to expect. They know that there is a certain particular pattern of alarm lights that come on when there is a reactor trip. These expectations can influence whether or not people perceive information correctly.

And working memory is also very important here, in that the amount of information an operator can maintain in their active attention is limited. And so, they are susceptible to information overload. Or high attentional workload can impair retention of new important information.

So, these are basically cognitive mechanisms that help people to sense and perceive their environment. Each of these types of mechanisms leads to an opportunity for failure. And the models provide differing explanations behind the failure of these particular things.

So, there is clearly a degree of interaction, but clustering the literature this way allows us to pull out what are the relevant PIFs for this particular type of process.

So, the detect notice proximate causes, as

we showed before, information is not perceived. And the literature suggests that, if information is completely missed, it is very often because, you know, it could be due to more the cue content. If the information is not attended to, that means that the cue is seen or heard, it is perceived, but it doesn't receive any additional attention.

And so, the causes of failure here can be rooted more in the sensory perceptual system or in the working memory. You know, information is not propagated for further understanding. If the information is misperceived, this can be due to expectations and biases.

This table is adapted from Table 6, I believe, in the literature review report. Basically, it takes our proximate causes here on the left and the five categories of literature provide different explanations for how this failure could occur.

So, for example, if cues are not perceived, then it could be due to cue content; it could be due to the operator being unable to maintain their vigilance as they are monitoring things. It could be due to inattentional blindness, which is an attentional problem when people just don't see something that is in plain sight. They just

completely miss it. Or it could be not perceived due to a mismatch between what they are expecting to see and what they actually see. Or working memory, you know, they are overloaded on their working memory capacity.

And each of these models or categories of models provides information about the different relevant PSFs or PIFs for this. So, I know that this is quite detailed, and I am sure you have questions, but I am open to questions on this or I am happy to refer you to the document and move forward if we are pressed for time.

MS. LOIS: Probably you want to cover a little the PIF.

MS. WHALEY: Sure. Sure. Cue content suggests that the most relevant PIFs are going to be, well, what is the quality of the human/system interface; what is the output? The system responses, are they salient? So, it has to do with the availability and quality of the information itself. That is the root cause of failure of the macrocognitive function of the tech notice.

Vigilance in monitoring, on the other hand, says, well, this is going to be affected by operator attention. What's their workload? What's

the task complexity, system responses? I would also add fatigue and stress here as kind of just general categories that are relevant.

Change detection suggests that problems with attention or knowledge and experience, you know, familiarity with the situation, these could lead, you know, be influencing factors for failure of the macrocognitive function.

Expectations is what are their biases, their knowledge and experience, their training? Is there a pattern of misleading indications or is there a pattern of a piece of equipment providing faulty indication? These things would be causes of failure of the tech notice.

And for working memory, it is going to be task load, task complexity, system responses in terms of the sheer amount of information that is coming at the operator that can overload them.

So, the value of this is that it identifies, okay, well, what are the causes of people missing alarms? For those particular causes, what are the reasons or the influencing factors that can lead to that?

CHAIR STETKAR: Questions?

MS. WHALEY: If you want, I am happy to

move on if you don't have questions.

CHAIR STETKAR: Continue.

MS. WHALEY: Okay.

CHAIR STETKAR: Never give this body too long to think.

(Laughter.)

MS. WHALEY: This is a very small excerpt from Appendix A-1 of the literature review report. Appendix A has a number of tables, you know, pages and pages of tables that are very detailed. And I wanted to just pull out a few of these just to show as an illustration.

This is the detailed results of the literature review. So, we have a cognitive model about attention that provides an explanation for a process that can fail.

So, an example is you have flashing lights; a loud noise tends us to look in the direction from which a sound emanated, but when the active stimulus is not of sufficient activation energy, we won't perceive it. And it provides what are the things that can cause this to happen and what are the PIFs that are relevant for this.

So, this is the guts of the literature review output. And what we are doing is we are taking

this information, of which this is just one page out of --

CHAIR STETKAR: Many.

MS. WHALEY: -- many, many, many pages, and we are trying to structure this into this cognitive framework that I showed an example of earlier, so that it is more easily used.

CHAIR STETKAR: I was going to ask, so there is work afoot to provide some structure?

MS. WHALEY: Yes.

CHAIR STETKAR: There is a lot of good information --

MS. WHALEY: Yes.

CHAIR STETKAR: -- back there, but, as you are all aware, there is a lot of information there, and in some cases it is repetitive.

MS. WHALEY: Yes.

CHAIR STETKAR: So, you are trying to organize it?

MS. WHALEY: Yes.

CHAIR STETKAR: That's good.

MS. WHALEY: Yes.

CHAIR STETKAR: I'm glad to hear that.

MS. WHALEY: That is what we are trying to do. This is the information that we are giving to the

group who is working on the qualitative and the quantitative assessments. There you need this information to inform how they develop the decision trees and the crew failure modes.

CHAIR STETKAR: One question on this slide, and it was something I did notice, is that the third line item here -- and I won't go into the detail -- but I notice in the righthand column there is a PIF called stress.

MS. WHALEY: Uh-hum.

CHAIR STETKAR: I have tried to define what stress is to a number of people for many years. And it is one of those things where you know it when you see it.

MS. WHALEY: Uh-hum. Yes.

CHAIR STETKAR: But I did notice that in the big, long list of PIFs that we saw a few slides ago that stress is not one of those.

MS. WHALEY: Yes.

CHAIR STETKAR: So, are you working on that?

MS. WHALEY: That is something that Katrina has been working on. She has another model that pulls out -- well, the discussion is this: that stress is something that is very, very hard to measure

because the same situation different people are going to experience very different levels of stress. And what can be measured is not stress, but stressors.

And so, her model has all of the stress -- you know, she focuses on the stressors, the task, the task load, the task complexity.

CHAIR STETKAR: That is what, when I read through the initial list of PIFs, I said, okay, I can see how stress is accommodated by things in that list.

MS. WHALEY: Yes. And so, she has a slightly different version of that table --

CHAIR STETKAR: Okay.

MS. WHALEY: -- that pulls all the stressors out into their own category because so many people or research and methods and models all refer to this very nebulous term of stress.

And what we did in the literature review is we used the language that the literature itself used. So, if the literature said, you know, stress can lead to this, well, then, we said, okay, stress.

And, then, we have a way to map that to the PIFs that we have in our table. So, that is how we are dealing with the issue of stress.

CHAIR STETKAR: Okay. Good. Thanks. That helps me.

MEMBER BLEY: Having heard the word "map" and looking ahead and seeing some things that aren't here, you included in your talk a lot of the tables and figures from the report. There are two in particular that they didn't make it into your slides. And the one is the picture of the microcognitive functions as overlapping circles.

MS. WHALEY: Yes, I have that in the backups.

MEMBER BLEY: And you made the point that you have moved away from a sequential information processing model to something that is this overlaying thing. And there was a figure a little bit later that you called the model, macrocognitive model of team collaboration, which is also overlapping circles.

To what extent is this becoming a model and do things map through across the model? And how does that work? Is that something you are still working on?

MS. WHALEY: Yes, that is. I mean I have those particular graphics on a backup slide. I can jump ahead.

MEMBER BLEY: The graphics don't tell me how you can actually use those very nice concepts.

MS. WHALEY: The answer to that question

is that we are using those concepts to inform, but not direct. I mentioned earlier that we had to adapt for our purposes and for the nuclear domain. And none of those models were directly applicable or designed with nuclear in mind.

So, we took what we could from those and adapted them to our purposes. And it is very possible that what we are going to end up with is a cognitive model, but we are not at a point where we can say that we have a cognitive model. We haven't done any sort of validation. But these are thoughts that are in my mind.

MEMBER BLEY: Maybe my question is really directed at the next presentation. Are there ways you are looking at implementing the things we see in these? So, I will raise it again.

CHAIR STETKAR: John is behind you.

MEMBER BLEY: Oh, maybe there is an answer.

MR. FORESTER: I am a little sensitive. I am not sure we are going to come up with cognitive model out of this. I think, obviously, there's a lot of cognitive models that they are reviewing, and they are different and they are all trying to explain the same thing. Yet, there is no validation in most of

these models. Different aspects have been validated; others have not.

And now we are moving towards the more neuroscience kind of approach where the reference to not serial. Well, it is still partly serial, but the point is there's a lot of parallel processing going on. Later decision processing might be activated very early based on just barely any kind of processing on one end.

So, obviously, it is a very complex situation here. We are just using the models to help us, to alert us about the kind of things we should be thinking about.

And I think it is fortunate that most of what you find in cognitive psychology is -- there's very few counterintuitive findings. So, there is not a lot of danger, I don't think, in using that information to guide what we do.

(Laughter.)

MS. WHALEY: Yes.

MR. FORESTER: But, from my perspective, we will not develop a cognitive model. I mean we may gain some insights about what a good one might look like, but we are using this as a framework to help us.

MEMBER BLEY: So, we are just getting a

better underpinning for things we thought were pretty reasonable?

MR. FORESTER: That is the way I look at it, yes.

MEMBER BLEY: Thank you.

MS. WHALEY: Yes, and I would agree with that statement. That is why we are using the term "cognitive framework" rather than "model" because we are not going through the necessary activities to engage in model-building. I think that is something that potentially theoretically could be done in the future, but that is beyond our scope.

MS. LOIS: That will be April's doctoral dissertation.

(Laughter.)

MEMBER ABDEL-KHALIK: Let me just give you a hypothetical scenario. Let's say we have a plant with a somewhat unreliable fire detection system. It alarms in the control room randomly, to the point where the operators see the alarms and just ignore them.

Where does that fall in when you talk about either information not perceived or information not attended to?

MS. WHALEY: That would probably be

information not attended to. It could also be not perceived. I recall reading an actual event where people, where operators put up a piece of paper over the fire alarm panel because it was constantly doing just that. And so, they missed seeing an actual fire alarm.

So, we have a number, there are a variety of ways to assess that. We could assess it in the PIFs, which we have a PIF that would account for that in the hardware and software commissioning events, and the system outputs. So, we can get at aspects of it there.

We can also get at that through the qualitative analysis. That would be part of what we are trying to build into the pre-failure modes and the decision trees.

So, there's several different ways we can get at that. It is a question of modeling preferences.

Okay. So, in conclusion, the whole point of this is to bring the psychological foundation of HRA up to date and to develop this cognitive framework, this tool that aids in identification of causes and mechanisms for human error and identifies the relevant PIFs for human error.

Limitations, like I mentioned before, this is not a cognitive model. This is more a cognitive framework based off of current psychological theory. It hasn't been validated or empirically tested.

Also, a literature review can never be 100 percent complete. There are hundreds of papers published every year.

And what we have done is we have taken an iterative peer review process to try to ensure a reasonable degree of completion. And our intent would never to be 100 percent competence. We wanted to make sure that we adequately covered the areas that are the most relevant to the nuclear fire plant domain.

Our next steps: we are still in the same process that we went through for detect notice. We are working on the other macrocognitive functions. We should have those, we should have all of them done by the end of third quarter.

We are going to be completing this cognitive framework and tool as we continue to refine the results. This information is given over to the qualitative and quantification group, so that they can use this in developing their quantification approach. So, we are feeding them information as we get it.

So, this is still in progress, and we

should have the rest of it done by the end of this quarter or the third quarter. Are we in third quarter now?

CHAIR STETKAR: This is -- go back there -- the third quarter of fiscal year or third quarter of calendar year?

MS. WHALEY: Fiscal.

MS. LOIS: Summer of 20 --

CHAIR STETKAR: Hokey Smokes. Okay. That is "Hokey Smokes" for the recorder.

(Laughter.)

I wanted to ask you a bit about this. I guess I didn't appreciate that we are talking about fiscal year quarters. Were you also, Erasmia, in the introduction talking about fiscal year?

MS. LOIS: Yes. Yes. We have a target date for completion, June of 2011.

CHAIR STETKAR: June of 2011?

MS. LOIS: Yes. So, many people are working in parallel. It is not just April. It is others also. Ron Boring and others are working in different areas.

We believe that we extended the literature search beyond our original intent or focus. Some of that was created from feedback from ACRS. Also, a lot

of that had been created, as April mentioned, from feedback from stakeholders, the NRC, human factors psychologists, et cetera, PRA/HRA experts.

But what we would like to do is, starting July or August of 2011, go through independent literature review, peer review of this piece of the work, and in a way have it done by December of 2011.

CHAIR STETKAR: Let me ask you about this. I don't know whether now is the appropriate time to talk a bit about this slide or at the end of the next presentation. You tell me, Erasmia, about schedule.

MS. LOIS: I think the next presentation will also give you an idea of how we use the results for quantification purposes and, then, the level of usage of this literature search.

CHAIR STETKAR: Let me ask you, then, in the context of what we just heard about. You talked a little bit about the failure-to-detect function and the pages and pages of information that are in Appendix A, and that there is apparently some work being done to better organize that information.

I found that information really, really useful as background information, as an analyst, things to think about, to be aware of.

Given this schedule, and given the fact

that failure to detect in my mind is a relatively simple function, I mean it is something that I can actually get my mind around in terms of things that might influence that type of process as compared to some of the other, the sense-making and understanding functions, is there enough time? Because of the time constraints, is there a danger that for the other functions, and, in particular, sense-making, understanding, decision, the second and third bullets, and coordination/communication, that we will have relatively sparse information in the report, only because we spent so much time and effort on this failure-to-detect function, which obviously has taken quite a bit of time and effort?

And I am concerned, you know, as you are aware, ACRS doesn't normally concern ourselves with resource or schedules, but from a technical perspective, I would really hate to see the other cognitive, more cognitive-type issues, understanding, decisionmaking, shortchanged simply because the project has spent so much time developing what I think is really, really good information, but the amount of time and effort that went into that one function is really clear.

MS. LOIS: We will take that as a

feedback, and we will ensure ourselves that we are putting the appropriate level of effort and attention. But I believe that other areas also are looked as closely and from the same perspective, the same level.

John, do you want to answer?

MR. FORESTER: Well, I was just going to remind everybody that it is not that they haven't started on these other functions. I mean the first pass through, you know, they came up with a whole -- they addressed all of these different ones already. So, it is just filling in, making sure --

CHAIR STETKAR: I understand that, but the report is basically blank pages.

MR. FORESTER: Yes, I understand.

CHAIR STETKAR: So, it is not clear how far along you are. And if the intent is to publish comparable amounts of information with comparable thought and organization, there is a lot of work to be done in areas that are probably more difficult to map than just this failure-to-detect function.

MS. LOIS: So, I don't think we established a schedule on the basis of rushing the project, if you wish, although there is an urgency to rush the project, to accomplish, you know, to move forward.

But we believe that we will take that into consideration.

CHAIR STETKAR: I mean I made a note to myself when I misunderstood that you were talking about end of calendar year 2011, that there might not be enough time left to attend to the other functions. Now, if I am thinking about four or five more months for the fiscal year --

MS. LOIS: There are several experts that are working in the same area.

CHAIR STETKAR: I understand. Okay.

Anything else? April, are you finished?

MS. WHALEY: That is it. You want a more thorough reference, listed references, that is in the report? This is just what we used in this presentation.

CHAIR STETKAR: Pages and pages.

MS. WHALEY: Pages and pages.

MEMBER BLEY: I have one question.

MS. WHALEY: Sure.

MEMBER BLEY: You refer to the framework very often.

MS. WHALEY: Uh-hum.

MEMBER BLEY: And that is the framework that is within the report on literature review? Or is

it some separate report on the framework you are talking about?

MS. WHALEY: The framework itself is not yet in the report. But in the final version, it should be.

MEMBER BLEY: It will be part of that report?

MS. WHALEY: Yes.

MEMBER BLEY: Okay.

MS. WHALEY: Because we are still working on it. It has evolved under a number of different guises and evolutions.

CHAIR STETKAR: Anything else from members?

(No response.)

If not, thank you very much for getting us back. We got off to a little bit of a slow start and some glitches, and we are only about five minutes behind schedule.

Let's take a break. We were only scheduled for a 10-minute break, and I will hold us to that. So, let's recess until 10:35.

(Whereupon, the foregoing matter went off the record at 10:24 a.m. and went back on the record at 10:38 a.m.)

CHAIR STETKAR: Okay. We are back in session, and we will hear from the people who are trying to make sense of how to implement this, I guess.

MR. PARRY: Right. So, okay, I am Gareth Parry with ERIN Engineering, as a contractor to EPRI. With me here is John Forester from Sandia.

And we are going to do like a tag team sort of presentation here. I will kick it off.

In terms of what we are going to discuss today, we will talk about the scope of what this quantification model is currently.

I guess I ought to start with a statement that really what we are trying to do is do things in baby steps, if you like. So, we are trying to do the easiest stuff first. So, obviously, we are going to try to restrict the scope to stuff that we feel pretty comfortable with and, then, expand it as we test out the model to see how we can extend it to other applications.

CHAIR STETKAR: Let me ask you about that, Gareth, since you brought it up.

MR. PARRY: Okay.

CHAIR STETKAR: I understand that. There is always benefit of trying to come to closure on the

things that you think you can easily come to closure on.

MR. PARRY: Right.

CHAIR STETKAR: The danger of that is sort of a carryover from the discussion we had just before the break. The danger is that you spent an awful lot of time dotting the "i's", crossing the "t's" on those things that weren't quite as easy as you thought they were.

And because of schedule pressures or other resource pressures, when you get to the really difficult things to do, you find you need to take shortcuts that you might not necessarily feel all that comfortable about. In other words, there is also the philosophy that you maybe want to tackle the difficult things early to try to have some type of balanced -- you know, if you need to sacrifice, you sacrifice on the easy things, where you do have a little bit more confidence in terms of how to implement them.

Have you had any thoughts about that?

MR. PARRY: Yes. I think the problem is that we really are trying to distill, as you saw earlier today, a tremendous amount of information into something that is practical and usable.

I think we have to see if we can do that

first in an environment that we feel relatively comfortable with before we try to tackle everything all at once --

CHAIR STETKAR: Okay.

MR. PARRY: -- because I think that is just going to lead to confusion.

CHAIR STETKAR: Okay. That is a fair point. Thanks.

MR. PARRY: Okay. So, after discussing the scope and clarifying what we are talking about, I will talk a little bit about the qualitative analysis of human failure events. Even though I think that is not the focus of what we are trying to do, I think what we are trying to do does have an influence on the qualitative analysis that is done. And what I hope to convince you also is that, as a result of the quantification method, we get a better understanding of creating stories for how human failure events could occur.

Then, I will talk about the HRA quantification model and what it looks like, the approach we are using. And there is an element of this model that depends on things that we call crew failure modes. So, it is necessary for me to spend a little bit of time defining what those are, so you can

understand the model a little bit better.

John is then going to talk about how we use the results of the literature survey to map to the model that we are creating. And this model that we are creating, as Stuart sort of I think mentioned earlier today, it has some resemblance to the cause-based decision tree approach, at least in the way it looks. I think it is quite a lot different in detail, but it looks like that.

So, what we want to do is give you an example of what the decision tree might look like. I wouldn't say we have completed any of them to our satisfaction yet. We are still in the process of developing those. I think in discussion the example, I will show where it is that we need to make more improvements.

MEMBER BLEY: Gareth -- go ahead.

CHAIR STETKAR: Before you flip the slide, the material that we got for this meeting was all on the information that was covered --

MR. PARRY: Right.

CHAIR STETKAR: -- in the preceding presentation. Do you have anything written up on this? Or are there draft reports? Or is this still very much a work in --

MR. PARRY: No, we have a draft. Really, it was an internal document. Sorry. It was a document written for internal discussion within the project. But it does have words that explain the concepts in a little more detail.

CHAIR STETKAR: Is there any sense of -- I am trying to think ahead about something we will discuss at the end of this morning's meeting in terms of schedule for future meetings and our involvement. So, I am trying to get a handle on when things may be available.

MR. PARRY: Okay.

CHAIR STETKAR: I think we have some information about the first part that we heard of.

MR. PARRY: Right.

CHAIR STETKAR: So, do you have any information or guesses about when there might be something?

MS. LOIS: We have a target date of June again to have a draft for internal review.

CHAIR STETKAR: Okay.

MS. LOIS: So, if we meet with you again in the fall, then, probably we will have a good draft for your information.

CHAIR STETKAR: Okay. We will talk a

little bit then. Thanks. Okay. Thank you.

MEMBER BLEY: Before you go, I had seen a definition of crew failure modes. I am looking forward that. But I am wondering about the link back to what we heard for the last several hours because it appears that what April had described as primarily a set of models for either a single person or at least it is not at all specific, that it is somehow crosslinked to crew behavior.

MR. PARRY: Right. And, yes, we have tried to work at the level of the crew as much as we can. So, it is a bit more of a holistic model, if you like. But, clearly, even if you are talking about a crew, at some level the way that crews fail is going to be affected by the way individuals fail to make the right decision or to carry out things.

So, John will talk to that I think, of how we have mapped those individual things into the crew failure modes for the purpose of quantification.

MEMBER BLEY: Okay.

MR. PARRY: I mean there is definitely an element here of -- I don't want to say "And then a miracle occurs." But you know what I mean?

(Laughter.)

We are taking a tremendous amount of

information and we are trying to condense it into something that is a workable, practical tool. So, there is a lot of condensation and a lot of, to some extent, faith that we are getting it right.

So, I hope to be able to persuade you that we are making progress in that area.

MEMBER BLEY: Okay. Great. I will look forward to what John --

MR. FORESTER: I would say we aren't assured of getting that specific, but we are certainly trying to look at crew issues, you know, communication between the crew, crew dynamics.

But, of course, to me, I still struggle with what seems to be, in terms of performing HRA, trying to get a sense of what all the crews are going to do is a very difficult kind of process. Again, it is just hard to measure those things. So, again, we want to try to incorporate whatever we can, but it is hard to ask HRA analysts to collect that kind of information because they need to look at all the crews and a lot of scenarios. So, it is a very difficult thing to actually achieve, practically speaking.

MR. PARRY: Okay. In terms of the scope, what we are doing initially is that we are focusing on the predefined HFEs. So, we are not talking about the

process by which you define HFEs in a PRA model, you know, as a large part of ATHEANA is designed to do that.

So, we are really saying that we are starting with a definition of an HFE that is embedded in a PRA model in some sense.

We are also specifically focusing initially on procedure-directed responses. So, I don't want to say it is necessarily all post-initiating of the event. It could be those involved with development of an initiating event, such as responses to a failure of an operating train of component cooling water system, for example.

But we are not really talking right now about knowledge-based responses where the procedures do not apply or where there are no procedures, I should say.

So, that is something I think that the model that we are creating will still address to some extent, and we will be capable of doing. But it is not our focus right now.

In terms of where this could be applied in PRAs, I think we are talking primarily about internal events, CDF evaluation. I probably should add LERF onto that as well.

But we are not really addressing SAMGs at this point, again, because they are different types of procedures than -- it involves much more decisionmaking rather than following procedures, if you like.

MEMBER BLEY: Is there any reason to suspect that the framework that is being developed would not be applicable to SAMGs when we get there?

MR. PARRY: No, I don't think so. I think it might be used in a slightly different way.

MEMBER BLEY: Sure.

MR. PARRY: And different parts of the framework will be, I think, more relevant than others.

CHAIR STETKAR: That is the same question about you carefully said internal events at power.

MR. PARRY: Right.

CHAIR STETKAR: External events at shutdown, for example, if I can take the other end of that spectrum, I would hope that the framework would equally well handle those types of issues --

MR. PARRY: Yes.

CHAIR STETKAR: -- which, again, might be less procedurally-driven.

MR. PARRY: Yes.

CHAIR STETKAR: But one would hope that we

are not spending an awful lot of time on a more holistic framework, if I can put it that way, that we, then, say, well, we need to rethink the problem because now we are going to focus on internal events at shutdown; now are going to focus on SAMGs, and now we are going to focus on fires at shutdown --

MR. PARRY: Right.

CHAIR STETKAR: -- versus flooding, versus seismic events at shutdown. This is the chance to have some --

MEMBER BLEY: Coherence.

CHAIR STETKAR: -- coherence. Thank you. That is a good word.

MR. FORESTER: I would expect that most of the CFMs are going to still be relevant.

MR. PARRY: Yes, I think they are. It is just I think there's more -- I wouldn't be surprised if we had to add a couple because there are probably more diagnostic activities involved in some of these things than in following procedures.

MEMBER BLEY: Framework is the basis for doing that.

MR. PARRY: Right.

MEMBER BLEY: Okay.

MR. FORESTER: And the questions asked

through the decision tree, there might be some additional things to think about to address the knowledge-based environment or fire environment, or something like that, too.

CHAIR STETKAR: I just hope we are not heading on a trajectory where you get to completion of this task, then think about, well, how do we expand this methodology or framework, however we want to call it, for whatever the other application that we are talking about here, and recognize that you have to step back 30 or 40 or 50 percent of the way and restructure the fundamental framework. That while you are moving forward at this stage, you are at least thinking about those other elements.

I mean it is not that we don't know about the types of problems that operators are faced with during, let's say, a seismic event at shutdown or SAMGs for any mode of operation, for example.

MR. PARRY: Since we are basing it on the results of the work on the psychological mechanisms, I don't think that the framework is not going to be applicable to those.

CHAIR STETKAR: Okay.

MR. PARRY: It might have to be adapted.

CHAIR STETKAR: That's good. I mean I

hear that, but I also hear you saying, well, there might be other things that we need to think about.

MR. FORESTER: Well, for example, you know, smoke is not an issue in Level 1. So, when we are going to apply this same model for the same issue, we are going to have to somewhere make sure we have addressed the problem smoke can introduce.

CHAIR STETKAR: Okay, but smoke is, that is sort of fine-structured detail. I am talking more about --

MR. FORESTER: Right, but the structure is still the same. Like I say, I think as Gareth suggested, maybe we have to add in CFM for particular situations. But, for the most part, all the issues hold up because it is based on the human information process and stages, essentially.

MS. LOIS: By the way, I do want to acknowledge this is a take-home issue, to ensure that the framework or our structure is not limiting, so that later on we will have to revise. As a project manager, this is a very good feedback. And I should also realize that there is a little bit of back and forth among the team members.

CHAIR STETKAR: I am sure there is. That is why I am always a little bit hesitant in 2011

hearing people say, well, we are developing this for internal events at power. Now I understand in 1985 that was perhaps an appropriate statement, but --

MS. LOIS: We believe we are not -- and we believe that the more detailed methodology probably will start from the internal event analysis where we have a lot of experience, but the framework, we will ensure ourselves that what we are talking about is --

CHAIR STETKAR: No argument there. I mean, obviously, we have models. We have experience in terms of pilot applications or things like that. That is the place to begin. It is just the concern about, you know, are we going to come back in two years and say, well, we have to rethink this whole methodology because there was some element that we didn't think about looking forward to, you know, as I said, pick an example.

MR. FORESTER: Sure. I understand.

MR. PARRY: Okay. The last thing on this is that initially at least we are going to apply it through prospective analysis. I don't see, again, any problems with applying this to event assessments and things like the SDP. It just that the conditions, the boundary conditions, are already set for you as opposed to having to assess them, I think.

Okay. I said I would talk a little bit about qualitative analysis. Okay. Obviously, you understand these first few bullets. But let me just say we have had some discussions internally about what we mean by qualitative analysis. So, in terms of the qualitative analysis of an HFE that we would expect to use as a starting point for the application of the quantification model, it is that we have a PRA scenario which I am going to index by S, as I will use it in an equation later on, that leads to the HFE that we are concerned about.

It provides a characterization of the context in terms of the plant status, and particularly in how it got there and it is likely to develop once the requirement to perform an action by the crew is identified.

An important part of the qualitative analysis is clearly to do -- remember, we are talking about procedural approaches right now, so the procedure task analysis. This is the identification of the tasks and subtasks that the crew has to perform.

The reason for doing this is to look for the opportunities of failure. What we have been doing so far is to represent these opportunities to failure

as what we call crew response tree sequences. Now you saw some crew response trees, I think, in the past presentations. I will have a picture of one in a minute, just to remind you what they are. We are not really going to discuss them here. It is just really as a crutch for the remainder of the presentation.

CHAIR STETKAR: But, Gareth, you are retaining that concept as an underlying formal model structure to help you quantify this or not? I mean we had some discussion during previous --

MR. PARRY: I know. I know.

CHAIR STETKAR: You brought them up.

MR. PARRY: Yes. For the purposes of this presentation, what we are retaining the crew response tree sequences as is a representation of the failure steps in following the procedure that could lead to the specific HFE.

Now in the earlier presentations, you might have seen the CRT as a much more complex thing linking different HFEs.

CHAIR STETKAR: Uh-hum.

MR. PARRY: For the purposes of this presentation, I don't want you to think about that. Just think about what steps in the procedure, if performed incorrectly, would fail this particular

function. So, we are keeping it at the level of the specific HFE.

CHAIR STETKAR: But you are retaining it, if I were thinking of guidance to a practitioner, you are retaining it as a separate type of model that that practitioner would use to then feed into the CBDT format or whatever you are going to be using, is that correct?

MR. PARRY: Let me --

CHAIR STETKAR: I will let you go. Maybe it will fall out here.

MR. PARRY: Yes. When I show the CRT at the level that we are using it for this presentation, okay, I will explain that.

CHAIR STETKAR: Okay.

MEMBER BLEY: Can I ask a point of clarification?

MR. PARRY: You can.

MEMBER BLEY: When we specific steps in the procedure --

MR. PARRY: Uh-huh. Dennis, before you get there, maybe when I present, when I show you the picture, it will become more obvious.

MEMBER BLEY: I will wait.

MR. PARRY: Okay. All right. Thank you.

The other thing I want to point out is that an important part of understanding the HFE is not only the opportunities that occur for making an error, but also we have to figure out whether there is potential for recovering from that before the failure occurs. Okay.

So, part of developing the crew response tree is also to look for the opportunities to recover from an initial error because every crew failure has to start somewhere. And if it starts at one point, is there at some point during the development of the accident is there an opportunity for the crew to recover, so that, in fact, they get back on track? And this comes from things like new cues, new procedure steps, all within the time scale of the success criteria or the failure criteria for the human failure event.

Now, as a result of what we are proposing, we will eventually end up with the identification of crew failure scenarios. Okay. These are explanations of why the crew failed in this particular, why they failed to perform this particular response.

And this requires assessment of those performance-influencing factors that are not explicit in S, things like aspects of the training, experience,

and things like that. These are the aspects that we will address in the quantification model. And therefore, when you apply the quantification model, it will require you to do qualitative analysis sufficient to support that quantification.

Okay. So, it is the complementary part from, you know, we have got the qualitative analysis that leads to S and the task analysis. The complementary part comes from the quantification model. And the stuff that we put in there comes out of the psychological mechanisms.

Okay. Now we will go back to this is a crew response tree that is for a specific function which is failure to identify and isolate a steam generator, and it is a Westinghouse plant. So, what I meant by saying we are looking at this for a specific function, we are looking at this for a specific HFE. Okay?

So, if you look at some of the paths that are outlined in orange, they are ways that you can fail this HFE. Look at the one most to the left. Okay?

So, to fail to transfer, one of the ways you could fail this function is you fail to transfer to E-3 which is the steam generator tube rupture

event-specific procedure. And there are various steps in the procedures that you could leave you, if you fail to do those steps, it could lead you to failure of that function.

So, in this case, we have the first opportunity, the failure to transfer to E-3 at step 23. And, then, beyond that, though, there are other opportunities to get into E-3 as you go further down. So, there is a failure to transfer, it is actually a failure to transfer to ES-1.1 at step 25e. And, then, the foldout page for that, there is a transfer to E-3. So, there are different ways that you can get to E-3.

Don't worry about the details of this --

CHAIR STETKAR: No, no, no, no, no.

MR. PARRY: I can see you getting concerned.

CHAIR STETKAR: Believe me, I am not going to worry about the details on this.

MR. PARRY: Okay.

CHAIR STETKAR: What I was going to note, though, is that this example is what I would characterize as a very procedure-centric view --

MR. PARRY: Yes.

CHAIR STETKAR: -- of the way the world works.

MR. PARRY: Right.

CHAIR STETKAR: Akin to the way Swain and Guttman sort of thought about the way the world worked 30 years ago, that all you needed to do is look at the steps in the procedure, and you could determine particular places where there were opportunities for failure.

How does this construct, if I think of this as a general construct, going back to what I was talking about earlier, apply to scenarios for which there are no procedures or there are very, very limited in the sense of Pirates of the Caribbean just general guidelines.

(Laughter.)

No, seriously.

MR. PARRY: No, I understand.

CHAIR STETKAR: In the sense of some of the SAMGs which may or may not be more formally proceduralized --

MR. PARRY: Yes.

CHAIR STETKAR: -- depending on the plant. But, in particular, fire response procedures and things like that, which do tend to be rather vague. They set out general guidance about functions that you want to achieve, but certainly not at this level of

detail.

MR. PARRY: Right.

CHAIR STETKAR: So, if we are developing now a framework that is fundamentally rooted in the evaluation of procedure steps, it strikes me that that framework may not be adequate for handling many of the other types of situations that we do face in the PRA environment for external events or even shutdown conditions in some places.

MR. PARRY: Yes, I think that is a good point. I think that we could still develop crew response trees. They just would be a little different. And they would have to be tied to the types of decisions that people have to make.

CHAIR STETKAR: Uh-hum.

MR. PARRY: So, they would decision points rather than procedural steps.

CHAIR STETKAR: If that is the case, though, then does it make sense to develop the crew response trees at that level for internal events at full power, for example, this example for it?

MS. LOIS: Can I interrupt here? I think this is an issue, the original concept when we talked to you a year ago, the crew response tree was actually attempting to capture the more global crew response in

1 different circumstances. So, that framework, it is
2 still retained.
3 What we tried to do here is, okay, we
4 believe we have the overall framework. Probably we
5 will need to go back and document it better and
6 elaborate it more. However, what we present here is
7 assuming now that the overall process is such, what we
8 would do if we had to deal with internal event
9 procedure analysis.
10 But, again, that is very good feedback to
11 us. We need to not lose the forest for the
12 specific --
13 CHAIR STETKAR: I think one of the
14 concerns in the previous meeting was the way the crew
15 response trees were presented at that time, it seemed
16 like they had an awful lot of detail in them. And the
17 concern was that, from a practical implementation
18 perspective, is it reasonable to expect a
19 practitioner, an analyst, to try to develop those
20 models even though, if I recall, and my memory is
21 pretty bad, even though there might have been some
22 templates proposed?
23 And I think one of the concerns that we
24 had was, do you really expect people to do all of
25 that? I see this as a way of trying to focus and

simplify that process, so that it can be used in practice, but at least in this example the pendulum seems to have swung to focusing almost exclusively on procedures. Now maybe it is a bad example, but the caution is that we don't swing it too far in that direction.

MR. PARRY: No, I think that is fair enough comment. I think, though, that really the quantification model that we are proposing can be equally applied to where these are not procedural steps, but they are decisions.

CHAIR STETKAR: Okay.

MR. PARRY: Okay? Now we may need to make some, as I say, some adjustments. You're going to have to, right?

CHAIR STETKAR: Uh-hum.

MR. PARRY: Because we are making some assumptions when we develop some of these trees, based on what we understand of the common practices and the nature of procedures and the nature of the man/machine interface, for example. So, some things will change.

But I don't think, I don't really want to get us hung up on this. The point I think I want you to take away from this is that we will develop crew response trees. Okay? And in those crew response

trees, we will identify sequences of decisions or steps that, if they are failed, they will lead to the failure. So that there is going to be more than one way of failing the HFE, depending on its complexity. And that is really all I want you to take away from that.

CHAIR STETKAR: Okay.

MEMBER BLEY: Before you leave this, I would like to make a couple of comments. One, I like the way you phrased these are really decision points, and there might be decisions that aren't in the procedures that you might uncover that people might do. I think that is an important one to carry over. All of them, or almost all of them, when you get to the SAMGs, will be like that.

There is a little bit of definitional thing here that at least interesting to me. Well, if we just pick the international benchmarks, whatever it is called. I always forget the names. There the HFE would have been defined as failure of one of those last two boxes, either isolating that goes out or failing to isolate that goes in.

MR. PARRY: Right.

MEMBER BLEY: All this earlier stuff hadn't been defined. I like the idea of laying them

out. It is not clear to me that in all cases these earlier branches, alternative paths through the decision process or through the procedures are necessarily errors. They may happen because of timing issues or judgment calls that are made along the way.

But, in the end, the failure is surely associated with the things you get to at the end. And it might be caused by choices along the way.

MR. PARRY: Right.

MEMBER BLEY: They might make it too long or they might lead you down a path that never gets you there. A minor point, but I like the way you described it.

MR. PARRY: Okay. We will move on.

So, I want to talk a little bit about crew failure scenarios because that is ultimately what we are trying to identify. And in terms of this process that we are trying to develop, a crew failure scenario is an explanation of why a crew failure occurs. The explanation involves a recognition of a cognitive mechanism, the PIFs that enable that failure to occur, and, also, at least in this version of the quantification model we are going to address the potential for recovery directly in the form of the model.

Because I think that several of the crew failure scenarios have something in common, which is how they all start out, we are going to group them by what we call crew failure modes, which essentially is the first failure mode that is made, but the definition of HFE really is that it is a failure mode that is made and not recovered in time to prevent the failure.

This has, I think, some similarities, some strong similarities with the MERMOS approach, and if you are familiar with that, with the seekers of MERMOS, which are representative of the modes of behavior of the crew, which are essentially not necessarily bad, but they are influenced by the context in which they are operating, and including in the MERMOS approach, too, there is the probability that they don't recover in time.

Okay. So, I mentioned crew failure modes then. They are determined, the way we determined these was an identification of the ways in which an operating crew can fail to perform three functions. We have called them plant status assessment, response planning, and execution. Just to make the distinction a little bit between the IDA, not that they are tremendously different, but within the IDAC model, and

maybe I am going to butcher this, but Ali can correct me if I state it incorrectly.

There is a sense there that there are sort of nested things. You know, the "I" has an IDA underneath it; "D" has an IDA underneath it.

But, to try to make this a somewhat more holistic approach, we are looking at it from the bigger picture of what the function is. So, we have created this thing, the plant status assessment, which is like "I", if you like, but it is a super "I", the response planning, which is a "D", and an execution, which is the action.

And what we have done in this particular case is tailoring it to an understanding of the nature of the subtasks that need to be performed to achieve success. So, there are things like responding to an alarm, obtaining information, evaluating information. Now we have got here using procedures. Okay? So, to preempt a question there, John.

(Laughter.)

We could always have evaluating information, using procedures or guidelines, and then execution.

And what we have done is to map the results of the review of the cognitive psychology and

behavioral science literature, and particularly, the proximate causes, we have mapped them to the CFMs. Okay? So, that is part of why we are bringing in all the information that Idaho has been doing into this model.

Then, what we are going to do with this is we are going to construct for each of these CFMs, we are going to use the decision tree approach. And the decision points on the tree relate to existence of, I don't want to call them PIFs; I want to call them PIF categories. And you will see examples of that in the final example that I will do after John has talked. And these are the categories that relate to the cognitive mechanism that leads to the CFM.

The paths through the decision tree represent different crew failure scenarios that are differentiated by the specific characteristics of those PIFs. And what we are going to do is to have as objective measures of those PIF characteristics as we can generate. Because one of the things we want to do with this model is to make it as objective as possible because we are trying to address the problem of analyst-to-analyst variability.

That is why you won't see anywhere on here stress, for example, because that is a very difficult

thing to measure. We will talk specifically about trying to nail down the context for those particular aspects that can affect the occurrence or not of the cognitive mechanism.

I think this may become a little, well, hopefully, will become a little clearer when John talks and when I talk later.

CHAIR STETKAR: I sure hope so, yes.

(Laughter.)

MR. PARRY: I hope so, too.

CHAIR STETKAR: Gareth, let me try to see, and if it will become clearer, John, just tell me it will.

If I think of kind of traditional PIFs, PSFs, this little sketch that you have here on this slide seems to treat those bimodally. Yes?

MR. PARRY: Yes, it does.

CHAIR STETKAR: So, this is just applicability of those PIFs? For example, if I evaluate traditionally a performance-shaping factor, it isn't yes or no. It is some graded, is it on a scale of 1 to 10, you know, a 7 or a 3, for example?

MR. PARRY: Right.

CHAIR STETKAR: So, is this logical framework just to make me aware of which PIFs apply to

this specific CFM or is it actually a quantitative, so that those are quantitative branch points that you are showing?

MR. PARRY: No, they are not quantitative branch points. They are really designed to help the analyst determine whether this particular PIF category is applicable for this HFE.

CHAIR STETKAR: Got it. Thank you.

MEMBER BLEY: And, then, maybe, if I can, in combination with the next one --

MR. PARRY: Oh, yes.

MEMBER BLEY: So, path one through the tree is, are they likely to be there together?

MR. PARRY: Right.

MEMBER BLEY: And the next one is, is it --

MR. PARRY: Right.

MEMBER BLEY: -- likely to be one? Yes, okay.

MR. PARRY: Yes, that is the idea.

MEMBER BLEY: Okay.

MR. PARRY: And, you know, we are not totally averse to the fact that we might put multiple branch points in here, either, yet, if we decide that at some point we have to subdivide those PIFs. But,

currently, we are going to try to keep it to the binary, just to make it a little simpler.

Then, the last thing I want to say about this type of thing is that what we intend to do initially is to get a group of experts together to actually determine the probability of these endpoints for these types of scenarios.

CHAIR STETKAR: So, you get the degree aspect that way?

MEMBER BLEY: There are only four possible paths through here?

MR. PARRY: Well, yes.

MEMBER BLEY: And you have used the experts to evaluate how likely they are exist together.

CHAIR STETKAR: Well, that is true, but that is just differentiation among the possible outcomes. It doesn't tell me that, if a PIF is, I don't know, quality of the alarms or something like that.

MEMBER BLEY: Right.

CHAIR STETKAR: It just says that quality, as I understand it, if I am on the yes-yes path, if I say PIF 1 is quality of the alarms and PIF 2 is -- well, just stay with the first one, quality of the

alarms. That is important to this particular HFE.

MR. PARRY: That would be my interpretation.

CHAIR STETKAR: That would be my interpretation.

MR. PARRY: Right.

CHAIR STETKAR: It doesn't say anything about the actual --

MR. PARRY: It is likely to affect this. It is likely, that it will increase the likelihood of failure of this particular CFM.

CHAIR STETKAR: Well, but, then, I need to evaluate in an absolute sense what is the quality of the alarms, right?

MR. PARRY: Yes, and that is what we --

CHAIR STETKAR: I mean, given the fact that -- is this trying to tell me that, if I am on the no path, alarms are not important, and if I am on the yes path, alarms are important, regardless of the quality?

MR. PARRY: Okay. If the quality of the alarm were the thing that were measured here, okay --

CHAIR STETKAR: Yes.

MR. PARRY: -- then, yes, the no branch would tell you that we had no concerns about the

quality of the alarm for this scenario, that it was perfectly adequate.

CHAIR STETKAR: Oh.

MR. PARRY: On the yes branch, the quality of the alarm was questionable for this particular scenario and the context. That is the way it works.

So, what we are going to do, I will come to that later, is that we are going to ask questions that will enable us to answer that in as objective a way as possible.

CHAIR STETKAR: Okay. Good. Let's go on.

MR. PARRY: Yes.

CHAIR STETKAR: I am still a little bit fuzzy about what this might mean.

MR. PARRY: Yes, I am not surprised.

MEMBER BLEY: Let me just ask you one more and then let you go on.

MR. PARRY: Okay.

MEMBER BLEY: It strikes me what you are saying, so you get this laid out. You ask the experts. I would think, then, that not only do they give you a P-a, b, c, and d, but for each one they give you a description of how they see these things affecting this particular event we are looking at that you, then, use. Like there is another column here

that is the qualitative description of these things.

MR. PARRY: Yes, I would expect that the experts would be thinking about what's happening along each of these paths. And that's what they would base their performance, their evaluation on.

Let me say, though, that these are going to be done a priori for the decision tree. Okay?

MEMBER BLEY: But you said for the particular event?

MR. PARRY: Well --

MEMBER BLEY: Or do they apply for any event?

MR. PARRY: They apply to any event. The path through is what will differ, what will be different for the different events.

MEMBER BLEY: I will only say one more thing and, then, I will be quiet.

Which, to me, means those probabilities might be different for each particular event, and whatever qualitative expression of the significance of these things would be different. And you are saying that is not true?

MR. PARRY: No, that is not true. The intent is to construct -- I don't know how familiar you are with the CBDT. Okay. But that is a set of

decision trees, and there are probabilities associated with endpoints. This is similar. Okay?

MEMBER BLEY: I guess I didn't realize you did them a priori. I thought you did them in the context of the events you are quantifying.

MR. PARRY: No. In the context for the HFE, what you decide by understanding the context is which path to go down, which could be different for a different HFE. Like if the HFE is depressurization, for example, in the boiler, okay, you can get there in lots of different ways. And so, depending on the accident scenario and the context, you will choose a different path through the decision tree that corresponds to that particular context. And that is what differentiates the probabilities of the different HFEs.

MEMBER BLEY: Okay. And the P-a, b, c, and d on here, what do they mean?

MR. PARRY: They are the probability of the CFM causing the HFE, given the context.

MEMBER BLEY: Okay. Okay. I misinterpreted them. So, go ahead. Move on to the next --

MR. PARRY: I don't know if this will help or not, but this is the quantification equation.

Okay? Remember, earlier we saw that, for each HFE, there might be several CRT sequences.

MEMBER BLEY: Right.

MR. PARRY: Okay? And, then, for each CRT sequence, there could be possible several CFMs that apply. So, this is just an expression of the fact that the HEP for the HFE, given the context there, is a double sum, the sum over the CRT sequences that result in the HFE of the sum over all the CFMs that apply to that sequence of the probability associated with the path, given the context for the event.

Is that clear?

CHAIR STETKAR: As a general concept, but --

MR. PARRY: Yes. Okay.

(Laughter.)

MEMBER BLEY: I think we are at the general concepts.

MR. PARRY: Okay. All right. Yes, we are. We are.

MR. FORESTER: Without more details, the sums, you know, the CFM at the bottom there, you are quantifying each CFM using the decision trees, and you are summing across the CFMs to get the probability for the HFE. But, again, the decision trees are a little

bit separate from that in the sense you use the decision trees to quantify each of the CFMs. Does that seem --

MR. PARRY: Yes. Okay. Now the crew failure modes, this is our current set of crew failure modes. Okay. You will notice that there is not a one-to-one correspondence with the proximate causes in the previous presentation. But we have done a mapping of the one to the other, and therefore, we at least feel comfortable that we have got the scope covered.

Now I don't necessarily want to discuss each of these in detail, but I am willing to, if you want to. But we have separated them into the three categories that I mentioned earlier, the plant status assessment, the response planning, and the execution. I will pick on a couple of them.

Plant status assessment, one of the CFMs is the key alarm is not responded to. Another one let me look at, this would be third from the bottom, data dismissed or discounted. What we are thinking about here is that the data has been collected. And so, that it is not that it is incorrect information. It is the correct information has been collected by the crew, and the crew is deliberately dismissing or discounting it.

MEMBER BLEY: Can I ask a conceptual question about this?

MR. PARRY: Sure.

MEMBER BLEY: You are trying to link what we see here, which are a reasonable set of crew failure modes, I would think, to what we saw earlier in the more detailed material April presented. There is a kind of failure where perhaps an individual has an incorrect mental model of the situation, makes a judgment based on that, and, then, either through poor communication, because that is the individual who saw this, but, then, made the individual judgment through miscommunication or through some dominant traits of, by golly, here's why this doesn't matter, back to your why we dismissed this. That getting to the crew failure mode from the individuals is a fairly complex set of alternatives that could get you to any one of these crew failure modes through combinations of the way the individuals interact?

MR. PARRY: Yes, I mean that is something, clearly, that we have to be concerned about. In terms of the miscommunication problems, we have got that as a separate CFM.

MEMBER BLEY: Oh, you do?

MR. PARRY: We do have that.

MEMBER BLEY: Okay. Since I didn't see that, I thought --

MR. PARRY: It is the third one down. It is called data --

MEMBER BLEY: Okay. I see it.

MR. PARRY: -- miscommunication. That is what really that is intended to address.

MEMBER BLEY: Okay.

MR. PARRY: So, what we are trying to do is to make these -- I don't know if orthogonal is the right word to use, but we are trying to make them non-overlapping, if you like, so that we don't double-count.

And because of that, we may end up, when we have finally developed all the decision trees, we may find that we might collapse some of these. For example, data incorrectly processed, I am not convinced that we necessarily need that yet, but we won't know until we have finally worked through all the trees.

CHAIR STETKAR: I guess I will need to see some examples of how this actually works because, again, a couple of my comments in the preceding presentation is that perhaps I am misunderstanding what you mean by plant status assessment because I am

mapping that to what April was talking about as failure to detect.

MR. PARRY: No, that is not what it is. It is actually really, if you like, it is getting the right mental model of what is going on in the plant.

MEMBER BLEY: So, this is both detection and situation assessment?

MR. PARRY: And sense-making.

CHAIR STETKAR: Because your second bullet there --

MR. PARRY: Right.

CHAIR STETKAR: -- I was trying to map into the kind of sense-making and decision process. The concern I was getting is that we are again focusing too much on quality of the alarms and the indicators --

MR. PARRY: Yes, yes.

CHAIR STETKAR: -- at the top, and too much on pushing the button at the bottom.

MR. PARRY: Right.

MEMBER BLEY: But this is the sense-making --

MR. PARRY: It is embedded in the first, yes.

CHAIR STETKAR: If that is the case, then

that is fine.

MR. PARRY: Right. Okay.

MEMBER BLEY: So, this is trying to not dwell on the mechanisms, but come up with how they might turn out?

MR. PARRY: Yes, these are --

MEMBER BLEY: What might be the consequences of mechanisms leading you astray?

MR. PARRY: Right. And what we need to do in the decision trees, then, is to generate the way these things can occur, by considering the mechanisms.

MEMBER BLEY: Okay.

MR. PARRY: And what we are trying to do is incorporate the end result of the stuff that April talked about, which is the cognitive mechanisms and the PIFs that drive those, and link those into the decision trees for the CFMs.

MEMBER BLEY: So, that is a crucial step. I mean that is tying the --

MR. PARRY: That is really the --

MEMBER BLEY: -- psychology back to the plant sort of?

MR. PARRY: That is exactly what we are trying to do, right. Yes.

MEMBER BLEY: That is the hard part.

MR. PARRY: That is the hard part, and that is the part where we are doing a lot of synthesis, if you like, of all this information that we have got.

MEMBER BLEY: I'm sorry. This is supposed to be synthesized by next quarter?

MR. PARRY: No.

MEMBER BLEY: The first quarter of next year? Is that right?

CHAIR STETKAR: June of this year is what I heard.

MEMBER BLEY: June of this year.

MR. PARRY: No, no, no, no, no. June of this year we will have --

MEMBER BLEY: This is first quarter of next year?

MR. PARRY: -- the document that describes the process, not the complete -- we will have a couple of examples, but we won't have all the decision trees done by that time.

MS. LOIS: By December of --

MR. PARRY: By December --

MS. LOIS: -- of 2011, though, we should.

MR. PARRY: We will have a first shot at it. Right.

MEMBER BLEY: That will be fascinating.

MR. FORESTER: Well, in some sense, you know, it is not like it is a big surprise what the PIFs are in a sense. I mean we already know a lot about what influences performance, and the literature has led us to look at some different things. But there has been a lot of confirmation in terms of the kinds of things we would need to consider.

So, I mean actually describing how to measure those PIFs is the challenge. You have a general notion that workload is going to be an issue or your complexity is going to be an issue. Well, based on the cognitive mechanisms, that gives us some hints about what we might need to measure to get at that. To me, that is kind of the tricky part. It is the specific questions that go into the trees.

You're right, the whole thing is non-trivial, but I think it is doable because we know a lot about it already in a way. So, we can use some help from the human factors folks, I think, in terms of how you are going to measure these things.

MR. PARRY: For example, one of the PIFs that would be my concern is workload and how that affects things. If we want to make that into a good metric, then we have to be able to have some means of

measuring workload for a specific context. And what does it mean?

That is where we are going to need some help to develop these types of questions. And that is part of the challenge, I think, of doing this.

But the aim is to try to be as objective as possible. I mean I think that is one, certainly that is one of the objectives to using stress as PSF, right? I mean you can't measure it, and all attempts that have been made are not very good. You know that one analyst is going to say high stress; another one says, "No, no, there's no stress at all." I mean they are trained to do this, right? So, that is the issue.

So, let me say a couple of more things about the decision tree structure. As I said earlier, the branches are the categories of the performance-influencing factors that are determined by considering the cognitive mechanisms that can lead to failure.

And what John is going to talk about, he will talk about how we map the work that Idaho has done into identifying these PIFs. And, then, underlying that we are also looking at the drivers for those PIFs, how can we measure them?

The drivers, in fact, are going to be the things that we try to measure objectively by the use

of questions that leave the analysts, the HRA analysts, to assess whether this particular PIF category is likely to be there for a specific context.

The other thing I mentioned earlier is that we are going to talk about the potential for recovery that is afforded by the dynamic nature of the crew interactions with the plant internally for this HFE. This is not the same as saying, okay, I can go down this PRA sequence. I have failed this first event, and, then, I have another chance later on. That is different. That is the dependency issue, which we will talk about sometime later, although we have, I think, some good ideas of how this approach can help deal with that in a better fashion than it is currently addressed.

So, I think, with that, I will hand over to John to talk about the mapping that is being done. Then, I will come back and talk about an example.

MR. FORESTER: Yes, I think at some level you guys already have a fairly good understanding, based on our discussions, about what is going on here. But I will talk about it a little bit more.

Here is the figure that April put up this morning. If you look at the blue column, the second one from the right, there is a list there or examples

of cognitive mechanisms that were identified from the literature. Maybe these are more like categories of cognitive mechanisms.

But the notion, again, was, when they did the lit review, they went in and they were looking for these cognitive mechanisms that could lead to failure. And so, divided attention, you can imagine that if attention is divided, that could lead them to not attend to certain information. So, that could lead them to fail.

So, again, the notion was you look for these cognitive mechanisms. From that, they identified some proximate causes, again, which is sort of the consequences of those mechanisms or how they would manifest in terms of, again, if they had divided attention, you know, they were trying to divide attention among multiple items, then, they might not attend to something they should have. So, that is sort of the proximate cause.

And again, this particular example is focusing on the detect notice macrocognitive function. Again, in my mind, the macrocognitive functions are sort of categories for the areas where you need to look to identify these mechanisms.

MEMBER BLEY: Just from my understanding

of this picture, we are on the right side. The dark orange boxes are specific PIFs, and the grayed ones are somebody who might fill in specific PIFs for the specific other things that are in the light blue boxes?

MR. FORESTER: Correct.

MEMBER BLEY: Okay.

MR. FORESTER: That is correct. So, those are just examples.

MEMBER BLEY: Okay. That's good.

MR. FORESTER: Again, for divided attention, the cognitive literature, you find the mechanisms and, then, you look for PIFs or PSFs that might lead that to occur. If there is a lot of divided attention, there is multiple information they are trying to process, maybe multiple tasks, well, then, certainly task load could be an important PIF.

And again, the literature gives you hints, in some cases direct notions about what is going to cause that. It can be sort of a logical, intuitive process to sort of back out what the important PIFs are.

MEMBER BLEY: Let me try something else from my understanding. Because since Gareth brought up workload, that is one that has always troubled me

a bit because you see people think of it very differently. One person says, "Gosh, they've got to do 10 things in 15 minutes. That's a terrible workload." Well, it might not be for a guy.

And the way this seems to be categorizing it is, if, in fact, whatever task you have to do, no matter how cognitively-challenging, if they are dividing your attention, then they become important. If they are not, then perhaps they are not important. This gives you a framework for separating those effects. That is the way you are using it?

MR. FORESTER: That is the way we are using it, right.

MEMBER BLEY: Okay. I like that. What you are getting at there, too, is how you are going to measure that.

MR. FORESTER: Yes.

MEMBER BLEY: That is a very good example.

MR. FORESTER: And you do see a lot of people say, well, if there's too many tasks -- and people can; I mean that is not a problem if that is all they are doing and they have done it before.

MEMBER BLEY: Sure.

MR. FORESTER: This gives you a structure --

MEMBER BLEY: There may be a lot of them to get done, but if they are work through them steadily, they will get there. So, workload is not an issue, I would imagine, unless they have got those 10 things to do in one minute.

MR. FORESTER: Or it is taking them away from something else that is very important --

MEMBER BLEY: Yes.

MR. FORESTER: -- which this is flagging.

MEMBER BLEY: Okay.

MR. FORESTER: So, that is sort of the basic framework. And, then, Gareth has talked about the cognitive failure modes are the crew failure modes, which we essentially, I wouldn't say derived or extrapolated, but, rather, we looked at the proximate causes, and, well, I will address that in just a second, actually.

But just note that this is a framework. We, then, used this to support the crew failure modes and in identifying, as you described with the example about divided attention, what kind of PIFs do we want to measure in the decision trees to quantify the crew failure modes. So, we used that information for that purpose.

If you go to the next slide, April talked

about Stage 1. I should have said Stage 1 of the literature review this morning.

You know, they are going deeper, and so forth, and more complete. But that initial review did produce a long list of cognitive mechanisms that could lead to failure. They were at least guided to some extent by the item model or the macrocognitive functions. So, again, the intent was to cover a range of the information-processing stages.

They wanted to identify, you know, from that, we got the consequences of the mechanisms or the proximate causes. I have essentially already said this. Yes, actually, I have covered most of this.

And, then, the PIFs, of course. You know, we got these things from that initial literature review, the notion that we identified some of the PIFs that could contribute to the failure of the cognitive mechanisms. Again, there wasn't always this direct relationship, but, anyway, I sort of summarized that before.

Okay. So, now we have the proximate causes from what they have given us, but there is a sense that, you know, they are the failure modes from the cognitive model perspective. There is a sense that we needed to couple these PCs with an

1 understanding of the tasks that go on in a nuclear
2 power plant control room. So, again, it is focusing
3 more on the cognitive side. We wanted to take those
4 and look at the tasks that have to be performed in
5 terms of the systems interaction, is probably a better
6 way to put it. It is not just the system-centric
7 point of view, but, rather, the role of the operator
8 interacting with the system.
9 That led us to the CFMs, as Gareth
10 described them, which are a subset of a little bit of
11 an extrapolation of the PCs, again, because there is
12 a sense that they fit better with the actual
13 application, that is, using procedures or not using
14 procedures, but interacting with the system. There's
15 cues; there's procedures to follow. Again, the CFMs
16 are very related to the PCs. I think you guys can see
17 that. Does that seem reasonable?
18 But, again, because there is a correlation
19 or a relationship between the proximate causes and the
20 crew failure modes, the PIFs are still relevant. So,
21 whatever we identified from the literature or backed
22 out from the literature in terms of what is relevant
23 for a particular cognitive mechanism that leads to a
24 particular proximate cause, because of the
25 relationship between the CFMs and the PCs, that

information is all still relevant.

And that is ultimately what we want to capture. Even though we might have altered the PCs a little bit to reflect the nuclear power plant environment, again, we want to capture what kind of things could lead to the cognitive mechanisms that would lead to that crew failure mode, essentially. Okay?

And, then, in turn, as Gareth has described, we will have a quantification model that estimates the probability of each of those CFMs in the decision trees, again, using the PIFs identified from the cognitive mechanisms to the extent possible in the sense of, again, the PIFs are not always given. And we certainly can go beyond the literature in the sense that if we think of other reasonable kinds of influencing factors that we think need to be incorporated in this model, we can certainly add those in.

Not everything has to be restricted only to what we find in the literature review. Okay? If we have logical identification of something that might be relevant, then it certainly can be added in. But the key to this is in being able to measure these things.

MEMBER BLEY: May I?

CHAIR STETKAR: You may.

MEMBER BLEY: Let me just break away to an observation and kind of a question.

MR. FORESTER: Okay.

MEMBER BLEY: When Gareth began, he said you were doing this for defined HFEs. But thinking about the crew response trees that you showed us, the one you showed us, the way you are talking about developing them and the idea that those, rather than individual procedure steps, could also be other kinds of decision points, that strikes me as almost a search mechanism to find a number of HFEs in and of itself. So, I think there are some of that at least so far embedded in what you are doing, even though that isn't what you set out to do.

MR. PARRY: You are right. It is a way of looking for HFEs. And it is a way maybe of redefining HFEs into smaller specific consequence states, if you like.

MEMBER BLEY: And defining the contexts, even deeper contexts.

MR. PARRY: And the subcontexts, yes. I mean the whole concept, the whole framework of how we use the CRT to search for HFEs, and how we decide

break them down into more defined HFEs, we haven't gone through that right now. Okay? We are just saying that, but I think that what we are doing here won't prevent that from happening. I think what will happen, I think there is a law of conservation of failure scenarios, basically. So, if you break down the HFE into smaller groups, probably what you will find is there are fewer CFMs for each of those HFEs, but the total number will remain the same, whether you lump them all together or not.

And part of it comes from whether it is worth exploring the consequences of the different failure scenarios through the CRT. If they are different, then, clearly, you ought to separate them. If they are the same, there's no advantage from a PRA point of view in separating them, except maybe for the possibility of looking at dependency.

MEMBER BLEY: Well, yes, that is what I was going to say, dependency and the likelihood of them occurring --

MR. PARRY: Right.

MEMBER BLEY: -- dependent on those pathways.

MR. PARRY: Right.

MR. FORESTER: And identifying those

different paths and maybe new FIPs certainly parallels, I think, the notion of deviation scenarios from the ATHEANA methodology, too. There is certainly a very close relationship.

MEMBER BLEY: Okay.

MR. FORESTER: All right. The next slide, I have a couple of examples here of sort of our thinking in terms of associating the proximate causes of the CFMs and how we use that information. This is a work-in-progress, but I will try to give you a feel for what we are doing here.

The particular crew failure mode we are looking at here is misinterpret procedures. There are some boundary conditions associated with this. There is an assumption that something has happened, and they are responding to a scenario. They know something has occurred. There is data that they have processed.

And as they look at that data, given the data they have obtained so far, they are reading the procedures, given that information. So, the issue here is we are interested in whether they misinterpret the procedures, and specifically looking at a reading error, so to speak.

So, under the different macrocognitive functions, you can identify, you know, there are sets

of proximate causes that were identified. For example, on the top row up there, it says, "cue information misproceed." That is a proximate cause that seemed to relate to how they might misinterpret the procedures in the sense, if they read the procedures wrong, they misperceive what is there, they read it in a different way, because, for example, the procedures are overly complex, then that could lead them to misinterpret the procedures, obviously, if they read them wrong.

Okay. Well, some of the PIFs that were identified in looking at that particular proximate cause were the quality of the procedures. Of course, the issue, then, is, what do you want to measure about quality of the procedures? You don't ask the analyst, "Well, was the procedure quality high or low?" You have got to give them more than that. You have got to give some ideas about how you are going to measure it.

Well, one aspect might be is there a complex logic involved; are there a lot of and's and or's in some way, or conditional kinds of questions? If that is the case, then, maybe they might misread things because they are confused about the logic.

Is there ambiguity involved? Does the language or phraseology -- again, we have to have a

reasonable way of measuring these types of things. That, I think, is one of our challenges. And we have to measure the right ones to some extent.

But, again, the intent here was to look at the proximate causes identified from the literature review, the PIFs that were identified as relevant to the cognitive mechanisms, and then incorporate that information into how we address each of the CFMs, in this case, misinterpret procedures. This gives us some guidance as to what we are going to measure in the decision tree for this particular CFM.

Another example there is finding an incorrect understanding -- no, no, go back to that -- an incorrect understanding because it is not that they read it wrong; they simply extract the wrong meaning from the information they are reading. Why might they do that? Well, the cognitive mechanisms involved and the distraction; is there a PIF to think about in a sense, and how we are going to measure that task load?

So, again, this is just trying to give you an idea of how we use the literature and try to be logical about our extraction of that information in terms of being able to predict the different crew failure modes.

And the crew failure modes, again, they

start sort of at the beginning in terms of perceiving the cues, and they work to your understanding. So, it is, in general, a serial process, although it doesn't imply that the human information processor only does one little thing at a time.

So, there is a contingency in the sense of some of the crew failure modes ask about understanding. Well, there is an assumption that they have got the right information by that point.

So, if you go to the next slide, and I am open to questions on these, but we are a little bit short of time here. So, I am going to kind of move through this.

Here's another example of one we have already talked about, about the data being dismissed or discounted. So, again, here is a crew failure mode. You can look up at, well, see the boundary conditions there in the middle.

There is an assumption in this case that they processed the cue or the data correctly. So, I will say another boundary condition is that something has gone on in this scenario. They have collected information. They have collected it correctly. And that is leading them to perform a mental model. Okay? So, those are sort of boundary conditions for this.

So, if you look up at the top, we have a proximate cause up there: cue information misperceived. Cue or the information has been misperceived.

Well, we have already said that the boundary condition here is that the data has been processed correctly. So, that is not a relevant proximate cause for this particular crew failure mode. So, that is one we wouldn't have considered or the PIFs necessarily that we related to that, because there is an assumption that they have read it correctly.

The next level there, the understanding level, now we are interested in, because of this mental model that they have developed -- and maybe they developed it on the basis of a partial signature. So, they have been collecting information along this scenario. They have collected it correctly. But because of some sort of bias -- well, their activities, you know, they are working through the procedures, they are trying to understand what is going on.

And maybe there is more than one scenario that could occur from the same set of cues. And because of their training, for example, or the

similarity between these things, or the kind of knowledge they have, they might begin to form an incorrect hypothesis about what the scenario is. And so, they are developing an incorrect understanding.

So, when they get a cue that is inconsistent with their mental model, they might dismiss or discount that cue. So, again, to measure that, you would look at the kind of training they have, the relative frequency on the different kind of scenarios. So, for that particular PIF, that is what you might look at.

The next one down talks about indicator reliability and fidelity. I think John or someone brought this up earlier this morning.

So, once they have this mental model, and they are deciding whether they are going to dismiss information that doesn't fit with their mental model, if there is some history with the indicators about the reliability or fidelity of those instruments, and you can ask operators about it, and you can find this kind of information out, about how reliable or how well they believe the certain information, how reliable it is. Again, they might be more inclined to dismiss the information if that was the case.

So, again, we are trying to get at the

kind of conditions or factors that would lead to these crew failure modes.

MEMBER BLEY: Can I ask a language question?

MR. FORESTER: Sure. That's probably enough for now.

MEMBER BLEY: I have been thinking about ATHEANA and how it aligns with what you are doing now and where it doesn't align. And most of the areas where there is something a bit different, you have defined new words, which is helpful.

There is one word that is kind of troubling me because over there we talked about a mental model being a picture of the plant the guy has coming into the event, and the situation assessment being the adaptive model as you go through the event. And you seem to be using mental model as either one of those kind of things.

MR. FORESTER: You're right. I think I look back on it. Actually, I think the mental model coming into the event I think we might have called the system model. Is that possible?

MEMBER BLEY: I don't think so, John.

MR. FORESTER: You don't think so? Then, I will stand corrected.

But you're right, that is a fair point. As I described it there, the mental model here is really talking about the situation assessment. And if we need to change that terminology a little bit, that could be appropriate.

MEMBER BLEY: I think it would be helpful just to avoid confusion.

MR. FORESTER: Okay.

MEMBER SHACK: Are the colors supposed to be communicating something to me here?

MR. FORESTER: No. No. Just to help you read the --

MEMBER SHACK: They are just random?

MR. FORESTER: Yes. Yes, in fact, when I pasted it out of Excel, that is what it gave me. So, I thought okay.

(Laughter.)

MEMBER BLEY: Instead of drawing lines, Bill.

MR. FORESTER: Yes, that is a good point. I should have been more careful about that. If it is not meaningful, then it shouldn't be there.

MEMBER SHACK: I was trying to figure out, picture something you were trying to tell me.

MR. FORESTER: I'm sorry.

MEMBER SHACK: I could not.

MR. FORESTER: I'm sorry. That is a very good point. Again, I copied it from Excel, and I pasted it in there, and I didn't really attend to the fact I was getting different shading. And, yes, you're right, that shouldn't have happened.

MEMBER BLEY: Some of us could read it okay.

(Laughter.)

MR. FORESTER: Okay. Well, fair enough.

MR. PARRY: Are you done, John?

MR. FORESTER: I am done.

MR. PARRY: Okay. All right.

We will go on to the next one. Okay. So, this follows on specifically from John's last slide. You can see on this slide that the branch points, at least the first three of them on this decision tree corresponds to the PIFs that John identified on the previous slide. Okay? And you will see that they are not your standard PSFs.

Specifically, we are going to talk about a mismatch of expectations, which might come about, well, because of a bias in their interpretation of things. The indications being unreliable, as John said, that this could be to do with the fact that it

is known that some of these indications are unreliable. Therefore, it is easier to dismiss them.

And, then, the third one is confirmatory indications. And, finally, we have got the recovery potential.

I will talk a little bit about what we intend to do with these branch points to convert, to turn this into a guidance for qualitative analysis and the way to interpret which path you go through for a specific HFE. Okay? So, I will talk about the last two.

So, let me talk about the branch point questions for the third one, which is confirmatory indication. The sort of things that we thought were relevant here was that, given that they have this piece of information that they have correctly processed and they want to dismiss it, it is going to be a lot harder to dismiss if there's other information that reinforces that particular bit of information.

So, the types of things we are going to ask here -- and I have got to say that these are not the final sets of questions. These are to give you an indication of the flavor of the types of things that we will do to try to make this as objective as

possible.

So, the things that we would ask are: are there additional indications that would be used to confirm the plant status indicated by the information that they are willing to dismiss? Clearly, we can only find this out by discussions with the crew and what their standard procedures are.

And the second question related to this is: is checking these additional sources emphasized in training, and is it standard practice? Okay? So, we want to know, first of all, can they have the information that can help support this information that they are going to dismiss otherwise? And are they likely to look for it?

If the answer is yes to both these questions -- and I think one of the things we are going to have to be very careful about is how we structure these questions. We don't want just to have a list of questions and, then, without specifying that you have to have yes to all of them or no to all of them to decide which way you are going. So, we are going to have them as sets of conditions that we need to discuss.

So, in this case, if the answer is yes to both these questions, there should be a lower

likelihood of dismissing the information. And at least in this initial stage, we are going to say if it is no to either of these, then we will assume there is no confirmatory information in this case. So, it is a somewhat conservative approach that we are taking here I think.

MEMBER BLEY: Well, I would even hedge it. It sounds conservative on the surface, but there are some indications that create or some situations that create a strong bias to do what is happening here. And there may be things in training that kind of drive you away from digging more deeply.

So, those things don't seem to be elevated. So, I like having that assumption, and rather than calling it conservative, it seems almost compensatory for not having some emphasis on the strength of the indication and other biases that might exist.

MR. PARRY: Yes, I think we are leaning towards trying to phrase the question so that either -- like in this case, as you say, a confirmatory indication is a potential recovery mechanism in a way. So, we would want to make the criteria that enabled you to take credit for that to be more tight, and if there are not identified, then don't take credit for

it. That, I think, is the philosophy that we are dealing with here.

MEMBER BLEY: I kind of like that, but, again, I hope it isn't just offered as a conservative thing --

MR. PARRY: No.

MEMBER BLEY: -- but is somehow compensating for some things you aren't looking for.

MR. PARRY: Right.

MEMBER BLEY: Otherwise, some events that really happened can't be explained because there is --

MR. PARRY: Right.

MEMBER BLEY: -- confirmatory information that would drive you to do something different that is often ignored or dismissed because of the strength of that original decision.

So, go ahead.

If it is conservative, then it is real easy for somebody next year to come along and start digging out the conservatisms without thinking about the other side of it.

MR. PARRY: Right. And I think the way to do that, what I think, probably we need to expand the number of branch points. That would be an easier way of doing it, I think.

MEMBER BLEY: One other thing might be, just a suggestion, mismatch with expectations --

MR. PARRY: Yes.

MEMBER BLEY: -- in a number of events has shown to be a very strong --

MR. PARRY: Right.

MEMBER BLEY: -- biasing mechanism. And maybe that is a thing that there also shouldn't be a strong mismatch situation here to allow you to start taking care of these things.

MR. PARRY: I think that is something we would have to have the experts who are going to be estimating these probabilities to consider what they think when they go down that path. Because I think you are right, the mismatch with expectations actually runs in several of these trees because that is the mechanism we are seeing in a lot of the literature.

One of the things that I think that needs to be done upfront probably is to understand -- maybe we need to construct something like a confusion matrix or something, but a map of this is what the plant parameters are doing for this sequence; this is what they would be doing for something else.

And we have got to figure out if there is a likelihood that the signatures are so close that

this is easy to miss. And why is it easy to miss? It is because maybe they have been training so hard on the non-correct situation compared to the other one.

MEMBER BLEY: That certainly popped up.

MR. PARRY: Yes.

MEMBER BLEY: I guess my worry a little bit is that the experts that would be pulled in to do this might be people who know the plant real well and the procedures real well, but might not be familiar with the strengths of some of these mechanisms. As long as we have got people who understand, that is part of our experts, I don't worry so much, but they are harder to find.

MR. PARRY: We haven't defined that group.

MEMBER BLEY: Yes.

MR. PARRY: But it is clear that they have to have on expertise on the way the plants are and the way crews operate and the way these mechanisms actually have applied. So, I think you are going to have to have a fairly diverse group to come up to be the group of experts that comes up with these --

MEMBER BLEY: That makes me much more comfortable. I know there has been pushing that it would be nice to just have Joe on the PRA team do this without any help.

MR. PARRY: Oh, right. No.

MEMBER BLEY: That is worrisome.

MR. PARRY: Yes. That is why I think that one of the reasons we wanted to go down this approach is, in fact, to avoid that situation because I think it is impossible for somebody to have all that information.

MEMBER BLEY: Yes.

MR. PARRY: And I am pretty sure that a licensee isn't going to go out and hire a cognitive psychologist to come and help him understand these things.

MEMBER BLEY: Right.

MR. PARRY: I mean you know. So, we want to embed all that in the methodology.

MEMBER BLEY: You need some real guidance for that, yes. Okay.

MR. PARRY: Yes.

MS. LOIS: If I may make a clarification, Dennis, so the intent here is to have the CFMs to have kind of generic probabilities for each one of the CFMs and not to have plant experts to give us expert opinion, expert judgment for each one of the potential failures. So, in a way, these are generic data, and, then, the guidance is how to apply this data to your

1 particular plant.

2 MEMBER BLEY: It will be real interesting

3 to see how you are able to do that.

4 MS. LOIS: You are concepts and your

5 values or a similar idea.

6 MEMBER ABDEL-KHALIK: If I may just follow

7 up on the mismatch with expectations, if you look at

8 this problem at a much, much higher level, it doesn't

9 matter what HFE or combination of HFEs you have; at

10 any one point following one or more HFEs, there is a

11 mismatch between the plant status and the step in the

12 procedures.

13 These are all procedurally-guided actions,

14 right? So, one would expect that there will always be

15 a mismatch between the plant status and the step in

16 the procedure that the operators are at.

17 MR. PARRY: That is not what this means.

18 What this means is that the crew has a mismatch with

19 what they are expecting to see. If there is a

20 mismatch between the plant status and the procedures,

21 that is a different problem.

22 MEMBER ABDEL-KHALIK: The fact that an

23 error had occurred means that the crews are at a step

24 in the procedure that is mismatched with the plant

25 status.

MR. PARRY: Okay.

MEMBER ABDEL-KHALIK: So, there is a real mismatch.

MR. PARRY: No, there will be, yes.

MEMBER ABDEL-KHALIK: Right.

MR. PARRY: Down the road, there will be, but this really talks about the initial point at which there should not be a mismatch, but there is because they have a bias. So, it is a different issue.

MEMBER ABDEL-KHALIK: A different point.

MR. PARRY: The cognitive mechanism here is the bias. Okay?

MR. FORESTER: But you are right later on, but that is another situation. If the cues that are being presented sort of mismatch with the procedures in the sense that they are telling them to do the wrong thing, then that would be addressed in a different place, essentially.

MR. PARRY: But I think part of maybe what you are concerned about maybe comes up in the next point. Now, in terms of the recovery potential that we are going to put in these trees, okay --

MEMBER ABDEL-KHALIK: Right.

MR. PARRY: This is recovery. So, they have dismissed this information. Is there a mechanism

by which they are forced to reconsider dismissing that information and get back on track? Okay, this is internal to the HFE. That is what we are discussing about in this recovery potential.

So, what we are going to look for here is -- and this happens because, typically, the plants have a lot of inertia. Okay? There are relatively few things where, if you do something, you are screwed. I mean if you inadvertently depressurize, it is pretty hard to stop.

(Laughter.)

But, typically, you have time to correct yourself. Okay? So, the things that we would be concerned about this recovery potential internal to the HFE is that we are going to assume that they have not just made a decision and then they sit back and twiddle their thumbs. No, they are monitoring what is going on, and they are proceeding through the procedures or they are certainly checking to see that what they have done is the right thing.

CHAIR STETKAR: Well, they know what they did is right.

MR. PARRY: Well, okay.

MEMBER BLEY: That's the problem; they are not recovering.

(Laughter.)

CHAIR STETKAR: They know what they did is right.

MR. PARRY: Okay, they know what they did is right, but does new information come to them because of their interaction with the plant that makes them think, well, maybe I didn't do the right thing after all? So, it is making them change their mental model. Okay.

And, then, given that, not only do they have to have understood that they have made the wrong decision, they have to understand that they have a way to correct it. Okay? And that could be from training or from procedures.

And the other thing is that there has got to be sufficient time to allow the correct response to take effect to prevent the HFE. So, these are the types of things we are going to talk about in terms of the recovery potential.

Now this has been a point of contention within the project team as to whether we should do it this way internal to the decision trees or whether we should try to nest things. Certainly, as a first shot, we are going to try to embed in the trees because it seems a little more compact and potentially

easier to use.

But, you know, we have to be careful because, obviously, with things like if the data is dismissed, we don't want the new information to be just a repetition of that piece of data that is dismissed, right? So, we want the data to be something new and somehow force them to --

CHAIR STETKAR: And so compelling that it convinces me that I need to admit to myself --

MR. PARRY: Right.

CHAIR STETKAR: -- that I am stupid.

MR. PARRY: Yes.

CHAIR STETKAR: Or I was stupid.

MR. PARRY: Right. So, those are the things that we have to consider when we are crafting these things. And again, I think what we are looking for is to see, is there a potential for recovery, and if there is not, if we don't see a compelling reason, then we won't allow recovery in this decision tree. That is the intent of it at least.

MEMBER BLEY: Now it seems to me, I think you just covered this. Going back to your -- don't pull it up on the screen, but back to the tree you showed us in the beginning.

MR. PARRY: Uh-hum.

MEMBER BLEY: Some of these what I will call alternative paths through the procedure --

MR. PARRY: Right.

MEMBER BLEY: -- may not have been in error. It might have been a dealer's choice at this point because things are confusing or the timing might have been off.

MR. PARRY: Yes.

MEMBER BLEY: But if the procedure eventually leads you back to where you wanted to go, that is not kind of a special recovery. It is just continuing in the procedures, where some others you have to actually realize something is out of whack --

MR. PARRY: Right.

MEMBER BLEY: -- and respond to it, and maybe jump procedures or something --

MR. PARRY: Yes.

MEMBER BLEY: -- based on that. They are different in nature.

MR. PARRY: They are different in nature, and I think the questions you would ask would be different, depending on the types of CFMs, and since the recovery for action could be very different, right, because there you really have to be following the function.

MEMBER BLEY: I like your idea of embedding it in the tree for one particular reason, and for these ones that are just "I realize it's wrong and I recovery." Without that structure that is tracking the situation, it is often easy to stack up recovery factors --

MR. PARRY: Yes.

MEMBER BLEY: -- and get a factor of a thousand or something --

MR. PARRY: Right.

MEMBER BLEY: -- that is not real.

MR. PARRY: Right. I think this way forces, well, the intent is to force the HRA analyst to construct the reason why and to give a story of why that happens.

MEMBER BLEY: I like that.

MR. PARRY: The quantification, and this maybe is something that perhaps has not been as clearly communicated, is that what we want to do is to look at the probabilities of the pass through the decision trees a priori by the panel of experts. This is very similar to what was done in the CBDT, only the panel of experts there was two people. It is arguable whether they were experts.

MEMBER BLEY: Yes, but they got it right.

(Laughter.)

MR. PARRY: And the intent here is to provide a consensus out of HEPs that can be used, and in this way reduce the analyst-to-analyst variability.

Again, part of the challenge I think that we will have is to craft the questions that determine whether these PIFs are acting or not for a particular HFE, given its own context. We are going to have to be very careful about trying to make those as objective as possible.

Go on to the next slide.

And finally, well, I have just stated the first one. Basically, the concept behind the model is really trying to force the analysts to do a good qualitative analysis of the HFE because I think some of the more crude models for HFEs, and I have mentioned possibly SPARH, they don't really require you to do a very detailed qualitative analysis that you have to think about do they have training; do they have stress. I think when a lot of people use it, they do it at a very superficial level without really understanding the story behind what is going on.

There are questions that, obviously, we have to address. The two I put down here are just examples of the things. We have already discussed

them I think today. It is, you know, whether the binary structure is adequate and whether the approach to dealing with recovery is adequate.

These I think can only be explored by developing the model and applying it and seeing if it -- I am not sure we will have an objective way of deciding any of these things because we really have no benchmarks to go against.

But I think what we would find is, if in applying the model we find that we are not able to be discriminating enough, although I think with the number of trees we have and the number of paths, we should be.

But, anyway, I think the intent is to develop this first model, play it out against some real PRA scenarios, see what we can learn, and then refine it, and then project it forward to other phases, operational states, and other hazard groups.

With that, I think that is all we have to say.

MEMBER BLEY: I have really enjoyed this morning. I feel a lot more comfortable perhaps than after the last meeting we had.

There is one thing that wasn't mentioned even conceptually that is surprising to me. That is

uncertainty. Nary a word. Is that off the table or when do you plan to start thinking of that and results? Because some of these are going to be very narrow choices sometimes in what you see in these trees, I think, and not just variability between analysts, but actual uncertainty and the results that would probably always be there. It is uncertainty in the performance of the people.

MR. PARRY: Uncertainty in the performance of which people now, the analysts or the --

MEMBER BLEY: No, the operators.

MR. PARRY: Oh, the operators, okay.

MEMBER BLEY: Yes.

MR. PARRY: One thing I think that may not be too obvious is that I think at least my perception of this is that what we are looking for is in some sense the average operator. We are not really able to address, I don't think, crew-to-crew variability in the trees.

I think where that comes into play, if anywhere, is in the assessment of the probabilities. That is sort of difficult to do, but I think that will be the job of the expert panel, because I think that is where your probabilities come from, is from crew-to-crew variability.

And this perhaps is where we will have to rethink things for event assessment because in those cases sometimes you do know by doing a root-cause analysis what peculiarities of the crew caused something to happen. But I think at least for a prospective PRA it is really difficult to think in terms of crew-to-crew variability.

MEMBER BLEY: Okay.

MR. PARRY: Now in terms of uncertainty, we will probabilities and, presumably, people will want to put their factors on them. I am not sure it is all that useful.

MEMBER BLEY: Given the tree I saw, I think you will have time distributions, too, on tasks from which there will be uncertainty in the time, which will give you a probability of success --

MR. PARRY: It's possible, yes.

MEMBER BLEY: -- for some of the things.

Erasmia, we talked about applicability to external events, shutdown events, that kind of thing. Is this structure going to be -- the stuff we saw in the first half, and I am not sure why it wouldn't apply to the second half, either -- is this going to be applicable to new reactors, passive reactors, Small Modular Reactors, that whole group? Those analyses

are being done now.

MS. LOIS: We believe it should work. However, now you need to do the PRA and HRA of the new reactors and understand the differences of accident scenarios probably, potentially, or the different kinds of human failure events that you may have. For example, the multi-modular reactors may have different cognitive challenges. We believe that they are covered by the literature search.

The structure, the other structure, which before it was information collection, decisionmaking, and taking action, now is assessment of the plant status, again, decisionmaking and action. We believe those processes are universal, but the particular areas probably we may need to have different decision trees. I don't know. Even the decision trees may be applicable. But unless we identify the particular domain needs and turn around and see how well they are addressed from the framework, we cannot say. But we do believe that the overall framework should be adaptable. Let me put it this way. That is the intent.

MEMBER BLEY: I hope you are thinking about that, and it would be nice if something forward-looking about where things might be different could be

included in what you eventually write here. It would be very helpful, at least to me. The basic search and the basic framework seem like they ought to hang together, as you said, some of the decision tree work, and we have to see how that actually pans out. It could be different, but I think identifying those, where things might be different and why they would be the same in other cases, would be especially of interest to everybody, and not just us.

MS. LOIS: Okay.

MR. FORESTER: Yes, the interaction with the digital interface is an issue that certainly there is an awful lot of literature of people looking at that. So, it shouldn't be that --

MEMBER BLEY: There has been some work on that.

(Laughter.)

There has been some work on that sponsored through the same organization you guys are working with. So, I hope it is crossing boundaries here.

Your turn. I'm sorry.

MS. LOIS: So, that is an area, for example, interface, man/machine interface with what is the control room interface with the operators, the procedures, how the procedures are being used, et

cetera. We would need to plan out how we are going to deal with all of those issues.

MR. FORESTER: It is a good idea to start thinking ahead in terms of what the implications might be and build in what we can as we are doing the whole thing.

CHAIR STETKAR: Well, the message is, you know, as people have said, the last time people took a hard look at a lot of this stuff was on the order of 20 to 25 years ago. If history repeats itself, you know, I won't be sitting here, but there will be somebody else sitting here in 2035 or so saying, "Well, gee, why didn't those people think about this stuff 25 years ago?"

Any other comments from other members? Bill? Said?

(No response.)

We are kind of running short on time. I mean, my observation, I think Dennis summed up a few of the concerns.

I must admit I don't quite see exactly how it all hangs together yet. I am probably being, you know, muddle-headed a bit, but I don't quite see how it is going to hang together.

I do have some concerns about whether or

not it can be brought together in the timeframe that you have presented. I think there is an awful lot of good information out there. I see how it is, indeed, starting to focus into a practical framework that can be used in a quantitative sense. I don't quite see it yet.

And some of the uncertainty that I am hearing from both the first presentation and the second presentation leads me to believe there's still quite a bit of thinking to be done about how that is brought together, given the fact that this project has been ongoing for, I think somebody said four years --

MR. FORESTER: About two and a half.

MEMBER BLEY: Two and a half? Okay. We are down to the next three to four months. There has got to be an awful lot of acceleration of work done or we are going to be left dangling. So, that is a caution, as I said. I don't know what we do about it. Erasmia, that is your problem.

As far as our next meeting, what I wanted to do is just mention quickly -- and, John and Erasmia, you can work together -- it sounds like if, indeed, all of this is going to come together in the next three months or so, we should be thinking about another Subcommittee meeting probably September or

early October timeframe, unless you go back and decide that the schedule is going to slip.

But I think we would be really interested in seeing as soon as possible some more specific information on this latter part of the process and, in particular, I guess I have a bit of concern about the notion of the fact we are going to be developing generic probabilities that will apply. We need to have some confidence on how that will work.

So, I think we would be looking at probably September, if, indeed, everything is accomplished according to the current schedule. But the message is as soon as we can hear from you again, at the point where you have information coalesced, we would like to do that.

MS. LOIS: So, we hope that we will be able to have expert groups for given estimates in the fourth quarter of 2011, probably November/December.

CHAIR STETKAR: That is the fourth quarter of calendar 2011.

(Laughter.)

MS. LOIS: Calendar.

CHAIR STETKAR: I keep thinking back. You have corrected me that I am supposed to think fiscal, but --

MS. LOIS: So, what we may have, may be ready to present, is the way we plan to conduct the expert elicitation and how, in preparation for that, we will need to ask the structure of the whole process, which probably will lead us to obtain --

CHAIR STETKAR: I think that would be useful. I think that would be useful.

MS. LOIS: And you are right, it may be very ambitious, but I find that if we lose momentum in the project, given the research and given that you can do so much when we tend to dive into a lot of detail and not plow through the actual --

CHAIR STETKAR: Well, as I mentioned earlier when April was up, it is a bit my concern on that part of the work that so much time and effort has been spent with so much detail on one specific function. And maybe there is, I hope that, indeed, there has been a lot more progress on the other functions that we just haven't seen because it hasn't been brought together.

MS. LOIS: Yes.

CHAIR STETKAR: But my concern is a bit that, because of the schedule pressures and budget pressures, that some of the difficult issues in terms of cognitive performance might be given short shrift.

MS. LOIS: Yes, there is a reluctance to give drafts that were not well --

CHAIR STETKAR: Sure. I understand.

MS. LOIS: That's one. The other thing is, as John mentioned, the 50-page literature review that was given to you six months ago, it seems that although we have done so much more work and probably reconfigured the whole structure, underneath the information that we have covered it is pretty much what we got.

CHAIR STETKAR: It is there, yes.

MS. LOIS: We added the coordination and communication macrocognitive function. So, we have at least, on the optimistic side, I think we have a good chance to have good progress by September, December.

CHAIR STETKAR: Okay. Good.

Anything else from the Committee members?

(No response.)

If not -- nothing?

MEMBER BLEY: Nothing more.

CHAIR STETKAR: You may.

MEMBER BLEY: But one more thing. No, no.

CHAIR STETKAR: With that, I would like to thank you. I think this has been a really, really useful exchange. There is good evidence that things

are becoming focused, that, indeed, there is a more cohesive framework, maybe not all of the details worked out yet, but it seems to be coming together. So, this is a lot better than we felt, I would say, whenever the last time we got together, six months ago.

So, thank you very much for the presentation and the information. You have a challenge ahead of you, but thanks a lot.

Now we will adjourn for lunch.

(Whereupon, the foregoing matter went off the record for lunch at 12:28 p.m. and went back on the record at 1:16 p.m.)

A-F-T-E-R-N-O-O-N S-E-S-S-I-O-N

1:16 p.m.

CHAIR STETKAR: We are back in session.

This afternoon I guess we are going to hear about NUREG-1921 and all of its nuances.

Mark?

MR. SALLEY: My name is Mark Salley. I am the Branch Chief, Fire Research, the Office of Research.

Just a minute or two of introduction. As you are well aware, we have an MOU with EPRI where we work on technical projects together. You have seen a number of these. This is another one of those projects.

You are well aware 6850 is how we are doing the fire PRA today. HRA is covered up to a screening level, but there is a need for a lot more information in how to do the detailed HRA.

This project is a joint project, again, between EPRI and NRC's Office of Research. The project is very near to completion. We are 99 percent there, I could say, Susan.

What we would like is to get a letter of endorsement at the end of this for this NUREG to go and be published as final. So, that is what we are

looking for today.

And with that, I will turn it over to the group and let them get started. They have got a lot to cover today.

CHAIR STETKAR: Let me, before you get started, Susan, we will need to talk about the letter because, as you are aware, we are a Subcommittee. We don't issue letters. So, for schedule purposes, if you want a letter, we will need to get a full Committee presentation scheduled. If there are any ramifications from the Subcommittee meeting, you will have to take that into consideration. So, from a scheduling perspective, we will need to work through that.

Also, as a point of information on the record, in the current version of the NUREG, in a couple of sections of the NUREG there are references made to reviews that have been performed by the ACRS. The ACRS has not performed any reviews of this document. It was presented to our Subcommittee in June of 2009. That is not an ACRS review.

MS. COOPER: Right.

CHAIR STETKAR: It also references this particular meeting in April of 2011. This is also not an ACRS review. An ACRS review is performed by a

presentation only to the full Committee with feedback through one of our letter reports. So, you need, certainly in this version of the document, to make those corrections or clarifications.

MS. COOPER: Okay. Thank you.

CHAIR STETKAR: And with that, Susan, it's yours.

MS. COOPER: Dr. Susan Cooper from the Office of Research. I am going to be talking about, as Mark Sally introduced, the joint EPRI/NRC RES fire HRA guidelines. I am going to be talking, giving you the introduction and summary along with my counterpart, Stuart Lewis. Both of us will be up here for the whole presentation to guide us through.

So, let's go ahead and give you an idea about what we are going to talk about today. We are going to give you a brief background as to why this effort was developed; talk a little bit about the development team; refresh your memory on the project history and what is in the guidelines right now, and then tell you about what we are planning to present today.

As Mark mentioned, we do have a substantial number of U.S. plants who are planning to transition to NFPA-805. The way that is being done is

to do fire PRA using NUREG/CR-6850. And within that guidance, there was some recognition of the human reliability analysis tasks, at least so far as identifying human failure events, providing some guidance on screening values and what kinds of performance-shaping factors to address in the context of fire.

However, that document, 6850, did not provide a methodology for doing detailed HRA or providing best-estimate human error probabilities. So, that is a gap. And also, in the interim, we have had the development of the ASME/ANS standard for fire PRA.

So, there is a need identified to provide fire-specific guidance on doing detailed HRA. As a result of that, there was a project identified under the MOU between EPRI and NRC to have a joint effort to develop some methodology for fire HRA and, also, provide guidance for implementing that methodology.

The product of that effort was to be a joint EPRI/NRC report, and that report, as John mentioned, on the NRC side that is NUREG-1921. I understand from Stuart and others that the EPRI number is going to be different than the one that was for the draft for public comment that was already issued.

And, then, we also want to make sure that we consider the requirements of the ASME/ANS standard.

Yes?

CHAIR STETKAR: Question: I know you went out for public comments and factored in those comments. Was the scoping method -- this is something I probably should know, but have forgotten -- was the scoping methodology in the draft version that went out?

MS. COOPER: Yes.

CHAIR STETKAR: Okay. So, you are not planning to go out again with the current version of the report for public comments?

MS. COOPER: No.

CHAIR STETKAR: Except for editorial fixes --

MS. COOPER: That's correct.

CHAIR STETKAR: -- this is the final document?

MS. COOPER: That's correct.

CHAIR STETKAR: Okay. Thank you.

MS. COOPER: I just want to say a little bit about the development team. Most, but not all, of us are here today. Kendra Hill, who is here in the back, is on the NRC side with me. I mentioned Stuart

Lewis, who that is the management side.

Here at the table we have some of the EPRI contractors who will be talking a little bit: Jeff Julius of Scientech and Erin Collins of SAIC. We also have Kaydee Kohlhepp from Scientech in the back. And, then, we also have John Forester and Stacey Hendrickson from Sandia. They will be up here after a while.

Folks that can't be with us today are Mary Presley from ARES, who is a subcontractor to Sandia, and Jan Grobbelaar of Scientech and Bill Hannaman, SAIC.

But, anyway, all these people have been working together now for, well, look at the timeline here. It is actually four years or just over four years, and not all of them all this time, but that is the group.

MEMBER BLEY: Susan?

MS. COOPER: Go ahead. Yes?

MEMBER BLEY: Just before we get started, since we spent all morning on the new approach and the response to the SRM, is there any crosslinking between what you are presenting this afternoon and what we heard this morning?

MS. COOPER: Yes, although I wasn't

supposed to answer that question. That was supposed to be Erasmia's answer.

But, anyway, there is. As you can see, we have some overlap of personnel. Stacey and John are an overlap of personnel between the two, and Stuart now is involved on the industry side.

My understanding at this point in time is the SRM team is looking at our document for things that they can be addressing. And although I don't have personal knowledge of it, direct knowledge, but my understanding is that they are looking at our document for ways that they can incorporate that into what they are doing.

Because we started first -- I mean the SRM might have been issued earlier, but you can see from this timeline that we had our first integrated draft out in May of 2008, and they weren't really doing work yet.

And although we have a timeline that goes up to today, the essential elements of what we have in the guidelines were there in May 2008. We have taken a lot of feedback from peer reviews. We will be talking today peer reviews, pilot testing, other testing, author feedback, and then the public comments. All of those have allowed us to refine

focus and make the guidance better especially. But the essential elements were there back in 2008.

MEMBER BLEY: Is there any expectation on the part of NRC or EPRI that, by the time the other work is published, that this methodology will be consistent with that framework or an expectation that eventually this will have some modifications, so that it will be consistent with the other one?

MS. COOPER: I guess I don't know exactly what is going to happen in the future of fire HRA at this point in time. I mean we have had some discussion, actually, in the last few days about what we thought was going to be happening next.

I think the notion that most of us have, and certainly Stuart and the rest at the table can say something, is that we need to get what we have out and get people to continue to use it before we can identify what the needs are for the technical analysis, before we want to think about doing something different now.

So far as integrations with the SRM, certainly the EPRI approach is already, you know, that has the CBDT trees in it, and they are using tree-like structures in SRM, as we saw this morning. And in fact, the scoping approach is also a decision tree,

although a different one than what they are using in the SRM.

So, there are overlaps, but, you know, like I said, we are --

CHAIR STETKAR: Well, but, in fairness, Susan, they are overlaps in the sense that there are logic diagrams, but the basic philosophies are wildly different. This uses made-up numbers primarily for scoping without real evaluation of cognitive responses. It relies heavily on time margins as a surrogate for a lot of things.

Nothing that we heard this morning relied heavily on time. So, it seems to be quite a different philosophical approach to dealing with evaluating human performance, this being primarily a time-driven issue, the other being a more detailed evaluation of the decision process.

MS. COOPER: I will agree, and I sense that Stuart wants to say something, too.

(Laughter.)

CHAIR STETKAR: He seemed to perk up.

(Laughter.)

MS. COOPER: Yes, he did.

First of all, the charter that we had for our development was to use existing methods. It was

not to develop a new method. It was to use existing methods. So, that is one point.

The other one is that you were talking about the time margin, and so forth. That is principally in the scoping method.

And I would argue a little bit about the fact that there is no cognitive element. The reason why we are able to put that sort of to one side is because we have criteria for using that scoping approach.

And part of it is there are questions asked getting at whether or not the procedures match the scenario and other complexities that allow you to say cognitive complexity is not an issue for this set of scenarios.

So, there is a whole host of other things that can't be treated by the scoping approach, and then have to be dealt with either in the EPRI approach or ATHEANA.

So, you're right, there is a different philosophy. I think it is a matter of timing and different charters. I think it is going to be up to Research management and also what the needs are.

I mean we have got plenty of other things coming up. You folks mentioned SAMGs, and that is

obviously going to Level 2. We have efforts looking at whether or not we should be doing some Level 3 studies and what our emphasis is going to be. We have got a lot of work to do in HRA if we are going to be doing Level 2 and Level 3 and areas that we haven't done.

So, whether it is realigning everything, and so on and so forth, I am not sure what the priorities are going to be.

Maybe Stuart first and then John --

CHAIR STETKAR: We will let Stuart go.

MS. COOPER: Yes.

CHAIR STETKAR: You said you wouldn't hop, but you did jump.

(Laughter.)

MR. LEWIS: I wanted to point out that at least in my view the strongest connection between these two projects is that, given that the fire HRA development preceded most of the work that has been done, the SRM project is going to draw heavily on the qualitative analysis as it is defined for the fire HRA.

There is a lot of really good work there. We don't need to reinvent that particular wheel. And I think that is going to be the strongest connection.

I don't envision that -- I could be wrong or we might prove the need somewhere down the line -- I don't envision, though, that the SRM project will adapt anything that looks like the current scoping analysis in the fire HRA. There is fairly unique and specific to fire.

CHAIR STETKAR: Yes, yes.

MR. LEWIS: I think in the longer-term, as we expand the scope or the hybrid model and start adapting for other contexts like fire, we will certainly draw on all of the information that was assembled in the fire HRA and make sure that we address those same considerations in the methodology.

But the models will not look necessarily like the ones in NUREG-1921 right now. That is my view at least.

CHAIR STETKAR: Okay. John?

MR. FORESTER: Yes, I would agree with that. I was going to make one point about, again, the qualitative analysis is the way we describe it and the issues addressed are going to be relevant to the SRM. There is going to be a connection there.

Certainly, too, I think that you mentioned the time issue. The decision trees in the SRM project are going to have to consider the time element because

time is a factor.

CHAIR STETKAR: Yes.

MR. FORESTER: So, that has to be addressed on our side, too.

CHAIR STETKAR: Yes, yes.

MR. FORESTER: But, you know, overall, I mean the guidance that is there, that is in the fire guidelines is certainly all relevant. There are methodologies to quantify. So, I think it is on the SRM to make sure that we incorporate, again, the qualitative analysis and other lessons learned from like designing the questions for the flowcharts and the scoping. I think those are binomial decisions. I think there is some guidance on how to handle some of that in decision trees, too. So, there is a carryover there.

But, when it is all done, there will be the SRM approach, and that should handle fire, but that doesn't invalidate the methodology and things that are being done in the guidelines.

CHAIR STETKAR: It is a bit of a question of timing, though, because if this is published, if the SRM project meets some of the schedule deadlines that we heard about this morning, we are going to have this document conceivably on the street sometime this

year. We are going to have some form of workshops -- you know, we were talking about first quarter of 2012 fiscal year, I think -- workshops and training sessions on those methods. Maybe I am reading some things into it. Maybe some pilot applications.

So, I would be a little bit less concerned if we were talking about a five-year time gap rather than perhaps several months of gap.

MR. LEWIS: I don't think it will be several months for fire applications in the SRM hybrid approach. I think it is going to be sometime beyond that before we have guidance for that.

We are talking about the basic approach for internal events -- we talked about scope this morning -- this year. I think there is a very immediate need. In fact, it is a need that has already passed.

(Laughter.)

CHAIR STETKAR: It may not be so immediate.

MR. LEWIS: Well, maybe not.

CHAIR STETKAR: That's one of the problems.

MR. LEWIS: But certainly a lot of the people that haven't committed to the transition to

NFPA-805 are still trying to decide exactly what they should be doing. They may do that or they may take other avenues, and they would still benefit from having this fire HRA guidance in the near-term.

I think it is going to be sometime beyond that before the SRM project is likely to produce a usable product that can be used in that context.

MS. COLLINS: And even in draft form -- I'm sorry -- even in draft form, I would say that we are certainly implementing some of the issues that are going out in the guidelines right now in our fire PRAs that we are consulting on. As part of a joint EPRI/NRC training courses on fire PRA, we are transitioning these methods in there.

So, they are there out there. They are being used. Some of the feedback from that is coming in. So, that is on the street already. It is just we don't have our final published, but people are very aware in the community of the draft.

MR. JULIUS: And the final point I have, one of the reasons we invented or developed the scoping method was the stepping stone to do the successive screening that you need to do and a spatial analysis to get you to the point where you can then apply the detailed method for the risk-significant

actions.

I don't envision, even if we had the SRM results today, and starting my fire PRA today, that I would apply all those trees to all the different actions and the different scenarios. So, we need it as a stepping stone in the process.

CHAIR STETKAR: Okay. Point taken.

Continue.

MS. COOPER: Okay. I think I was on this slide. But we may have covered most of what I wanted to point out.

I wasn't planning to go through each of these bullets, but I basically just wanted to draw your attention to the fact that we did start off with a draft in May of 2008. The point of us being here is to really talk about the updates that are a result of a number of things that I have highlighted on this slide.

For example, the peer review we had done back in June of 2008, some piloting of principally the scoping approach and the approach for identification and definition of human failure events in the fall of 2008, and then, also, we have had independent piloting by the PWR Owners' Group. We have had public comments given to us, and, then, a number of the members of the

team, as we have just discussed, have been actively using the methods in the report in work that they are doing.

I think the current draft of the document says that there are at least eight plants at this point in time that have used some elements of what is in the document, either one of the detailed approaches or the scoping approach or some combination of.

Jeff or Erin, do you want to --

MS. COLLINS: I think when we conferred amongst ourselves, we figured there were about eight plants.

MS. COOPER: Yes, just within the team.

MR. LEWIS: If I could comment, I think that is an important point because at least some of the public comments suggested that we needed another round of piloting of the methodology after it was revised to reflect the comments.

So, we tried to weigh the value of doing that kind of piloting against the additional time it would take to do that and the fact that it would make the guidance even less useful to people currently engaged in fire PRAs. And we felt that the work that especially Scientech and SAIC have done to apply the updated draft, whatever you call it, the revised

guidance, was a pretty good surrogate for a pilot at this point and was adequate to convince ourselves that we weren't far off in the way the guidance --

CHAIR STETKAR: Without jeopardizing the identities of specific plants at which the methodology has been piloted, have any of the pilot applications been submitted yet?

MR. JULIUS: June 29th.

(Laughter.)

CHAIR STETKAR: Okay. Thank you.

MR. JULIUS: But some of them have been peer-reviewed.

CHAIR STETKAR: Some of them have been peer-reviewed?

MR. JULIUS: Yes.

CHAIR STETKAR: Okay.

MR. JULIUS: I think we have tallied up six out of eight have been peer-reviewed, have been.

CHAIR STETKAR: Okay. Good. Okay. Good.

MS. COOPER: So, I mean, all told, we have got the pilot testing with two plants in 2008. The PWR Owners' Group actually used a particular plant to do a test, and we had interactions with them and a report that at least some of the team could look at. We had some trouble getting it released to the NRC or

how to treat it. And, then, in the eight plants represented by the author's individual efforts.

So, the joint team felt like that was enough testing, at least at this point in time, to go forward, and then get it out there, get it used some more, and then see what happens next.

MEMBER BLEY: Can you tell us anything about how the peer reviews have gone? You know, having the methodology, do they go better or can you say anything at all?

MS. COLLINS: I am trying to think. Well, we have had, subsequent to the peer review, then there have been some additional findings, I will tell you, on the using scoping methodology. And so, we have had some, even between the different plants that we have done, we have seen some differences in what happens in terms of the number of, let's say, values that are quantified with scoping that then have to go on to be requantified with detailed analysis because they end up being risk-significant.

In one case, there were not that many. In other cases, there seemed to be, as they do further iterations and get more feedback from the fire modeling, it seems to be more surfacing they have to be redone.

So, yes, that has been one of the challenges, I think, in our document, is we have the methodology, but, then, in certain areas coming up with specifics, there are still very plant-specific issues that have to be dealt with.

MR. JULIUS: For ours, the comments primarily fell into three areas. One was the dependency analysis for the risk-significant scenarios. Well, the risk-significant scenarios were evolving fairly rapidly, and they still continue to evolve.

The second one was in the area of the plant procedures. As part of this 805 transition, the plants are using these opportunities to update and revise the procedures. And so, one of our findings was yours was developed on a set of procedures that is going to be developed. And so, in the third level, it was the plant changing and the modeling changing and the dependencies were the three. So, the PRA, you know, the fire-growth models or splitting in different scenarios, or splitting the transients up into different -- and finding out where the cables are -- those have bigger impact than the method.

CHAIR STETKAR: I assume sometime this afternoon we will get into -- you mentioned

dependencies. Is part of the presentation on that issue?

MR. JULIUS: Yes.

CHAIR STETKAR: Okay. Thank you.

MS. COOPER: Susan Cooper.

I just wanted to pick up one point that was related to something that we were talking about a little bit earlier. That is that at this point in time the authors believe that the guidance is useful to the industry generically. Issues that may still be lurking out there that would be maybe steps in the future for maturing the fire HRA further are likely to be more plant-specific. I think that is probably consistent with what I think this Subcommittee has heard from the public earlier, like last November and December.

Anyway, let's move on, if that is okay, unless you had something else.

CHAIR STETKAR: No.

MS. COOPER: Okay. I think I have covered some of this. We have addressed the public comments. In the interim, we have developed a full track of training for the joint EPRI/NRC fire PRA training course. We presented that track last fall, and we are on schedule to do that again this coming fall.

It says public resolution, a comment resolution now. The report we sent over to you folks is the technical comments resolved. We are now into polishing and cleanup, that sort of thing, and, then, moving into the final report this summer. So, that is where we are at now.

CHAIR STETKAR: So, if I can, because there are obviously in the report, the version that we received, a number of editorial issues. The references weren't --

MS. COOPER: Yes.

CHAIR STETKAR: But, essentially, that report has full resolution to your satisfaction of all of the technical details?

MS. COOPER: The technical details have been resolved.

CHAIR STETKAR: Okay. Thanks.

MS. COOPER: So, I just wanted to just remind you and summarize some of the key topics in the fire HRA guidelines.

First of all, we have used a standard HRA process for fire HRA based on other HRA processes that are out in print, such as what is in the standard good practices, SHARP1, so on and so forth.

However, in order to address some of the

fire-specific needs for HRA, we have had to develop further guidance for particular tasks. We will be talking about that some today.

So, some of the steps that are identified in the fire HRA guidelines, and I am presenting them here in the order that they are in the document:

The first is the identification and definition step for human failure events. One of the added tasks for analysts that we discussed in some detail is the notion that, because we have new human failure events that are being defined, particularly in the fire response procedures, we need to have some kind of test, if you will, to make sure that these are things that can be credibly modeled in the PRA.

So, we have what is called the feasibility test. This is further discussed and described.

And the next step in the analysis, which is the qualitative analysis, but this notion of feasibility is actually carried through throughout the analysis and, then, sort of transforms itself into reliability.

So, initially, you want to know whether or not this is something you really can put in the model. And, then, as you get more information, you may refine that answer. In the end, some of that same

information, then, gets kind of input into your reliability assessment.

We have had some discussion already on the second item here and in conversation. That is the qualitative analysis. The team decided to call out qualitative analysis explicitly as a task.

This is in part due to feedback from, for example, the international empirical study or benchmarking study, where the results indicated that qualitative analysis was an important driver to the types of results that you can get and the understanding of events, and so forth. So, we decided to call this out as an explicit step.

Some of the refinements that we have made have tried to even further emphasize the fact that the overall process is iterative, and the qualitative analysis as underlying every step in the analysis is also iterative. You are constantly or almost until you finally publish the number that you are going to put for failure probability, you are constantly updating your information and understanding of what is going on.

I already mentioned that feasibility -- and this is actually a change to the document. We will talk about this some more in another

presentation. We now have a discussion about feasibility for human failure events in the qualitative analysis section. It is picked up elsewhere, both in the identification and definition and also in the scoping approach. But it was decided that we would move the bulk of the material to this section since it is used throughout. Anyway, that is the principle.

Yes?

CHAIR STETKAR: Actually, it is Chapter 4 of the report. I would have brought it up to make it 3. You already say that you ought to do it. I don't know if that is considered editorial or not.

MS. COOPER: There were a lot of comments.

CHAIR STETKAR: It is just a side comment.

MS. COOPER: Yes. Yes.

CHAIR STETKAR: But keep going.

MS. COOPER: It has been moving around, and we have had suggestions.

CHAIR STETKAR: Move it up to zero.

MS. COOPER: Put it in the beginning, put it in the appendix, put it in --

CHAIR STETKAR: No, I wouldn't put it in the appendix. I would make it Chapter zero or something like that.

(Laughter.)

MS. COLLINS: You want it right upfront.

MS. COOPER: Yes. Point taken.

CHAIR STETKAR: No, I mean I am sure we will have more detailed discussion about it this afternoon, but the point is made, and you have just made it also, it is something you need to do at the beginning and keep in mind throughout the whole process.

MS. COOPER: Absolutely, and some of the comments that we have received on some of the other sections are, "Well, I can't do this now because I don't have enough information in this step." Well, maybe in the beginning you don't, but as you go through -- none of the steps are serial or you finish it and you're done forever. You are constantly going through it. But in the qualitative analysis, there is certainly that aspect.

Does anyone here want to add something?

I mean we will be having a presentation --

CHAIR STETKAR: Yes.

MS. COOPER: -- specifically on the qualitative analysis.

CHAIR STETKAR: There is a lot of material here.

MS. COOPER: Yes.

CHAIR STETKAR: As I said, we don't have lives, either. So, we can go until midnight.

MS. COOPER: Well, we will try to press along.

CHAIR STETKAR: We will try to keep on schedule a little bit.

MS. COOPER: Okay. So, there are three quantification methods. We are not going to talk about screening today, but we will be talking about the scoping and the two detailed methods, and we will be talking about dependency recovering and certainty analysis.

So, our focus today is principally to talk about how we have updated the document since the draft issued in December of 2009, and specifically focusing on what came out of the peer-review testing and public comments, how we responded to that, and, then, what are the resulting changes, especially, like I said, from the December 2009. So, that is it for getting started.

CHAIR STETKAR: I think, from my perspective, it is interesting because the last briefing that we had had on this was, as we said, in June 2009. At that time, I think the only thing that

we had was a paper that you had prepared for a conference, which that is sort of general concepts, but not a lot of the details. There was a notion that a scoping analysis would be performed, but not any of the details at that time.

I looked back through mine. At least I couldn't find anything.

MR. JULIUS: I thought the scoping was there.

MS. COOPER: The scoping has been there since 2008. It did undergo a restructuring based on the piloting at two plants in the summer of 2008. So, it was actually, the pilot, those two pilots and the peer review then resulted in some rework that then resulted in an April 2009 draft. So, we have been responding as best we can from these inputs. We felt like they have been productive and useful. But, like I said, the basic concepts of a scoping approach and the two detailed --

CHAIR STETKAR: No, those concepts were there. It is just that the amount of information that is currently in the current document about scoping. As I said, the notion of time margins, I don't recall that. Maybe I am not -- anyway, that is history. Let's go on with what we have today.

MS. COOPER: Okay. All right. So, here is the outline of what we are going to try to plow through today. We are going to finish up here and, then, start talking about the reviews, tests, and public comments. Then, we will move into presentations specifically on the different steps, guidance in the document, and how it has changed. And, then, we will wrap up with just a quick here's where we are and where we are hoping to go next. So, that is it for the introduction, unless, Stuart, did you want to add anything?

MR. LEWIS: No, I think I made whatever comments I would have made along the way there.

MS. COOPER: Okay.

MR. LEWIS: So, we can get onto the next topic.

MS. COOPER: Jeff, it might be easier for you to use the mouse over there than me try to use this thing here to get that the way you want it.

MR. JULIUS: Just push F5.

MS. COOPER: Okay.

MR. JULIUS: Hi. I'm Jeff Julius of Scientech, under contract with EPRI, and I am going to co-present today with Erin Collins. We are going to present the summary of the reviews, tests, and public

comments that we have done along the way and summarize the changes we have made in our fire HRA guidelines.

So, this timeline picture is meant to color-code and show when and where the different types of reviews. So, we had an internal review at the start of the project. We have had a peer review, NRC review, and a public review/comments. So, that is the yellow highlighting. And, then, the light purple is the testing.

And again, the testing was done by the project team initially in 2008 at two plants, and that was of the scoping method. Then, it was piloted by the PWR Owners' Group in 2009. And along the way, between the SAIC and Scientech, we have applied the guidelines at several of the non-pilot plants.

So, you can see we didn't wait until the very end to get a set of review comments, or whatever. It has been done throughout the entire project.

Splitting those into reviews, tests, and then public comments, we will start with the reviews. There were two types of reviews, the fire data review, which I was counseled yesterday that is probably a bad term. It was really more of an internal review, but it was meant to cover three different areas.

So, we did this upon project initiation to

make sure that we as a writing group team knew what were the requirements of a fire HRA. So, what was needed from 6850? What is the historical experience and data? And what really goes on at the plant? So, we could better capture the as-operated plant.

So, we first looked at the requirements from the PRA standard. We looked at the existing guidance in NUREG-6850.

Then, we benefitted from Sandia having done part of the 6850 development and just some background, looking at fire historical events for the types of performance-shaping factors to see if there were any new performance-shaping factors that we needed to add for fire or if there was something fundamentally different in the process or the approach or the methods.

In addition to the foundation work that Sandia had, we looked at some of the historical events that had occurred since the publishing of 6850. So, there was the San Onofre fire and I think a Diablo Canyon fire. So, looking to make sure that we were capturing the historical and operational experience of fires.

CHAIR STETKAR: Jeff, the document, you know, throughout the document there are numerous

1 references to the fire PRA standard, specific sections
2 of NUREG/CR-6850. I found no references to things
3 like Reg Guide 1.205, NEI 04-02, NEI 00-01, which also
4 contains substantial guidance, especially in the area
5 of treating fire-induced multiple spurious operations,
6 the scope of those analyses.
7 Was that guidance consciously not
8 included? I mean, you know, there seems to be a lot
9 of -- and we will get into some more details on this
10 and specific issues --
11 MR. JULIUS: Sure.
12 CHAIR STETKAR: But there seems to be an
13 awful lot of reliance on the ASME/ANS standard to the
14 exclusion of other guidance that might be out there.
15 And obviously, 6850 because this is in response to
16 that.
17 MR. JULIUS: Right. Well, let me back up.
18 So, we didn't explicitly or consciously exclude the
19 NEI guidance.
20 First, the concepts of multiple spurious
21 operations, MSOs, comes up in 6850. Then, the
22 development or treatment of the multiple spurious has
23 changed as the PRA standard has evolved.
24 So, we made sure that we were able to
25 address the what needs to be done. Typically, the NEI

guidance --

CHAIR STETKAR: Let's wait.

MR. JULIUS: Yes.

CHAIR STETKAR: I am sure we will get into it in a different area.

MR. JULIUS: Okay.

CHAIR STETKAR: I was just curious.

MR. JULIUS: Okay.

CHAIR STETKAR: It wasn't a conscious --

MS. COLLINS: Yes, not a conscious exclusion, I would say.

MR. JULIUS: That's right.

MS. COLLINS: But you're right. I mean we did look at the PRA standard quite a bit because we knew that our target audience would be very interested in making sure that whatever they produced was consistent with --

CHAIR STETKAR: Well, your target audience also should be concerned about the Regulatory Guides also, since the staff reviews of any submittals will take that into consideration.

MS. COLLINS: Point taken.

CHAIR STETKAR: Okay.

MR. JULIUS: Okay. So, after our internal review, we developed our first draft. Then, you see,

on slide 5, we worked on, had an independent peer review. This was a team consisting of NRC and utility folks and industry experts who maybe worked for a different company at the time.

Then, the purpose was to check the validity of the method and the technical basis and, also, the detail and the clarity of the guidance. So, they wrote up, had several pages of peer review findings that we had addressed, then, in the development of the first draft.

Testing. So, the testing was started, and one of the peer review comments from the initial peer review was that the method ideally would benefit from doing some testing at some sites. So, we picked a site that was a NUREG-6850 pilot where we had some previous experience from 6850, and, then, we picked one of the sites further west.

(Laughter.)

CHAIR STETKAR: Good enough.

MR. JULIUS: And we developed some test problems and, then, went out to the plants and sat down and, as part of the feedback, talked to the PRA teams at the plants and got some operational feedback as well as the plant feedback to benchmark or hone our activities, if you will.

Then, the testing by the developer. So, this is what we described earlier. In other words, outside of this fire HRA project, part of the writing group team, we have applied this method for some of the fire PRAs that we are developing. Actually, for all of the fire PRAs we are developing.

CHAIR STETKAR: Jeff, since you did mention one of the two sites was one of the pilot projects --

MR. JULIUS: Sure.

CHAIR STETKAR: -- it doesn't need to be named.

MR. JULIUS: Well, actually, one of the two that hasn't been submitted for the --

CHAIR STETKAR: Oh, okay. Never mind.

MR. JULIUS: Is that helpful?

CHAIR STETKAR: That hasn't --

MR. JULIUS: That didn't submit yet, yes.

CHAIR STETKAR: Oh, okay. When you say the pilot project, I think --

MR. JULIUS: It was actually a 6850 pilot that was used to develop 6850 and not the --

CHAIR STETKAR: Oh, okay. I understand. I understand.

Because what I was going to ask is 2008 --

MR. JULIUS: Right.

CHAIR STETKAR: -- the two NFPA-805 pilot projects were really early in their process then.

MR. JULIUS: Actually, that was an issue at all these plants and actually one of the peer-review things. We struggled to find plants that were sufficiently along outside of the pilot plants.

And even the pilot plants at that point in time had detailed scenarios, but a lot of the other plants had done the whole-room burnup initial quantification, but really didn't have detailed scenarios. And so, that was one of the things we struggled with, was getting the data.

CHAIR STETKAR: Yes. Okay. Fine. Right. I didn't get the nuance that --

MR. JULIUS: Okay.

CHAIR STETKAR: -- it was one of the 6850 pilots and not NFPA-805. Thanks.

MR. JULIUS: Okay. And, then, last, or it seemed like only a year, but it was 2009 in the spring that the PWR Owners' Group, and this was a request from EPRI, and specifically Ken Canavan. The idea was a comment that: okay, it is nice for the second, the middle round, that you guys in the writing group team can develop guidance that you wrote. I would

1 certainly hope that you could follow guidance that you
2 wrote, but the rest of the industry has to follow this
3 as well. And so, we want to give this over to
4 somebody that hasn't been involved with the
5 development process and get their comments and
6 feedback.
7 And so, the PWR Owners' Group did that and
8 went out and did operator interviews with the guidance
9 and developed some human error probabilities. They
10 were one of the major commenters in the public review
11 comments that we will get. But they did produce a
12 Westinghouse report on the --
13 MS. COOPER: Yes, Susan Cooper. If I
14 could just interject?
15 PWR Owners' Group and actually the BWR
16 Owners' Group both got advanced copies of what was
17 then published as the draft for public comment in
18 December of 2009. So, just ahead of that, whatever we
19 had, we gave both PWR Owners' Group and the BWR
20 Owners' Group copies. The PWR Owners' Group actually
21 did do a test with a particular plant. I guess the
22 BWR Owners' Group just had it ahead of time for their
23 public comments.
24 MR. JULIUS: So, then, the report was
25 finalized in November and released in December to

ADAMS in 2009. It went out for public comment, and the industry requested an extended public comment period.

We received several sets of comments, which I will address here in the next couple of slides. And we broke those comments into, you know, we triggered them to each report section, but, then, we also pulled out of them -- there were 10 specific major, public, high-level comments that we will address here in the next couple of slides.

So, we went through and addressed each of these comments technically we have talked about. Then, the actual response and the summary of the public comments and the summary of the reviews and testing is provided in Appendix F, or Foxtrot, to the NUREG.

The current version that you have, the approach is not fundamentally different, but we have made some important changes in the way that we present as well as implement the information.

So, in addition to the BWR Owners' Group and the PWR Owners' Group, the Boiling Water Reactors and Pressurized Water Reactors, EPRI's HRA Users' Group commented as well, and Exelon commented.

Each comment was tracked with a numbering

system and was addressed. Then, in a couple of cases, the comments applied to multiple areas. So, we ended up subdividing them out. And overall, there was a total of 290 comments, and the distribution looks something like this.

MEMBER BLEY: Jeff, I did not look through that appendix and look at the comments in any detail. There is an area where I might have thought you would have received some strong comments. I wonder if you can talk about that.

Early in the qualitative analysis section, there is a section about special cases where little or no credit should be allowed. Some of these are pretty strong in what they disallow, some completely and some without strong justification.

Did you get comments on those areas? Because some of them I have heard people argue the other side of, although I tend to fall into your camp on this.

MR. JULIUS: Not so many, although those primarily came from 6850, and there were several places in 6850 where, then, we went back and, as part of the development of this update, we revised and revisited some of those considerations.

MEMBER BLEY: Okay. Because the ones that

kind of jump off the page for me were the ones that, if you are in breathing apparatus, you can't count on your good communications. I believe that from my experience, but I have heard a lot of people who hardly ever have had it on claim it is no problem.

MR. JULIUS: Well, my experience --

CHAIR STETKAR: Because they have hardly ever had it on or --

MEMBER BLEY: Perhaps.

(Laughter.)

MR. JULIUS: My personal experience, I have operated for several hours with it on, operating machinery in a reactor and a boat.

MEMBER BLEY: But if you had never had it on before, you hear a lot of "rah-rah-rah".

And the other ones were about equipment that may be starting and stopping, and that kind of thing, and all of that should be no counted unless there was some strong basis for it.

MR. JULIUS: I don't recall our treatment on individual comments on this section, but --

MS. COOPER: We can try to dig that up.

MEMBER BLEY: I was just curious if you got a bad reaction to it. And if not, I think that --

MS. COOPER: I don't think there were many

comments on that.

MEMBER BLEY: Okay.

MS. COOPER: I think we adjusted one or maybe two of those kinds of special cases from 6850 based on either comments or discussion in our group. But I don't recall it as being a major category, but we can dig that out.

MS. COLLINS: I don't recall us getting formal comments about that, but sometimes during our training sessions --

MR. JULIUS: Yes.

MS. COLLINS: -- when we were talking about implementing it, we might get audience participation, comments to the effect that, "Oh, gee, we think that we would be able to do" X, Y, Z in SCBA, but nothing formalized.

MEMBER BLEY: That was a pretty thorough, I mean there was about seven or eight of those. Were they in 6850? Is that what you are telling me? I didn't remember that.

MR. JULIUS: Yes.

MEMBER BLEY: Okay. Okay. Well, they are still pretty strong, whatever you had to fix, they are still pretty strong.

CHAIR STETKAR: Notable on here, you have

1 got representation here of the BWR and PWR Owners'
2 Groups and EPRI and one owner/operator. The notable
3 omission is I don't see NEI up there.
4 MR. JULIUS: NEI coordinated with EPRI.
5 CHAIR STETKAR: They were active on 6850
6 and anything else related to fire PRA in terms of
7 public comments. Do you feel they are effectively
8 represented through the Owners' Groups?
9 MR. LEWIS: I think they were. They were
10 involved in the process when the reviews were done.
11 They provided some comments through the HRA Users'
12 Group.
13 CHAIR STETKAR: Oh, okay.
14 MR. LEWIS: Those aren't EPRI comments
15 necessarily. They came, a lot of them came from the
16 utility --
17 CHAIR STETKAR: Yes, I understand it is
18 users' groups.
19 MR. LEWIS: And the NEI participated
20 through that avenue.
21 CHAIR STETKAR: Okay.
22 MR. LEWIS: I think they decided not to
23 submit a separate set of comments themselves on the
24 document.
25 CHAIR STETKAR: Okay.

MS. COOPER: I will say that NEI was the one who requested additional time for public comment.

CHAIR STETKAR: I was just curious, you know, only because on other areas of fire risk assessment they have commented rather extensively, you know, on a lot of details, actually.

MR. LEWIS: And the request for the time extension wasn't because they wanted more time to review it themselves. It was on behalf of the membership --

CHAIR STETKAR: Oh, yes. Sure, sure. Okay. Thanks.

MEMBER BLEY: Although we have been talking about public comments, you had lots -- what was the extent of the comments and changes internal to NRC? Were they pretty broad or --

MS. COOPER: No.

MEMBER BLEY: I assume all the organizations had a chance to comment.

MS. COOPER: I guess there is some overlap between the peer review and some of the NRC comments. To the extent that Gareth used to be here, he gave us some comments on multiple occasions. But, otherwise, other than his comments, I don't think there were many.

I mean the principal comment came to me early on, and that came from Ray Gallucci there in the back. That is, "I want a method that is simple for me to understand and review and know where the number came from."

That is the reason, to my mind, for the scoping approach. The information that I have heard him say is that it does allow the reviewer and the licensee to very quickly focus in on where disagreements are. If the number is different, you can trace it to why, what assumptions or decisions or how the decision was made differently. And that is the genesis for the scoping approach.

MEMBER BLEY: Okay.

MR. JULIUS: Okay? All right. So, we will go through, in the next three slides or so, go through the major public comments.

The first one is an overarching one. That was the NUREG presents methodology and guidance as well as the background on how the methodology and guidance was developed. It was written as a nice kind of a textbook read from beginning to end, but it is hard to use as a methodology document, and it was hard to separate the background from the guidance, and specifically, in the Chapters of 3 and 4.

Chapter 4 with the qualitative analysis had this long, flowing descriptions of these different performance-shaping factors, but it lacked the "So what?" You know, what does this mean to me if I am doing the fire PRA?

So, we did a rewrite on Chapters 3 and 4 to provide better clarity and distinction and, then, restructured the appendices. The very first appendix before was the description of these background documents that we did the historical data review. And it is like, well, none of the users are particularly or may or may not be interested in the historical data review. So, we will move up the definition of terms and the detailed quantitative analyses to be at the forefront of the appendices.

So, that was the first major public comment. And that was one that it is difficult to strike the balance between you're writing too much guidance or too simple on the guidance, and how much background, and what your intentions were when you wrote the guidance. So, we tried to strike a balance there.

The second comment was that the identification and definition needs to better match the fire PRA tasks. And again, that was somewhat of

an overarching comment because the initial version of the report was written that there was pretty much one approach to fire HRA and it has three different quantification methods, but it didn't recognize that the fire PRA develops from the 6850 Task 7, the whole-room burnup, to some scoping quantification, to more detailed scenario quantification.

And so, we added a mapping table in Chapter 2 to show where the fire PRA tasks -- actually, our initial diagram in there pretty much had the fire HRA with about, I don't know, it seemed like 1200 different arrows pointing into every single task and coming out of every task because it interacted with every task.

MS. COLLINS: But the table scopes it out very nicely, I could say, because you guys drew it. It is a very nice correlation now, and I think it really helps the user quite a bit in terms of visualizing which of these 6850 tasks, and what type of interface you are talking about, you know, as early as component definition and, then, as late as the requantification iterations. So, hopefully, it helps.

MR. JULIUS: That's right.

We simplified Chapter 3. We had in 3 a lot of drill-downs that, when you get into the initial

identification of actions, the different types of actions that you may encounter. And we simplified that to be those actions from the existing internal events analyses or from the fire procedures or from the undesired response to spurious.

The third one was, again, it appeared to be aimed at Capability Category III. This was primarily because, when we had the timing, the timing section in there for the time margin and the feasibility, it said, well, we are going to require these guys to go out and demonstrate for each of these actions that they could go perform the action. That is great, and in the PRA standard that is Capability Category III. So, when you start thinking that these fire, you know, if you have 50 HEPs and there's several hundred different scenarios, to demonstrate them for every particular area was onerous to the plant. It is a requirement that was beyond what is in the existing requirements for the internal events PRA.

CHAIR STETKAR: Well, I will let you finish the thought.

MR. JULIUS: We scaled that back. So, to allow for talk-throughs or walk-throughs or existing analyses that may have been done, for example, if you had done fire protection or 805 transition or Appendix

R, if you had done walk-throughs for the feasibility analyses, that you could use that information.

CHAIR STETKAR: I thought I read somewhere that the basic focus of this guidance is, indeed, to meet Capability Category II. Is that correct?

MR. JULIUS: That is correct.

CHAIR STETKAR: Okay. Yes, I see in one of the responses in that Appendix F you tried to make it clear that the NUREG is focused on Category II, not III.

MS. COLLINS: Right. Right, but apparently there was still some uncertainty about that --

CHAIR STETKAR: I understand.

MS. COLLINS: -- because of certain requirements that they thought were overly stringent and related more to Category III than II.

CHAIR STETKAR: Right.

MR. JULIUS: The next one is on the feasibility and the qualitative analysis level of effort. And for this particular one, the feasibility criteria that we established, they are written up in Chapter 4, although we invoked the first feasibility when you first do the identification and definition. The criteria or things to consider are the same.

And it is kind of like a continuous action step in a procedure that you would be following in a plant, where you look at the criteria, and do I meet these, and with the information I have right now, yes, I do. So, I can include these and continue on.

But it is recognized that, as the fire PRA develops, you know, you are going to get more information or the information is going to change. So, that is why we made it continuous action steps, and really invoked this, then, this treatment throughout. But, again, the criteria are the same throughout, but the level of information may change as you develop your fire PRA.

And this is a case where, again, we allowed the existing information from walk-throughs or your fire protection review, the NUREG-1852, of feasibility for operator manual actions.

So, we did, in this sense, we might not have called it out very explicitly, but we did specifically recognize that in the fire protection world and programs that you are things like operator manual action feasibility, and that those weren't stovepiped and completely separate from what we are doing, that there are overlaps and that the things that were being done there we should recognize and

take credit for as an input to the fire HRA.

In terms of guidance improvements, it was interesting, we had a section, okay, so now we have to say that the timing or the information on the progression and identification of tasks, you know, you could get this through talk-throughs, but recognize that within the existing HRA references that are out there, there isn't guidance on talk-throughs yet. So, we added some guidance in the current report

And we also increased the guidance on the ATHEANA approach. So, ATHEANA is a detailed method for fire HRA.

We revised the guidance on stress. In the EPRI HRA approach, we had this concept that, okay, if you had these regular stress factors, that if it was a fire, that you would have even more stress. We scaled that back.

MEMBER BLEY: We passed over the previous page in discussion. But I am not sure, did you do anything in response to those comments about it looked like it was too much like Category III?

MR. JULIUS: Yes, that was, in addition to the discussion on the timing and scaling back from requiring a demonstration for the timing of the actions, we also went back in and in the qualitative

analysis, the background on that was, when we put it in the qualitative analysis, we were thinking about the SRM project. And as Susan said, we had learned from one of the lessons from the empirical study and the benchmarking that a good, fundamental qualitative analysis is important for giving the qualitative insights and feedback, but it is also, if it is done well and consistently, it supports any quantification that you do.

Well, great, except for when my fire project manager calls up and says, "Well, I don't need the full detailed set of operator interviews and things on things where I am still the initial screening and quantification."

So, then, we scaled it back to say that the qualitative analysis needs to mesh with the quantification you do. So, if you are doing a screening quantification or a scoping quantification, particularly the level of detail and level of efforts, you wouldn't necessarily go and do the full qualitative analysis at the onset.

See, John, you're looking --

CHAIR STETKAR: Yes, I didn't get that out of reading the report. Go on, though.

MR. JULIUS: Maybe that is why we have to

focus or relook --

CHAIR STETKAR: I didn't get sort of that hierarchical qualitative analysis out of reading the report.

MR. JULIUS: Okay.

CHAIR STETKAR: I am not saying I necessarily agree with a hierarchical qualitative analysis because --

MR. JULIUS: Well, we kind of went, again, the full pentaloom was we wrote up here's how you do a nice, detailed qualitative analysis.

CHAIR STETKAR: Yes.

MR. JULIUS: And, then, we kind of backed off and said, well, you know, read this and think about, with the endpoint in mind, though, if you are at the point of just doing screening, maybe you will use some estimates or maybe, instead of going and getting the transit times or the routes for all the rooms, we will take the first room and apply it across the board.

MEMBER BLEY: Let me push just one aspect of that.

MR. JULIUS: Okay.

MEMBER BLEY: You may have it covered. So, just tell me how it is covered.

MR. JULIUS: Sure.

MEMBER BLEY: If we cut back on the qualitative analysis to match the level of detail in the quantitative, and we are doing a screening, without a thorough qualitative analysis, there are issues about dependencies and complexities that you might miss. So, I would expect that you ought to be assuming dependencies more often than you might if you have done the thorough qualitative look.

Do you do anything to take care of what you don't see because you don't look for it?

MR. JULIUS: Well, generally, I mean the screening HEPs are high. So, when you got to the dependency approach, those events would come up in conjunction, and, then, you would go back and revisit that combination.

MEMBER BLEY: The combination?

MR. JULIUS: That's right.

MEMBER BLEY: And that's right, well, because I don't remember just how it is -- okay.

MS. COOPER: Susan Cooper. If I could just clarify?

It is mostly the notion of having to do a walk-through to demonstrate or develop a timing estimate for every human failure event that you might

need to address.

And we had, actually, a lot of discussion on the team about how to address this particular comment, but it was just too onerous, too time-consuming. And I think the way the report reads is that that is still the best approach. But if you have similar information or information for similar tasks that you can extrapolate from, you know, but --

CHAIR STETKAR: Okay. That I remember reading, yes. That is a really subtle point, but I remember reading that.

MS. COOPER: You have to build on what you already might have in hand to develop some timing information such that maybe, then, you will only, you know, you do an initial quantification, and maybe there is only a doze then you have to go out and revisit and maybe develop some detailed information.

CHAIR STETKAR: Just out of curiosity, I mean, if doing walk-throughs and talk-throughs of fire response scenarios to develop reasonable timelines for a qualitative analysis is judged to be an onerous effort, that tells me that whoever says that is an onerous effort must have tons of these actions in their PRA, which to me says there is a problem. It says they are probably putting human actions in the

PRA as a quick-and-dirty way out of doing detailed fire analysis.

MR. JULIUS: Not necessarily.

CHAIR STETKAR: Because I have done a numerous number of -- you know, walkdowns to trace cables hand-over-hand takes some time. Getting operators together and saying, "What would you do and where would you go to do this? And let's go walk there to see if, oh, gee, I forgot the door is locked" really doesn't take a lot of time and money, unless I have to do it 150 times for my plant.

MR. JULIUS: Well, that is a factor of six low, in that when this comment was made, the requirements and the amount of fire modeling and detailed scenarios have grown dramatically from when we first embarked on the transition to 805. It was originally for the plants that we were working on, you know, we proposed that, oh, maybe the top 10 or 15 areas you will have a few scenarios that you will develop further. And I think on the average for the three plants that I was personally project manager on, it was anywhere from 800 to 1200 different fire scenarios.

CHAIR STETKAR: All of which contain at least one operator action?

MR. JULIUS: This is without even considering fire HRA. So, this comment was made without even considering that the HRA might have one or only one. Even if it had one for every other scenario, you would still have maybe 600 things you would want to demonstrate.

Now it turns out some of those you weed out or with ignition frequencies and the fire damage state frequencies --

CHAIR STETKAR: That is not my point. I mean I have done a bunch of fire risk assessments. And you look at a scenario, and the quick-and-dirty way out is, if you give me a number of 10 to the minus 3 for an operator error and I can put that in and somebody will accept it, I will put it in because it costs me time and money to trace cables and find out a realistic fire development.

What you are doing, though, with that is you are implicitly telling people to just throw a number crunch in there and say, well, the operators can take care of it, and we will give you an easy way out. We will give you a quick way out of getting your fire risk down by saying the operators can fix everything without necessarily refining the fire-initiating event frequency or doing some detailed fire

modeling to say how much time does it actually take for a fire to grow from Point A to Point B, where it will damage those other cables. Or maybe the cables aren't even there, if you went to look for the cables. But that is resource-intensive --

MS. COLLINS: Yes, and I think you are right.

CHAIR STETKAR: -- and it is a bit of a concern that, if we try to make the HRA too easy for people, they will use it as a crutch instead of understanding the response of their plant to a fire.

MR. JULIUS: But we have --

MS. COLLINS: I don't think we have.

MR. JULIUS: Even in the current, the number of cases where we have a 10 to the minus third probability, I mean the screening HEPs are in the .1 to .5 range.

MS. COLLINS: Well, 10 to the minus 3 I think is below value on the scoping approach as well. So, yes.

MR. JULIUS: Yes. So, I mean we have had project managers begging us for lower values. We have said, "No, we don't have the development, and we need to go back and look at this."

CHAIR STETKAR: And 10 to the minus 3

says, given a thousand times that I am going to be challenged, I only going to fail once.

MR. JULIUS: Yes.

CHAIR STETKAR: That is pretty darned good.

MR. JULIUS: It is.

CHAIR STETKAR: It is a lot better than surgeons will give you on any kind of life-threatening surgery by probably a couple orders of magnitude, at least one, if not --

MS. COLLINS: But I think you have a valid point. It seems to me my experience has been different. I seem to have fewer human failure events to quantify because it seems in our projects there is a lot more, there is so much additional circuit analysis --

MR. JULIUS: A fair amount of circuit analysis --

MS. COLLINS: -- in the fire modeling. So, by the time they get to working that all out, then they have very few left to give me.

CHAIR STETKAR: Okay.

MS. COLLINS: So, I think it just depends on the approach that is used.

CHAIR STETKAR: Okay.

MS. COLLINS: And I am sure that changes with each person you work with.

CHAIR STETKAR: It does, but from what you said, Erin, I am happy to hear that because part of the deterministic problems that we have had over the years is that people have been using operator manual actions and things like that as a surrogate for actually addressing the fire issues.

MS. COLLINS: Uh-hum.

CHAIR STETKAR: And I would hope we are not perpetuating that in the PRA space just by giving people numbers that they can throw at the pot, rather than --

MS. COOPER: I don't think we are letting them -- we are not giving it away. We are saying, okay, if you want to try to justify, you know, an extrapolation from something that might be extending, you know.

Anyway, John wants to --

CHAIR STETKAR: Yes, John.

MR. FORESTER: Maybe I am clarifying something that doesn't need clarifying, but the changes we made, for example, to the feasibility assessment, initially, we were asking for the sort of detailed walk-through simulations where they would go

out, they would walk through, and they would take time measurements.

So, that was the concern about the resources when we offered up the notion of -- I mean what they wanted was, can we use talk-throughs and sort of existing information to do these assessments? We did back off to that point in a sense. Yes, if you do the talk-throughs in a good way and you do an elicitation for the timing in a reasonable way, you use existing information that you can count on, taking the fire context into account, then that was our relaxation.

So, it is not like they didn't want to do talk-throughs. That is what they were looking for in a sense. What they didn't want to do was have to start out in a simulator, have the cues come up, have the operators assign someone. They go through all the timing, trying to put on their SCBs. All this physical execution is what they didn't want to do.

CHAIR STETKAR: I mean my only point is I don't understand the concern if I only have to do that for a dozen scenarios because it doesn't strike me in the grand scheme of resources that that is very resource-intensive, even going through the type of exercise that John was just talking about.

If, instead of a dozen, I need to do it for 500, well, I understand the resource concerns there, but my point is that why, in heaven's name, does your fire PRA have 500 operator actions in it for which I need to do these walk-throughs?

So, if you do have it in there, it probably means that you have not done enough work on trying to correctly characterize the actual fire scenarios by either ignition frequency, fire growth suppression, damage, tracing cables, or something like that.

MR. LEWIS: And I think one of the things that has been done to the report, whether it goes as far as it could I don't know, but it may not have been in reaction to a specific comment, but there has been an attempt to describe the implementation of the fire HRA in the context of how you actually do the fire PRA and stage the tasks in a more logical manner --

CHAIR STETKAR: Yes.

MR. LEWIS: -- as opposed to treating them all like they are, more or less, a linear process all the way through. I think that is helpful to people as well --

CHAIR STETKAR: Yes.

MR. LEWIS: -- to kind of find a happy

medium between --

CHAIR STETKAR: Yes, between the two extremes.

MR. JULIUS: My only comment was that, talking whether there was HRA involved, was that if the plant was seeing that there is potentially 500 different scenarios, that potentially they were extrapolating on that. But for any of the scenarios, there are requirements in the fire protection world as well as the fire PRA world to demonstrate the feasibility. So, I mean those are done for the action.

CHAIR STETKAR: That's right. That is regardless of whether we are going --

MR. JULIUS: Regardless, that's right.

CHAIR STETKAR: -- deterministic or --

MR. JULIUS: Exactly.

CHAIR STETKAR: -- probabilistic.

MR. JULIUS: Does that answer your question, Dennis? Did we get back on this one? We went back a slide for you?

MEMBER BLEY: Thank you very much.

(Laughter.)

MR. JULIUS: All right. And, then, the last bullet on this slide was the scoping

quantification, and we have talked about this, the revisitation of the time margins, but also some of the things on the suppression time. The NUREG-6850, Supplement 1, addressed changes in the suppression time, and we had some decisions based on using when the fire was out and things. We had them based on a fixed time instead of being driven by the scenario.

The last four comments, the uncertainty was a complete tear-down, throwout, and rewrite to basically match the internal events approach. We will get to further -- we have a section on dependency and uncertainty.

The comment from the PWR Owners' Group about the undesired response to spurious was one that said, hey, the standard focus is on the annunciators, alarms, but your guidance says we should look at going through the EOP steps and maybe having the EOP steps lead you off an undesired response to spurious.

And this is a case where we differed, I guess, from what the standard had because we developed this in parallel. But, then, the PWR Owners' Group developed their own document showing that, generally, if you are following the EOPs, there is either sufficient redundancy, it is either inconsequential, if you were to make some transfer or that would lead

you back to the initial response.

The last two are more general comments and not about a specific section. The first one is that the pilot application was needed, and this is the point we emphasized again, where we have essentially done the pilot through the different reviews and tests, and then the implementation at several sites, including six that have peer reviewed.

And the last comment was the PWR Owners' Group, the one about the training or additional guidance is really needed before any practical PRA person could use this. And we started the training sessions last fall. Actually, we started the year before that with some familiarization training, but we developed a separate track for the fire HRA in 2010, and for 2011 it is scheduled for August and November.

All right. So, in summary, we had conducted reviews, testing, and addressed the public comments. It wasn't just a case where the fire writing team was off writing this in an ivory tower without recognition of what is going on in the fire PRA world.

And so, the next set of presentations then drill-downs into each topical area and talks about the specific changes with that area.

We are now switching to the identification/definition of post-fire events which will be given by Jeff Julius and Erin Collins.

This is a relatively short presentation. We are going to focus on what is identification and the categories of human failure events, the definition, and the feasibility.

So, the feasibility is developed in detail in Chapter 4, but we do invoke it. As you have heard, first, identify an action. You have got to ask the question, is it feasible; can you do it? Then, the summary.

So, in terms of the process, the identification process was unchanged. But, again, we simplified the chapter and restructured it.

The fire HRA starts with developing an understanding of what are the different operator roles, but also the different types of procedures that are being used. So, we categorized these from the operator actions that are coming from the internal events PRA that use the emergency operating procedures and abnormal procedures as one category of events because they have certain not only the procedures, but the training and the familiarity of the operators, but then the fire response procedures, as the second

category of actions.

And again, the review of the process from the standard and that we have employed is you understand what is in the PRA model, but also what is the plant doing in terms of what is being invoked by their procedures and use operator interviews to help make sure that our reading matches what the plant is actually doing.

MEMBER BLEY: I am just curious because I don't remember what you said about it. There have been a couple of events in the last years where the simultaneous paths through the EOPs and the fire procedures have led to some problems in ability to devote the normal level of attention to the EOPs.

And I am just wondering if you have addressed that in any particular way because I don't remember reading about that.

MR. JULIUS: We do in the EPRI approach. One of the issues we actually struggled with when setting this up initially is that, like the variation of plants across the United States, there are variations in their implementation of these procedures.

Some of them, when we start the fire response, go completely over to a fire response

procedure and set aside the emergency operating procedures. Some are multiple and others are in the EOPS that are augmented or supplemented by the fire response procedures. So, we had to write the approach and guidance to cover the range.

But we do have increased error probabilities or contributions from being in multiple procedures in the EPRI approach.

And in the scoping approach, did we address it or not?

MS. COOPER: I don't believe there is anything in the scoping approach, but, as I recall, the ATHEANA example tries to look at some aspect of that. But I would say that we have had some discussion just recently that that might be one of the things that could be explored further.

But, as Jeff said, because there is a variety across the plants, probably if you dove in more deeply, you would probably have to have three or four different approaches, depending on how a specific plant used their procedures.

MR. JULIUS: So, once we have identified these, these are the human failure events that are going to be used in the PRA model or were considered for the PRA model. Again, the three different

categories that we developed were those that were the operator actions from the internal events PRA. These were based on the emergency operating procedures and abnormal procedures.

The fire response actions, and these are new actions that were contained in the fire procedures, and sometimes they are used to recover the spurious actuation. So, John, a lot of times these were new events that were maybe added to the model in response to particular MSO pathways.

And we also considered, then, the main control room abandonment as a subset of these fire response-type actions.

CHAIR STETKAR: I assume we are going to talk about abandonment in more detail later, sometime this afternoon? No?

MS. COOPER: We had not planned to, but we could.

CHAIR STETKAR: Okay. I will wait. I am sure I can get it in somewhere else.

MS. COOPER: Okay.

MR. JULIUS: Okay?

CHAIR STETKAR: I have an overriding time concern here that deals with caffeine.

(Laughter.)

MR. JULIUS: We have this coveted first spot after lunch.

And a third category was human failure events or potential human failure events corresponding to the undesired response to spurious. So, this was a new category or a new consideration for the fire that an annunciator, an alarm, would cause the operator to go out and take an action that was, you know, a well-intended operator, but it was something that would make that plant response worse.

And so, we developed this treatment or categorization, yes, treatment or development for each of these three categories of actions.

CHAIR STETKAR: You are later -- I haven't had a chance to go through this -- in the sense of the questions that I did have in all seriousness, I am assuming, yes, you are, you are going to go through the different scoping trees and stuff like that.

MS. COLLINS: Yes.

CHAIR STETKAR: So, we can talk about some of that.

MS. COLLINS: That is a whole separate section.

MS. COOPER: Not all of them. We have an example or two.

CHAIR STETKAR: You will at least broach the subject?

MS. COOPER: Absolutely.

CHAIR STETKAR: Okay.

MS. COOPER: Absolutely.

MR. JULIUS: That's right.

So, coupled with the identification, the definition gives the initial basis or justification for even including that event in the PRA. So, again, have you looked at it in enough detail that you can convince yourself that this is something that you can add with a probability as opposed to saying it is guaranteed failure?

So, we further defined or broke out the objective qualitative data that you would look at. So, again, something that would make it easy as a starter, and, then, we would further develop that data in a qualitative analysis.

But, for example, does this action exist in the procedures, yes or no? What are the cues and the alarms or indications? What is the time available and the time required to response, and the staff, and the specific tasks and the associated human failure event success criteria? I need to open these two valves to provide so many GPM flow within a certain

time.

And that was all part of the definition. Once we have that, that gives you enough information that you can do the initial feasibility evaluation.

Well, if this takes three operator actions, and it has to be done within 13 minutes, and that is my time window, and it takes 10 minutes to do it, maybe the initial quantification is zero or we don't even put it in the model.

So, the changes here were to clarify and to make this more succinct.

The initial feasibility assessment we clarified. First of all, the purpose of the feasibility assessment is to decide whether an operator action can be accomplished or not, given both the plant-specific and the scenario-specific fire impacts. So, it is, again, not only what are the procedures and things, but the fire impact as well?

So, we will fail the human failure event or set the human error probability to one. If there was no procedural guidance or if all the instrumentation was failed for a particular area, or not sufficient time or insufficient manpower -- we did struggle on this one because, if you started to ask, "Well, what about the case where I do this," or "What

about this," "What if I get to there and there's not tools or things?" So, we added, we have one category we call "other"; for example, the fire in the same location or inaccessible due to tools. But, really, the focus initially is on the procedures, instrument, timing, and manpower. Then, the other factors come up more when we get into the qualitative analysis.

MS. COLLINS: Yes, upfront now in this definition section, you are just mainly looking at, is it a go or no-go, and you are setting it, you may set it to one initially, but that doesn't mean you might not reevaluate it later when you have further information.

MR. JULIUS: That's right. Actually, a strategy of several plants is, for the fire response action, they would rather for most of them, you know, minimize the number of fire recovery actions in terms of their licensing basis. So, a lot of them prefer to we won't even credit it to begin with; let's just see what the impact is and what the scenarios are, and, then, add the actions as we need to, to further respond to the risk.

So, that was a short presentation. Again, we do this identification and definition to focus on finding out the human failure events that are in the

model and defining in sufficient detail that we can hand off information into the qualitative analysis, to then evaluate the human reliability impact of that particular scenario.

CHAIR STETKAR: I had a question. I don't know where the most appropriate place to ask it is. So, perhaps you could give me some guidance.

I sort of alluded to it before, but you mentioned one of the categories of actions that are evaluate are HEFs that correspond to an undesired operator response as a consequence of spurious signals. In several places in the report, and I probably didn't find them all, there is explicit mention made of the fact that the scope of that spurious signal analysis to meet Capability Category II needs to consider one, and only one, spurious instrument signal. Is that the direct intent of this document?

MR. LEWIS: Yes.

CHAIR STETKAR: Okay. How do you reconcile that with guidance in the Regulatory Guide 1.205 which endorses NEI 04-02 and NEI 00-01 that says you basically don't have a limit on the number of simultaneous multiple spurious operations that you need to consider? Or do you reconcile that with the

results of the CAROLFIRE testing program that basically concluded that there is no limit on the number of multiple spurious operations that can occur in a real fire?

MR. JULIUS: We reconcile it through the standard. Initially, before the standard was developed, it was --

CHAIR STETKAR: So, a fire will proceed according to the rules of the standard rather than according to the rules of fire?

MR. LEWIS: It is a requirement, actually.

CHAIR STETKAR: Okay. I will make a note of that the next time I have a fire.

(Laughter.)

No, seriously, this is an important topic because in any reasonably-designed power plant with any reasonably-designed set of procedures, any reasonably-educated set of operators, if I have one, and only one, spurious instrument signal in the control room, I probably can cope with that pretty well maybe, but a lot of plants only have two trains of things.

So, it is not clear to me perhaps in some cases, if half of my instruments are failed high because I only have two, that I know that the failed

high one is the result of the fire. Certainly, if I have four trains of instrumentation or three or other things, coping with a single failure is pretty easy to do.

Real plants and real fires might have fire locations where you could get spurious indications from perhaps two out of four, maybe three out of four, but the guidance in this NUREG says I don't need to consider that. That, to me, sounds rather arbitrary and rather simplistic, and it doesn't necessarily sound consistent with what people are being required to -- "required" is too strong. The guidance that is available from NEI and the Reg Guides say you have to evaluate in terms of multiple spurious operations of the way people normally think of it, motor-operated valves, for example.

MR. JULIUS: Let me back up because I think you are somewhat mixing and matching requirements in there. Okay?

CHAIR STETKAR: Okay.

MR. JULIUS: First off, let me just back up and break them into different categories. Okay. First off, we do model and respond to cases of multiple spurious signals operating multiple components, but it would cause an undesired either

electrical plant impact or valve line-up that would lead to things --

CHAIR STETKAR: I understand.

MR. JULIUS: Okay. And, then, the second one is a multiple spurious or signals that were failed. If you have a two-train system, we break up and differentiate between whether both trains are available or one train is impacted or you've got no instrumentation.

So, the impact of the operator response on the reduced reliability of the instrumentation is factored at least in the EPRI detailed HRA approach.

CHAIR STETKAR: It is EPRI detailed HRA, but that is not, for example, what I need to think about when I do scoping and screening perhaps.

MR. JULIUS: Perhaps.

CHAIR STETKAR: But my point is that, if you need to consider the effects of the fact that I have four valves in the plant that went closed spuriously, and for some reason that puts me on a scenario trajectory where I need to deal with that, what is the difference between that and having four pressurizer pressure channels fail high or four steam generator level channels fail in bizarre ways? The fire doesn't know that it is an instrument signal that

goes to the control room versus a signal that goes to tell a valve to go closed. It just doesn't.

MR. JULIUS: Understood. I agree with that.

So, we would look at that, the design and the training, and most of these procedural rewrites that I was talking about earlier would identify for this particular area this is the success path that has the good instrumentation. The fire in this area potentially impacts these two or three other channels, and these are not reliable instruments to use for the safe shutdown. And we don't use a nominal or low HEP because we just say the operator does have to figure that out.

But where we draw the line, or what we don't do in terms of the different categories -- so, that first example would be either No. 1 or 2, either a fire response action or operator action that has the spurious going on that influences the response.

CHAIR STETKAR: Yes. Yes.

MR. JULIUS: The third category is, okay, you have got one of these pressurizer channels or steam generator levels, and that causes the operator to go out, and I don't know, trip the auxiliary feedwater turbine-driven pump because the steam

generator level is high and he is worried about failing the pump.

CHAIR STETKAR: Right. But, under that situation, I only need to consider one, and only one, out of, for example, four steam generator level channels that does fail --

MR. JULIUS: Yes.

CHAIR STETKAR: One of two, one of three, depending on what my plant time is.

MR. JULIUS: That's right. That's right.

CHAIR STETKAR: I don't need to consider a case where, let's say, I only have two channels, and both of them are failed high spuriously, where the operator absolutely knows that the level is high.

MR. JULIUS: But for those, with the redundancy and diversity we have in the plants, we know for those cables and for those particular channels that you listed whether we have those or not. And so, we know for that particular area what steam generator level indicators --

CHAIR STETKAR: Let me twist it around. Let's say I do have an area that has both of the steam generator level channels routed through it. Let's just say that. Let's say that I was dealing with it in my deterministic world by some means, and now I am

going to do a PRA, a fire PRA, on that fire area. Does this guidance say that I only need to consider one spurious high level signal?

MR. JULIUS: No, this guidance says that, if you have no instrumentation that is needed for that action, that the operator error probability is one; it's failed.

CHAIR STETKAR: No, this is two spurious high level signals, and the guy says, "Oh, my God, I need to shut off all feedwater to that steam generator." So, he does that.

MR. JULIUS: No, this guidance doesn't address that.

CHAIR STETKAR: Okay.

MR. LEWIS: The guidance would only cause you to look at that if one instrument failure could cause that action to be taken.

CHAIR STETKAR: I mean the examples are in there that, from a single channel that gives me high bearing temperature on a pump to shut it down, or something like that.

MS. COOPER: Yes, the intention was, if there was a single signal, erroneous signal, that would lead you to take an action without verification --

CHAIR STETKAR: I understand that. That is the deterministic single failure criterion type of thing creeping into PRA.

MS. COOPER: Yes.

CHAIR STETKAR: I am talking about a fire that could cause multiple spurious signals.

MS. COOPER: I understand.

CHAIR STETKAR: And are we treating that consistently with this guidance compared to the guidance that people are given to treat multiple spurious operations of valves, for example, where there isn't that -- it doesn't say you do your PRA assuming that one, and only one, valve operates spuriously.

MS. COOPER: Yes, we do not have that right now. At one point in time, we started developing that and, then, the standard changed.

But Ray Gallucci from NRR is back here, and I sense he wants to weigh-in on this.

CHAIR STETKAR: Yes.

MS. COOPER: So, I want to make sure he gets a chance.

MR. GALLUCCI: I will ask the authors to correct me on this, but isn't there something in the NUREG that says you have to assure that you will have

enough diversity so that you wouldn't be misled by one spurious signal before you take this type of credit?

MR. JULIUS: Yes. But that is the $50 question.

MR. GALLUCCI: I thought I remembered something.

MR. JULIUS: So, even if you have one, are you going to be influenced by the fact that you might have two or three that are telling you something different?

CHAIR STETKAR: I was really looking for that. There are a few places that there is a bit of qualitative discussion that says, well, you have to be careful about this; you have to think about this scenario. But, ultimately, I am led back, and I have numerous quotes that say the standard only requires you to consider one spurious instrumentation signal. And if you can justify the fact that the operators would not take that undesired action in response to one, and only one, spurious instrumentation signal, then you do not need to consider that HFE in your PRA.

And I kept coming back to that, you know, as reasonably explicit. I can give you quotes.

So, I just wanted to make sure. I think what I am hearing back from you is that is a distinct

intent --

MS. COOPER: Yes, I guess the only refinement in what I would say is one spurious indication as an input to a particular decision that influences an HFE, not necessarily that -- for the scenario in its entirety, there could be other things going on.

CHAIR STETKAR: That is a different thing, though, given one spurious channel, if the HEP is to manually start recirculation and I have a spurious, one spurious high-level signal in my RWST compared to two spurious high-level signals in my steam generator, which the operators would then interpret as guidance for them to stop all feedwater to that steam generator. Those are two different, distinctly different types of responses.

If I can, unless other members -- we have stopped, come to the end of this presentation. As I said, there is an overriding concern here regarding caffeine.

Do any of the members have any more comments on this particular presentation?

(No response.)

If not, what I would like to do is to take a break, only because the coffee apparently closes at

three o'clock.

MS. COOPER: Oh, I thought it was 4:00.

CHAIR STETKAR: I thought it was 4:00, too. If it is 4:00, yipee. But, still, it is a decent time for a break.

So, why don't we recess until, let's come back at 3:05. If you can keep it to 10 minutes, I would appreciate it because we are starting to run long here. Let's do that.

(Whereupon, the foregoing matter went off the record at 2:65 p.m. and went back on the record at 3:08 p.m.)

CHAIR STETKAR: Let's come back in session.

Let's see what the next topic is here.

MR. JULIUS: Transferring the presentation, the next one is on qualitative analysis by John Forester.

CHAIR STETKAR: Right.

MR. FORESTER: I should say that both Jeff and Erin have had more to do with this section than I have.

(Laughter.)

MS. COOPER: Lately.

MR. FORESTER: Lately. I have been a

constant reviewer, a crab in their side, I guess. That's okay.

MS. COOPER: Do you want me to drive it for you (referring to the slides)?

MR. FORESTER: If you wouldn't mind, yes.

MS. COOPER: All right, I can try.

MEMBER SHACK: All that responsibility.

(Laughter.)

MR. FORESTER: The next slide just tells us where we are at in the presentation.

I think a lot of this -- it is nice to be downstream a little bit -- I think a lot of this has already been discussed.

So, again, we have talked about the different steps of the process, and now we are to the qualitative analysis module. Essentially, what we do in the document is go through the steps of what has to be done for the qualitative analysis. And I am going to do that, too, just give you sort of a high-level overview, and, then, talk about the changes that have been made based on the public comments.

For the most part, in this section it is mainly just clarification or additional information or emphasis on things, except as has already been mentioned earlier the feasibility assessment. We did

make some fairly big changes with respect to that.

Obviously, everyone here knows the qualitative analysis lays the foundation for the quantification steps. So, it is an important step in the whole process.

And it starts with the input from the definition of the human failure event. Again, in classic HRA terms, whether you are doing fire or any other kind of HRA, in defining the HFE, you are defining, you know, you know the actions; you are going to look for the timing for the actions, how much time is available, what procedures they are going to be using, what's the accident progression been, what kind of steps have occurred before they get to a particular place where an HFE occurs? What else? But, again, you are generally defining this information as you do in any HRA.

The notion here, though, is that within the NUREG-6850 steps you may not have all of this information that you need at least initially. So, it is an iterative process, and you collect more information as you move through the process.

Then, we have the method steps, as we have here. It talks about the qualitative analysis that needs to be done. Some of this information will

already be obtained in defining the HFE, again, the classic information about timing, actions, procedures, and so forth.

Okay. So, then, we will move forward and I will talk about the different steps of the analysis.

So, the first step is the data collection process. Again, the emphasis here is on collecting all the information you need, as much as possible, for all the quantification methods. The notion is to have that in mind, but not all of it may be available. So, you will have to do this more iteratively as you move through the different steps of the overall fire PRA analysis.

But, in addition to that, I think as you build this particular set of information that you are going to be using to perform the HRA, not every piece of that information will necessarily be used in all the quantification methodologies. They have their own particular things that they called out that they use directly in the quantification.

Nevertheless, the overall development of the qualitative analysis serves as the foundation. And that is, again, what we found in an empirical study, that even if a particular method only addresses a subset of the performance-shaping factors, if they

have done a good qualitative analysis and understand sort of the big picture about what is going to be going on, those methods that do that seem to have a better result essentially.

So, again, the first step in terms of the response to comments, again, we added some additional information to sort of emphasize the importance of the subtasks.

So, the first step, then, is to look at the operational, historical, and the model data. Again, you are collecting information about the plant. Again, this is the same thing that you might do in defining the HFE. You are looking at PRA information. Again, all this is looking at things like how is the staff going to respond after they detect a fire; what kind of staffing is going to be available? You will be interested in fire procedure usage, as we have already discussed, whether they are using an EOP separate from the fire procedures. And are those things being done in parallel or are they integrated in some way? This is all sort of basic information about the operation of the plant that you are going to need.

Also, things like the control room interaction with the fire brigade. Are some of the

control room personnel going to be on the fire brigade, and how are they going to interact with them?

So, again, you are sort of setting the context for quantifying your HFEs by collecting the plant- and the PRA-relevant information. What is the timing again? What are the cues going to be, the specific procedural usage, and so forth?

A lot of this will come from defining the HFE. To the extent you don't get that, then you have to add this additional information.

Another thing, particularly in the fire application, is that different HRA methods were used in the Level 1 analysis. So, analysts are going to have to understand how that analysis is done, what methodology was used. You are going to collect information about operator interviews that were held in terms of how they would respond to the scenarios; also, any simulator work that was done.

Again, setting the basis for what you are going to do, because now you have to look at those same kind of events and take the fire context into account. So, you want to have a good understanding of the situation, so you can now appropriately consider the fire effects.

Historical experience, again, is a useful

thing to include. And there's descriptions in the guideline as to how you should treat these things.

If there have been incidents at the plant, you are going to look to see how the crews responded. What seemed to influence operator performance? Were there any gaps in training or in procedures? Again, understanding what you can about how you expect the plant might respond in the fire conditions.

And more generally, you think experience from industry would also be relevant, other fire events, how the crews respond. So, again, you are building up your understanding of the situation.

Okay. So, again, that is just giving you an overview of what that step is about. And again, we have provided more emphasis on that in response to the comments.

The next step is the feasibility assessment, which has grown to be a fairly significant part of this analysis. I mean in some ways it has always been a part of HRA. You begin to look at how much time is available. Do you have enough time to diagnose and respond to the situation, given when the cues occur? You know, that is traditional HRA kinds of questions, but it is very important in all steps of the analysis because the point is that that might

change across time.

Initially, you might think there is not going to be enough time, but later on you might find additional information that there is going to be staffing available to take care of some of these things, or vice versa, in the sense that you take credit for it initially and find out later that they are going to be so busy and there is going to be so many different things going on that you can't assume it is going to be feasible. So, it is an iterative kind of process.

In response to the comments that we received, again, we have already really talked about this, that we modified the requirements for doing these feasibility assessments in the sense that we provided guidance for them to take credit for information they will already have and, also, for how to do good talk-throughs, rather than having to do the very detailed, systematic demonstrations that we were originally arguing for.

This is particularly relevant for scoping, for example, and for Capability Category II, in the sense that this kind of approach is certainly adequate if you are identifying for the non-risk-significant events. Once you have identified risk-significant

events, and you are going to do a more detailed analysis to address those, at that point you need to decide, you may decide you need to be a little more systematic about how you do the feasibility assessment.

But, again, we tried to relax it in the sense that, at least for non-risk-significant events, talk-throughs and, well, existing information, if you have good, reliable information, and you take the fire context into account to make sure that the times come from the operator manual -- well, operator manual action feasibility would include the fire impacts.

But if you are looking at training exercises, and if you haven't really tried to simulate the fire conditions in any way, you are going to need to think about those things. What are the fire conditions going to be? Could it impact, even though they have been trained on this, and we have these times, could the fire impact assessment of those times? Job performance measures, once again, those probably weren't done under fire conditions.

So, the evaluation and the talk-throughs that would be conducted along with these assessments are going to have to take the fire conditions into account. But, again, there less emphasis on doing the

very systematic demonstrations except where it appears to be very risk-significant events.

CHAIR STETKAR: John, one thing, and this is kind of an item of detail, but we have had discussions of late about the integration between safety and security issues at plants. And indeed, I have seen a couple of plants, not in this country, I will say that, where fires in certain areas can affect security systems and, indeed, will lock people out of locations. You know, I can't generalize, but, indeed, I have seen them.

That type of notion doesn't come through. You talk an awful lot about, you know, accessibility in terms of going through an area that might be full of smoke, about the need to obtain keys to unlock cabinets that might contain special equipment that you might need, use of breathing apparatus.

And PRAs typically don't look at fire effects on plant security systems because what does the security have to do with safety response of the operating crew?

MS. COOPER: That is a good point, John.

This is Susan Cooper.

We actually have incorporated an example in one of our training exercises. I don't know, it

probably has not been factored into the report.

CHAIR STETKAR: It is just a sensitivity.

MS. COOPER: Yes, right.

CHAIR STETKAR: You know, as you are walking through this exercise --

MS. COOPER: Yes.

CHAIR STETKAR: -- to determine feasibility, especially for ex-control-room actions --

MS. COOPER: Yes, you are absolutely right.

CHAIR STETKAR: -- that there might be fire impacts that you haven't even thought about that would affect that.

MS. COOPER: That is absolutely true.

MR. JULIUS: You're right.

This is Jeff Julius of Scientech.

CHAIR STETKAR: It is part of this integration that we have been trying to address as a Committee in other areas, the integration of safety and security. And here is an area where it could come together.

MS. COOPER: Yes, I think it actually came up as -- I can't remember how it came up, but we have it in -- and Kaydee Kohlhepp in the back is nodding her head. We have actually incorporated an example

like that --

CHAIR STETKAR: Good. Excellent.

MS. COOPER: -- in our training exercise. I guess I am not certain how or where it might be in the actual document, but it is something that we have thought about.

CHAIR STETKAR: Okay. Good.

MR. JULIUS: And we have asked it during our operator interviews that we have conducted.

CHAIR STETKAR: Good. Good. Okay.

MR. FORESTER: There is nothing explicit, I don't believe, in the guidance.

CHAIR STETKAR: I was looking for it a bit, only because I have stumbled across it occasionally.

MR. FORESTER: That is a good point. We should add it.

CHAIR STETKAR: I was rather surprised the first time that I did. The security people said, "Yes. No, that is the way the system works." Maybe it ought not.

MS. COOPER: Right.

CHAIR STETKAR: Okay.

MR. FORESTER: Okay. We are going to move on to the next slide, I think.

So, this is, again, a continuation about the feasibility assessment. And we added clarification here, again, emphasizing, too, then, that the feasibility assessment, you can't just do it initially and forget about it. As you obtain more information, that is one things the folks doing these actual fire PRAs found, is that early stages of the fire PRA you don't have a lot of the information you are going to need. So, you are going to be making judgments to some extent based on insufficient information. So, you have to keep looking, and as you collect more information, revisit these kinds of issues.

But whether you are using scoping or screening or whatever, the same issues need to be considered. Those are described in the document, about what, particularly once you get to risk-significant events, but, overall, the same issues remain.

I think we have talked about examples of how the timing might change or the staffing might change, or whatever, depending on how the scenario is evolving, what the fire is doing, the fire growth and what is happening there, what the fire brigade is doing.

So, again, looking at what happens across time and in this scenario can change your view on feasibility. And there is an emphasis in there about it.

MS. COLLINS: This is Erin Collins from SAIC.

I know I tried to input some of this because I was saying, when I was even looking at the guidance originally, I was saying, but I don't have a lot of this information yet because cable and circuit analysis is in its early phases or still ongoing. Fire modeling hasn't got to the point yet. So, I may not know a lot of this information early on when I am doing screening and scoping.

So, I have to make some initial guesstimates as to what is feasible and what is not. And so, I may go a little farther on the, well, it is a little no-go at this point, but, then, I can evaluate it further once, as you said, these other pieces needing analysis start coming in and I have further details.

So, I was kind of championing the idea of we need to consider what is available at different phases of the analysis in terms of how you feed it into your HRA and, then, how much detail you can go

into in the evaluation.

CHAIR STETKAR: Well, I think the guidance is important because this concept of telling the story. At least that notion is there that, regardless of where you are in the evolution of the analysis, you need to tell the story.

You need to do what you just said. Well, I don't have this information available.

MS. COLLINS: Right.

CHAIR STETKAR: I should, but I don't. And because of that, I have made the following assumptions.

MS. COLLINS: Exactly. And, then, you go back and --

CHAIR STETKAR: That at least is, then, documented for later examination.

MS. COLLINS: Uh-hum.

CHAIR STETKAR: Maybe those assumptions were conservative. Maybe they were optimistic.

MS. COLLINS: Right. No, that is exactly right.

CHAIR STETKAR: But at least it is documented, and the guidance sort of walks you through that process.

MS. COLLINS: Uh-hum. That is the intent.

MR. FORESTER: Okay, next slide.

This section addresses some guidance and discussion about method selection. Again, where you are at in the fire PRA, whether you are at quantitative screening or at the fire scoping or detailed fire scenarios. And again, as a function of the information you have, you may select different approaches, whether it is scoping or screening or detailed.

So, to some extent, where you are at in the analysis may dictate what kind of methodology, and what information you have may tell you what kind of method that you can select. Although both the screening and certainly the scoping have a set of criteria that, some sort of initial criteria, that if you can't meet those criteria, you can't use those methods. So, there are some requirements for information, even to use the more conservative type of approaches.

So, again, the level of analysis sort of dictates which method is selected. We also provide a discussion in there, though, too, about how different methods use different information directly in the quantification process.

And in terms of doing the qualitative

analysis, if you identify some factors that appear to be relevant and they are not really directly addressed in the quantification methodology you are using, then you have to find either another methodology or make some sort of adjustment to be able to account for those factors.

So, yes, the notion is, if you are using the CBDT approach and you are finding some factors that aren't really covered very explicitly, some specific fire effects, then maybe the ATHEANA approach, which provides a little more open-ended approach for dealing with these things, might be a better way to go.

Similarly, if you identify that maybe time is a really important factor for a particular HFE in this particular context, then maybe the time reliability correlation could give you some good information to see where you stand, at least at that point, before you move on to other kind of more detailed approaches.

So, again, the thinking is that you have to give some thought about what methodology you are using, I think, to be able to adequately cover the fire situation.

Okay, the next one.

Okay. The HFE narrative, this actually parallels what you guys were just talking about. Again, another thing we saw in the empirical study is that methods that require an HFE narrative, and I will talk a little bit more about what that is, what we call an operational story, seem to do a little bit better, regardless of what method they are using.

And I think if you look at the ATHEANA kind of approach, it ends up relying on this narrative by default. I don't recall ever talking about developing an operational story specifically.

But the notion is that you look at the scenario. You are collecting information about what you think is going to be affecting the operator. You are looking at the cues, the classic kind of information. And you begin to ask the question, well, what kind of thing should be going on that could cause them problems, if they are in certain places in the procedure? You know, just based on your description and what is going to be evolving, try and identify where the operators might have problems.

So, you are developing this narrative or story about what you think the operators are going to do, given the situation you are in. And just by writing that down, you have a little bit better

picture about the situation you are dealing with.

So, then, when you go to use a particular quantification methodology, you have some background and some understanding of where the problems might arise. And, then, that gives you the ability to make sure those things are addressed in the methodology you are applying.

So, this is just a tool in a sense, and we have added emphasis about doing this in the guidelines, that seems to benefit the results. So, it is not a new idea necessarily, but sort of the explicit notion that you need to do this is something you haven't seen before, I don't think.

So, all right.

MS. COLLINS: That is something I have been hammering people about. Sometimes you have folks who say, "Well, I just really want a number from you, Erin." I'm like, but I need to give you -- it needs to be a story. I need to establish the context. I need to establish all these things. Otherwise, the number has no meaning. You know, I need to put it in the context of what is happening. I have to have the background.

So, I am glad we are talking to that.

MR. JULIUS: And the task is integrating

generally two or three different sources of information. You are doing the thermal hydraulic response information that was done over here in left field, and the fire progression that is over in right field, with the operational information about what procedural path and things are going on. Those need to be in a consistent and integrated story.

CHAIR STETKAR: Yes, and when you finally write the story, you never find differences between those pieces of information, do you?

(Laughter.)

MS. COLLINS: It all comes together in a nice, happy format.

MR. FORESTER: Okay, next slide.

And, then, the last slide, the step has to do with addressing the performance-shaping factors. You are looking at, again, the fire impact on the PSFs in terms of how they might later on impact the HEP.

As you have more information about the fire and the analysis area and what the impact is going to be, is it going to be a whole-room burnup, you can also look at the fire impact on the specifics of the scenario. You are really interested in how the fire is going to affect the things you normally assess in doing a PRA.

There is a set of performance-shaping factors that are outlined in the standard and in ATHEANA and the HRA good practices document, and so forth. You know, those are the same kind of factors we look at here, but the notion is you have to consider how the fire is going to affect these particular kinds of factors.

And, also, there is new fire-specific PSFs that get introduced, like the effects of smoke and toxic gas, the presence of the fire brigade, and if you have to get somewhere and the fire brigade is there, there's hoses there, there's water on the floor. There is this environment created because of the presence of the fire. That also has to be considered.

So, again, it is this interplay between the fire and the PSFs, and we provide quite a bit of guidance about the kinds of issues that need to be considered. Again, if you have a good understanding of these, by following the guidance you get a good understanding of the expected fire effects on the different PSFs, then, even though you might not necessarily use all that information in the quantification approach, you are aware of it and you can decide whether you need to account for it in some

way.

So, I guess, again, as I said, and as Jeff has said, most of the stuff in here was more just adding clarification or emphasizing the task. The main significant change had to do with feasibility.

So, that is a little whirlwind tour, I think, of the qualitative analysis. Obviously, it is a fairly big chapter, and there is a lot of information in there. But that should give you a picture of the steps involved. Okay.

MS. COOPER: Okay?

CHAIR STETKAR: Good. Thank you.

By the way, I thought Chapter 4 was pretty good.

MR. FORESTER: Good.

CHAIR STETKAR: That is my own personal opinion. It is not an ACRS review comment.

(Laughter.)

I just want to make that clear.

MS. COOPER: Good point. Duly noted.

Now we move into the quantification approaches. There will be three presentations, starting with the scoping approach and, then, one each for the detailed approaches.

There was a very slight change, I think,

in the screening, mostly in clarification, that is described in the appendix. We actually decided we didn't need to take up time talking about that here. So, we are going to press forward with scoping.

CHAIR STETKAR: By the way, before we get into this, why does Appendix D, "Dog", exist in the report?

MS. COOPER: I forget which one that one is.

CHAIR STETKAR: It is one on the self-induced station blackout discussion.

MS. COOPER: Oh, that is a good question.

CHAIR STETKAR: It, quite honestly, hangs out there by itself. If you read it, it seems to have a few contradictory statements to the rest of the report.

And it wasn't clear to me that the guidance in the rest of the report in terms of the qualitative analysis or anything else, why that would not apply to that particular scenario. So, I was curious why, among all of the appendices and the body of the report, why it was called out as something unique.

MS. COOPER: It has been carried forward since some notions from the very beginning, although

there have been some modifications along the way, none in this last round, no modifications as a result of public comments.

First, I mean I think you understand that this document represents a step forward in providing guidance for fire HRA. It isn't the end of development here, but it is the start.

So, most of what we discuss in the document is with the expectation that it applies to a wide variety of plants. But it was the expectation that at least, for example, the scoping approach and probably the screening approach may not be a good fit for the SISBO-like plants.

And so, we decided that we would have this appendix to try to capture some of the ideas that might be important there, principally because of a very different procedure format than any of the other approaches.

I mean we have talked a little bit about procedure format. We don't have very much in the document right now about this, but we do have quite a bit more right now in our training. We are thinking about including some more because there are different procedure formats and, then, different approaches to procedures.

But the SISBO plants seem to have an entirely different set of procedures, which we really haven't tried to address lumped in with everybody else.

CHAIR STETKAR: You know, I don't want to take up a lot of time on it, but the general guidance, you know, I was kind of sensitive to it. It does acknowledge the fact that the level of detail in the procedures, fire response procedures, may be wildly different. Their invocation may vary from plant to plant. And the guidance sort of makes you aware of that.

So that, if I am picking up Plant A with their procedures, I know what to think about if I am picking up Plant B. You know, I think about the same things, but I might make different decisions.

It is just other than the fact that that appendix says you need to do a detailed analysis, there were things in there that seemed to be a bit different from the rest of the guidance. And it didn't seem to add anything to the whole report.

MS. COLLINS: I think, initially, the concern was that in some of these SISBO plants you had had these procedures where they would be calling for the operators to go and take what we would call

preemptive action --

CHAIR STETKAR: Yes.

MS. COLLINS: -- and taking equipment out of service, and that later you might regret that.

CHAIR STETKAR: You might.

(Laughter.)

MS. COLLINS: To put it mildly.

Now, as I think more plants are doing the NFPA-805 transition, part of the reevaluation of procedures, and as Jeff was mentioning, what you might recommend in terms of changing your procedures, so these SISBO issues are kind of falling out by people looking at this and saying, "We don't want to take all this stuff out of service."

CHAIR STETKAR: Well, but that is a pragmatic. I am just talking within the context of this document.

MS. COLLINS: Of the document? Yes.

CHAIR STETKAR: Presuming that there is some subset of plants out there that, indeed, still retain those.

MS. COLLINS: Well, we can certainly look at that again.

MS. COOPER: I think my notion is that everything up to quantification that we have addressed

in this document ought to apply to SISBO. But what we were trying to recognize is that, in developing the scoping approach, and I think in the way -- I mean Jeff is not up here, but he's got a microphone, so he can respond -- in the way that EPRI looked at modifying the EPRI quantification approach, that there wasn't any explicit consideration of what some of the particular issues that might be of concern for SISBO.

We haven't thought those through and provided guidance for doing that in this document. All we have are some things that you probably ought to think about, and it says you ought to do detailed. But we haven't provided a detailed approach that would incorporate some of the specific issues that might be of concern for them. We haven't made that development.

So, this is kind of we made a start in this area, but I wouldn't say we finished it.

CHAIR STETKAR: Well, my only concern is that, if there are -- and you focused on one specific, rather dramatic, but one specific procedural response to a fire. There are other procedural responses to fires that may put you in a plant configuration that may or may not be completely conducive to your ultimate goal.

Shedding DC loads, if your procedures are not very careful about telling you what DC loads to shed to sustain the life of your battery, it might put you on a trajectory for a specific fire scenario that you hadn't anticipated. But you don't call out DC load shedding procedures as a separate procedure, for example.

MS. COOPER: Right.

CHAIR STETKAR: You know, so I am trying to understand if there is something fundamental in the guidance that is deficient, which is why you called out SISBO as a specific issue. The guidance should be corrected to remove that deficiency. If you claim that the general guidance should be adequate to handle those procedures and any other types of procedures that I can envision, or lack thereof, then it is not clear why that topic deserves special attention. Because you do bring attention to it very, very dramatically.

MS. COOPER: Yes. We will look at that again. That is a good point. And to be honest, we have not revisited that appendix.

CHAIR STETKAR: I read it thinking, my God, this is an interesting topic. What I am going to learn about this here?

MS. COOPER: Yes. Yes.

CHAIR STETKAR: It didn't seem to add.

MS. COOPER: Right.

MS. COLLINS: Well, it could be as our guidelines have developed overall, you know, the need for that as a separate chapter has gone away.

CHAIR STETKAR: Yes, but, again, I view this as suppose there are still plants that you are going to do a PRA on, and they do, indeed, have those procedures and claim that they are going to use them. And therefore, you, as a PRA analyst, need to account for them. Will the guidance in this document handle that situation?

MR. FORESTER: I guess I would say, as you begin, that certainly you are looking at the procedures that are relevant for that particular plant. The guidance does lead you to look at the types of procedures, how they are going to be implemented. So, it becomes a very analytic kind of process. I don't think it implies that the existing, particularly the detailed -- I wouldn't use scoping or screening so much, but the more detailed approaches, given the right analysis of the relationship between doing those procedures and what is going to be going on in the scenario, could certainly quantify that

situation.

I don't think we have given any specific guidance that sort of lays out the kinds of things explicitly to consider, other than how it is described in that appendix, which really sort of describes the situation at hand that you are going to have to deal with.

But it is going to take this sort of analytic process to understand all those relationships and determine that they are quantified appropriately. But the method --

CHAIR STETKAR: No differently than any other, though.

MR. FORESTER: Exactly.

MEMBER BLEY: It is almost sounding like this is just left over from the last time you revised the report. It is less than eight pages long. Just discussing it in brief somewhere in the body of the report instead of having an appendix might certainly be a simpler way to deal with it.

MS. COOPER: Yes, that sounds like a better option.

MEMBER BLEY: And not raise so many --

MR. FORESTER: Because I think the issues are pretty much mapped out there. So, it is just a

matter of alerting.

CHAIR STETKAR: I mean, if you read those however many pages there are --

MEMBER BLEY: It is not many.

CHAIR STETKAR: -- the only thing unique is it said we recommend you don't use scoping, that you do a detailed analysis. That was the only thing that I could find --

MEMBER BLEY: Which could almost be a caveat on the scoping chapter.

CHAIR STETKAR: Right.

(Laughter.)

MS. COOPER: All right. We can do that.

CHAIR STETKAR: That is why I brought it up, just as an introduction to the scoping.

MS. COOPER: Okay. Yes. No, that is a good idea.

And, Stacey, do you want to drive your presentation?

MS. HENDRICKSON: Sure. Will it reach that far?

MS. COOPER: I think so.

(Laughter.)

Okay. So, first, just to give a very brief overview of what scoping is, just in this one

slide.

And, then, I want to give an overview of what the biggest comments were that impacted the scoping approach and how responded to those, and, then, go into detail of how each of those comments changed or applied to the scoping method.

So, first, just a summary of the scoping quantification. It is really that middle-of-the road approach. It is less conservative than the screening, but less resource-intensive than the detailed.

It can be applied to in-control-room or ex-control-room, those location actions, alternative shutdown, including main control room abandonment then, as well as recovery of errors due to spurious instrumentation. And I will talk a little more about each of those categories further into the presentation.

And the quantification is going to be based on an assessment of feasibility, but that has already been discussed in the qualitative analysis; an assessment of the time margin, and, then, some simple judgment about a few performance-shaping factors. And, in fact, there are six elements that have to be evaluated. And, then, we use flowcharts to actually do the quantification.

So, first, let's go through what the high-level or the big comments were that impacted the scoping approach. The first one is that it is possible to obtain a number through the screening method that is actually smaller than the scoping method. And the reason that might happen, and it is not going to happen very often, but in the rare case it could happen, is screening actually allows the internal events HRA to be used. It applies a multiplier in some cases to internal events.

Typically, then, that internal event evaluation was using a detailed analysis. So, when you actually get down to it, what you are comparing is a scoping approach to a detailed analysis. And that is why the scoping approach may actually result in a higher number.

The second comment that was made about the scoping method is that the scoping method is excessively resource-intensive. It is not commensurate with the scoping level.

To address this, in fact, we have discussed this already a bit in the qualitative analysis, is we lessened the demands on the feasibility demonstration. In fact, now it is called an assessment of feasibility.

But we lessened the demands of requiring the walk-through and simulation to be a talk-through and the use of other measures, such as job performance measures or earlier demonstrations that may have been done.

A third comment that was made is the time margin application is too conservative. In the earlier draft that we had, there were times when we required even a time margin of 200 percent. And what we decided is that was too conservative. In fact, the times that a time margin of 200 percent was required is for the greater execution complexity, when there is an increased execution complexity for the action.

When there is increased execution complexity, there is already a multiplier applied. And so, having this kind of double-counting of an increased time margin was a double-penalty. So, we brought that back and said now we will just have the time margin set at 100 percent. And a little later, I will go into what actually the values of the time margin are. But the big picture here is that we got rid of that 200 percent time margin.

And the last two comments, one was about the 60-minute rule that was required for determining if a fire had been suppressed or not. So, once they

received the cue, how much time needs to have elapsed before you can consider the fire has been suppressed?

And we went back to FAQ-0050, which has now been included in the 6850 Supplement. Now they can use those times that are mapped out in that Supplement or in FAQ-0050 as long as they know what type of fire it is they are dealing with.

If they don't know what type of fire it is, or if it is one of four special cases that I will outline in a moment, they must use now a 70-minute rule. So, in fact, it backfired a little bit in that it actually became a little more conservative for some instances. But as long as they know what type of fire it is, they are allowed to use the suppression times that are outlined in that table.

And, then, finally, a comment on main control room abandonment. They said that it was confusing to use; it was not well-defined. And so, we went in and tried to clean up the flowchart for main control abandonment, relabeled it, and clarified when it is that it is used. And in particular, it is used when command and control is relocated outside of the control room, so that diagnosis, then, and execution are both done outside of the main control room.

Okay.

MR. FORESTER: That could be done due to habitability issues or their inability to control the plant from the control room. For either situation, where they have to, I guess she said, move the location of command and control outside of the control room, then that is when it would be relevant.

MS. HENDRICKSON: Exactly.

MEMBER BLEY: I hate to be pedantic, but No. 4 --

MS. HENDRICKSON: Yes?

MEMBER BLEY: -- it has always seemed apparent to me that this is arbitrary. I have never quite understood how we can claim it is conservative. Can you explain it to me, why it is conservative?

MS. HENDRICKSON: I will say the 60-minute rule was, I don't want to say it was arbitrary. There were some numbers that backed it up. But the 70-minute rule is conservative in that it assumes that 99 percent of all fires have been contained. So, I guess conservative in the sense that it is lumping all fires into that 99 percentile.

MR. FORESTER: But a lot of them may be out long before that time.

MS. HENDRICKSON: Right.

MEMBER BLEY: Yes, they might.

MR. FORESTER: Probably most of them.

MS. HENDRICKSON: Yes. Which is why they then decided that, okay, if they know what type of fire it is, and, in fact, if they know what type of fire it is, they still have to use the 99th percentile in that table that is provided in the Supplement to 6850.

MEMBER BLEY: Okay.

MS. HENDRICKSON: Okay. Now let me go through the scoping approach and show in detail each of these, the impact of the steps, and how they fit into the method itself.

So, the first one is the difference between the screening and scoping method. And as we said, we are not going to really get into screening today. Basically, it was presented in 6850, and we did a slight modification that was in the earlier draft of this NUREG and EPRI document.

The one thing that is highlighted there is that it does use the internal events or allows the use of the internal events HRA in certain instances that applies a multiplier to those numbers.

The scoping quantification approach, then, as I have already said, was kind of less conservative than the screening method, more conservative but less

resource-intensive than the detailed approaches. And it is intended to meet the Capability Category II for non-risk-significant events.

Delving into the scoping approach --

CHAIR STETKAR: Stacey?

MS. HENDRICKSON: Yes?

CHAIR STETKAR: Before you get to scoping, I was trying to find the quote in the -- I found it. I didn't go back to 6850 to look at the specific sections for screening. So, I don't know whether this is from 6850 or whether it is from the NUREG.

But, for example, there is a criterion that says that I can use the set one criteria for existing HFEs with perhaps a multiplier. It says, "There is no spurious behavior of instrumentation or spurious equipment actuations that can occur in this fire beyond those with the following general characteristics. Spurious events are not associated with safety-related equipment and instrumentation relative to the critical safety functions and, hence, would only be minor distractions, not immediate challenges to safe shutdown."

That seems to tell me that I can have large numbers of spurious signals from non-safety-related instrumentation, and I can completely ignore

that because it is not directly related to a safety-related operator action. I submit that if I have a fire that causes, for example, my turbine bypass valves to start blowing open, non-safety-related equipment, my feedwater system to start cycling wildly, non-safety-related equipment, neither of which may be modeled in my PRA, if that fire causes those effects before the damage progresses to something that I have modeled in my PRA, I might be really concerned about the effects of that fire. I might be focused entirely on the effects of that fire and ignore, or at least not be aware of, other things that are happening in my scenario.

So, I am not sure why the guidance tells me that I just basically ignore other things that are going on in the control room as long as it is not specifically focused on the absolute HFE that I am told to evaluate.

It was one of the areas in the screening, as I was going through the guidance, that I said, gee, I don't quite understand that. And in fact, we have evidence from reasonably-recent fire events to show that people will focus on the original fire damage and trying to cope with that, to the exclusion of other things that are going on in the plant that could be

getting them into more difficult situations.

MR. FORESTER: I think it is a very fair point. I do think the set one criteria, even given that it is only in non-safety-related equipment, there is still a multiplier for general fire effects. So, you are going to get an order of magnitude increase. Whether that is adequate or not, I don't know.

CHAIR STETKAR: I was going to say, if that original thing was a 10 to the minus 4 number, though, that is still saying I am pretty doggone good.

MR. FORESTER: Fair enough. Well, let's see now. I am trying to remember for set one. They either get by 10 or --

CHAIR STETKAR: No, set one I think is just 10.

MR. FORESTER: It is just 10? Okay. You raise a good point. And I don't know whether the treatment there is adequate.

CHAIR STETKAR: Now I don't know whether that is a carryover from 6850.

MS. COOPER: It is.

CHAIR STETKAR: It is?

MS. COOPER: It is.

CHAIR STETKAR: The problem with 6850, as we all know, is it was not written by PRA people or

human reliability analysts, by and large.

(Laughter.)

MR. FORESTER: I played a role in those screening --

CHAIR STETKAR: Oh, you did? Okay. I'm sorry.

(Laughter.)

MS. COOPER: Point taken. We actually had a pretty serious team discussion back in March, when we were trying to wrap up the public comments, on the screening approach. We seriously debated scrapping the whole thing and starting over, but that would mean substantial delays.

I would argue it is not a screening approach. It is a preliminary approach or the initial approach, but it doesn't act like screening in the traditional sense for HRA, which means you don't have a lot of information. You get a big number. And that means, then, you get more information for the risk-significant one. It is not like that.

CHAIR STETKAR: Right.

MS. COOPER: I mean, as Erin has said, and I think Jeff said when he was up here earlier, it actually requires a lot of information in order to be able to assign a number through that screening

approach.

So, it is not, strictly speaking, a screening approach, but we are stuck with that terminology. I mean I guess if you have a --

CHAIR STETKAR: Let's go on. In the interest of --

MR. JULIUS: An additional point to soften it, for your particular example, the steam generator atmospheric dump valves and the regulating valves are probably on the safety shutdown equipment, unless there would be --

CHAIR STETKAR: I was very careful in terms of the equipment that I specified. I said the turbine bypass valves, which are the valves that go to the main condenser --

MR. JULIUS: Right.

CHAIR STETKAR: -- not the steam generator atmospheric dump valves, and I said the main feedwater control valves. I didn't say emergency or auxiliary feedwater.

MS. COOPER: Right.

CHAIR STETKAR: Very few plants actually model the turbine bypass valves, and depending on the PRA, they may or may not model the main feedwater system --

MR. JULIUS: Right.

CHAIR STETKAR: -- because it is deemed conservative to not model those things.

MR. JULIUS: Right.

CHAIR STETKAR: It might be conservative for your loss of steam generator makeup under an internal event full-power PRA. It might not be conservative if things are happening in that part of the plant because operators who really operate the plant really care about all of that other stuff over there.

MR. FORESTER: I don't recall exactly what the thinking was, but my sense of it is that if you have an initiating event, and they are entering the EOPs, they are entering the fire procedures, that the crew is going to be responding to those EOPS as they normally would. The set one criteria apply to existing HFEs in the model already. So, those are the same HFEs that were addressed in the Level 1 analysis.

So, the thinking was probably that these are the same kind of events they are trained on. They are going to be following their EOPs. Now those other things may serve as a distraction.

CHAIR STETKAR: Let me ask you --

MR. FORESTER: Yes.

CHAIR STETKAR: -- this is procedures, and I want to get to the scoping because is it much more important for the task at hand. But something you just mentioned, in the EOPs, for example, I am probably prompted to make sure I have cooling for the reactor coolant pump seals.

There was a fire at a plant, and it is documented, where the operators focused on the non-safety-related effects from the fire that damaged non-safety-related switchgear, to the exclusion of the fact that they didn't recognize that they had lost cooling for the reactor coolant pump seals for a long time, a long time. Now they didn't have seal damage.

So, simply the existence of a procedure does not ensure that the operators will not get tunnel vision on things that they determine are very important because that other stuff, that non-safety-related stuff that is not in the EOPs, that is not assumed in the PRA, is, indeed, a very major part of their normal lives and represents not investment problems, but also plant transient problems.

So, that is where I think we, as analysts, need to be very, very careful about relying too heavily on this construct of a PRA model that looks at specific HFEs and this construct of EOPs are always

going to safe me. They should, but not necessarily if what else is happening is significant enough. Now if it is a fire in a trash can, I will give you that. But there can be non-safety-related things that really cause people to take attention.

Anyway, going through the screening, there were a couple of things. That was one that jumped out at me. But I now understand you basically inherited that.

MS. COOPER: Yes, we did.

CHAIR STETKAR: And made the active decision not to wholesale redefine it.

MS. COOPER: Right.

CHAIR STETKAR: So, I think for the purposes of this meeting it is much more important that we spend time on scoping. So, Stacey?

MS. HENDRICKSON: So, what this shows is the high-level steps to the scoping approach. You will notice No. 2, assess feasibility of operator actions, has been marked out. That is not because the feasibility does not have to be assessed for this method. It is because that has now been removed from this chapter and all put together in Chapter 4. And as we said, it has been softened a bit.

But the first step, then, is to ensure

some minimum criteria are met. I will go through those in the next slide.

And, then, there is the calculation of the time margin, an assessment of some conditions and performance-shaping factors, and, then, the use of flowcharts. There is the initial section scheme flowchart and, then, four flowcharts following that that address in-control-room actions, ex-control-room actions, alternative shutdown, or the transferring of command and control outside the control room, and, then, the recovery of errors due to spurious instrumentation.

The red text that you will see throughout these slides are the things that have been changed. So, here we renamed the alternative shutdown. It used to be the CRAB for control room abandonment. And so, now it has been labeled ASD.

And, then, also, clarifying the transferring of command and control.

CHAIR STETKAR: Can you talk more about ASD later, I think?

MS. HENDRICKSON: I will.

CHAIR STETKAR: Okay.

MS. HENDRICKSON: To some extent, so we can get a little more in detail, if we need to.

This is the addressment of the time margin. First, the minimum criteria that must be met. That was not changed. The minimum criteria or the procedures must be in place for the actions being modeled. There must have been training on the procedures as well as the action. And, then, any equipment that is needed must be available and accessible.

As soon as these minimum criteria can be assured to be met, then, the next thing is to address the time margin and calculate what the time margin is. The time margin is put in place to account for unexpected variability, either crew-to-crew variability or variability that couldn't be modeled or couldn't have been addressed maybe in the talk-through or the assessment of feasibility.

It has now been changed. There are three levels of time margin that are assessed throughout each of the flowcharts. Less than 50 percent is going to result in HEP of 1.0, a time margin of 50 to 99 percent, or greater than 100 percent. There used to be, then, also, a greater than 200 percent, and that one has been removed. It has been softened a bit.

CHAIR STETKAR: Stacey, this looks like our opportunity to discuss time margins because --

MS. HENDRICKSON: Yes.

CHAIR STETKAR: -- I don't see them in the next slides. I see you have a backup slide that defines this.

MS. HENDRICKSON: Do you want me to go to that one?

CHAIR STETKAR: Could you pull that up?

MS. HENDRICKSON: Uh-hum.

CHAIR STETKAR: A couple of questions. I mean I understand this process.

MS. HENDRICKSON: Sure.

CHAIR STETKAR: A couple of questions that I had. The first one, and I think the most fundamental one, is there's no mention whatsoever in the guidance about discussing, documenting, or quantifying uncertainties in these times.

The argument is made that the time margin is a surrogate for that uncertainty or variability, however you want to characterize it. However, that time margin, if it is 49.9 percent, I use one number. If it is 50.01 percent, I use a different number. And if it is 99.9 percent, I use one number, and if it is 100.01 percent, I use another number. And those numbers are substantially different by factors of five or more.

So, I was curious because, if, indeed, the scoping analysis progresses to a more detailed analysis, and you use this time information, these timelines, as part of the documentation for that detailed analysis, it strikes me that you would need to somehow address uncertainties.

I would expect that there would be a reluctance to go back and quantify uncertainties if you do a detailed analysis because people will say, "Well, my God, we already went through this exercise. You're forcing us to do it twice."

So, the question is, why don't we just ask people to do the uncertainty analysis as part of the basic timeline development, so that we have it? So, for example, if there is a 30 percent probability that the time margin is less than 100 percent, you know, that would translate into a .3 chance of failure. The .7 chance, let's say it is between 50 percent and 99 percent. Then, you apply, you know, it is not guaranteed success, but you apply the other things.

It is also notable, the reason I started thinking about it is, this slide is important, is that in the equation there you see T1/2. That is a holdover from the EPRI HCR/ORE model of human performance. And that is characterized as the median

response time. That means that half of the operators, if I apply that approach, half of the operators will have response times longer than that. It is the median response time. It is not the mean. It is not the upper bound. It is not my best -- it is the median response time.

Depending on the uncertainty and the shape of the distribution, the upper-bound tail of that could extend rather long because it is only the median.

MS. COOPER: That is a good point. Regarding that last, it may be that this is an inappropriate homogenization of all the different timing factors that we are using, so that --

CHAIR STETKAR: Indeed, I hoped that may be the case, but there are footnotes in the report that say that T1/2 means the median response time in the construct of the EPRI HRA Calculator.

MS. COOPER: Yes.

CHAIR STETKAR: So, I was very, very -- and, indeed, there were comments, I believe, from somewhere that said, well, you know, you are being too conservative because half the crews will have response times better than this.

(Laughter.)

MS. COOPER: Yes, yes, yes.

CHAIR STETKAR: You know, without noting that, oh, half of them will have longer than that.

(Laughter.)

MS. COOPER: Right.

MEMBER BLEY: Not in my plant.

(Laughter.)

CHAIR STETKAR: No, that's right. I'm sorry. Lake Woebegone.

MS. COOPER: Regarding the uncertainty, I think that is a very good point. We should include that not only in the scoping discussion, but probably in the qualitative analysis in general.

And I sense that maybe Stuart Lewis would like to say something about this.

CHAIR STETKAR: Because in a lot of the qualitative discussions there is a lot of discussion saying, well, there obviously will be variability in this; there is uncertainty, but we believe that the time margins are conservative enough that it accounts for that.

MEMBER BLEY: It is not a hard calculation.

CHAIR STETKAR: That is a belief. That is not a hard -- it is important, though, if you are

doing this for operator interviews, walk-throughs, talk-throughs, whatever, if there is variability, just document it. Capture it, the fact that we polled six people, and three of them said they could do it in five minutes, and two of them said it would take ten minutes, and one of them said, "God, you'd never be able to do it."

CHAIR STETKAR: Okay.

MR. LEWIS: I was concerned at one point, but you obviously do understand the way the time margin is used. This isn't in itself part of a reliability correlation. It is used to kind of determine what regime you are in with respect to how you apply the scoping results. So, uncertainty analysis has a little different connotation in this parameter than it might in other areas.

CHAIR STETKAR: In this parameter, Stuart, but if, indeed, you did the uncertainty analysis, for example, and let's say there was a 25 percent probability that the time margin was less than 100 percent because of the uncertainty distribution for the response time, and it is 75 percent that it is more than 100 percent, and let's call it between 50 percent and 99 percent, for example.

That has implications on, I think, the

values that you would use in your quantification. Because if you say there is a 30 percent probability that the response time, that the time margin is less than 100 percent, you can't use the greater-than-100-percent values for that 30 percent, right?

MR. LEWIS: That is true. And again --

CHAIR STETKAR: So, it is not going to make a numerical difference if you are well away from those discrete break points in the scoping.

MR. LEWIS: That is right. And we are using them as guidance for how to apply the scoping values.

The other thing I would like to point out is it probably isn't really quite correct to refer to the T1/2 as a median response time, even though I know that is what the report said.

(Laughter.)

CHAIR STETKAR: It is not. So, you should take it out of the report.

MR. LEWIS: That is fine. What it really is is an estimate of how much time it takes to decide to take the action. In reality, and when we do this, we don't have a distribution on these response times. We have a point estimate, typically, of how long it takes to decide on a response and an estimate of how

long it takes to implement the response in Tm.

So, from that standpoint, again, that is probably a --

CHAIR STETKAR: I recognize the way that they are implemented as point estimates --

MR. LEWIS: Yes.

CHAIR STETKAR: -- on taking one level and taking issue with that.

MR. FORESTER: We put it in to be consistent with the calculator approach. We had it different before, but --

MS. HENDRICKSON: We were trying to go for consistency.

MR. FORESTER: It is a point estimate. It still seems, though, that at least by having the time margin, you at least have more confidence that, I mean, sure, the values vary, but you could set up a whole continuum and gradually change the HEPs. But this is, again, a more -- the values are pretty conservative for a lot of other reasons.

So, the time margin at least gives you some assurance that your time estimates will be within a reasonable range. I wouldn't know exactly how to assess the uncertainty associated with the estimates of the time we get. You can certainly associate the

uncertainty of the HEP based on this, but, yes, I guess I am not so sure exactly how you would do that.

MR. LEWIS: But, again, I would argue that for a scoping analysis, we should be talking about whether or not, for a sensitivity study, whether or not it makes sense to credit this event, not worrying about characterizing the uncertainty in the value that we specify. If we think that the value tends toward the conservative, we have to be very careful. I shouldn't say it doesn't make sense, but you have to be very careful what kind of a distribution you ultimately create about this parameter. It may make more sense to do other things to evaluate the implications of changes in this value or whether or not to credit the event at all.

I think we have tried to capture that in the new approach that we may or may not get to on uncertainty analysis later on.

(Laughter.)

CHAIR STETKAR: We will get to it.

(Laughter.)

MS. HENDRICKSON: Okay. Were there any other questions about the minimum criteria or the time margin?

(No response.)

Okay. The next steps, then, are the assessment of these key performance-shaping factors. In fact, there are six elements that need to be evaluated before moving on.

The only one that has really changed is the timing of the cues in relation to if the fire has been suppressed or not. But I want to briefly review all of them.

The first, how well the procedures match the scenario is a question asked at the very beginning of the flowcharts. This actually serves as a proxy for diagnostic complexity.

The decision here, then, is if the procedure does not match the way the scenario is unfolding, the way the scenario is moving along, then the diagnostic complexity or the cognitive complexity is really too much to be handled by the scoping approach. So that, if the procedures don't match the scenario, the diagnostic complexity is too high, then it is given an HEP of 1.0 and the detailed analysis would be recommended in that case.

The second one, then, is the response execution complexity. This is for the scoping approach assessed just as high or low, and the guidance for this judgment is provided in the

document.

Finally is the timing of the cue in relation to if the fire has been suppressed. We have already talked about now they can use the table that is outlined in the FAQ-0050, the 6850, Supplement 1. And they have to use the 99 percentile value. If the fire type is not known, they have to assume 70 minutes.

There are some special cases we outlined. There's four cases listed here: fires of turbine generators outside, outdoor transformers, high-energy arcing faults, and flammable gas fires. For these special instances, no matter what the timing, they have to assume this fire is ongoing.

Just to complete the PSFs that have to be assessed within the flowcharts, these three have not changed from the earlier draft. The action time window was set at 30 minutes, meaning that if the time from the occurrence of the cue until the action is not longer beneficial, if that time window is 30 minutes or less, then they are directed in one branch of the flowchart as being the short-time window. If it is greater than 30 minutes, then it is the long-time window.

For each of these elements, each of these

PSFs that are addressed here, there is a multiplier applied if they have to go with like the less than 30 minutes or if the fire is still ongoing.

The next one, the level of smoke or other hazardous elements in the action area, this procedure really gets at the need to wear breathing apparatus, CBAs. And so, what is at issue here is if their communications might be impacted by the need to wear it, the impairment of vision from the level of smoke in the area, and so on.

And, then, finally, accessibility to the area of the action. So, the ability to get to that action area and the ability to actually be within that area.

CHAIR STETKAR: Stacey, there is a lot of emphasis in the report, in the guidelines, on the need to wear self-contained breathing apparatus, a lot of emphasis on it. That, to me, says that it must be an issue that has been identified in a number of ongoing fire analyses. Is that true?

MS. COLLINS: I think, again, certain plants have identified that they would be much more willing than other plants to be able to take actions in CSBA. And for that reason, we felt that it was important to address those issues.

CHAIR STETKAR: Okay.

MS. COLLINS: And maybe some of the concerns that Dennis raised earlier, saying that some plants said, "Oh, yeah, sure, we can do that in SCBA," and then, really?

So, that is why the scoping approach provides for a bit more conservative value as you go up the scale. There is a nominal fire case.

CHAIR STETKAR: Yes, I know.

MS. COLLINS: There is an SCBA case. There is a smoke case.

CHAIR STETKAR: Yes.

MS. COLLINS: And so, I can't say across the board, but when we have our training sessions and when we do our fire PRAs, there are certain ones that reflect different indications of whether they would or wouldn't use it. So, we are saying, well, you know, this is something we need to address in our approaches.

CHAIR STETKAR: Right. I was more thinking about the inventory of plants that actually have fire vulnerabilities that would force operators to operate in self-contained breathing apparatus rather than --

MS. COLLINS: Okay.

CHAIR STETKAR: And it sounds like there are enough of them that it merits consideration. Okay. Thanks.

MS. HENDRICKSON: Then, we can actually get into the flowcharts themselves. So, as I have mentioned earlier, there is, first, a selection scheme that directs them to one of four quantification flowcharts.

There is the first one being the in-control-room flowchart. It has not changed. Some of the HEPs changed, only because of like the lowering of the time margin from 200 percent. And, then, the ex-control-room flowchart as well. Both of these are meant to address HFEs that may have been identified outside of the internal events PRA.

The in-control-room flowchart would be used if diagnosis as well as execution occurs within the main control room. The ex-control-room flowchart would be used if diagnosis occurs within the main control room, but, then, the action is actually a local action.

The flowcharts that have actually changed, the one that changed the most was the alternative shutdown flowchart. First, as we have mentioned, it has been renamed from the CRAB, which was a focus just

on main control room abandonment, we wanted to have a little broader application to alternative shutdown, and, then, just clarified, really, the language and the instances in which this flowchart would be applied and clarified that it is when command and control is located outside of the control room. So that not only has the execution of the action been moved outside, but diagnosis then has also taken place outside of the control room, typically, like a remote shutdown panel or some other alternative shutdown location.

Then, the recovery of error due to spurious instrumentation, the SBI flowchart, we went through and the flowchart itself had not changed, but clarified some of the definitions and writing on its application and when it would be used.

CHAIR STETKAR: A couple of questions on this, as long as we are on this slide. First, I was trying to walk my way through the procedures and understand how I would use them.

If I have a scenario, a fire scenario, that evolves to the point where a decision is made to abandon the control room, during that scenario, let's say that the scenario starts at T0 and at some later time the decision is made to abandon the control room. During the first part of that scenario, I use the in-

control-room flowchart, is that correct?

Now let's say when I abandon the control room, I need to transfer command and control through -- a lot of plants have transfer switches located in a panel or several panels distributed who know where.

To implement the actions to transfer, do I use the ex-control-room flowchart?

MR. FORESTER: Yes. It is in the guidance.

MS. HENDRICKSON: That is in the guidance.

CHAIR STETKAR: That is in the guidance. Okay. It wasn't real clear to me.

And, then, after the transfer is affected, I use ASD?

MS. HENDRICKSON: That is correct.

CHAIR STETKAR: Okay.

MS. HENDRICKSON: That is correct.

CHAIR STETKAR: I thought that's what it was, but there were a couple of places where I wasn't quite sure about that.

In the sense of time, I can't find it in my notes, where I got confused.

MS. HENDRICKSON: Okay.

CHAIR STETKAR: A bigger-picture question to me is, because of the complexity of both timing and

decisions to abandon the main control room, is the whole concept of a scoping analysis for that activity appropriate, in light of Appendix D says don't use scoping analyses for this one specific type of procedure, for example?

This is a very complex decision process that strikes me is very scenario, not only plant-specific in terms of philosophy of how do you operate the plant, but very scenario-specific. And the criteria in the NUREG simply refer to those very, very specific -- you do a fire analysis and determine some heat load or some smoke. And when you get to that, you assume the operators are going to abandon the control room. And therefore, you invoke that at that time.

Well, a scoping analysis, it strikes me that people aren't going to have that kind of detailed fire modeling done. So, you don't know when those conditions will be reached during a particular scenario.

It is not necessarily conservative always to assume that the operators abandon the control room, even though your HEPs for ASD-type scenarios are higher than in control room. Because if they inappropriately decide to stick with the ship because

eventually we are going to plug the leak, and that isn't necessarily the most prudent thing to do, staying in the control room might be worse.

It strikes me as a very complex analysis, and it is not clear to me that the whole concept of scoping applies very well.

MS. COLLINS: It is very complicated, and I think it depends on what the plant-specific philosophy is. You know, although you do have these criteria that we have listed, as you said, part of the complexities are this decision process of when to go. And certain plants seem to be clearer on that than others. Maybe they are not really, but --

CHAIR STETKAR: I was going to say on paper perhaps they are, but when you are standing there and you sort of know in your heart that life is going to get really difficult when you leave the place that you live in, and have lived in there for the last 15 years of your life --

MS. COLLINS: Right.

CHAIR STETKAR: -- what is on paper might be interpreted a bit differently.

MS. COLLINS: Uh-hum. Well, I can only say I have just recently implemented some of the scoping values for a case where they decided to do a

variety of flavors of situations and have a fire case where there is no fire in the control room itself.

CHAIR STETKAR: Yes.

MS. COLLINS: Then, I had an in-control-room fire that was promptly suppressed. So, that had a little different flavor to it. And, then, I had something that was more of the we're getting out of here flavor.

And they had done a separate analysis on their own to determine, based on fire modeling and other different situations, when they felt that the decision would come. And, then, they had identified certain HFEs that they felt applied to the abandonment scenario. And so, in that specific instance, I used scoping values for the first time.

However, in the other instance that I did main control room abandonment, there was none of that. I did a very detailed analysis, and I looked through the procedures very carefully and I used the EPRI method to go test by test and step by step and timing by timing.

So, for me, I think it is working with the folks and what is their tendency, and what can I recommend to them, and how do they have their model set up, et cetera? So, there is a lot of complexity

even in the concept of how one models abandonment and, then, that subcomplexity of how one quantifies it.

CHAIR STETKAR: But even the examples that you mentioned where you used a scoping HFE or scoping HEPs --

MS. COLLINS: Right.

CHAIR STETKAR: -- the way you described the scenarios, it sounded like they had already done a reasonable amount of fire modeling --

MS. COLLINS: Right.

CHAIR STETKAR: -- and characterizing the scenarios, which, if I understand the whole purpose of going from screening to scoping to detailed fire HRA, in the context of a typical evolution of a fire PRA, the scoping comes, if I am starting with a plain piece of paper, the scoping comes at a time for a large number of plants where they don't have that level of detail.

MS. COLLINS: Yes, absolutely.

CHAIR STETKAR: They don't do that until --

MS. COLLINS: This was a strange --

CHAIR STETKAR: -- they have identified important scenarios.

MS. COLLINS: Yes.

MR. LEWIS: I would like to respond to that very point. It does get kind of confusing. You don't necessarily do scoping HRA in conjunction with a scoping assessment of the fire scenarios. You may, in fact, have a detailed assessment of the fire scenario, but you are not going to necessarily do a detailed HRA for that if you can get away with a scoping HRA.

I would agree that if you have a very general idea of how your control room abandonment scenario plays out, you can't do much of an HRA at all at that stage. You have to have some reasonable level of detail. Then, you may choose to do a fairly simplified HRA, including the scoping approach, for that scenario.

CHAIR STETKAR: Well, that, to me, in this particular area didn't come out. And I agree with you. Within limits, I agree with you. But I think in this particular instance that the guidance should emphasize the fact that you just can't do a simple go/no-go; we are going to assume that the operators abandon the control room according to these, I'll call them, deterministic criteria in 6850. You really do need to do a bit more modeling of the fires as a prerequisite even to use the scoping HFE, HEPs. I

have to be careful.

MR. FORESTER: Yes, that has to be done to use the scoping. They have to be able to do those calculations to be able to use the scoping approach.

CHAIR STETKAR: No, I didn't read that for a lot of the other things.

MS. HENDRICKSON: I mean we should be clear about that.

CHAIR STETKAR: You should be clear about that because this is --

MR. FORESTER: I mean that is the assumption. Once the smoke gets to a certain level, the assumption is they will abandon the control room. If you haven't done those calculations, yes, maybe we need to make that clear, but you shouldn't be using --

CHAIR STETKAR: But even the assumption that they will leave could be an optimistic assumption.

MR. FORESTER: But that is going to be the case for the detailed analysis, too, though.

CHAIR STETKAR: Well, that is true, but the detailed analysis at least, I mean the implication of the detailed analysis is you really need to think about all of those nuances.

MS. COOPER: I think that is a very --

CHAIR STETKAR: I mean, you know, practitioners are looking at the scoping analysis as some way of quickly reducing the amount of work that I need to do for my detailed analysis, quite honestly.

MR. FORESTER: But it is hard problem because, even when doing detailed analysis, personally, I don't see a lot of basis for deciding, other than these kinds of criteria, whether they are going to leave the control room. You can't ask them.

CHAIR STETKAR: It is an uncertainty. I don't want to get too much on the uncertainty. The only thing I wanted to kind of stand up on the soapbox for uncertainty was on the timelines because the time margin is such a critical parameter in the scoping analysis. But, indeed, in a detailed analysis, in principle, you would do an uncertainty analysis about do they decide and the time at which they decide. It is not an easy analysis at all.

MR. FORESTER: No, no.

CHAIR STETKAR: But, in principle, you should address that. But since the major emphasis of this particular document in terms of a new thought process being inserted into 6850 is, indeed, the scoping part of the HRA, you know, how you actually do the detailed analysis to me is not -- that will always

be an issue.

MR. FORESTER: That is always going to be an issue.

CHAIR STETKAR: It is an issue of, if this document was never published, it would still be an issue.

MR. FORESTER: Right.

MS. COOPER: Yes, we can certainly clarify that some of the decisions are not easy ones. I mean or the assessment of the decision, for example, is not an easy one. And if there is some question about whether or not the simplistic approach of scoping is suggesting to model that situation, is not a good fit, then you should be doing something else.

And that is, in general, how scoping should be thought of. But it would be good to clarify that.

Anyway, so, yes, we can certainly do that, make sure that it is clear, so that we can push them to doing detailed analysis when they ought to. If it is an important --

CHAIR STETKAR: I understand. I am not trying, you know, as a practitioner, to put on my day job hat, as a practitioner, I understand the need to do several levels of progressively less-conservative

analysis. So, I am not advocating the fact that analysts should always do a detailed analysis for everything.

MS. COOPER: Yes.

CHAIR STETKAR: But there are some issues, and this is one, that are potentially so thorny --

MS. COOPER: Yes.

CHAIR STETKAR: -- that if you are not willing to outright say always do a detailed analysis, as you were on the self-induced station blackout, at least make it difficult enough that people recognize the type of thought process that they need to go through. And that didn't seem to come out in this particular -- there is a lot of discussion about uncertainties, but, well, we are assuming that these criteria are sufficiently conservative.

MS. COOPER: Yes, yes. I agree.

MR. FORESTER: Maybe this is not directly related, just something that is interesting. But the assumption is that, based on -- you know, the formulas and stuff for determining abandonment are based on calculations, at least for habitability issues, are based on calculations or formulas from 6850.

And there is an assumption there that if it gets that bad, then they are going to have to

abandon the control room. Now if they stayed, I don't know what you would do with that in the sense of it could be worse, but you have to have something that determines what they are going to do. And if the assumption is the smoke is so dense that they couldn't physically stay, then, you know --

CHAIR STETKAR: You know, you still -- that's true. At some point where people are falling over on the floor, the remaining people might get the idea that it is time to leave. But short of that, you just have to remember that this is the environment that the people live in.

I mean, regardless of how well you say the procedures are structured and how well you say the alternate shutdown panels are instrumented, they visit those procedures and perhaps walk through activities at those panels rarely.

MEMBER BLEY: And you lose a lot of information.

CHAIR STETKAR: And you lose a lot of information. It is not your home environment.

MR. FORESTER: Thus, when you abandon the control room, your probability figure goes up, even in the simple scoping approach.

CHAIR STETKAR: Oh, yes. No, that is

true, but in some cases that reluctance to leave might place you on a trajectory that would have been worse than had you decided to leave. Or if you leave too early, it might place you -- you know, that is conversely. That is why it is such a difficult issue.

MR. FORESTER: Even within the scoping approach, if you are leaving due to control issues, you are going to have to do, just as in the detailed case, you are going to have to do interviews and develop some kind of a basis for when -- well, you can also look at the instrumentation that has been affected. Based on the fire, people are going to have to make judgments about how bad it is going to be.

CHAIR STETKAR: That, too, but you always have Joe who can go out. You know, send Joe out to look at that instrument. Give me a call back. Send Ralph out to look at this instrument. Give me a call back. Because this is where home is, and I answer the phone here. Even if I know I don't trust those instruments, it is --

MR. FORESTER: But it is the same issues in doing detailed analysis, too.

CHAIR STETKAR: Yes, yes. Okay.

MEMBER BLEY: Just an aside, I am thinking way back a long time ago and a slightly different

world, but we had an alternate shutdown area. We actually planned to keep somebody in the main control room as long as you could, but send people out to those alternate areas and work by communications.

I haven't seen people lay out that path in their procedure, but I haven't looked at a lot of them.

MS. COLLINS: I recently have seen a procedure --

MEMBER BLEY: Have you?

MS. COLLINS: -- that is like that sort of.

MEMBER BLEY: Okay. Because I have seen "stay here until....and then go over there."

MS. COLLINS: Right.

MEMBER BLEY: But the idea of dispatching somebody there and still trying to keep the command and control in the area where you had information that might be getting unreliable, but it is still more than you have got --

MS. COLLINS: Yes. Just recently I saw --

CHAIR STETKAR: I haven't done any work -- I have done work in the last decade overseas.

MEMBER BLEY: Do they do that?

CHAIR STETKAR: They do, but they have

bunkered, fully instrumented, independent instrumented shutdown facilities. And their facilities typically say, "Send somebody there."

MEMBER BLEY: Dispatch somebody?

CHAIR STETKAR: Because they have diverse instrumentation, and it is diverse, and it is bunkered. So they send somebody there and keep in communication. But it is a different environment than some of the add-on, you know, alternate shutdown panels, or whatever, in some of the plants in the U.S.

MS. COLLINS: Right. Yes, one of the ones I had had flowcharts specifically to locate this guy's still in the control room for a while and he is directing some traffic, even if it is just to make the NRC informations and things like that, but they are communicating with this other guy who is over enabling certain things in the panel and, then, operators see who is taking care of other things. And, then, at some point, they meet up again.

MEMBER BLEY: I am surprised we haven't seen more of that --

MS. COLLINS: No.

MEMBER BLEY: -- but I am glad you have seen it somewhere.

MS. COLLINS: Yes.

CHAIR STETKAR: Well, maybe people haven't done enough of these types of analyses to highlight the benefits of doing some of that.

MEMBER BLEY: And the downside, yes, and we haven't had that kind of fire yet -- yet, or in a long time.

(Laughter.)

MS. HENDRICKSON: So, that is all for how the public comments address the scoping approach.

CHAIR STETKAR: Any other kind of -- because we are going to detailed analysis.

MS. HENDRICKSON: Detailed next.

CHAIR STETKAR: Any other questions on the scoping approach?

(No response.)

Thank you.

In the interest of time, by the way, it is your presentation and, quite honestly, we are willing to stay here as long as it takes. If there are places that you can cover in less detail, keep that in mind, elements of the analysis.

I know you are going to talk about the detailed fire analysis. If there are particular elements of the detailed fire analysis that are unique to this document, rather than just the methods in and

of themselves, we are certainly interested in hearing about that. A general presentation on the EPRI detailed fire analysis methods or ATHEANA as a fire analysis method as a standalone, considering the time limits that we have here, maybe something you could treat at a fairly superficial level.

MS. COOPER: Okay. I think we can do that.

CHAIR STETKAR: So, can you provide a little bit of guidance?

MR. JULIUS: Yes. So, this is Jeff Julius from Scientech, representing EPRI on the detailed EPRI HRA fire approach.

What we will focus this presentation on is the difference in the methods, the detailed methods, from the draft NUREG, the changes in the draft NUREG.

MEMBER BLEY: Oh, good. Yes. Good.

MR. JULIUS: The scoping, and, then, following me will be the changes in ATHEANA.

So, as we have described earlier, there's two methods or two options for detailed analyses in the approach here. One is the EPRI method is implemented through our HRA Calculator tool, and it has for cognitive modeling the caused-based decision tree and/or HCR/ORE for the time/reliability

correlation. For execution, we use the Thickenings for Human Error Rate Prediction, THERP.

We limited changes primarily in the guidance on stress. That was the main emphasis from the public comments, was our evaluation of stress, which I will describe on the next slide.

So, the EPRI approach, you know, we have the tasks and we follow the process for identification and definition in the qualitative analysis. Specifically, the EPRI approach, I guess the detailed analyses go off into the fire impacts on the performance-shaping factors associated with the workload, the procedures, the multiple procedures question that Dennis asked earlier, the cues in instrumentation as far as failure mechanisms, but also in the stress for the execution.

And what we had was a generalization that, whenever you are in a fire scenario and you are taking events from the internal events actions, that the stress should be higher. And the basic industry comment was, well, say, for example, if you are in an internal events station blackout or you are in a fire-induced station blackout, is your stress going to be really any different?

If you are already in a stressful

situation where you might use a multiplier for dynamic stress or extreme stress, it was a factor of five. That shouldn't necessarily be 10 or 15. The stress, you should max out on the stress.

So, I guess we backed off on that and said, in general, the stress should be higher, but you really need to take into account and talk to the operators.

The other end of that spectrum was, okay, if you have a reactor trip, and some of these fire scenarios lead to a reactor trip without impact on the safe shutdown equipment, and if I am in the control room doing an operator action, and that fire is going on in the radwaste area of the plant, should that be a factor of two or an additional increase on the stress for the main control room actions?

So, we said to look through the operator interviews and the talk-throughs and decide, and look closer and not just take a blanket approach to the application of stress. Look at more of the scenario impact on the stress.

The other piece that we did was this integration in the EPRI, this timeline and the time picture that we have had before, but showing where you are overlaying and integrating the thermal hydraulics

timeline with the fire growth timeline, the time to damage, and the growth and suppression, as well as the plant response timeline in the control room and out of the control room.

MEMBER BLEY: I am sorry. Let me take you back even one slide further.

I am thinking of a recent fire that you are probably very familiar with where we had many levels in the control room that met all the rules, but they were lower than usual because of getting ready for an outage and people were signed off doing other things.

And, then, the way they handled emergency procedures and fire procedures was one of the panel operators took over the fire procedure, which left them shorthanded for some of the other activities going on. So, there's the fire. There is a situation that became difficult. Does that add stress? Well, yes. Does it add workload? Well, yes. If you had had your normal manning, you might not have noticed it, but if you are under that kind of condition, which they were, it can push this up.

So, I don't know how you handle that, except I think I do now. You would probably use a high stress value.

MR. JULIUS: And we separately look at the manning and the staffing.

MEMBER BLEY: Yes, but --

MR. JULIUS: You are at the minimum.

MEMBER BLEY: The manning is a range, yes, and you don't normally assume you are at the minimum, or do you? Do you force people to think they are at the minimum?

MR. JULIUS: We typically do force them to think they are at the minimum because you go through --

MEMBER BLEY: Does it say that in the guidance? I am not sure I recall seeing that.

MR. JULIUS: You're right, we might not have called that out or not very explicitly.

MS. COOPER: We do use that, do that in our training examples. We show that.

MEMBER BLEY: Okay.

MS. COOPER: Show it that way. We actually show tables with manning --

MEMBER BLEY: You know, that makes me a lot more comfortable, if you are doing that.

MR. JULIUS: And it has put the squeeze or it has been difficult with some of the scenarios at the plants. So, you are at the minimum and you have

got A, B, and C, and there's multiple things going on.

MEMBER BLEY: Yes, and you keep people out of the picture, yes.

MR. JULIUS: That's right because some of the plants, again, they donate somebody to the fire brigade and others don't.

MEMBER BLEY: That's right, yes.

MR. JULIUS: Others have a completely independent fire brigade.

MS. COOPER: That is a good point. We will see if we can find that, but I think that is, more or less, what -- I mean that is certainly the way we have been doing the training exercises and we have examples both for the EPRI approach and for ATHEANA, where we go through an explicit consideration of staffing and who is doing what and who is available to do what, fire versus EOPs versus local actions and stuff like that.

MS. COLLINS: Yes. Right. Yes. So, in a case like that, you have a whole variety of categories you could use to characterize that between the staffing and the workload and multiple procedures and a bunch of different things.

MR. JULIUS: It comes through in several impacts.

MS. COLLINS: So, you know, all the various screens that you have available in the Calculator, you can look at different pathways and say, all right, I would pick this based on that. And so, you can adjust it and override it.

MS. COOPER: It might be worthwhile picking that up in the qualitative analysis and in the individual methods.

MR. JULIUS: Right.

MEMBER BLEY: But the question came up earlier, and we can't address uncertainty, but if you are being conservative and take the minimum, it is one thing. But if you are not, you can't assume normal manning all the time. You have to consider that range, that it could be different, especially now that we have seen it.

So, go ahead.

MEMBER SHACK: Table B-16 calls out the minimum.

MS. COOPER: Thank you.

MEMBER BLEY: It says use the minimum?

MEMBER SHACK: Yes. Manpower requirements.

MEMBER BLEY: Okay.

MS. COOPER: We can elevate that, though.

Thank you.

MR. JULIUS: One of the others, the subtle change, too, is in our timeline or the impact, for example, on the manipulation or the feasibility. For the manipulation, some of the feedback was to take into account not only the transit time and time to collect tools, but the valve stroke time. If it is a small operator and it takes a long time to crank, make sure the time to take for the valve to fully close.

And similarly, on the feasibility end, if it is a 92-18 valve that is susceptible to MOV operability and the valve could fail because of the multiple spurious, you can't take credit. Even if the operator can go out there and successfully do it, it is not operable. So, we have added that in the guidance.

So, here at the bottom, in terms of the 92-18 valves were added to the list of factors affecting the manipulation and feasibility.

MEMBER SHACK: Well, it is an information notice for those of us who are not in the know, right?

(Laughter.)

MR. JULIUS: That's right.

CHAIR STETKAR: We had a big guy on shift named Tiny. That was his nickname. Tiny wasn't tiny,

and if you gave Tiny a big enough valve bar, he could have opened that valve.

(Laughter.)

MEMBER BLEY: Or sheered it.

(Laughter.)

CHAIR STETKAR: Yes, one of the two.

MR. JULIUS: So, those were our changes.

MS. COOPER: Okay. All right. So, we are going to move on to the next. I will see if I can make up some time.

Okay. So far as the description or discussion of the ATHEANA detailed method, I am just going to skip to the last slide in the interest of time. And if you want to go back and look at anything, we can.

But this summarizes what we have done. I think there were only two comments, and they basically said you need to give us more guidance on how to use it. And we have done some of that, but really, I mean, there is nothing different other than there are fire effects that you need to consider.

So, I think, as it has already been reflected, it continues to say that NUREG-1624, Rev. 1, and NUREG-1880 are still these sources for how to do ATHEANA.

So, there is no change in how ATHEANA is to be applied, but we have tried to provide some more guidance in the appendix, giving some more discussion on how to address certain fire-specific effects, some tips on how to apply ATHEANA, which we have carried over from our training slides. And we have added an example, and we have also referred to some of the examples that were developed way back when, in 1624 and the appendices, on how they might be useful or illustrate how you go about doing an analysis, developing the inputs, and using the inputs to develop your quantification.

MEMBER BLEY: So, something came up in a side discussion earlier. What you are saying is you look on the guidance that is here as supplemental guidance --

MS. COOPER: Yes.

MEMBER BLEY: -- for fire, to be used in concert with the usual kind?

MS. COOPER: That is correct. That is correct.

So, the rest of the slides in this presentation are either something about ATHEANA -- this is a slide we use in the training that tries to indicate that mapping the ATHEANA process steps

1 against the fire HRA guidance process steps -- the
2 chapter numbers may not be correct because this is
3 before we just changed all the chapter numbers. But
4 the bottom line is that it tries to identify where
5 there might be some more work to be done. That is
6 principally in the qualitative analysis.
7 So, this is to try to help people
8 understand what the differences are or where you might
9 need to do more work, and what has already been
10 covered as part of the fire HRA guidelines in general.
11 CHAIR STETKAR: Good. Any other
12 questions?
13 MS. COOPER: If there is nothing here, we
14 will go on to the last --
15 CHAIR STETKAR: Next to last.
16 MS. COOPER: -- next to last.
17 CHAIR STETKAR: I told you we would get to
18 it, didn't I?
19 MS. COOPER: I am trying to help.
20 (Laughter.)
21 Stuart wants to come up here.
22 CHAIR STETKAR: Good job. It is not 5:30
23 yet. So, we are not done.
24 MS. COLLINS: Okay. So, you seem to be
25 mainly interested in the middle of the topics. So, I

will kind of just go over what they are; essentially, recovery and dependency and uncertainty, which we have kind of streamlined since our last discussions in our draft guidelines, based on some feedback from public comments, as well as from the previous PRA Subcommittee meeting which we understand is not an official review.

CHAIR STETKAR: Erin, from what you are telegraphing, you are going to skip most of the recovery?

MS. COLLINS: Unless there is a particular issue that you want to --

CHAIR STETKAR: Well, one of the questions I had --

MS. COLLINS: I was going to kind of see what you felt.

CHAIR STETKAR: One of the questions I had was the scoping for spurious instrument signals is characterized as a recovery analysis, isn't it?

MS. COOPER: There are several different kinds of recovery. I think at one point in time we identified four different ways we use the word "recovery" in our document, and we tried to figure out a way to address that, but we need them all, as it turns out.

CHAIR STETKAR: I got really confused about it because I was trying to think of the numbers that the HEPs that fall out of that flowchart -- and I think they are characterized as recovery numbers. But they are not recovery numbers --

MS. COLLINS: They are not, no.

CHAIR STETKAR: -- that are applied to a preexisting HEP. For example, it is not a .1 recovery on a 10 to the minus 2 preexisting HEP, as it might be characterized in a different type of context. That is really the joint --

MS. COOPER: It is a self-recovery. It is not unlike what Gareth was describing this morning in the answers and presentation.

MR. LEWIS: But it is more than that because the initial error is taken as certain to occur.

CHAIR STETKAR: As unity. Yes, I finally figured that out because I said, well, my God, we have to be careful about recovering, you know, applying another factor on a number for a scenario that might really be difficult, again, in kind of a simplistic approach.

MS. COOPER: Right.

CHAIR STETKAR: But given the fact that

all of those HEPs in principle are 1.0 coming into that, it is really the joint HEP, or whatever you want to call it.

MS. COOPER: Yes.

CHAIR STETKAR: Okay.

MS. COLLINS: It is essentially saying that, given these various spurious indications, we feel that someone has already taken some sort of action, and now this scoping value addresses the recovery from whatever you have done in a bizarre way, yes.

MS. COOPER: In a lot of cases, it is, let's just say a pump trouble light or something like that, and it is in an abnormal operating procedure or something like that. And the direction is, if you get that, then turn off the pump. You want to protect the pump. But if you find out sometime later that you need it, and maybe everything is okay, you can just turn it back on. And if you haven't gotten outside of your window and meeting that thing, then it is fine. That is really what we are trying to address.

CHAIR STETKAR: Okay. Okay.

MR. JULIUS: One other comment on recovery -- this is Jeff Julius -- is that, and this is something that has evolved in the last few weeks.

So, in response to an earlier question actually, on the comparison of the guidance in Reg Guide 1.205 and the terms, we had in the --

CHAIR STETKAR: That is one of the reasons I brought it up.

MR. JULIUS: A couple of months ago, there was a recovery action, and it had the part from Reg Guide 1.205 about recovery actions in here. And, then, actually, it got too focused on that, and we didn't distinguish between the PRA recovery actions and the 805 recovery actions.

And so, we ended up ripping all that out and getting this guidance document out for your review. And, then, we had some discussion yesterday. Well, maybe we needed to go back and put some of that in, so we can distinguish and understand the difference between a recovery action that we are using as part of an 805 submittal, what is in that bin and bucket, and what is in the PRA, and how we categorize and treat them. Not necessarily that they are treated any differently, but certainly there is a certain emphasis and significance to the term 805 recovery action.

CHAIR STETKAR: Having gone through the 1.205 words, I now know that I have absolutely no idea

what the word "recovery" means.

(Laughter.)

MS. COLLINS: Well, that is just, as you are saying, just in this as we were comparing, okay, you have what we had embedded as a recovery into the scoping thing. As Gareth was talking about earlier today, you have what they call recovery within an HEF itself. That is addressed in our various quantification methods where you have other staff who are assessing the situation as it goes along, and maybe providing internal to that HRE recovery action.

Then, you have what we generally are focusing on in this guideline, which is what you might think of as the traditional. You have an accident sequence cutset, and you are providing a recovery action that addresses that you want to recover a particular function that you have lost.

More realistic assessment of the fact that somebody is not going to be just standing there doing nothing; they are going to say, "Well, even if I don't have that, I can take some action to get some sort of functionality back."

And, then, there is this 805 classification, which is a recovery action is something that is taken away from a, quote, "primary

control station" that is defined by the plant as part of the NFPA-805 process.

So, we have got all kinds of flavors of recovery going on, but ours right now is --

MR. JULIUS: And it has additional licensing implications.

CHAIR STETKAR: PRA, in this methodology, for example, allows errors inside the main control room and allows something called recovery of those errors inside the main control room, neither of which is within the definition of that word "recovery" in the context of the deterministic sort of 805. I know.

MS. COLLINS: Yes.

MR. JULIUS: But rather than skip it, we probably should add a section back in addressing the --

CHAIR STETKAR: It certainly would help because there are references. There are even a couple of references in the NUREG to -- I don't think 1.205 is mentioned anywhere; 1.189 is in one or two places in the context of Appendix R type of deterministic things that need to be done.

MS. COLLINS: Right.

CHAIR STETKAR: But, yes, if there is that confusion, you might as well add to it.

MS. COLLINS: Why not?

(Laughter.)

Say, "Here is a whole variety of flavors of recovery, and pick the one you like."

But from the standpoint of the document, we received some comments about, when you look at the actual process of quantifying a recovery action, it is very similar to what you would do for a detailed quantification, whether you are going to use ATHEANA or the EPRI method. So, we didn't feel we needed to have a whole of lot of detail in a separate chapter on recovery. What we have done instead is cut that down significantly and just say, "Refer to...."

For a feasibility analysis, for example, we have now a separate chapter, 4.3, that goes through feasibility. Refer to that. If you are going to do the whole detailed quantification, look at that.

So, what has essentially been cut down and pared down says, you know, recovery is similar to other things you might look at, and so we will quantify it in a similar way and have a much shorter chapter.

CHAIR STETKAR: Okay.

MS. COLLINS: So, that is kind of the summary for recovery. I don't think I need to --

CHAIR STETKAR: Talk about the interesting one.

MS. COLLINS: Yes, so I am going to jump to dependency, since it has been something that the Chairman has mentioned several times.

I think, truthfully, in our document we are looking at both, let's say, dependencies within a scenario, which is also addressed in the HRA Calculator. You have dependencies between operator actions, but I think, generally, we are trying to address the dependencies between actions in a cutset. Once you have done your quantifications and you find you have multiple HEFs coming up in a particular cutset, how does one address that?

CHAIR STETKAR: Erin, let me ask you, how does one identify those cutsets?

MS. COLLINS: Well, what we just recently did was -- well, what the PRA modeling guy who is on the customer interface side said to me: well, how about if I do this? How about if I change my HEPs to something, for the ones that are not one, let me change it to something that is less than one, like .9, and I'll search down a few orders of magnitude and up again, and I'll see what I have in terms of risk significance of these various things. And we will

look and see where we have multiple actions in the same cutset. And, then, we can discuss how we are going to address them.

CHAIR STETKAR: That is an excellent -- you know, one of the things that, as I was reading through this, that is a wonderful exercise to go through because what it does is it forces to the surface the cutsets that you wouldn't normally look at. You know, the ones that have .1 to the 9th multiplied by six hardware failures that are either truncated out numerically or they are so far down on the list that human beings never get that far.

MS. COLLINS: Uh-hum.

CHAIR STETKAR: It is a great exercise. It is a real confidence-builder for this scoping, from my perspective, from the scoping analysis because you mentioned the fact that the smallest individual HEP and scoping analysis is 10 to the minus 3. It is not clear to me, because as a human being I can't understand the PRA model and every place that people have put in HEFs, it is not clear to me that I am not multiplying 10 to the minus 3, times 10 to the minus 3 somehow in a given cutset --

MS. COLLINS: Right.

CHAIR STETKAR: -- multiplied by one or

two other hardware failures, for example.

MS. COLLINS: Right.

CHAIR STETKAR: Or 10 to the minus 3 times three .1s, each of which I have judged are appropriately conservative and getting rather small numbers.

Without providing some method, you know, the first dash under your third bullet there, identifying those combinations of multiple actions, I have never seen people do that. I am glad to hear that at least somebody you work with --

MS. COLLINS: Yes, I am sure a lot of people are doing it.

MR. LEWIS: It is happening pretty widely now.

CHAIR STETKAR: Is it really?

MS. COLLINS: Yes.

MR. LEWIS: It is difficult now to convince people to do it because it is painful to generate cutsets that look like that.

CHAIR STETKAR: Is it?

MR. LEWIS: It is painful in terms of the amount of time. We have gotten to the point now where people want to turn a crank and see an answer in a minute and a half.

MS. COLLINS: Right.

CHAIR STETKAR: Yes.

MR. LEWIS: And that doesn't happen.

CHAIR STETKAR: Well, but, I mean, in reviews I have done I have asked people to do it, and they come back with the cutsets the next day. And they say, "Well, here they are. It's your problem. Go look at it."

What you do, though, is you typically find patterns, so you don't have to look at hundreds of cutsets. You see, oh, my God, here are classes of scenarios where I am vulnerable to this.

I was curious whether this guidance, especially because you have added the scoping, you are probably not vulnerable too much to it at the screening level, given the screening values.

When you do the detailed analysis, there is enough guidance out there to make you aware of the fact that you should be doing this. There is qualitative discussion of this, as you presented, in the NUREG, and I was curious whether it ought to be more formalized to say, really, if you are going to do the scoping stuff to search for these dependencies, you really should do something akin to that type of quantitative evaluation to essentially force yourself

to look at, if it is something that people are routinely doing, they shouldn't view it as an added burden. If they are not routinely doing it, they ought to be doing it or something akin to that. It is something you may want to consider.

MS. COOPER: We are really struggling with our boundaries of this, because we are not trying to solve all the HRA problems.

CHAIR STETKAR: No, but I mean you are sort of adding this intermediate step that you are characterizing as something not nearly as conservative as screening, not nearly as realistic as detailed, and probably okay and probably conservative.

MS. COLLINS: Uh-hum. Right, but how do you really know --

CHAIR STETKAR: But how do you really know that you haven't fallen into that trap of six individually conservative numbers multiplied together?

MS. COLLINS: Sure. Or in the context of --

CHAIR STETKAR: Other than, I mean, qualitatively, the text says you need to be aware of this, but --

MS. COLLINS: Right. Yes. That is a good point. You know, it may -- well, we can have a team

discussion on it.

CHAIR STETKAR: Yes.

MS. COLLINS: I certainly think it would be worthwhile to have something in there just to give you a fallback as to how much influence do these scoping values have, and you can kind of take a peek at what happens in combination.

CHAIR STETKAR: Yes. Okay. I was just curious. Thanks.

MS. COLLINS: When you come right down to it and you have got to evaluate what type of level of dependency you have between these things, there are certain different things you can do, but --

CHAIR STETKAR: I think we all have the experience that the challenge is not necessarily applying these numbers --

MS. COLLINS: Right.

CHAIR STETKAR: -- or any other numbers. The challenge is identifying the cases where you are vulnerable to making, you know, the need to make the decision about what do I do.

MS. COLLINS: Yes.

CHAIR STETKAR: In a lot of cases, people pragmatically make the decision that, well, to avoid having to figure out what number do I apply, I can

just do away with a couple of these other actions that really aren't buying me much in the grand scheme. You know, it seemed like a good idea when I was looking at this little part of the model, but in the grand scheme of things I can do away with them --

MS. COLLINS: Right.

CHAIR STETKAR: -- and it still won't bother me.

MS. COLLINS: Yes, although, again, there is a lot to be said, then, for the qualitative issues related to dependency analysis in terms of how do you really make that dependence judgment, you know, the simultaneity of it, which especially in fire has some implications, and then the resources you have available and crew and cognition and our good old friend timing in general and stress.

So, you know, we haven't gone overly prescriptive in our guidance with providing things, but we do give people the table of numbers and this type of table. I think they are aware of what is available in the HRA Calculator in terms of dependency module and things like this, but a lot of it tends to be, again, plant-specific. We don't want to --

CHAIR STETKAR: Sure.

MS. COLLINS: We don't want to shove

everything into that bin, but there is a lot of it that falls into there.

CHAIR STETKAR: Sure.

MS. COLLINS: I don't know if I need to go into any more on that. You know, ATHEANA is a different beast in terms of considering dependency as part of the whole, overall holistic evaluation of the scenario in terms of unsafe actions.

CHAIR STETKAR: No, I don't think so. As I said, as I read through it, the only thing that struck me was, would it be worthwhile to provide a bit more guidance --

MS. COLLINS: Right.

CHAIR STETKAR: -- you know, just to enhance the sensitivity of people that some type of quantitative process to force those cutsets or sequences, whatever you call them, to the surface?

MS. COLLINS: Just so things are not hiding under there, and so that you have a little more confidence that you are capturing things --

CHAIR STETKAR: I wouldn't dwell on it, except for the fact that I have never asked somebody to do it that they haven't been surprised.

MS. COLLINS: Oh.

CHAIR STETKAR: Now, again, I haven't

worked in the U.S. in the last decade. So, people might be getting better at this. But they might be getting better at it doing the detailed analysis for internal fires or internal events --

MS. COLLINS: Uh-hum.

CHAIR STETKAR: -- and not necessarily recognize the need to do a similar type of analysis for the scoping.

MS. COLLINS: Yes. Yes.

CHAIR STETKAR: There will be pushback.

(Laughter.)

MS. COLLINS: Well, there might be, although I think it is --

MR. LEWIS: I think we have gotten people conditioned to think about this aspect. In fact, there are people that spend more time worrying about dependency analysis than they do about --

CHAIR STETKAR: Oh, yes. If they have done things right, there shouldn't be surprises. I mean, you know, you run the cutsets and take a look at them and say, "Okay, I feel pretty good. I don't see anything that requires adjustment or anything like that." That is fine. It is good saying, "I did it" and check off the box, document the fact that you did it, and move on.

I managed to keep them busy enough on dependency analysis, in case you had any questions.

(Laughter.)

MEMBER BLEY: No, no.

CHAIR STETKAR: Okay.

MEMBER BLEY: No. Good job.

(Laughter.)

MS. COLLINS: Well, again, uncertainty analysis is another one of these topics that we essentially took these three individual topics of recovery, dependency, uncertainty that used to be their own standalone chapters, and we put them together because we didn't want to reinvent the wheel. If there was guidance out there that was existing on these topics, either within our own document or outside our document, and available in the field, we would say go thither and find it.

I think the uncertainty chapter is something we got a fair number of public comments on and some previous comments from the PRA Subcommittee essentially saying we really needed to trim that down and to boil it down to some nuggets and say, in the detailed analysis, when you are going through these, you are calculating uncertainty bounds anyway.

We originally had something stated in our

previous issue of the document that talked about uncertainties on screening and scoping. But, as we are talking, I think a lot of people are addressing those more in terms of sensitivity analyses now rather than putting an uncertainty bound on a very, what we like to think of as a hopefully conservative value in terms of screening or scoping.

So, rather than provide the user with some sort of confusing guidance on how to assess uncertainty in a very high bounding value which we don't even know what percentage that is, what percentile that is on a distribution, we are saying address that in terms of more of a sensitivity value, which we are planning to do on our fire PRAs.

We also did, though, break out points where on --

CHAIR STETKAR: No, go on.

MS. COLLINS: -- where there may be certain scoping values, which, as you have already mentioned, there may be some scoping values that may not be as conservative, and especially compared with the internal events HEP. And so, you may want to do a little more scrutiny on those. Those become pretty evident.

What I have been doing in my assessments

is I will do an initial screening value to kind of throw at the early stage of the model. And, then, the mid-stage of the model, where I am getting a little information, I will do a scoping analysis. And I have the original internal events HFE, and, then, if I need to, I will do a detailed HEP. So, I might have in the same spreadsheet for the same HFE, I might have a variety of HEPs, and I can eyeball and say, oh, okay, screening is very high; scoping is here, but in this case scoping and let's say 10 times or even the original internal event HEP are a little close. So, I am really not sure, am I being conservative there? I really don't know.

So, some of these, when we are going through and doing sensitivity of the dependency analysis by showing what really matters to us from a risk significance, then I can evaluate it further as necessary.

CHAIR STETKAR: Let me just understand. One of the things I think about, though, is remember this NUREG is going to be used by, in principle, because I can't presume how a particular nuclear power plant owner or operator runs their business --

MS. COLLINS: Right.

CHAIR STETKAR: They may not necessarily

hire you as a consultant to do the HRA.

MS. COLLINS: I understand.

CHAIR STETKAR: They might have, you know, someone in-house who has some experience in terms of the overall methodology, but picked this up and without that experience.

MS. COLLINS: Right.

CHAIR STETKAR: You know, without the insights that you have about being able to look at things and have a sense of what may or may not satisfy that word "conservative".

So, when I read this, I try to pick it up as a PRA practitioner who understands the jargon and think about how I would use it.

MS. COLLINS: Right. Well, I think, in general --

CHAIR STETKAR: You know, if everyone is going to contract their HRA out to experienced professionals in the business --

MS. COLLINS: Yes.

CHAIR STETKAR: -- we might not need NUREGs like this.

MS. COLLINS: And so, conversely, that is what we have tried to do in our discussions amongst ourselves as a group, based on our experiences. And,

then, gleaning information from our training sessions, how can we factor in that experience better into the guidance, so that you have a bit of a flavor for what we have learned over time and someone doesn't have to be -- I mean you would like them to have as much HRA and PRA experience as possible, but we are trying to imbue our expertise in the document to the greatest extent that we can through our discussions and mods.

I think we have done quite a bit better in this iteration.

CHAIR STETKAR: Given the time considerations, as I said, I would reiterate the comment I made earlier. I think that the process, especially because of the reliance on the time margins, might benefit from the documentation and quantification of the uncertainties in those times. Because it strikes me that if you are going do the detailed analysis, you probably ought to be considering those anyway, and you probably don't want to ask people to go backfit the uncertainties by performing interviews differently or reperforming interviews and saying, "Well, can you give me your margins on what the high response time versus the low response time might be?" You probably want to gain that information during one -- if you are going to

interview the operators or go through the process of formal of walk-throughs/talk-throughs, you probably want to glean as much information about the scenarios or those time estimates as possible.

How you decide to use that later, you know, you need to think about, but you probably don't want to do it twice.

MS. COOPER: Yes.

MS. COLLINS: Great. No, that is a good point, especially, as you say, for that point where you know you are on the 49.9 versus 50.1.

CHAIR STETKAR: It is a factor of five, typically.

MS. COLLINS: Yes.

CHAIR STETKAR: Anything else, comments, questions from the members on this?

(No response.)

Thank you.

MS. COOPER: All right, we have a final presentation. But I think this is just an opportunity for us to remind you of where we are and where we are planning to go.

That is that we are trying to polish up, clean up, and get ready for the final report. EPRI is publishing at this time.

CHAIR STETKAR: Yes. Finish whatever you want to say about these final slides.

MS. COOPER: Okay.

CHAIR STETKAR: And if you are done, say you're done.

MS. COOPER: Okay. We are going to do training again next fall. We are expecting that people will use this and will continue to use this, but there might be a few changes for events, whatever. We expect that at some point for the fire HRA methodology.

That's it.

CHAIR STETKAR: Okay. In the introduction, Mark Salley said that he would like a letter from us on this. So, the question immediately comes to mind, I am assuming you want a letter on the final version that you are going to press with, meaning the editorial things cleaned up. And if you decide to react to any of our comments during this meeting, that might be folded in there.

A bit of planning is necessary, and perhaps it is premature. But recognize that we need to get that into our full Committee meeting schedule.

MS. COOPER: Right.

CHAIR STETKAR: And it might be the fall

before that happens. It probably would be the fall, given what our schedule is so far.

MS. COOPER: Okay.

CHAIR STETKAR: So, if you are really looking for a letter next month, you are not going to get it because we are already -- you know, our meeting schedules are laid out through June already.

MEMBER ABDEL-KHALIK: But they ought to just work with John and see what the schedule is.

CHAIR STETKAR: But I just wanted to make aware of that. You know, depending on when you wanted our letter and what you thought the implications of that letter might be --

MS. COOPER: Okay.

CHAIR STETKAR: -- there is a timing consideration here.

MS. COOPER: Well, I guess the other thing is you are going to want to write a letter on the polished-up final one.

CHAIR STETKAR: I mean that is your decision.

MS. COOPER: Okay.

CHAIR STETKAR: We can write a letter on anything that you request the Committee to review, honestly. It could be this draft version. I think we

generally prefer to see the final version. But recognize there is a timing issue here.

MS. COOPER: Okay.

MR. SALLEY: Yes, and just your thoughts on a letter, I understand, I believe, a letter isn't mandatory. But whenever we come out with a new kind of technique or something that is novel, we really like to have that. We have spent the time with you.

CHAIR STETKAR: Yes.

MR. SALLEY: You have given it a good look, and it just makes us a lot more confident --

CHAIR STETKAR: Yes.

MR. SALLEY: -- in our final product. So, I would, in discussing it with Susan, we would like a letter because this is something new.

CHAIR STETKAR: Okay.

MR. SALLEY: Are you good with that?

CHAIR STETKAR: We are fine. We are fine with that. You know, the way we work is that, if you ask us to review something, we generally will do that. We may decide after that to perhaps not write a letter, but we generally do. Occasionally, we decide to write a letter, even if not asked, if we identify a certain area of concern. That is rare, but not unheard of.

So, in this case, I understand it. It is something new, and the Committee will certainly accommodate that. It is just a matter of your internal discussions about timing of that letter, and if you want it on the final product, when that would be available to us. That is something you will have to work with John and the rest of our staff.

MR. SALLEY: Yes, we will let Susan take that back with the team. And based on the feedback that we have gotten today, I could see them taking a lot of notes and there are a lot of things that they are going to go back and look at. So, there is going to be some time involved there.

CHAIR STETKAR: Yes.

MR. SALLEY: But, Susan, you take it back with your team and work it out. And, John, we will come to you.

If we are going to update this draft, which obviously we are, maybe we weren't 99 percent. How about 93?

MS. COOPER: Ninety-seven.

MR. SALLEY: Ninety-seven? Okay.

(Laughter.)

MR. SALLEY: If we were going to go back and make those corrections, would you want another

presentation from this group?

CHAIR STETKAR: To the Subcommittee?

MR. SALLEY: To the Subcommittee? Or what would you like?

CHAIR STETKAR: I would leave that up to your discussions internally with John. It depends on, if it is primarily editorial things, you can discuss those differences in the full Committee presentation. If they are anything substantive from a technical perspective, depending on the nature and the extent of that, we might want another half-day, or something, Subcommittee meeting. I don't know.

MR. SALLEY: What is your sense right now? I mean while this is so fresh in our minds.

CHAIR STETKAR: I am not going to try to telegraph that.

MR. SALLEY: Okay.

CHAIR STETKAR: I think the team needs to go back and think about issues.

MR. SALLEY: Fair enough. Fair enough.

CHAIR STETKAR: And just picking up coordinating --

MEMBER ABDEL-KHALIK: From a scheduling standpoint, that would be a lot easier to work out than the full Committee presentation. Because even if

there is an additional Subcommittee presentation, it could be done the same week as the full Committee presentation.

CHAIR STETKAR: Sure. You don't have to write the letter.

(Laughter.)

MEMBER SHACK: We know you already like Chapter 4.

(Laughter.)

CHAIR STETKAR: That's right, my personal opinion.

(Laughter.)

Anyway, you get the message.

MR. SALLEY: Yes, and we are going to have another project, it is in the cue right now, that I believe will be coming to this same group. And that is the fire-model applications guide.

CHAIR STETKAR: Sure.

MR. SALLEY: So, again, that is another one that is kind of new and novel. Well, we thought this one won the race, but the race isn't over yet.

So, the fire-model applications guide is another big project that we have that will be coming to you to look at.

CHAIR STETKAR: With that, let me go

around the table and ask if any of the members have any other questions or comments.

We will start with Dr. Bley.

MEMBER BLEY: No, I would like to thank everybody for a good day of presentations and discussion. I think I asked everything I wanted to already.

CHAIR STETKAR: Good.

Said?

MEMBER ABDEL-KHALIK: Ditto.

CHAIR STETKAR: Bill?

MEMBER SHACK: The same.

CHAIR STETKAR: I don't have anything more.

MEMBER SHACK: It was an enjoyable read, actually, the guide. Considering I am hardly an expert, I thought it was pretty readable.

MS. COOPER: That's good.

MEMBER SHACK: It was quite interesting.

MS. COOPER: That is good to know. Thank you.

CHAIR STETKAR: And I would like to echo, I think. Thanks a lot for the presentations. I think it was really, really informative. You successfully organized your time to present an awful lot of

information in not a very long period of time, and the discussions were quite useful.

And again, given negative comments, I would echo Bill. I think the report is very well-written. I think it is clear that we have discussed a few issues that you might want to rethink, but it is clear that a lot of work has gone into this.

So, with that, if there are no other comments, I guess I should ask, do we have any members of the public here who would like to make any comments?

(No response.)

John, do we still have the bridge line open?

MR. LAI: Yes, it is still open.

CHAIR STETKAR: It is?

MR. LAI: Yes.

CHAIR STETKAR: Can you open it up to see if there is anyone out there --

MR. BROWN: It is open.

CHAIR STETKAR: It is open? Thanks, Theron.

Is there anyone listening in? If there is, just make some sound so that we know the bridge line is open.

(No response.)

Hearing nothing, I am assuming that no one has any comments.

And with that, the meeting is adjourned.

(Whereupon, at 5:24 p.m., the proceedings in the above-entitled matter were adjourned.)

Item # 1

Addressing SRM-M061020 on Human Reliability Analysis Model Differences

Erasmia Lois, PhD
Senior Risk and Reliability Analyst
Division of Risk Analysis
Office of Nuclear Regulatory Research

ACRS PRA Subcommittee Meeting

April 20, 2011

Introduction

- Background
- Aim of the Project
- Focus
- Interactions with the ACRS PRA Subcommittee
- Objective of Today's Meeting
- Milestones and Schedule
- Anticipated Uses

Background

- SRM-M061020 directed the ACRS to "work with the staff and external stakeholders to evaluate the different human reliability models in an effort to propose a single model for the agency to use or guidance on which model(s) should be used in specific circumstances"
- Through interactions with the ACRS, RES undertook the effort to address the SRM
- Periodic meetings with the ACRS for input
- Collaborative with EPRI

Direction of SRM-061020

- A single method is the most desirable
- Use of more than one method should be justified
  - Why more than one
  - Which methods should be used for which applications
  - Need for implementation guidance for each particular method and application
- Desirability for convergence of NRC and industry

Aim

- Establish a consensus approach by developing a "single" high-level method/structure that ensures
  - consistency throughout the analysis process
  - be of sufficient generality to support application for different domains
  - applications such as low power and shutdown, ex-control room actions, external hazards, and Level 2 analysis will require adaptation of the overall structure for addressing domain-specific needs
- Gain acceptance from PRA/HRA and human factors experts and practitioners

Focus

- Current
  - Start with addressing the issue for a detailed internal event/at power PRA/HRA
  - Converge with EPRI on HRA methods(s) and practices for internal events
  - Address event evaluations for Significance Determination Process and other risk-informed applications
- Future
  - Expand to other reactor hazards for existing light water reactors
  - Expand to new reactors

Interactions with the ACRS

- Periodic meetings with the PRA Subcommittee
  - April and October 2010 and April 2011
- In the October meeting we presented a basis and rationale for a "hybrid" approach being developed collaboratively with EPRI; basic features are
  - Up-dated technical basis from performing cognitive psychology literature review
  - Explicit use of literature review findings to create underlying frameworks to model human failure events in nuclear power plant settings
  - Quantification scheme reflecting improved qualitative analysis guidance and a structured approach for using the information
- The Subcommittee requested for the next (that is today's) briefing to be presented with a clearer picture of
  - Discussion on the breadth and depth of the literature search
  - Discussion how the literature search results are incorporated

Objective of Today's Meeting

- Discuss the literature search
  - How it was performed
  - Findings
  - How are used
- Present further development of the quantification scheme being pursued
- Obtain feedback and input by the Subcommittee
- Plan for the next meeting

Milestones and Schedule

- Draft on literature search for external peer review, 4th Quarter (Q)/11
- Expert workshop(s) for estimating HEPs for the various CFMs, 1st Q/12
- Draft on qualitative and quantitative analysis for Level 1, internal events PRA, for external review, 1st Q/12
- Draft User's guide for external review, 1st Q/12
- Draft report on applying the approach in event evaluations, 1st Q/12
- Revised approach addressing external review comments, 3rd Q/12
- Trial applications the overall approach, 4th Q/12
- Revised reports for public comment, 3rd Q/12
- Final NUREG/EPRI reports, 4th Q/13.
- Periodic meetings with the ACRS subcommittee

Anticipated Uses

- The tools developed should support NRC staff risk-informed activities
  - Guidance for reviewing risk-informed licensee requests
    - e.g., risk-informed licensing changes
  - Event evaluations (significant risk determination)
  - New PRAs and especially the Level 3 PRA
- Industry applications in the same areas

Back-up

Who is Involved

- Collaborative with EPRI
- RES staff
- NRC-sponsored organizations
  - Sandia National Laboratories
  - Idaho National laboratory
  - University of Maryland
  - Paul Scherrer Institute, Switzerland
- Interdisciplinary Expertise
  - PRA/HRA
  - NPP Operations
  - Human factors/cognitive psychology experts

Challenges

- High-level concepts appealing, resolving issues showing up in the details
- Effectively communicating view points and achieving consensus among the project team, comprised recognized experts in different disciplines
- ACRS buy-in
- Facilitating understanding and acceptance by the larger community, both in the NRC and within the industry

Item # 2

ELECTRIC POWER RESEARCH INSTITUTE

Development of a Hybrid Model for Human Reliability Analysis

Introductory Remarks

Stuart Lewis
Program Manager
Risk & Safety Management

ACRS PRA Subcommittee
April 20, 2011

Status of HRA Research at EPRI

- Basic HRA methods developed by EPRI in late 1980s/early 1990s still in wide use within nuclear industry
  - Guidelines to using the EPRI template
  - Complementary methods for representation and quantification of human failure events
    - HCR/ORE correlation for time-constrained human actions
    - Cause-based decision tree to capture influences not directly accounted for in a time-reliability correlation
- Use of EPRI and other methods is facilitated by HRA Calculator® (software tool)

Focus of Recent Developments

- Use of HRA Calculator as a platform to
  - Improve consistency in the application of HRA methods
  - Extend specific methods as needed (especially for treating dependencies among HFEs)
- HRA Calculator now used by every nuclear utility in US, some outside US
  - Methods are understood by users and applied effectively in PRAs and risk applications
  - Given age and nature of the methods, revisiting and updating are appropriate
- Joint development of guidance for fire HRA

Motivation for EPRI involvement in hybrid model development

- Take advantage of work done by NRC researchers to provide
  - Better psychological underpinning to HRA
  - More comprehensive understanding of potential human failure events
  - Updated approach to quantification
- Work toward ensuring usefulness of approach for NRC and industry

Process appears to be heading toward useful product

Together…Shaping the Future of Electricity

ELECTRIC POWER RESEARCH INSTITUTE

Item # 3

Building a Psychological Foundation for Human Reliability Analysis

The Psychological Literature Review and Cognitive Framework for the Hybrid HRA Method

ACRS PRA Subcommittee Meeting
April 20, 2011

April Whaley
Idaho National Laboratory

Outline

- Overview of the literature review process (3 slides)
- Overview of Macrocognition (4 slides)
- Structuring the results of the literature review(6 slides)
- Results from Detect/Notice (5 slides)
- Conclusions (3 slides)

THE PSYCHOLOGICAL LITERATURE REVIEW

Literature Review as Foundation for Hybrid HRA

- Provides a psychological basis for the Hybrid HRA methodology
  - Incorporates current understanding of human performance
- Produced a cognitive framework for the method
  - A tool for identifying errors and linking them to relevant performance influencing factors (PIFs)
- Informs the development of the qualitative and quantitative approach

Literature Review Process

- Stage 1: Initial literature review
  - Search for psychological mechanisms that can lead to human failure
  - Bottom-up, literature-driven approach
- Development of cognitive framework
  - Incorporation of macrocognition
  - Development of proximate causes of human failure
- Internal peer review
  - Results: adequate breadth, need additional depth
- Stage 2: Targeted review to support the cognitive framework

Literature Areas and Search Terms

- Macrocognition
- Detect/Notice
  - Working Memory
  - Attention
  - Vigilance
  - Monitoring
  - Problem Detection
  - Sensation/Perception
  - Information Foraging
  - Change Blindness
  - Situation Awareness
- Sensemaking/Understanding
  - Situation Awareness/Assessment
  - Sensemaking
  - Activity Theory
  - Complex Problem Solving
- Coordinate/Communicate
  - Team/crew collaboration
  - Team/crew sensemaking
  - Crew resource management
  - Communication
- Decision Making
  - Procedure following errors
  - Naturalistic decision making
  - Recognition primed decision making
  - Cognitive biases
- Action
  - Human performance errors
  - Slips, lapses
  - Errors of commission
  - Multitasking
- And other related terms

OVERVIEW OF MACROCOGNITION

What is Macrocognition?

- Macrocognition:
  - Focuses on the nature of human cognition in the field (real-world settings), where decisions
    - Are often very complex,
    - Have to be made quickly,
    - By domain experts or well-trained personnel,
    - In risky, high-stakes situations
- Macrocognitive Functions: The high-level mental activities that must be successfully accomplished to perform a task or achieve a goal in a naturalistic environment

Models of Macrocognition

- There are a number of different models of macrocognition
  - Different researchers divide the continuous spectrum of cognition up slightly differently
  - There is not one agreed-upon or “official” list of macrocognitive functions
- General consensus at a high level that key, generic macrocognitive functions include:
  - Detecting/noticing
  - Sensemaking/understanding
  - Planning/deciding
  - Communicating/coordinating

Macrocognition for the Nuclear Domain

- The macrocognitive functions reviewed were not developed for the nuclear power plant environment
- There are aspects of the nuclear environment that are unique
  - The NPP operating environment is highly proceduralized
  - HRA is concerned with errors in action implementation

Macrocognitive Functions in the Hybrid HRA Project

- Our macrocognitive functions:
  - Detect/Notice
  - Sensemaking/Understanding
  - Decision Making (includes aspects of planning)
  - Coordination/Communication
  - Action
- These macrocognitive functions served two purposes in this project:
  - To guide the literature review
  - To structure the cognitive framework built from the literature review results

STRUCTURING THE RESULTS OF THE PSYCHOLOGICAL LITERATURE REVIEW

Definitions of Terms

- **Macrocognitive Failure Mode:** Failure in one or more macrocognitive functions that may lead to a human failure
- **Proximate Cause:** A contributing cause of the macrocognitive failure mode
- **Psychological Mechanism:** The psychological/cognitive process that leads to failure when activated by contextual factors (i.e., PIFs)
- **Performance Influencing Factor (PIF):** Contextual factors (including plant factors) that influence the likelihood of failure of the psychological mechanisms ("activates" the mechanisms to failure)

Development of Proximate Causes

- The literature review identified psychological mechanisms that can lead to human failure
- Consequences of failure of the mechanisms tended to cluster into categories
- Categories became proximate causes of failure of the macrocognitive functions
- Proximate causes are sorted by macrocognitive function

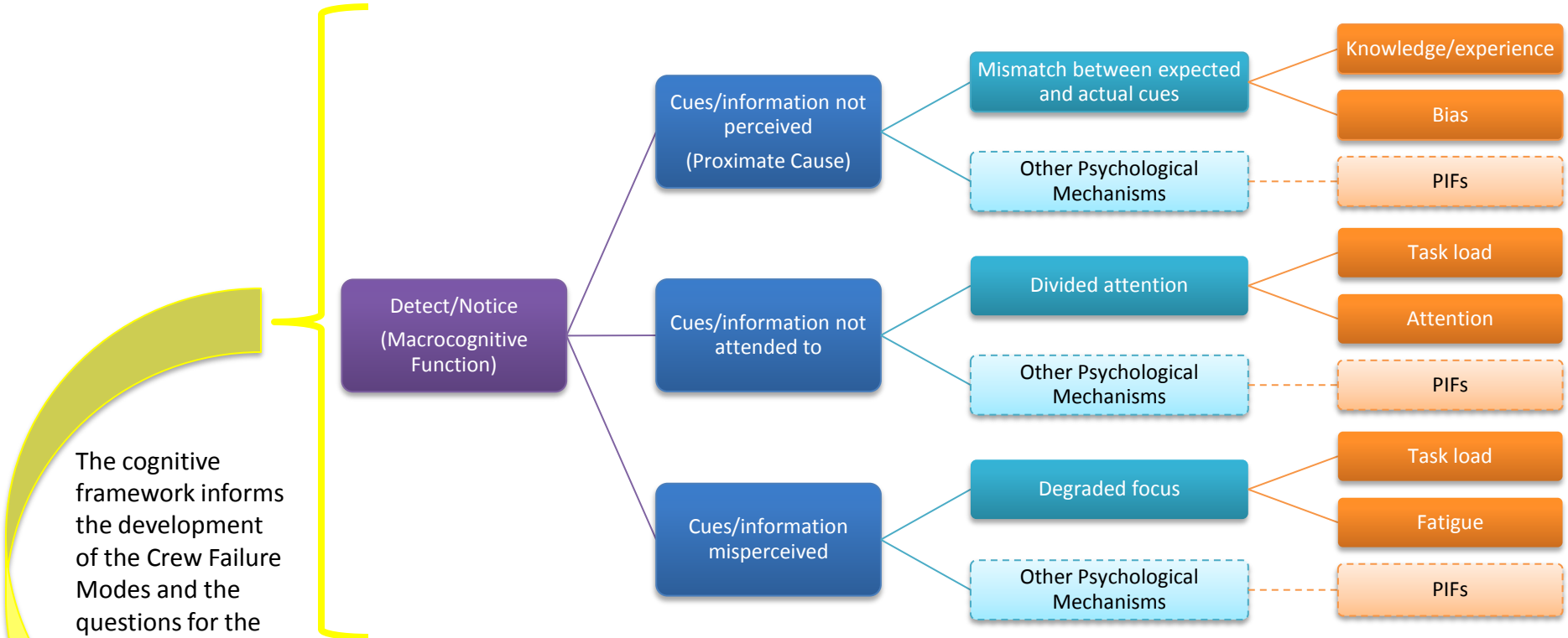
Process Example

Literature Excerpt:	Incorrect information sampling (e.g., inadequate sampling strategy or internal model for directing sampling, misperception of the statistical properties of elements in the environment, forgetting what has already been sampled). [Situation awareness; Endsley, 1995. Error identified by Endsley, page 41, 55.]
Question:	What is the end result of this?
Answer:	• Cue/info not perceived • Cue/info not attended to • Cue/info misperceived } Proximate Causes

Current Proximate Causes (4/2011)

- **Failure to Detect**
  - Cues/info not perceived
  - Cues/info not attended to
  - Cues/info misperceived
- **Failure to Understand**
  - Incorrect understanding/diagnosis
  - Inability to develop understanding/diagnosis from available info
- **Failure to Decide**
  - Inappropriate goal/priority selected
  - Failure to properly maintain/balance multiple goals/priorities
  - Consideration of incomplete/inappropriate list of alternatives (information/explanations/courses of action)
  - Decide upon incorrect alternative (information/explanation/course of action)
- **Failure to Act**
  - Omission (Failure to perform action)
  - Incorrect execution (force, direction, degree/distance, object)
  - Incorrect timing
  - Incorrect order/sequence
  - Commit incorrect action (specifically an accidental or unintentional incorrect action, e.g., habit intrusion, interference error, perseverations)
- **Failure to Coordinate**
  - Failure to communicate information verbally or nonverbally
  - Incorrectly communicate information verbally or nonverbally
  - Incorrect timing of communication
  - *Additional proximate causes are expected here*

Example of the Cognitive Framework



The cognitive framework informs the development of the Crew Failure Modes and the questions for the Decision Trees

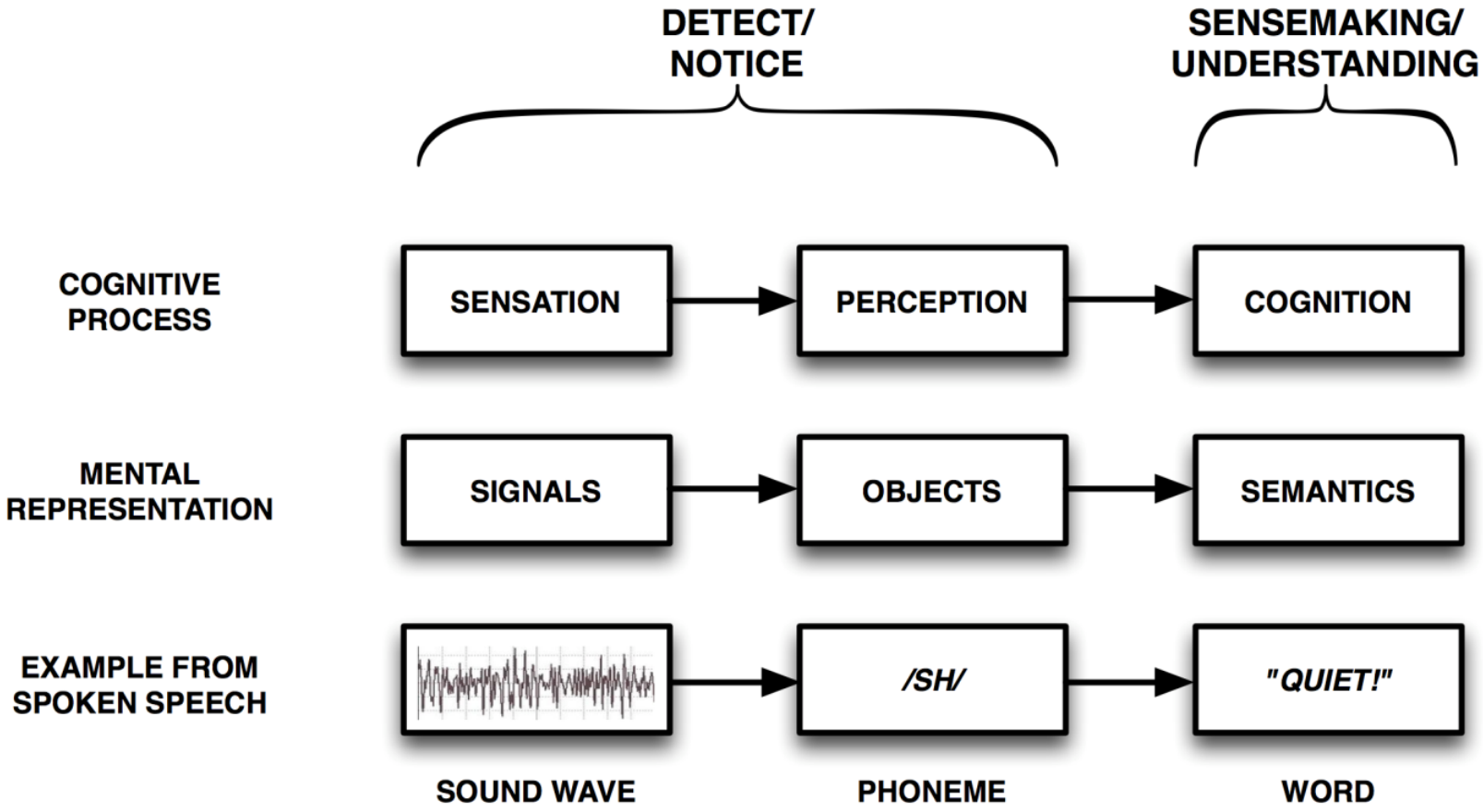
Crew Failure Modes → Quantification Decision Trees

Performance Influencing Factors (PIFs)

Organizational PSFs	Team PSFs	Personal PSFs	Situation PSFs	Machine Design PSFs
• Training Program – Availability – Quality • Corrective Action Program – Availability – Quality • Other Programs – Availability – Quality • Safety Culture • Management Activities – Staffing ∗ *Number* ∗ *Qualifications* ∗ *Team composition* – Scheduling ∗ *Prioritization* ∗ *Frequency* • Workplace adequacy • Resources – Procedures ∗ Availability ∗ Quality – Tools ∗ Availability ∗ Quality – Necessary Information ∗ Availability ∗ Quality	• Communication – Availability – Quality • Direct Supervision – Leadership – Team member • Team Coordination • Team Cohesion • Role Awareness	• Attention – To Task – To Surroundings • Physical & Psychological Abilities – Alertness – Fatigue – Impairment – Sensory Limits – Physical attributes – Other • Morale/Motivation/Attitude (MMA) – *Problem Solving Style* – *Information Use* – *Prioritization* ∗ *Conflicting Goals* ∗ *Task Order* – *Compliance* • Knowledge/Experience • Skills • Familiarity with Situation • Bias	• External Environment • Hardware & Software Conditioning Events • Task Load • Time Load • Other Loads – Non-task – Passive Information • Task Complexity – Cognitive – Task Execution • Perceived Situation: – Severity – Urgency • Perceived Decision: – Responsibility – Impact ∗ Personal ∗ Plant ∗ Society	• HSI – Input – Output • System Responses – *Ambiguity*

RESULTS FROM DETECT/NOTICE

What is Detect/Notice?



Categories of Literature Within Detect/Notice

- *Cue content*—the type, availability, quality, and context of the information can greatly affect detection
- *Vigilance and monitoring*—an operator's ability to attend to or monitor cues over time is affected by fatigue, workload, or stress
- *Change detection*—an operator's ability to detect change can be affected by change blindness or inattentional blindness
- *Expectations*—Perception of the environment is subject to expectations and biases, which are primed by experience and training
- *Working memory*—the amount of information an operator can maintain in active attention is limited and susceptible to information overload, or high attentional workload can impair retention of new salient information

Detect/Notice Proximate Causes

- *Cues/information not perceived*
  - The cues or information may simply be missed, in which case they are not perceived
- *Cues/information not attended to*
  - The cues or information may be sensed and perceived but not attended to—in other words, the sensory-perceptual system acts as a filter, and this information is not propagated for further sensemaking and understanding
- *Cues/information misperceived*
  - The cues or information may be sensed but misperceived—in other words, the sensed information is tagged with the incorrect meaning.

Explanations and PIFs indicated by the literature for proximate causes

Proximate Cause	Cue Content	Vigilance and Monitoring	Change Detection	Expectations	Working Memory
Cues/ information not perceived	*Cue quality is low and not detected.*	*Unable to maintain vigilance.*	*Inattentional blindness.*	*Mismatch between expected and actual cues.*	*Working memory capacity overflow.*
Cues/ information not attended to	*Too many meaningful cues.*	*Divided attention.*	*Change blindness.*	*Overreliance on primary indicator.*	*Working memory capacity overflow.*
Cues/ information misperceived	*Cues are too complex.*	*High stress, workload, or fatigue degrades focus.*	*Inattentional blindness.*	*Mismatch between expected and actual cues.*	*Memory segmenting error.*
PIF	HSI, System Responses	Attention, Task Load, Task Complexity, HSI, System Responses	Attention, Knowledge/Experience, Skills, Familiarity with Situation	Knowledge/Experience, Bias, Hardware & Software Conditioning Events, Perceived Situation	Attention, Task Load, Task Complexity, HSI, System Responses

Excerpt Detect/Notice Psychological Mechanisms

Proximate Cause: Cues/information not perceived

Cognitive Model	Mechanism/ Explanation/ Reference	Example	Causal Notes	PIFs
Attention guides visual gaze	Attention as a psychological construct (a construct is a hypothetical explanatory variable which is not directly observable) is a key aspect of detect/ notice. External stimulus or stimuli that attract our attention also tends to guide our visual gaze (e.g., a flashing light; even a loud noise tends to cause us to look in the direction from which the sound emanated). (Lavine, et al., 2002)	A cue such as flashing light; even a loud noise tends to cause us to look in the direction from which the sound emanated. However, when the stimuli does not have sufficient "activation energy" that exceeds a biologically determined threshold that triggers a sensory response in us, we fail to perceive the cue.	The external stimulus or stimuli must have an "activation energy" that exceeds a biologically predetermined threshold for detecting/noticing/sensing objects in the world around us, causing our attention to focus on that stimuli.	HSI
Attentional narrowing	The presence of a demanding central task effectively narrows or "tunnels" the functional field of view, making it more difficult to extract information from the periphery. (Referenced in Nikolic, Orr, & Sarter, 2004, pg 40)	When an operator is engaged in a cognitively demanding task, he is less likely to notice cues that are in the periphery of his visual focus.	Refers to visual cues. Mental workload (anything that loads the central executive) creates attentional narrowing.	Loads
Autonomic Nervous System (Sympathetic response)	The sympathetic response is the action to mobilize the body's resources under stress to induce the fight-or-flight response. It is what causes people to become more anxious under stressful conditions. (Aarts & Pourtois, 2010)	A) Not being sufficiently stressed causes an operator to not have sufficient attentional resources at the ready to perceive cues. B) Too many cues being presented simultaneously causes one to be over-stressed, and in this highly anxious state, an operator may not perceive a critical cue amongst the multitude of other cues	Depending on the magnitude of the sympathetic response, an individual may not be sufficiently stressed, or over-stressed. Not being sufficiently stressed may lead to the cue not being perceived. Being over-stressed, for example, by an alarm flooding situation, may lead to a critical cue not being perceived.	Stress

CONCLUSIONS

Grounding HRA in Psychology

- The literature review serves to:
  - Incorporate current psychological theory into the development of the Hybrid HRA method
  - Develop a cognitive framework and tool for
    - Identification of causes and mechanisms for human error
    - Identification of relevant PIFs for human error

Limitations

- The literature review can never be 100% complete
  - We have taken an iterative peer review process to ensure a reasonable degree of completion
- The cognitive framework is based on current psychological theory
  - The framework is expandable to include future psychological models

Next Steps

- Completing the same review process for the remaining Macrocognitive Functions
- Completing the cognitive framework and tool for identifying PIFs relevant to human errors
- Results of the literature review are used to inform the development of the qualitative analysis and quantification approach

Schedule

- The literature review is in-progress
  - Detect/Notice: Complete.
  - Sensemaking/Understanding: target completion 3rd Quarter, 2011
  - Decision: target completion 3rd Quarter 2011
  - Coordinate/Communicate: target completion 3rd Quarter 2011
  - Action: target completion 3rd Quarter 2011

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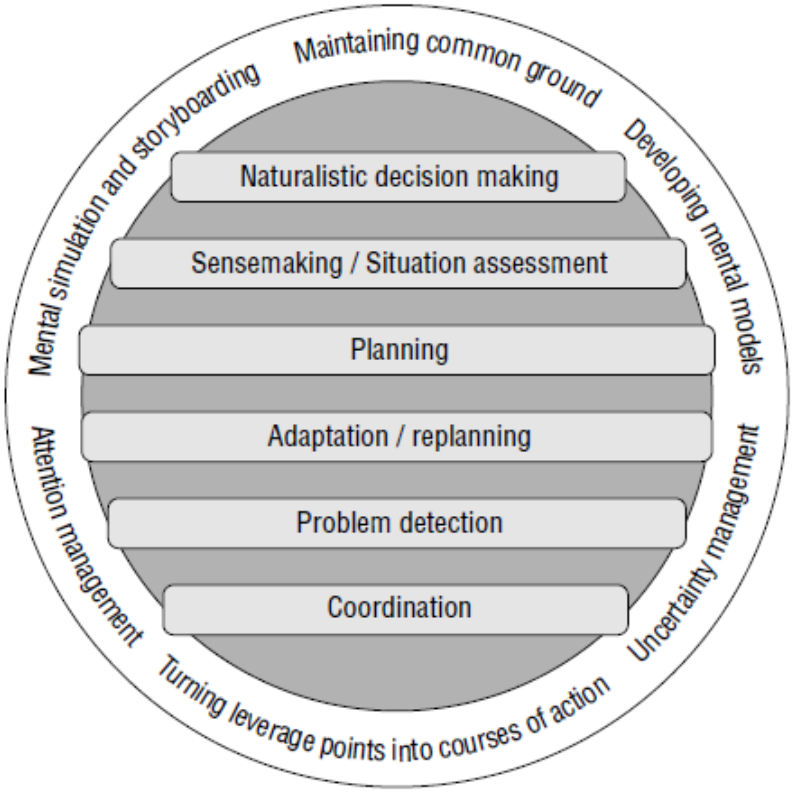
Back-up Slides

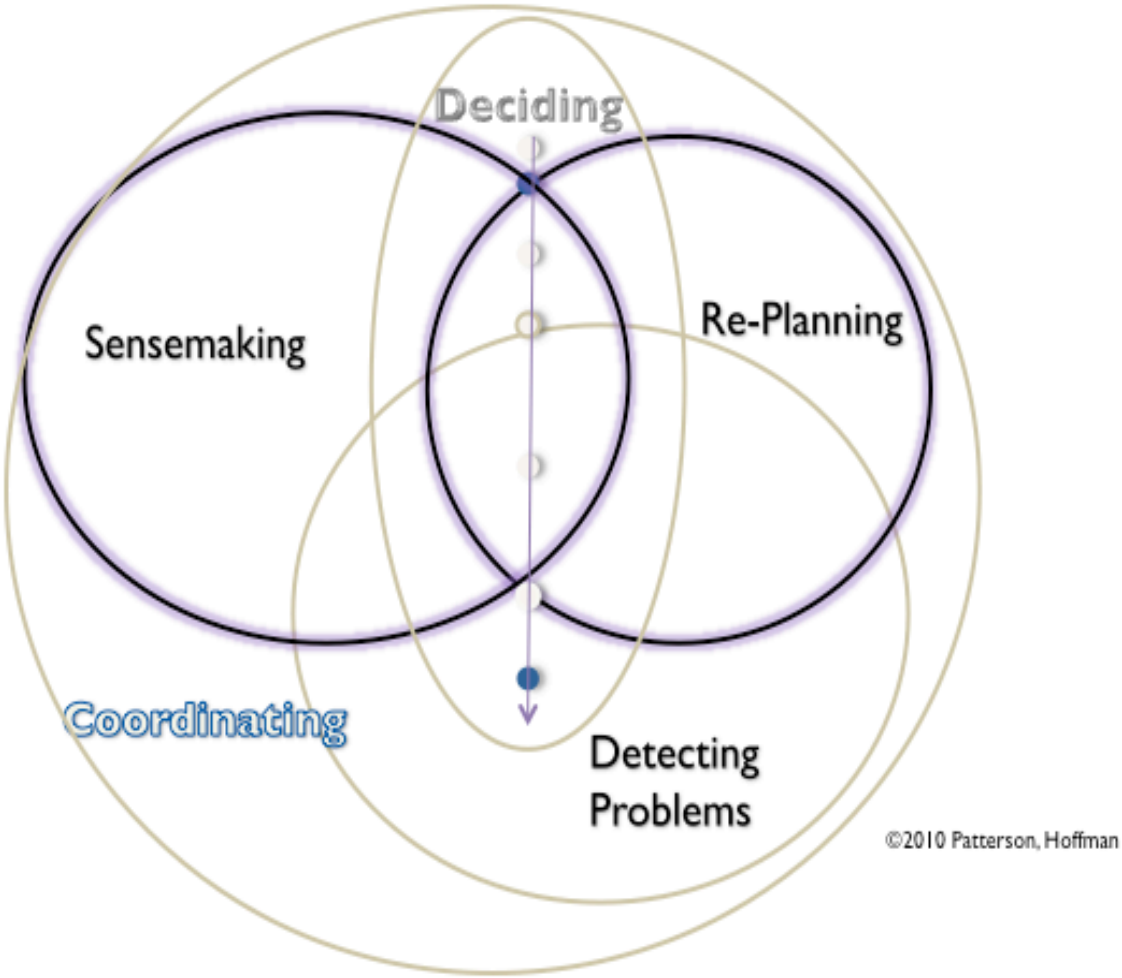
A Model of Macrocognition

- Klein et al (2003) proposed an initial model to prompt more research
  - Primary macrocognitive functions
  - Supporting macrocognitive processes used to achieve primary functions



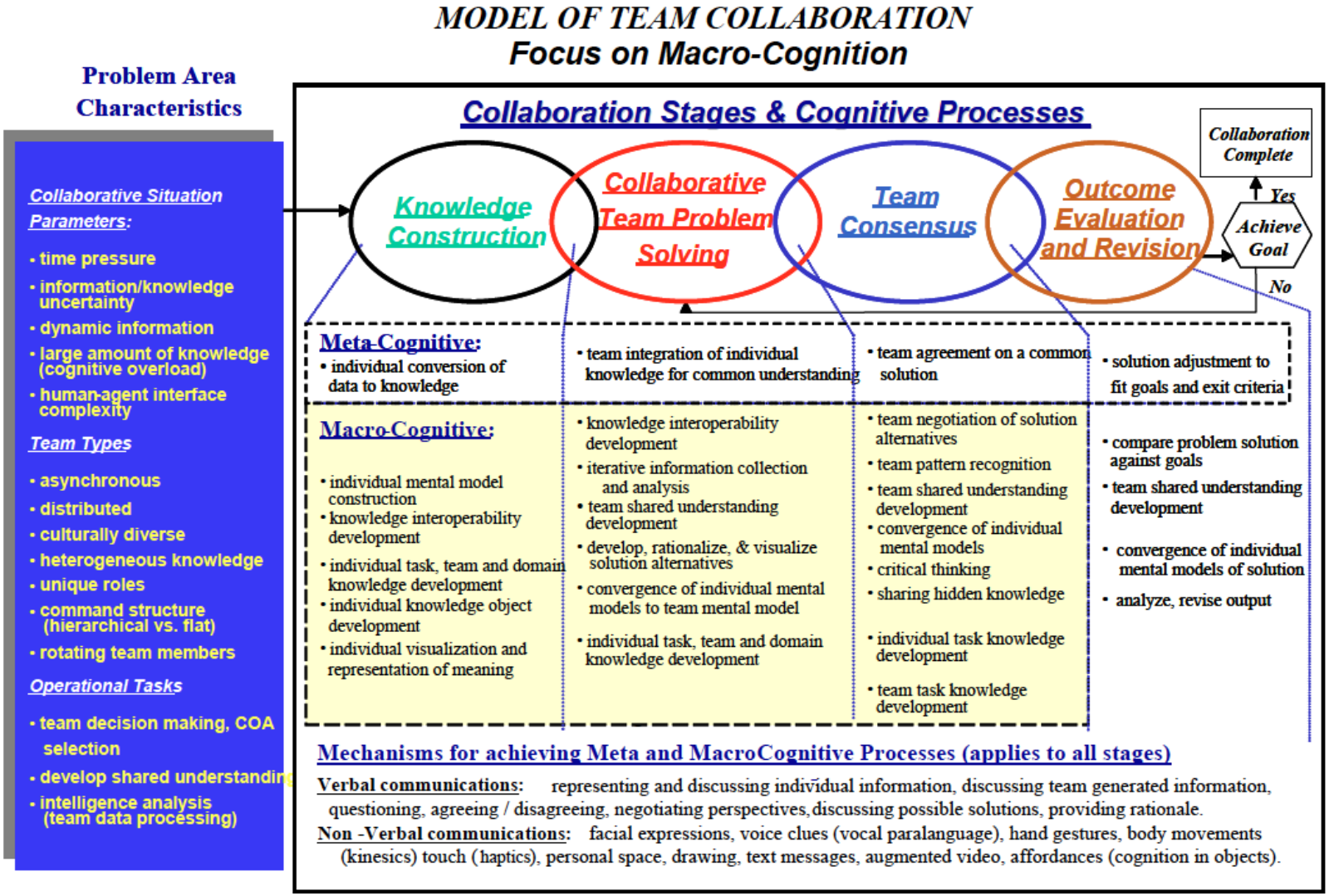
A Big-Picture View of Macrocognition

- Patterson & Hoffman developed an integrated macrocognitive framework
  - Provides a big picture view of human cognition
  - Illustrates the interrelationships amongst the functions



Macrocognition in Teams

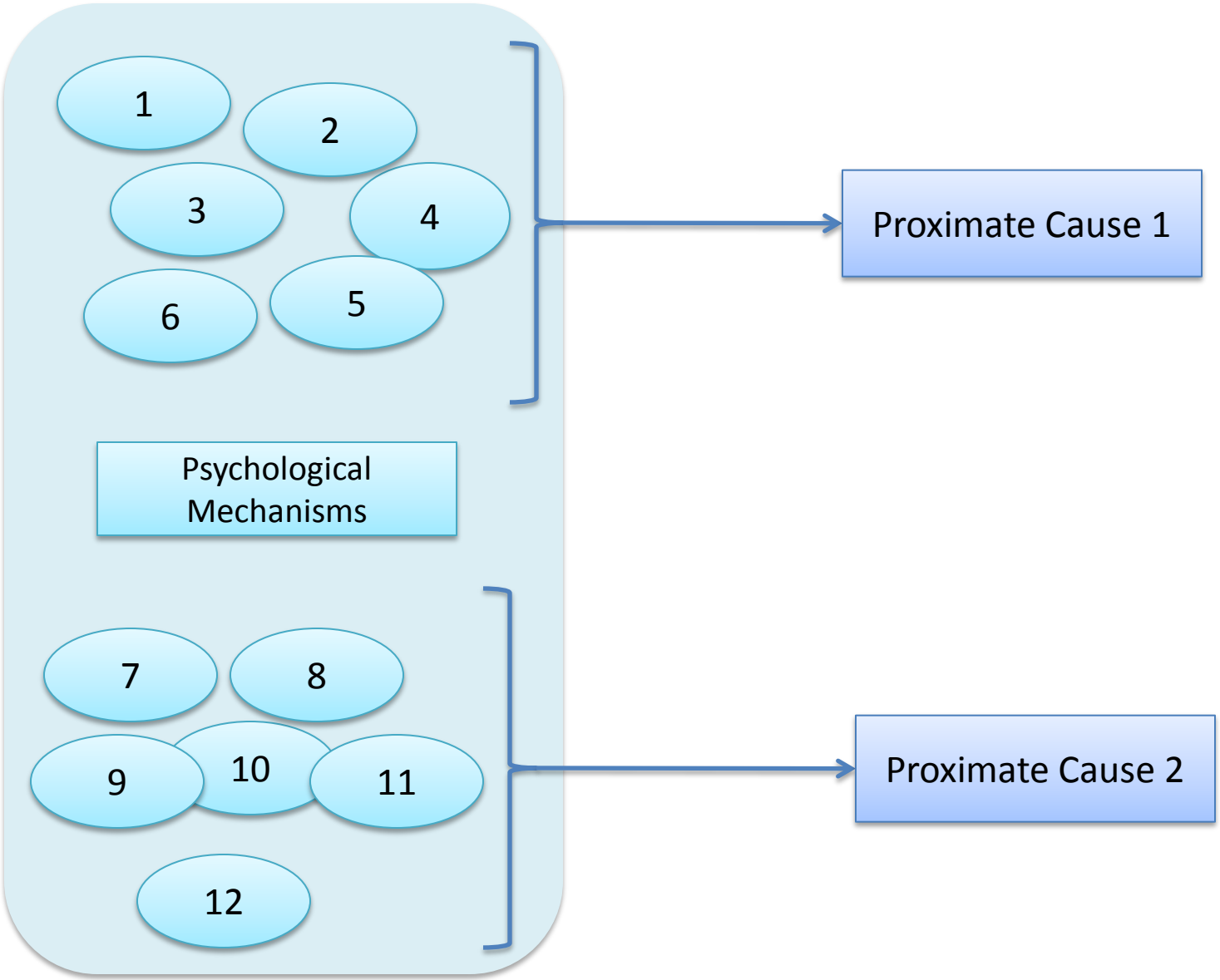
- Others have focused on macrocognition in teams (e.g., Letsky et al, 2007)



Building the Proximate Causes From the Psychological Mechanisms

- Bottom up approach
  - Psychological mechanisms identified by various theories and models, absent any top-down structure
- Psychological mechanisms were clustered into categories
  - Categories became proximate causes
- Psychological mechanisms and proximate causes and were described in generic terms
  - To allow application over wider range of situations
- Goal is to have a defined set of proximate causes that
  - Have distinct non-overlapping definitions
  - Are observable, identifiable, or inferable in a practical manner

Proximate Causes Emerged from the Psych Literature



Task Space vs. Cognitive Space

IDA is best used for task decomposition:

- I: Information
  - Task of gathering information
  - Involves perceiving information pushed to the operator AND actively seeking out information
- D: Decision
  - Task of understanding the situation
  - Task of deciding upon a response
- A: Action
  - Task of implementing the decided response

Macrocognition works better for structuring cognition:

- Detect / Notice
  - Sensation, perception
- Sensemaking / Understanding
  - Situation awareness, situation assessment, interpretation, understanding the meaning of information, integrating information together into a diagnosis
- Decision
  - Goal selection, planning, decision between alternatives
- Coordinate / Communicate
  - Verbal and/or nonverbal communication
  - Coordination between the crew members, command and control, etc.
- Act
  - Implementing the decided response

Related Processes

- Passive vs. Active Information Collection
  - Operators may actively look for information or passively receive information
- Procedure-based vs. Knowledge-based information collection
  - Procedures may guide operators on what information to obtain, but do not affect sensation or perception of the information

Item #4

Overview of Quantitative Approach

Presented to ACRS subcommittee on PRA, April 20, 2011 by

Gareth W Parry

EPRI/ERIN Engineering and Research Inc

John Forester

NRC/Sandia National Laboratory

Presentation Overview

- Scope
- Qualitative analysis of Human Failure Events (HFEs)
- HRA quantification model
- Definition of Crew Failure Modes (CFMs)
- Use of Results of Literature Survey
- Example Decision Tree

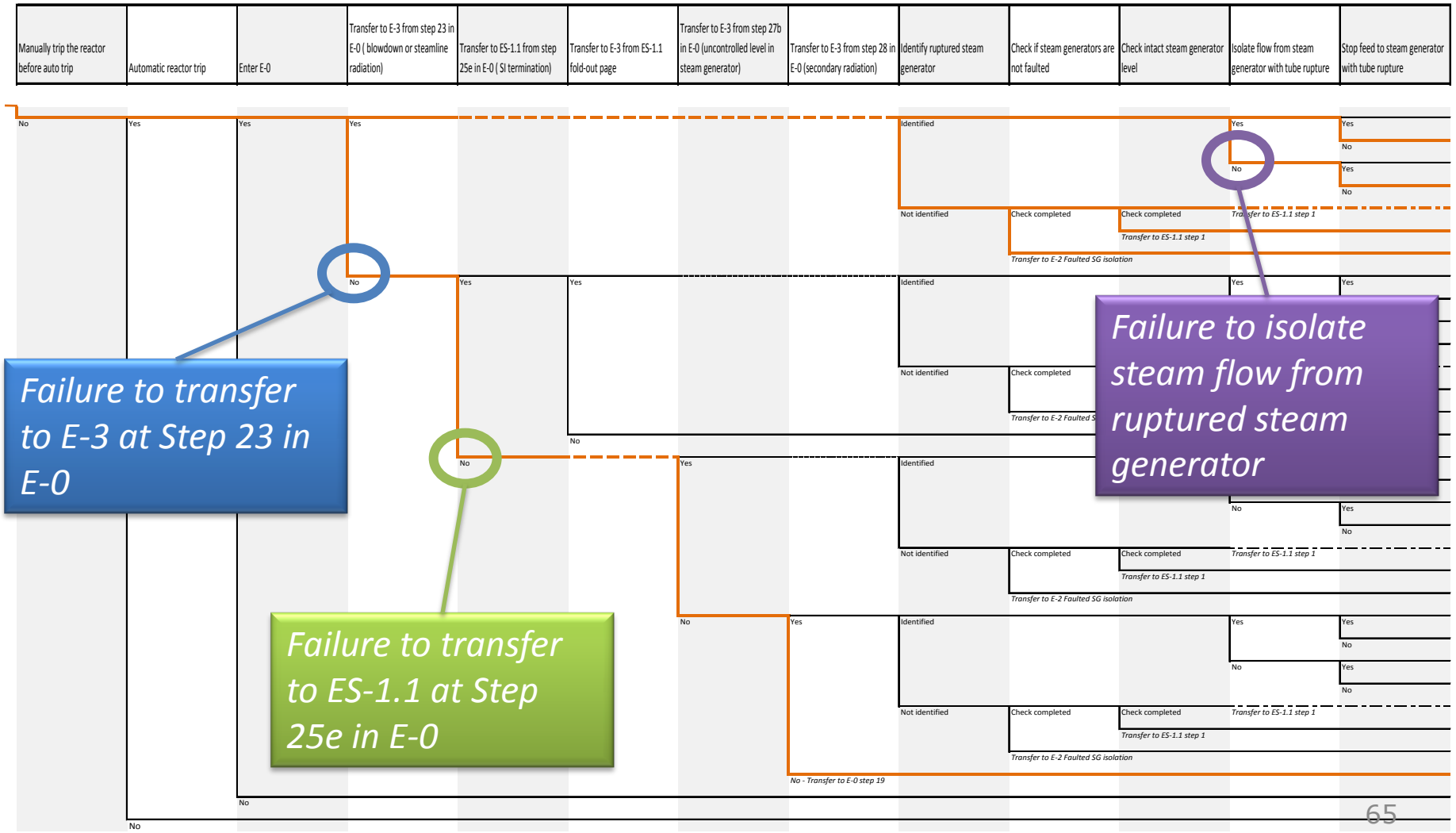
Scope

- Focusing on predefined HFEs
- Procedure directed responses
  - Knowledge based responses will be addressed later
- Internal events CDF evaluation
  - SAMGs not addressed at this stage
- Focus on prospective analysis initially
  - Event assessment and Significant Determination Process (SDP) needs to be addressed later

Qualitative Analysis of an HFE

- PRA scenario (S) leading to the HFE provides a characterization of context in terms of plant status
- Procedure task analysis
  - Identification of tasks/subtasks
  - Identification of opportunities for failure (Crew Response Tree sequences – potentially several for each HFE)
- HFE results from failure of a process
  - Identification of opportunities to recover from an initial error in time to prevent HFE
    - e.g., new cues, new procedure steps
- Identification of crew failure scenarios
  - Requires assessment of Performance Influencing Factors (PIFs) not explicit in S, e.g., aspects of training, experience

Branch-points in Crew Response Trees (CRTs)



Crew Failure Scenarios

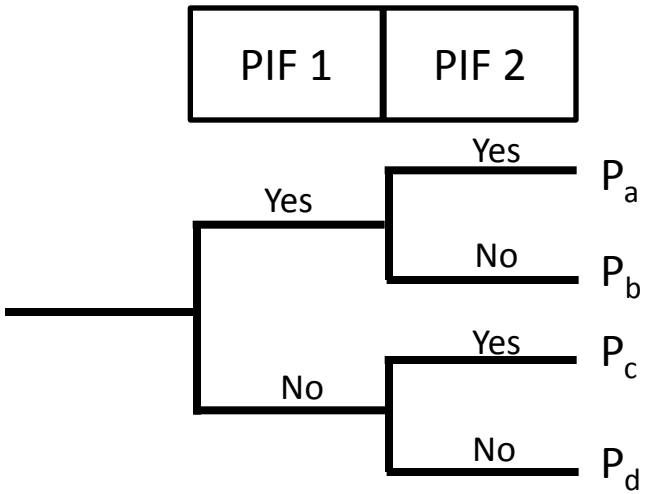
- An explanation of why a crew failure occurs
  - Cognitive mechanism
  - PIFs that enable the failure
  - Address potential for recovery
- Grouped by Crew Failure Mode (CFM)

Crew Failure Modes (CFMs)

- The CFMs are determined from:
  - An identification of the ways in which an operating crew can fail to perform the functions of:
    - Plant status assessment
    - Response planning
    - Execution
  - Tailored to an understanding of the nature of the subtasks that need to be performed to achieve success in those functions
    - Responding to an alarm
    - Obtaining information
    - Evaluating information using procedures
    - Execution
  - Results of review of the cognitive psychology and behavioral science literature to determine proximate causes of human failure mapped to CFMs

Quantification Model - Decision Tree Approach

- Decision points relate to existence of those PIF categories that relate to the cognitive mechanism leading to the CFM
  - Determined from the literature search
- Decision tree paths represent different crew failure scenarios distinguished by specific characteristics of the PIFs
- A probability is assigned to each end point (path)



Quantification of HEP

- For each HFE there may be several CRT sequences
- For each CRT sequence there could be multiple CFMs
- For a PRA scenario S with its associated context

$$\mathrm{HEP}(\mathrm{HFE}|S) = \sum_{\text{CRT sequence}} \sum_{\text{CFM}} \mathrm{Prob}\,(\mathrm{path}|S)_{\text{CFM}}$$

Crew Failure Modes (CFMs)

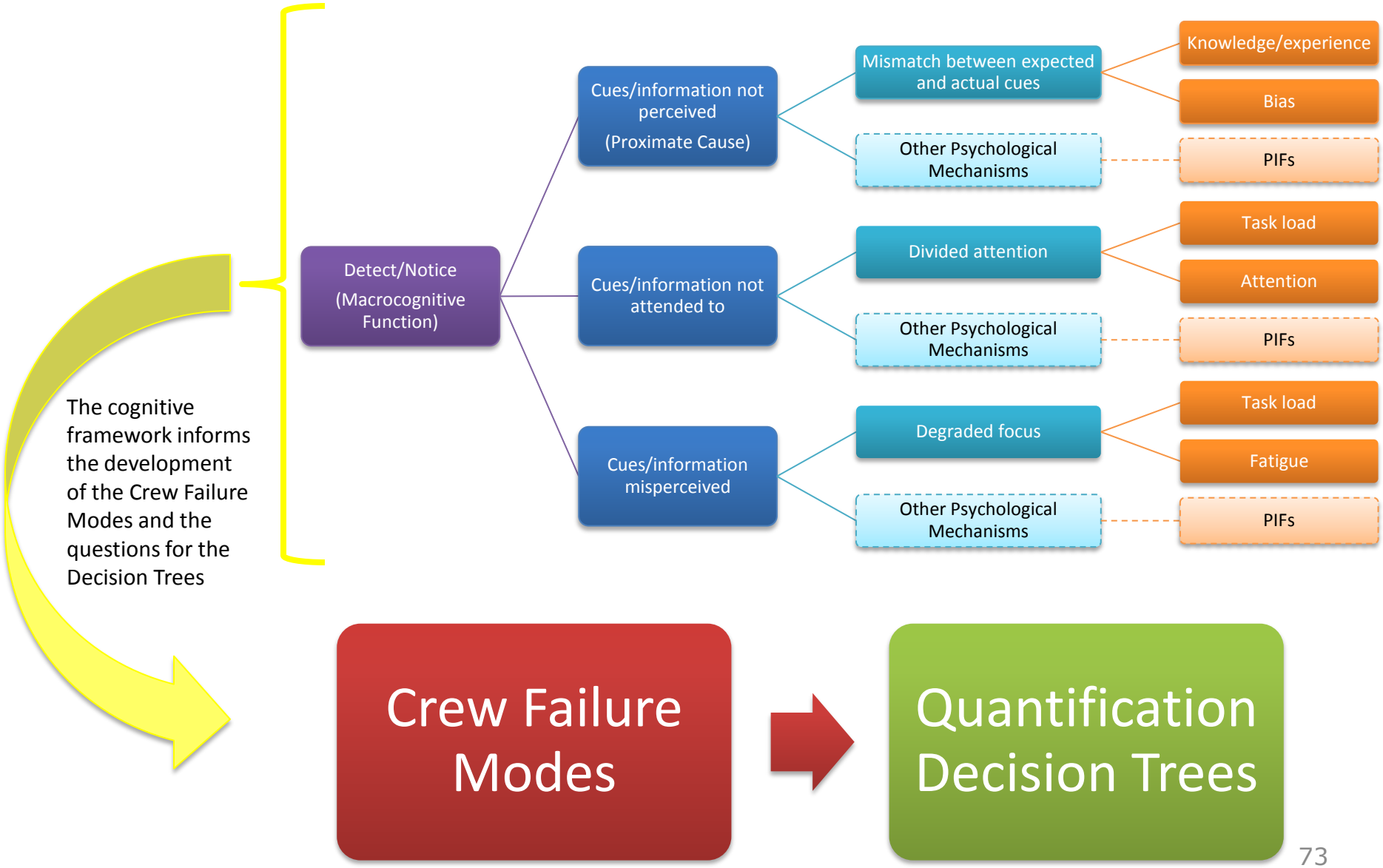
- Plant Status Assessment
  - Key alarm not responded to
  - Data incorrectly processed
  - Data miscommunicated
  - Data not obtained
  - Data dismissed or discounted
  - Decision to stop collecting data
  - Data not checked with appropriate frequency
- Response Planning
  - Misinterpret procedures
  - Choose inappropriate strategy
- Execution
  - Fail to complete action
  - Commit wrong action
  - Incorrectly perform response

Decision Tree Structure

- Branches are categories of PIFs determined by considering the cognitive mechanisms that can lead to failure
  - These PIFs are those not explicitly derived from the context S which are the system boundary conditions for the HFE
- The potential for recovery afforded by the dynamic nature of the crew interactions with the plant is included as a branch
- The direction taken at each branch point for a specific HFE is determined by the responses to questions
  - Associated with the characteristics of the PIFs that activate the failure
  - Associated with the characteristics of the identified recovery paths

Use of Results from Literature Review in Developing Quantification Approach

Example of the Cognitive Framework



Phase 1 of Literature Review

- Produced:
  - 50 page list of cognitive mechanisms that could lead to failure
  - Identified categories of consequences of the failure of the mechanisms → proximate causes (e.g., cue/information misinterpreted)
  - PIFs [Performance Shaping Factors (PSFs) and plant conditions] that could contribute to failure of the cognitive mechanisms
    - PIFs not always given directly by the discussion of the cognitive mechanism
    - Inferred by the analysis team

Associating Proximate Causes (PCs) with Crew Failure Modes (CFMs)

- PCs represent human failure modes from cognitive model perspective
- Needed to couple cognitive PCs with an understanding of the tasks in the NPP control room
  - System centric point of view
- Resulted in associating PCs with CFMs
  - PIFs from PCs still relevant
- Quantification model will estimate probability of each of the CFMs in Decision Trees (DTs)
  - Considers PIFs identified from cognitive mechanisms for the implied PCs/CFMs
  - Questions in DTs “measure” PIFs and impact on CFMs

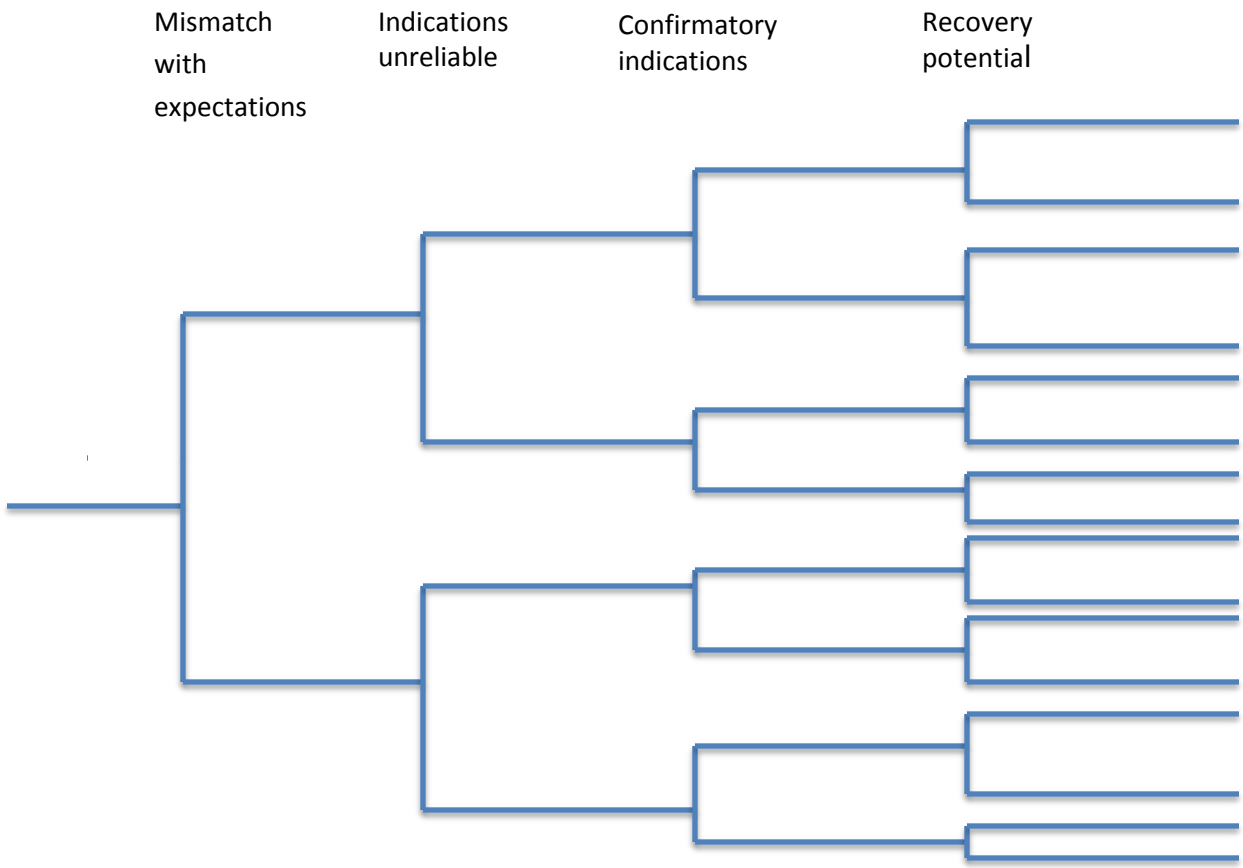
Example of Associating PCs with CFMs (Misinterpret Procedures)

Crew Failure Modes	PIF	Drivers / Measurements for PIFs	Boundary Conditions	Supporting DUDAC frame	Supporting Proximate Causes	Explanation of mapping PC to CFM
Misinterpret procedures	Quality of procedures	Logic	Have input/data. Reading procedures given that information	Detect	Cue/info misperceived	It is plausible that they may misread the procedure due to overly complex procedures, leading to misunderstanding the procedure.
		Ambiguity				
		Language / phraseology		Understand	Incorrect understanding	The information being misunderstood or misinterpreted is the procedure step(s) or words.
	Distraction	Task load				
	Familiarity with procedure	Training (on procedure)		Decide	Decide upon incorrect alternative	The consequence of misinterpreting the procedures is to decide upon an incorrect alternative.
		Knowledge/ Experience				
				Act	All Act	N/A this CFM is applicable to a task that is about reading and understanding the procedures and is not about taking an action.

Data Dismissed/Discounted

Crew Failure Modes	PIF	Drivers / Measurements for PIFs	Boundary Conditions	Supporting DUDAC frame	Supporting Proximate Causes	Explanation of mapping PC to CFM
Data dismissed / discounted				Detect	Cue/info misperceived	Perception of the information is not an issue for this CFM.
	Mismatch with expectations	Training (frequency on similar scenarios)	Processed the cue/data correctly Processed some earlier information that leads to the development of a mental model.	Understand	Incorrect understanding	The data was dismissed or discounted due to an incorrect understanding of the plant status based on their mental model based on a partial signature of the plant status.
		Scenario similarity				
		Knowledge/Experience				
	Indicator reliability and fidelity			Decide	Decide upon incorrect alternative	Dismissing the data is the incorrect alternative.
	Confirmatory information (of the signiture of the data being dismissed)	Procedural guidance				
		Training				
				Act	All Act	N/A

Example - Data Discounted



Branch Point Questions - Example

- BP3: Confirmatory information.
  - Are there additional indications that would be used to confirm the plant status indicated by the information (e.g., pump amps to confirm pump is operating correctly)?
  - Is checking these additional sources emphasized in training or is standard practice?
- If the answer is YES to both these questions, there should be a lower likelihood of dismissing the information. If the answer is NO to either of these, then assume there is no confirmatory information.

Recovery Potential

- The questions will be directed to direct the analyst to determine whether, given the changes to the plant status following the initial error :
  - New information becomes available to the crew that is sufficiently at odds with their mental model that it creates a high likelihood of reassessment
  - Given a reassessment, the correct response is likely given procedural directions and/or crew knowledge, training etc.
  - There is sufficient time to allow the correct response to be accomplished to avoid the HFE.

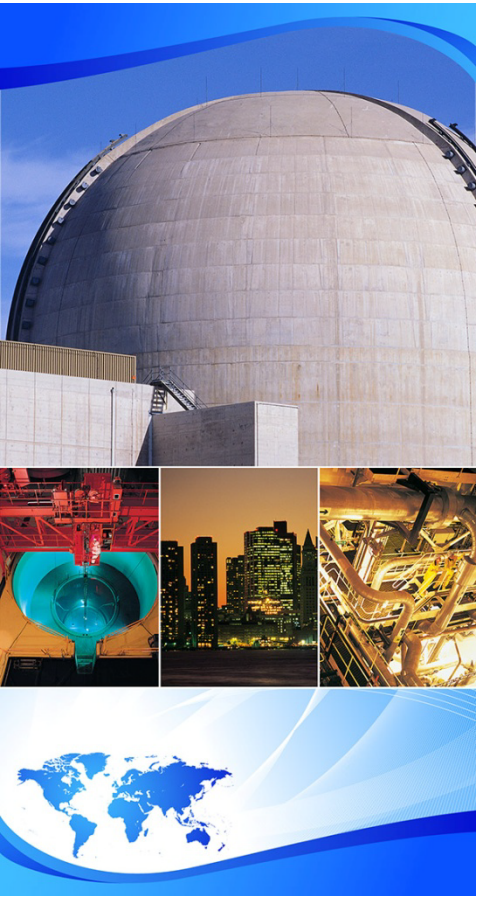
Quantification

- The probability of each path through the decision trees will be determined ***a priori*** by expert judgment representing a consensus of the experts, but not performed by individual HRA analysts.
- Similar, but not identical to the CBDT approach
- Its use is intended to provide a consensus set of HEPs
- The system will be designed to be as objective as possible in determining which branch is appropriate, thus reducing analyst to analyst variability

Summary

- The concept behind this model is that it will be easy to use but require the analyst to perform a qualitative analysis that is consistent with our understanding of human performance
- The questions that remain to be addressed will include the adequacy of the:
  - binary structure
  - approach to dealing with recovery

Item # 5



EPRI/NRC-RES FIRE HRA GUIDELINES

Introduction and Summary

Susan E. Cooper (NRC/RES) and Stuart Lewis (EPRI)

ACRS PRA Subcommittee Meeting
April 20, 2011
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Presentation Outline

- Background
- Development team
- Project history
- Summary of guidelines content
- Agenda for today

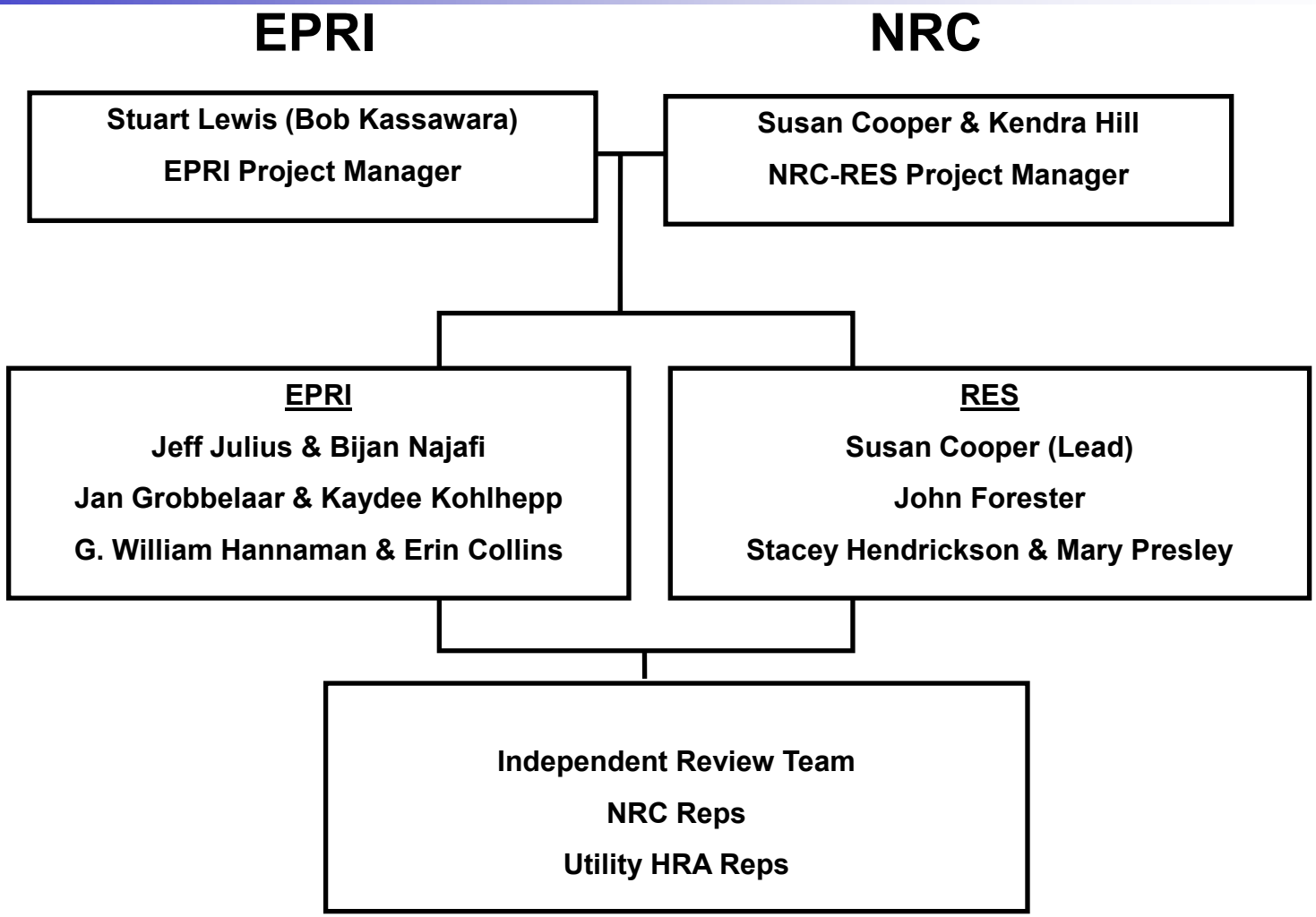
Background on the Issue of Fire HRA

- Almost 50% of USA plants transitioning to NFPA-805
  - Using NUREG/CR-6850 [EPRI 1011989] for the Fire PRA Guidance
- NUREG/CR-6850 [EPRI 1011989] addresses:
  - Identifying human failure events (HFEs)
  - Assigning conservative screening human error probabilities (HEPs)
  - Post-fire Performance Shaping Factor (PSF) information
- NUREG/CR-6850 [EPRI 1011989] does not:
  - Describe a methodology for developing best-estimate HEPs (given fire related effects)
  - Address the requirements of:
    - ASME/ANS RA-Sa-2009, "Addenda to ASME/ANS RA-S-2008, Standard for Level 1 / Large Early Release Frequency Probabilistic Risk Assessment for Nuclear Power Plant Applications," Chapter 4 for fires
- Consequently, there was a need for fire-specific guidance for best-estimate HRA quantification in fire PRA

EPRI/NRC Fire HRA Guidelines
High Level Objectives

- Through joint NRC and industry efforts, address the need for HRA guidance, especially for best-estimate quantification, for use in fire PRAs
    - Address methodology (e.g., expand or modify existing methods)
    - Address guidance for implementing the methodology
- Develop a joint EPRI/NRC report under MOU (similar to NUREG/CR-6850 [EPRI 1011989])
- Consider ASME/ANS PRA Standard requirements and user needs

EPRI/NRC Fire HRA Guidelines
Development Team



Fire HRA Project History

- Project initiated: March 5, 2007
- First integrated draft: May 2008
- Peer review: June 2008
- Testing at 2 plants: Summer/Fall 2008
- Revised draft: April 2009
- Quick review by NRR & NRO: April 2009
- ACRS sub-committee information presentation: June 2009
- Piloting by PWR Owner's Group: Summer 2009
- Issued for public comment: December 2009
- Joint EPRI/NRC-RES as part of NUREG/CR-6850 Fire PRA Training Course: June/October 2009 (for information only)
- Public comment period ended: March 2010

Fire HRA Project History (continued)

- Resolution of key public comments: June 2010
- Development of a new "track" for fire HRA in EPRI/NRC Fire PRA Course: Summer 2010
- ACRS sub- & full-committee presentations: Fall 2010
- Joint EPRI/NRC-RES NUREG/CR-6850 Fire PRA Training Course:
  - September 27 through October 1, 2010
  - October 25 through October 29, 2010
- Final public comment resolution: Now
- Presentation to NRC's ACRS PRA Sub-Committee: April 2011
- Publication of final report: Summer 2011

Fire HRA Guideline Summary
Major Topic Areas

- Standard HRA **process** used for Fire HRA modeling
  - Fire HRA process is based on other processes and guidance, e.g.:
    - ASME/ANS PRA Standard
    - NUREG-1792 (“Good Practices”)
    - NUREG-1852 (Fire Manual Actions)
    - SHARP1
    - ATHEANA
  - However, additional analyst tasks (e.g., information collection and analysis) are needed to address specific needs of fire HRA/PRA

Fire HRA Guideline Summary
Major Topic Areas (continued)

- Fire HRA **process steps**:
  1. **Identification & definition** of human failure events:
     - Substantial guidance provided, including “go/no go” feasibility test
  2. **Qualitative analysis**
     - Iterative process that continues throughout quantification steps
     - Addresses evaluation of HFE feasibility under fire conditions
     - As fire PRA develops, fire HRA must consider additional fire scenario-specific details that become available

Fire HRA Guideline Summary
Major Topic Areas (continued)

3. Quantification Methods – three levels

- **Screening Quantification**
- **Scoping Fire HRA method** (new):
  - Decision tree format
  - Guidance being developed to aid reproducibility & reviewability
- **Detailed Fire HRA**
  - Uses existing methods
  - Performance shaping factors modified for the fire context:
    - EPRI Cause-Based Decision Tree & HCR/ORE; & THERP
    - ATHEANA

4. Dependency, Recovery, and Uncertainty Analysis

- As for internal events HRA/PRA, with some modifications for fire event-specific issues

Focus for today….

- Discuss updates to Fire HRA Guidelines (from December 2009 draft for public comment)
- Includes:
  - Summary of peer review, testing, and public comments
  - Summary of updates

Agenda Overview

1. **Introduction and Summary**
2. Summary of Reviews, Tests & Comments
3. Updates to the EPRI/NRC Fire HRA Guidelines
   A. Identification and Definition
   B. Qualitative analysis
   C. Quantitative analysis
      1) Scoping
      2) EPRI approach (detailed)
      3) ATHEANA (detailed)
   D. Recovery, Dependency & Uncertainty analyses
   E. Other Appendices
4. Project Status and Path Forward

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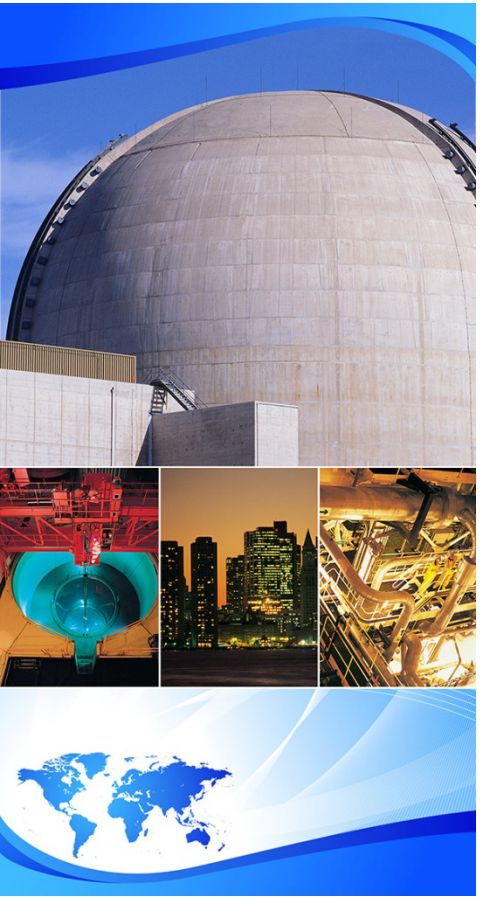
Item # 6



EPRI/NRC-RES FIRE HRA Guidelines

Summary of Reviews, Tests & Public Comments

Jeff Julius (Scientech) & Erin Collins (SAIC)

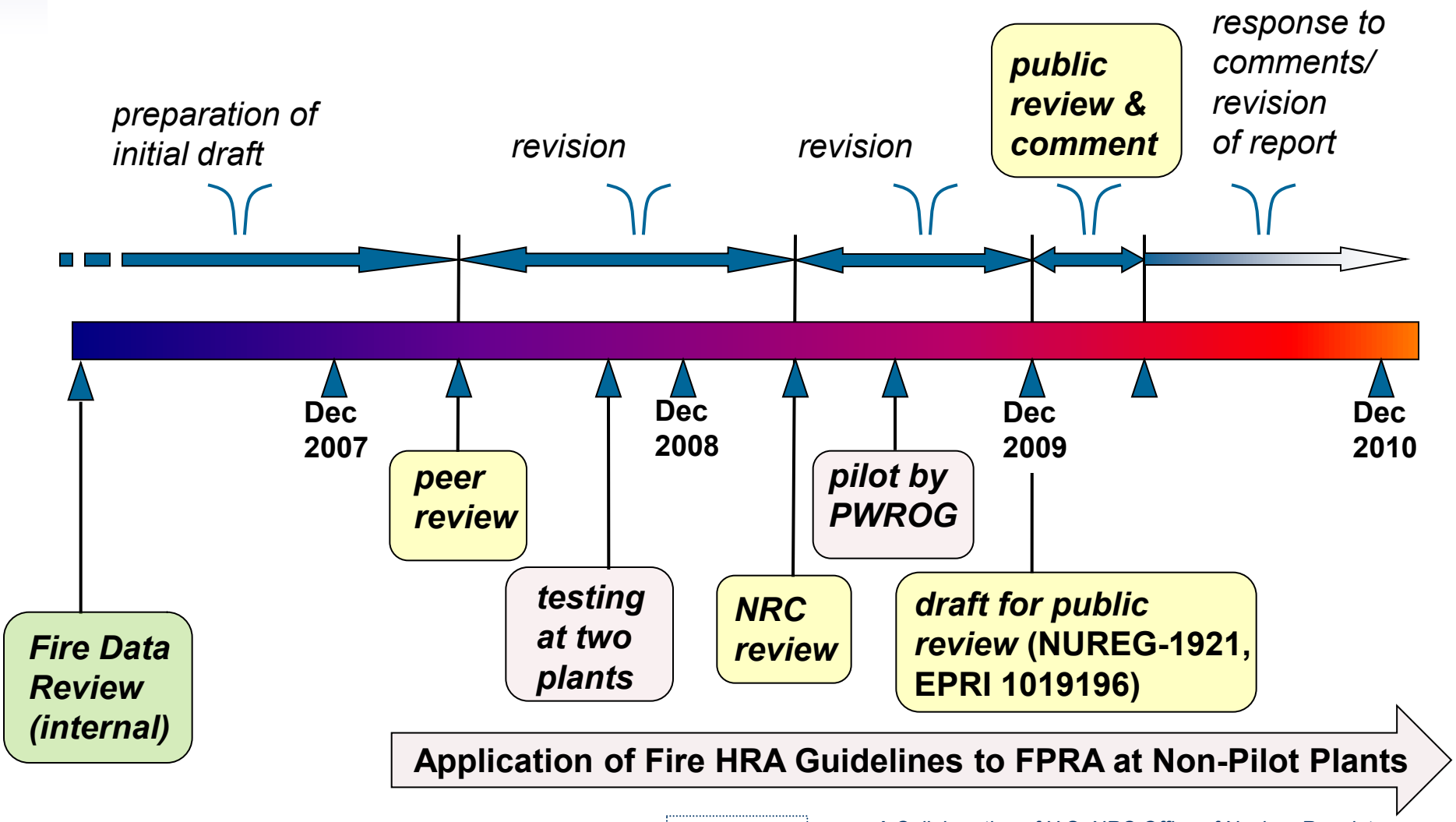
Joint RES/EPRI Fire PRA Workshop
September-October 2010
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Agenda Overview

1. Introduction
2. **Summary of Reviews, Tests & Comments**
3. Updates to the EPRI/NRC Fire HRA Guidelines
   A. Identification and Definition
   B. Qualitative analysis
   C. Quantitative analysis
      1) Scoping
      2) EPRI approach (detailed)
      3) ATHEANA (detailed)
   D. Recovery, Dependency & Uncertainty analyses
   E. Other Appendices
4. Project Status and Path Forward

Evolution of the Fire HRA Guidelines



EPRI-NRC Fire HRA Guidelines - *Review*

- Two types of review conducted
  - Fire Data Review & Peer Review

1. **Fire Data Review** (conducted upon project initiation)
   - Requirements of a Fire HRA, from Fire PRA
     - From the PRA Standard
     - Existing Fire HRA guidance in NUREG/CR-6850
   - Historical Experience/Data
     - To ensure the HRA approach, methodology & PSFs were appropriate following a fire-induced initiator.
   - Plant Experience/Data
     - Understand plant fire response in the as-operated plant

EPRI-NRC Fire HRA Guidelines – *Review cont'd*

2. **Peer Review (2008)**
   - Independent Technical Review
     - Check validity of method and technical bases
     - Check detail and clarity of guidance
   - Review team
     - Drs. Gareth Parry, J.S. Hyslop & Erasmia Lois, NRC
     - Dr. Zouhair Elawar, Arizona Public Service
     - Dr. Young Jo, Southern Nuclear
     - Ken Kiper, Seabrook
     - Stuart Lewis, Polestar Applied Technology, Inc.

EPRI-NRC Fire HRA Guidelines - *Testing*

- **Project Testing (2008)**
  - 2 sites selected for tests as part of this project
  - Results documented in an Appendix
- **Testing By Developers (2008 – Present)**
  - Outside of the project, by part of the writer's group.
  - Applied by contractors at 8 sites, with 6 Peer Reviewed.
- **Independent Testing conducted by PWR OG (2009)**
  - Independent of method developers.
  - Comments that guidance was too complex and resource intensive.
  - WCAP issued.

EPRI-NRC Fire HRA Guidelines – *Public Comment*

- NUREG-1921/EPRI 1019196 Nov. 2009 for public review
- Prior to public review period, obtained comments during presentation to ACRS PRA Subcommittee

- Public comment & response summarized
  - For the ACRS, in these slides
  - In Appendix F to NUREG-1921

- NUREG-1921/EPRI 1019196 Revision for ACRS is complete
  - Approach is not fundamentally different, but….
  - Some important changes have been implemented.

Summary of Public Comments

- Four organizations provided public comments:
  1. Boiling Water Reactor Owner's Group (BWROG)
  2. EPRI's HRA User's Group (HRA UG),
  3. Pressurized Water Reactor Owner's Group (PWROG)
  4. Exelon
- Each comment:
  - Tracked with a numbering system, and addressed.
  - However, for a few cases, a comment was subdivided because multiple issues were raised.
  - Consequently, the total number of public comments to address is two hundred and ninety (290).

Summary of Public Comments (continued)

Summary of public comments for the Joint EPRI/NRC-RES Fire HRA Guidelines (Draft NUREG-1921)	
Commenter	**Number of Comments**
BWROG	89
HRA UG	35
PWROG	102
Exelon	64
Total	290

Major Public Comments on Draft NUREG-1921

- **Separate the Background from Guidance / Overly Complex Document**
  - Ch. 3 & 4 re-written to provide better clarity & distinction (Identification & Definition, Qualitative Analyses).
  - Appendices re-structured (re-ordered based on use).
- **Ident. / Definition Needs to Better Match FPRA Tasks**
  - Added a table to Ch. 2 showing the mapping to FPRA tasks.
  - Ch. 3 re-structured (Identification & Definition).
- **Appears to be aimed at Capability Category III**
  - Guidelines was, and continues to be, to provide guidance on performing a thorough and technically appropriate analysis rather than to steer towards a particular Capability Category.
  - Comment relates to timing and level of detail addressed.

Major Public Comments (cont'd)

- **Feasibility & Qualitative Analysis Level of Effort**
  - Feasibility criteria & treatment made consistent across all Fire HRA sections (steps), but allows variations on the level of detail of the inputs.
  - Changed to allow existing information & talk-throughs, no longer require demonstrations.
- **Guidance Improvements**
  - Added guidance on talk-throughs & ATHEANA.
  - Revised guidance on Stress in EPRI HRA Approach.
- **Scoping Quantification**
  - Time margins modified, suppression time changed.
  - No longer require demonstrations.

Major Public Comments (cont'd)

- **Uncertainty**
  - Complete re-write to match internal events approach.
- **Undesired Response to Spurious**
  - No change, PWR OG developed document to address.
- **Pilot Application Needed**
  - Pilot application conducted by PWR OG in 2009.
  - Applications of guidance conducted through implementation on plants supported by writers group.
    - Applied at 8 sites, with 6 Peer Reviewed
- **Training or Additional Guidance**
  - Training started fall 2010 (2 sessions).
  - 2011scheduled for August & November.

Summary of Review, Test & Public Comment

- **Review** - Two types of review conducted:
  - Fire Data Review & Peer Review.
    - Fire Data Review – PRA requirements & plant response.
    - Peer Review – independent technical review.
- **Testing** (2008-2011) by project activities, project team independent of the Fire HRA Guidelines & PWR OG.
- **Public Comment**
  - Four organizations-BWROG, PWROG, HRA UG & Exelon
  - Ten major public comments & 290 total comments
  - Each comment has been addressed
- Next set of presentations address each topical area, & associated changes.

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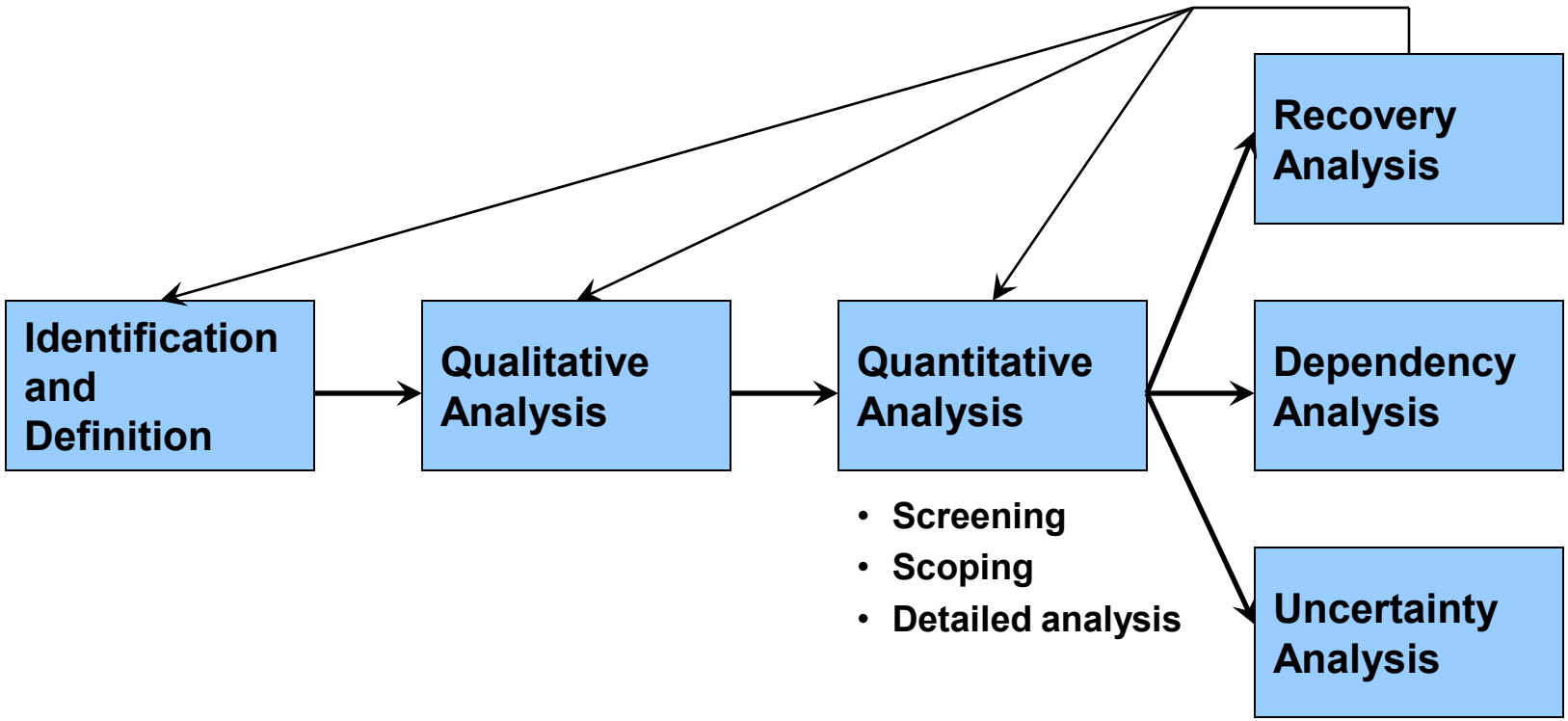
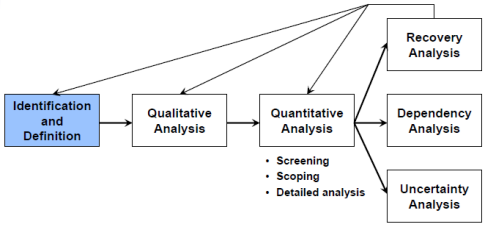
BACKUP SLIDES

Steps in the Fire HRA Process



Identification and Definition

Identification



- Determining where there are relevant operator actions
  - From understanding of plant response
  - From PRA models
- Accomplished by
  - Review of plant procedures, operator interviews, etc.
  - Review of PRA models: event trees, fault trees, etc.

Identification and Definition (continued)

Definition

- Supports justification for including human failure event(s) in PRA models
- Provides information needed as inputs to qualitative analysis
  - Procedures available
  - Cues to initiate and confirm action
  - Timing
  - Staff required, including impact due to fire
- Includes initial assessment of feasibility – go/no-go

Updates to Overall Fire HRA Process and "Identification & Definition"

- Fire HRA Process:
  - Draft NUREG identified the process independent of Fire PRA tasks
  - Added mapping of Fire HRA tasks to NUREG/CR-6850 tasks
- Identification guidance:
  - Comments on draft guidance included "poor layout" and "hard to follow"
  - Consolidated the discussion, focusing on 3 types of actions:
    - EOP actions from Internal Events PRA
    - Fire Response actions based on fire procedures
    - Undesired response to spurious
- Definition guidance – now better aligned the text to the combined PRA Standard, to define the PRA context before qualitative analysis

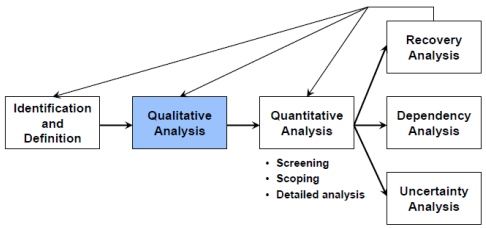
Updates to "Qualitative Analysis"- Feasibility Assessment

- In response to a major public comments - feasibility assessment information from various subsections throughout the document was consolidated into a new section
- Structured section by addressing the major go/no-go factor for deciding feasibility (i.e., sufficient time)
- Other factors were considered (both independent and as input to timing)
  - Sufficient Manpower
  - Primary cues available/sufficient
  - Proceduralized and trained actions
  - Accessible location (incl. environment & travel routes)
  - Equipment/tools available/accessible
  - Relevant components are operable

Updates to "Qualitative Analysis"- Feasibility Assessment (cont'd)

- Information provided to the reader regarding where this fits into the Fire HRA
  - NUREG/CR-6850 tasks
  - ASME/ANS standard requirements
  - Fire HRA Guidelines tasks
    - Linked to Identification & Definition and initial Qualitative Analysis
    - But is a continuous process based on the knowledge base at each step
- Discussion of feasibility vs. reliability (transition between qualitative and quantitative)
- Comparison and contrast between EOP actions and fire response actions and the implications for feasibility of EOP actions

Qualitative Analysis



- Involves assembling information needed to support quantitative analysis
  - Understanding of fire-specific context
  - Review of relevant historical experience
  - Review of plant operations
  - Evaluation of feasibility for action
  - Identification and characterization of relevant performance-shaping factors (PSFs)
- Nature of qualitative analysis oriented to quantification approach (i.e., limited for screening, more extensive for detailed analysis)

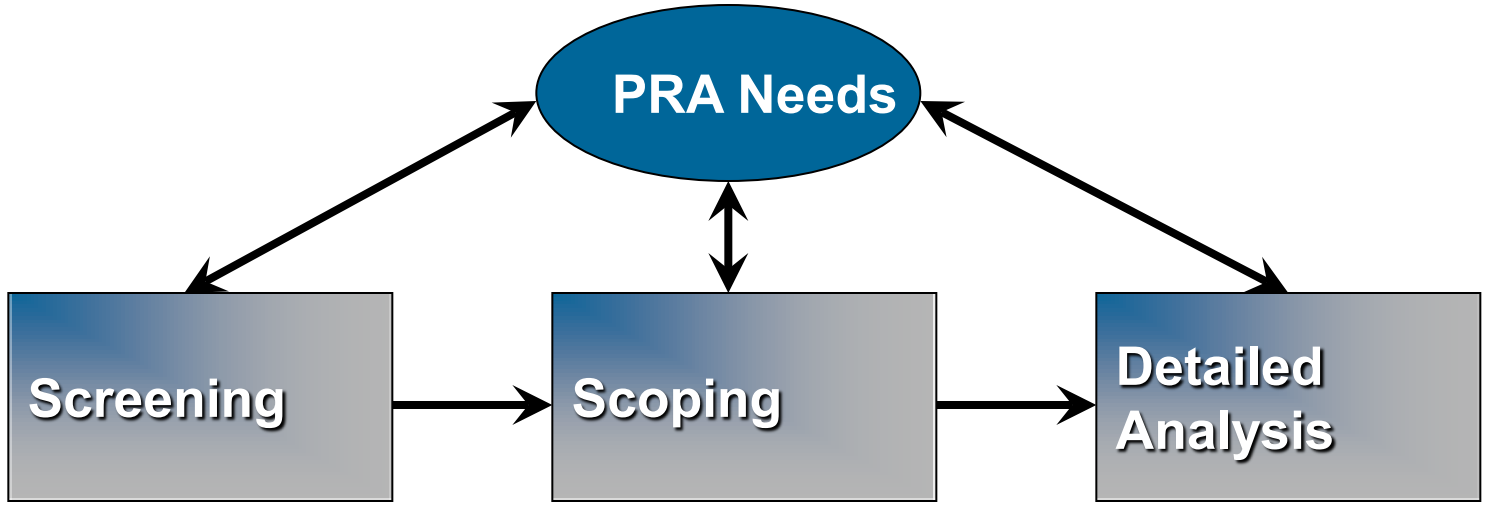
Updates to "Qualitative Analysis"

- Major public comment – lots of good information, but……
  1. Need to split-out the guidance from the background
  2. Approach does not fit actual FPRA progression, appears that you have to have detailed information to start and the results will be a Capability Category III Fire HRA

- Restructured the section to better define guidance from "considerations"

- Restructured the section to reflect the iterative nature / successive quantification approach applied during Fire PRA model development

Three Progressive Options for Quantification



- Simplest approach
- Bounding results

- Less bounding than screening
- Less resource-intensive than detailed

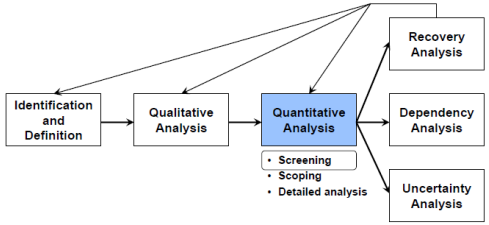
- Most realistic
- Most effort required

*Adequate for HFEs that **are not** risk-significant*

*Necessary for HFEs that **are** risk-significant*

Quantification – Screening Approach

Extension of NUREG/CR-6850



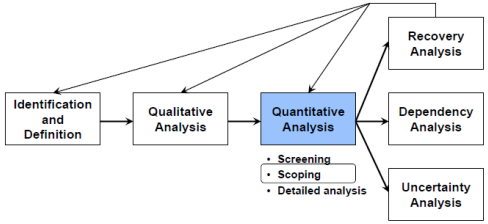
- Relaxation of values, especially for longer time frames (i.e., after fire is suppressed)

- Allows quick assignment of values for
  - HFEs from internal-events PRA, for actions only indirectly affected by fire scenario
  - HFEs from internal-events PRA, with complications from spurious actuations
  - New fire-related HFEs or HFEs significantly from internal-events PRA significantly affected by fire scenario
  - HFEs for actions following evacuation of the main control room

Updates to "Quantitative Analysis: Screening"

- Modified guidance to allow use of human error probabilities (HEPs) from internal events PRA for events that are demanded late (after the fire is out)
- Addressed availability of information for screening phase analysis & use of estimates in evaluating aspects such as spurious effects (in place of fire modeling & cable tracing results)
- Provided a new, simpler table that summarizes screening criteria

Quantification – Scoping Approach



Intentions for Scoping Approach

- Results less bounding than from screening approach
- Less resource-intensive than detailed analyses
- Adequate for human failure events that are not risk-significant (to meet Cat. II Supporting Requirements)

Formulation

- Series of decision trees (e.g., in-control room vs. local actions; response to spurious indications, etc.)
- Tied to assessment of time margin
- Intended to be applied via simple assessment of performance shaping factors

Updates to "Quantitative Analysis: Scoping"

Overall, five major categories of modifications have been made:

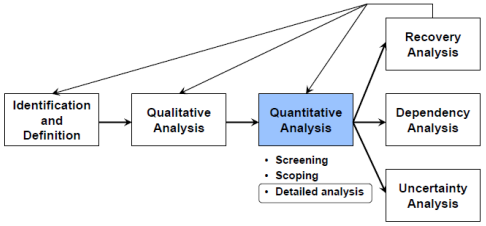
1. Revised scoping approach to reduce complexity & resource demand, & to provide additional guidance
   - Now allows use of talk-throughs to obtain feasibility-related timing information
   - Provides guidance on how to perform talk-throughs
   - Provides guidance on how to use other available information in assessing feasibility, e.g.,
     - Job Performance Measures, demonstrations from training exercises, Appendix R or NUREG-1852 feasibility demonstrations, assessments of similar actions
2. Addressed how scoping approach fits into Capability Categories
   - Added discussion on use of scoping approach to identify risk-significant human failure events (HFEs) in meeting CC II, as defined in ASME/ANS Requirement HR-G2

Update- "Quantitative Analysis: Scoping" (cont'd)

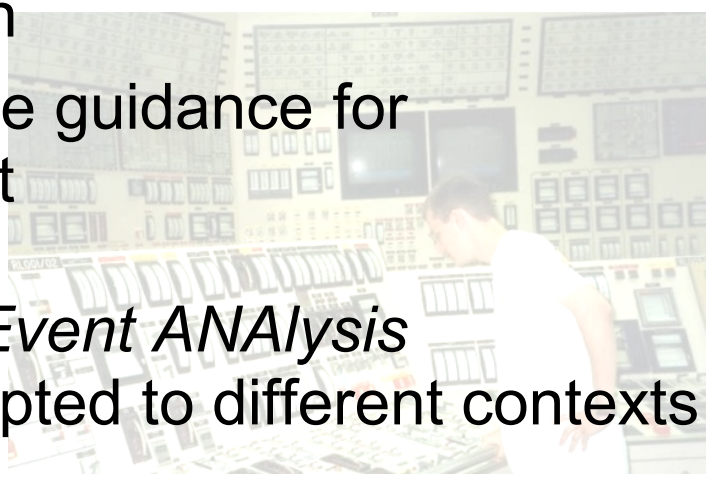
3. Reduced conservatism in HEPs assigned via scoping approach
   - Reduced potential over-conservatism in some HEPs from scoping flowcharts by:
     - Reducing size of required time margins (i.e., none are > 100% now)
     - Eliminating potential effects of double-counting some influences
   - Modified to allow use of less conservative estimate of fire suppression times when fire type is known (per 99% percentile timing estimates for fire suppression supplied in FAQ-08-0050)
4. Improved guidance for using scoping approach
   - Provided a more straightforward selection scheme to determine which flowcharts to use for quantifying different kinds of human actions
   - Clarified that timelines should represent realistic, <u>average</u> times (not worst-case)
   - Moved some discussion on feasibility assessment to "Qualitative Analysis" section
5. Added an example of how to use scoping approach

Quantification – Detailed Approaches

Two options for detailed analyses:

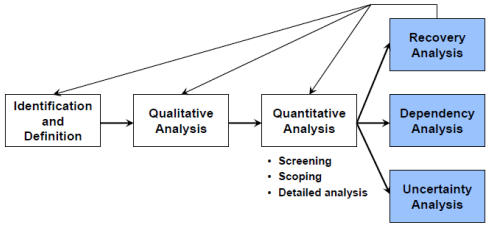


- EPRI methods, (e.g., as implemented in HRA Calculator®)
  - Cause-based decision tree method and/or HCR/ORE time reliability correlation for failure in cognition
  - THERP for failure in execution
  - Limited changes, but extensive guidance for implementation for fire context



- NRC's *A Technique for Human Event ANAlysis* (ATHEANA): designed to be adapted to different contexts

Recovery, Dependency, Uncertainty Analyses



Recovery analysis

- Analogous to process for PRA in general
- Evaluated via qualitative and quantitative methods as for other HFEs

Dependency analysis

- Qualitative level of dependence among post-initiators assessed (based on timing, same crew, cues, etc.)
- Quantitative interpretation of qualitative levels

Uncertainty analysis

- Guidance consistent with joint NRC/EPRI treatments of uncertainty (NUREG-1855, EPRI 1016737)
- Revised in recognition of ongoing work in this area

Update-“Recovery & Dependency

- For “Recovery” & “Dependency”:
  - Per public comments, realized that many of the issues were the same as other portions of the Fire HRA
  - Streamlined down to only a few paragraphs with definitions and pointers to Feasibility Assessment and Quantification
  - Now planning to combine three sections into a new section/chapter, titled, “Recovery, Dependency & Uncertainty”

Updates to "Appendices"

- Deleted Appendix B (Fire Event Review) & re-ordered Appendices
- Appendix A – Fire PRA Standard & Fire HRA Guidance
  - Added information from 2009 version of the standard, including fire-specific requirements
  - Paraphrased SRs from Internal Events HRA, Fire HRA and other areas indicating requirements for HRA task
  - Correlated standard SRs to Fire HRA Guidelines chapters/topics
- Appendix B (formerly "C") – Detailed Quantification Using EPRI HRA Approach
  - Changed guidance on Stress
- Appendix C (formerly "D" – Detailed Quantification Using ATHEANA
  - Added example using ATHEANA
  - Added tips for using ATHEANA
  - Added additional discussion on how to use ATHEANA

Updates to "Appendices" (cont'd)

- Appendix D (formerly "E") – Definition of Terms (some additions/revisions)

- Appendix E (formerly "F") – Summary of Testing & Peer Review
  - Revised title & content to reflect resolution of public comments

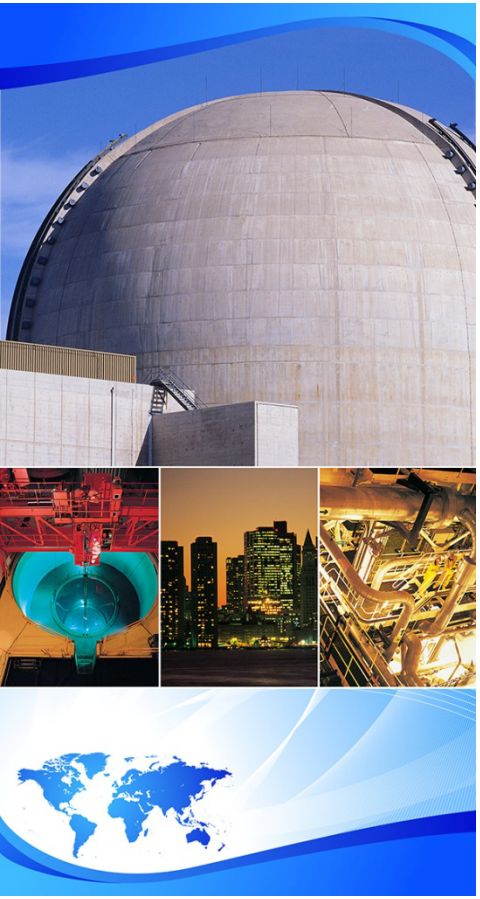
- Appendix F (formerly "G") – HRA Associated with Fire-Related Electric Bus Clearing….
  - Minor changes to address public comments

- Appendix G (formerly "H") – Justification for Scoping Approach
  - Updated consistent with main body of report

Summary – Fire HRA Guidelines

- Intended to be systematic approach, with detailed guidance for address fire-specific context
- Methods generally follow existing approaches for HRA, with emphasis on qualitative understanding of impacts of fire scenarios
- Scoping analysis is “new” approach, allowing analysis to go beyond screening values without detailed analysis

Item # 7



EPRI/NRC-RES Fire HRA Guidelines

Identification & Definition of Post-Fire Human Failure Events

Jeff Julius (Scientech), Erin Collins (SAIC), and John Forester (SNL)

ACRS Meeting – PRA Subcommittee
April 20, 2011
Rockville, MD

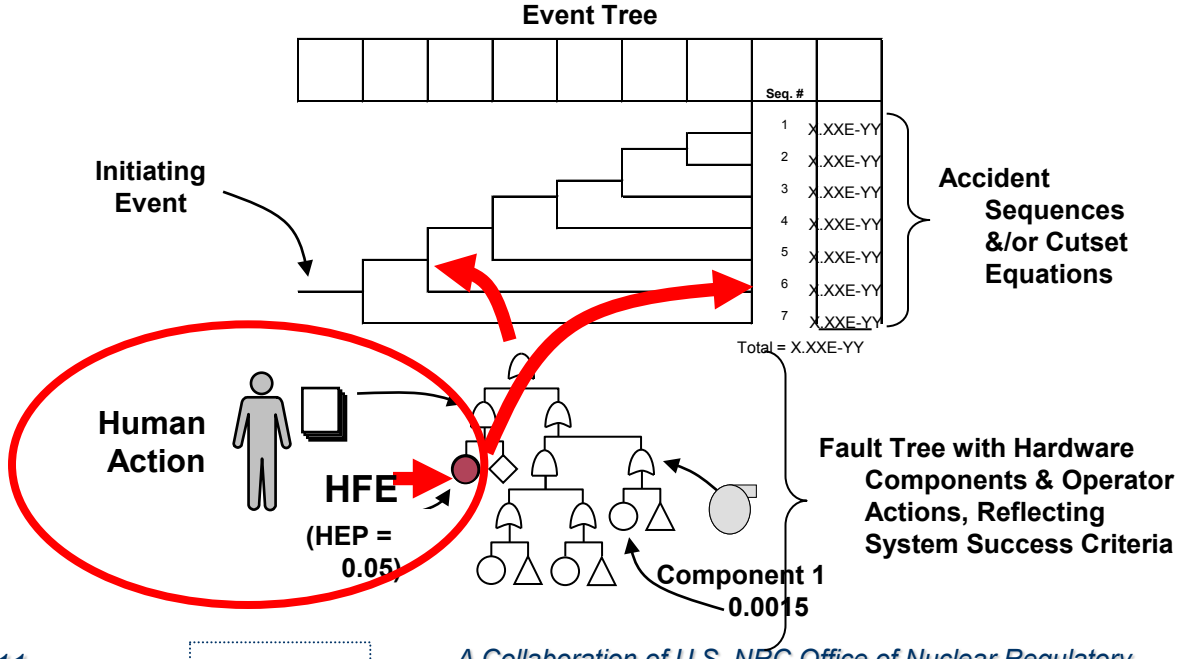
A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Agenda Overview

1. Introduction
2. Summary of Reviews, Tests & Comments
3. Updates to the EPRI/NRC Fire HRA Guidelines
   - **A. Identification and Definition**
   - B. Qualitative analysis
   - C. Quantitative analysis
     1) Scoping
     2) EPRI approach (detailed)
     3) ATHEANA (detailed)
   - D. Recovery, Dependency & Uncertainty analyses
   - E. Other Appendices
4. Project Status and Path Forward

Outline of the Identification/Definition Module

- Identification
- Categories of Fire Human Failure Events
- Definition & Fire Context
- Feasibility – Initial Assessment
- Summary



Identification - *Process Unchanged, NUREG-1921 Ch. 3 Re-structured*

- Human Reliability Analysis starts with developing understanding of role(s) of operators in responding to an event
- Actions relevant to post-initiator (or post-fire) response are identified via
  - Review plant Emergency Operating & Abnormal Procedures & Fire Response Procedures
  - Review of PRA Event trees, Fault trees, & Results (sequences and/or cutsets)
  - Operator interviews
- Once relevant actions are understood, corresponding ***human failure events*** are ***identified*** for the PRA models

Categories of Post-Fire Operator Actions - *Unchanged*

1. Operator actions from the internal events PRA
   - From the Level1/LERF PRA model used to develop the Fire PRA
   - Based on Emergency Operating & Abnormal Procedures
2. Fire Response Actions
   - New actions contained in the fire procedures
   - New actions to address recovery of spurious actuation
   - MCR abandonment is a subset of fire response actions
3. HFEs Corresponding to Undesired Operator Responses
   - New actions to address undesired operator actions in response to spurious indications per Fires (Ch. 4) in the ASME/ANS Combined PRA Standard

Definition – *Change to clarify & make succinct*

- After HFE Identification, ***Definition*** gives the initial basis for justifying inclusion of the action in the PRA model.
- Consists of objective, qualitative data:
  - Procedures
  - Cues (the prompts to initiate actions)
    - Alarms, indications, and/or procedure steps
  - Timing (Time Available & Time Required for Response)
  - Staffing
  - HFE tasks & associated success criteria
- Provides input to the subsequent Qualitative Analysis of the factors affecting human reliability
- Requires Initial Feasibility Evaluation

Initial Assessment of Feasibility - *Clarified*

- Purpose: To decide whether an operator action can be accomplished or not, given the plant-specific & scenario-specific fire impacts.
- Feasibility Evaluation – Set HEP to 1.0 for any of the following (as the action would not be feasible)
  - **Procedural guidance** does not exist
  - Failed **instrumentation** (so no cues for operator action)
  - Insufficient **time available** to complete action
  - Insufficient **manpower**
  - Other Factors that may preclude credit
    - Fire is in same location as required actions
    - Inaccessible tools or equipment
- Feasibility is an HRA "continuous action step" that is re-visited as the NUREG-6850/EPRI 1011989 tasks progress.

Identification & Definition Summary

- HFE ***Identification*** finds where operator actions occur
  - In the plant response to initiating events & in the PRA model
- Identification consists of:
  - Review plant operating procedures & understand operator response
  - Review PRA Event trees, Fault trees, Results & Success Criteria
- HFE ***Definition*** provides justification for inclusion of the action in the FPRA & provides input to Qualitative Analysis
- Definition documents objective, qualitative data:
  - Procedures, Cues, Timing, Staffing & HFE Success Criteria
- Initial Feasibility Evaluation is the first Go/No-Go check
- Next step is Qualitative Analysis

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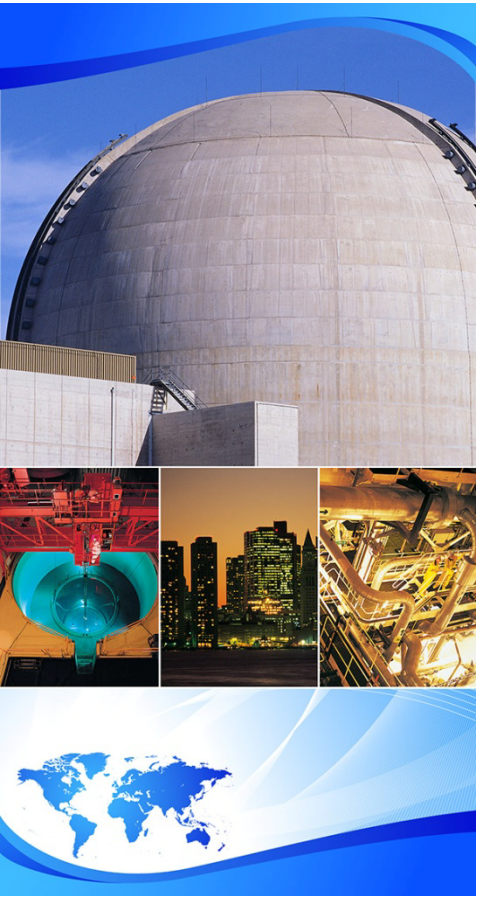

EPRI/NRC-RES Fire HRA Guidelines

Qualitative Analysis

John Forester (SNL) and Erin Collins (SAIC)

ACRS PRA Subcommittee Meeting
April 20, 2011
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

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      3) ATHEANA (detailed)
   D. Recovery, Dependency & Uncertainty analyses
   E. Other Appendices
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Outline of the Qualitative Analysis Module

- Qualitative Analysis lays the foundation for Quantification steps
  - Starts with input from *Definition (HFE)*
- Level of detail varies with NUREG/CR-6850 step
- Method Steps:
  - Data collection: plant, PRA, & historical
  - Feasibility assessment
  - HRA Method selection
  - HFE narrative / integrated timeline
  - Fire impact on Performance Shaping Factors

Qualitative Analysis – Data Collection

Added/emphasized this sub-task

- Data needed to support all quantification methods
  - Specific aspects of qualitative analysis needed to support various quantification approaches will vary
  - General understanding of potential fire effects supports application of specific approaches
- Operational, Historical and Model Data:
  - Plant information – needed to understand the actual "as-built, as-operated" plant response.
  - PRA information – needed to understand the modeled context for each HFE.
  - HRA-specific information – needed to understand existing HRA methods and data sources.
  - Historical experience – useful to understand insights from incidents and events.

Qualitative Analysis – Feasibility Assessment

Allow Use of Existing Information

- NUREG-1921 fix – allow use of existing information from previous analyses & demonstrations and information obtained from talk-throughs with appropriate plant staff
- Examples of existing timing data/demonstrations include:
  - Appendix R walkdowns
  - 805 Operator Manual Action (OMA) feasibility analyses
  - Results of training exercises (simulator for MCR actions; Fire Response Actions outside MCR)
  - Established job performance measures (JPMs)
  - However, access/egress & associated delays must be considered

Qualitative Analysis – Feasibility Assessment

Clarification Added

- Emphasized that the Feasibility Assessment is a continuous action step conducted throughout the FPRA, & may change as FPRA develops information
- While the level of detail may change as FPRA progresses, the factors considered for feasibility remain the same
- For example, the staffing and timing requirements for individual scenarios may vary widely.
  - More careful analysis needed as progress from screening to scoping to detailed analysis

Qualitative Analysis – Method Selection

Added/emphasized this sub-task

- Section was added to emphasize this sub-task
- Quantification method now dictates level of detail of qualitative analysis
- HRA methods may vary with NUREG/CR-6850 Fire PRA task
  - Task 7, Quantitative Screening
  - Task 8, Fire Scoping
  - Task 11, Detailed Fire Scenarios

Qualitative Analysis – HFE Narrative

Added/emphasized this sub-task

- Section was added to emphasize this sub-task
- Integrating the influences of the following elements into an HRA progression timeline:
  - PRA context
    - Time of cues & time window from thermal-hydraulic analyses
    - Fire-induced initiating event & accident sequence progression
    - Fire development & growth from fire modeling
  - Plant context
    - Response times based on
      - Accident-specific procedural guidance
      - Availability of cues & other indications for detection & evaluation
      - Physical layout (SSC impacted) & environment

Qualitative Analysis – Perf. Shaping Factors (PSF)

Clarified guidance for this sub-task

- Fire impact on PSFs, for subsequent impact on the HEP
  - On Analysis Area (whole room) or Scenario basis
  - Initiators that are fire-induced
  - Component & cable impact, including instrumentation
- PSFs are those aspects which can impact operator response
- Procedures, Cues, Timing
- Complexity
- Workload, stress, pressure
- Human-Machine Interface
- Environment (e.g., smoke, fire fighting)
- Special Equipment
- Crew Communication, Staffing & Dynamics

Qualitative Analysis Summary

- HFE ***Identification*** finds where operator actions occur
- HFE ***Definition*** collects objective context & establishes HFE Success Criteria
- Initial Feasibility Evaluation is the first Go/No-Go check
- HFE ***Qualitative Analysis***
  - Data collection: plant, PRA, & historical
  - Feasibility assessment (continuous action step)
  - HRA Method selection
  - HFE narrative / integrated timeline development
  - Evaluate impact on/of performance shaping factors
- Next step is ***Quantification***

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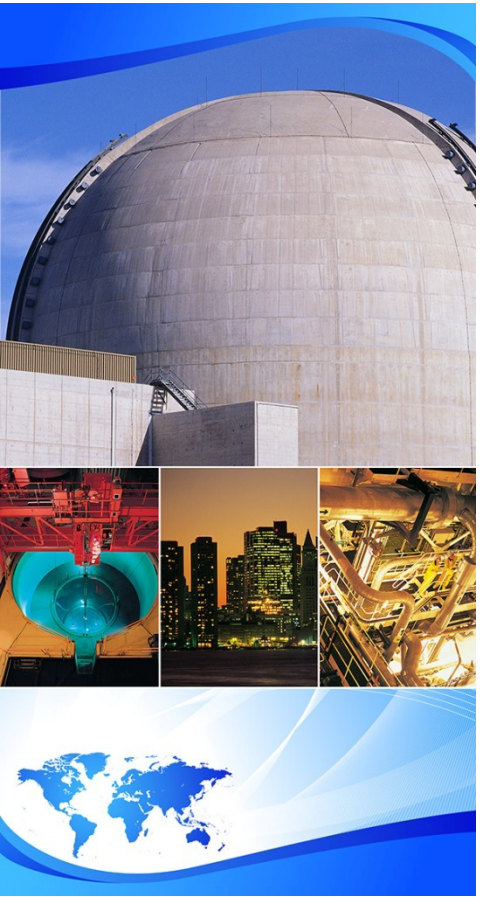


EPRI/NRC-RES FIRE HRA GUIDELINES

Quantification: Scoping Approach

Stacey Hendrickson (SNL)

ACRS PRA Subcommittee Meeting
April 20, 2011

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Summary of Scoping Quantification

- Purpose:
  - Offers less conservative and more realistic HEPs compared to the screening approach
  - More conservative but less resource intensive than more detailed HRA methods
- Categories:
  - In-MCR or local (ex-MCR) actions
  - Alternative shutdown
  - Recovery of errors due to spurious instrumentation
- Quantification:
  - Relies on assessment of feasibility of actions, time margin, and simple judgments about a few PSFs
  - Quantification is through the use of flowcharts

Overview of Changes Following Public Comment Period

Comment	Resolution
1. Possible to obtain a number from screening approach that is less than that from scoping approach	Screening sometimes allows the use of HEPs from internal events HRA which were calculated based on a detailed analysis. These HEPs may be lower than that obtained through scoping
2. Method is excessively resource intensive & not commensurate with a scoping level approach	Modified the feasibility demonstration to be an assessment and allow the use of talk-throughs, job performance measures, and earlier demonstrations (e.g. fire manual actions and training)
3. Time margin application is too conservative	Eliminated the requirement of a time margin greater than 100%. This also corrected the problem of double counting increased complexity

Overview of Changes Following Public Comment Period (continued)

Comment	Resolution
4. 60-minute rule for determining if fires are on-going seems arbitrary and overly conservative	Relied on FAQ-08-0050 and allowed use of these times for when fire is suppressed based on the 99th percentile. Otherwise, must use 70 minutes
5. Main control abandonment is not well defined	Flowchart for main control abandonment was revised and renamed as alternative shutdown. Clearer guidance on when to use based on location of command and control

Response to Comment #1 – Differences between Screening and Scoping Methods

- Screening
  - Slightly modified from NUREG/CR-6850 (EPRI 1011989) to cover late (after fire is out) events
  - Allows use of internal events HRA in certain instances
- Scoping fire HRA quantification approach
  - Less conservative than screening, but designed to be slightly more conservative than detailed approaches
  - Intended to meet Capability Category II for non-risk significant events
  - Some actions may not be able to meet some of the criteria (result in an HEP of 1.0)

Response to Comment #2 – Modified Steps for Using Scoping Fire HRA Approach

1. Ensure minimum criteria are met
2. ~~Assess feasibility of operator actions~~
3. Calculate time margin
4. Assess key conditions and PSFs
5. Use flowcharts to quantify - Selection Scheme directs to one of the following:
   - INCR = In MCR actions
   - EXCR = ex-MCR actions (actions normally performed locally)
   - ASD = Alternative Shutdown (including MCR Abandonment due to habitability or transferring command and control to outside the MCR due to an inability to control the plant)
   - SPI = recovery of errors due to spurious instrumentation

Response to Comment #3: Changes related to Minimum Criteria & Time Margin

- No change to minimum criteria required:
  - Procedures
  - Training – on the procedures and the actions
  - Availability and Accessibility of Equipment
- Time Margin
  - Account for potential unexpected fire effects and variabilities
  - Assessed as either <50%, 50-99%, or ≥ 100%

Response to Comment #4: Assessing Key Conditions & PSFs within the Scoping Flowcharts

- How well the procedures match the scenario
  - Serves as a proxy for diagnostic complexity
- Response execution complexity
  - Assessed as high or low - guidance for judgment provided
- Timing of cues for the action relative to expected fire suppression time
  - Need to assess on-going fire effects
  - If fire type is known, may use the 99th % value from FAQ 08-0050
  - If fire type unknown, fire suppression assumed to be 70-minutes ("all fires")
  - Special cases: fires of turbine generators, outdoor transformers, high energy arcing faults, and flammable gas fires

Response to Comment #4 (continued)

- Action time window
  - Time from the occurrence of the cues for action until the action is no longer beneficial
  - Short time window = 30 minutes or less
  - Long time window = greater than 30 minutes
- Level of smoke and other hazardous elements in the action areas
  - Need for special equipment (e.g., SCBA)
  - Impairment of vision or prevention of the execution of the action
- Accessibility
  - Location of action
  - Travel path

Response to Comment #5: Scoping Flowcharts

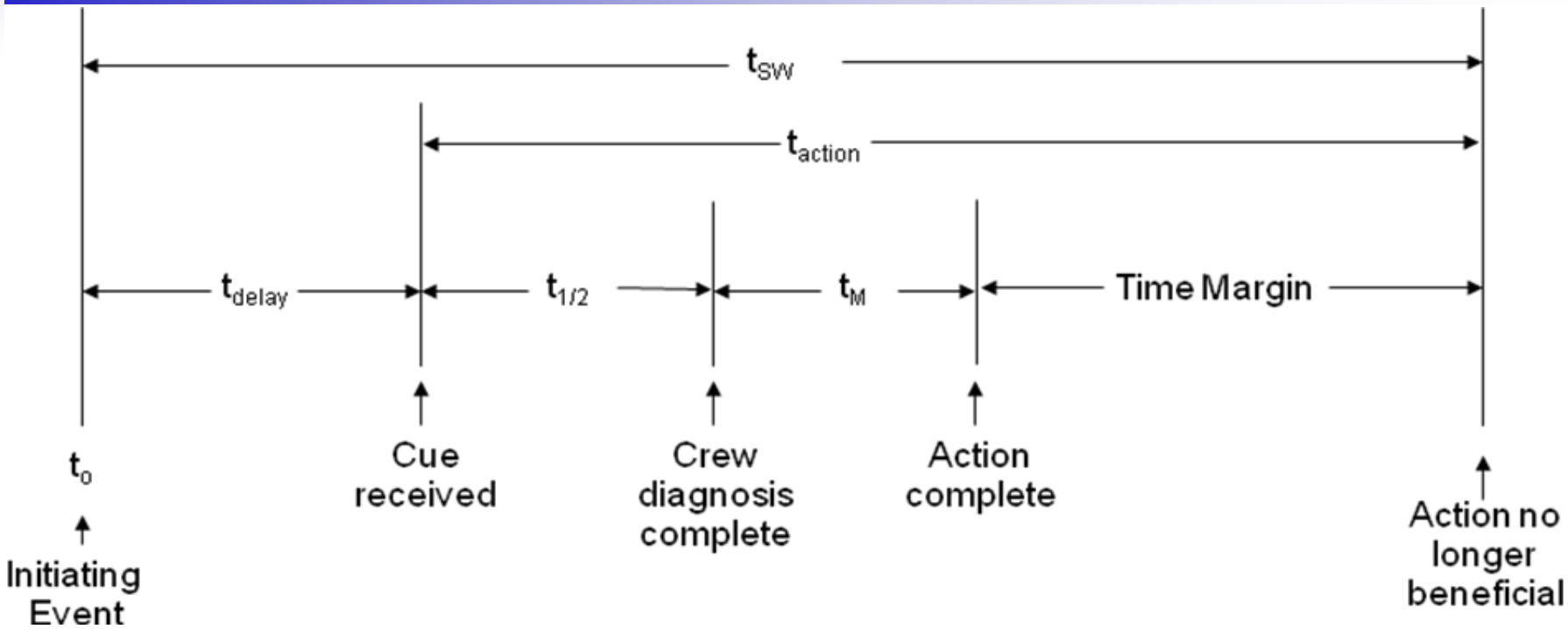
- Search Scheme
  - Directs the analyst to the correct flowchart for quantification
  - Renamed from Selection Scheme
- In-MCR action (INCR)
  - Addresses:
    - New HFEs identified outside the Internal Events PRA
    - Existing HFEs from the Internal Events that survive quantitative screening
  - Diagnosis and execution of the action in the MCR
- Ex-MCR action (EXCR)
  - Addresses:
    - New HFEs identified outside the Internal Events PRA
    - Existing HFEs from the Internal Events that survive quantitative screening
  - Diagnosis of the action within the MCR, but execution is local

Response to Comment #5 (continued)

- Alternative Shutdown (ASD)
  - Renamed from CRAB (MCR abandonment)
  - Used in cases in which command and control is located outside the MCR; therefore, diagnosis and execution are done outside the MCR
    - Uninhabitable environment in MCR
    - Inability to control the plant (loss of MCR functionality)
- Recovery of error due to spurious instrumentation (SPI)
  - Clarified application and definitions
  - Spurious instrumentation refers to the instrumentation necessary for the operator to diagnose the action (e.g., expected cues from the procedure)

BACKUP SLIDES

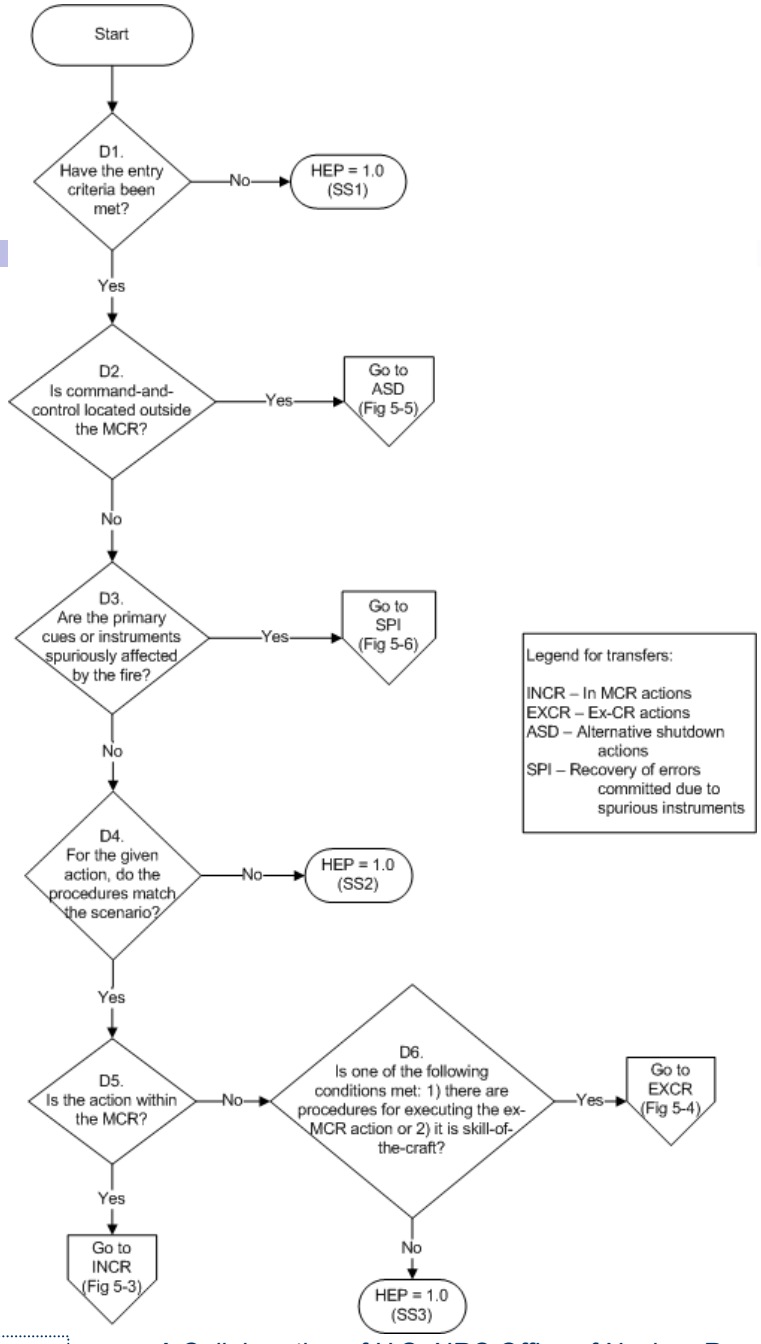
Calculation of Time Margin



$$TM = \frac{t_{action} - \left(t_{1/2} + t_M\right)}{\left(t_{1/2} + t_M\right)} * 100\%$$

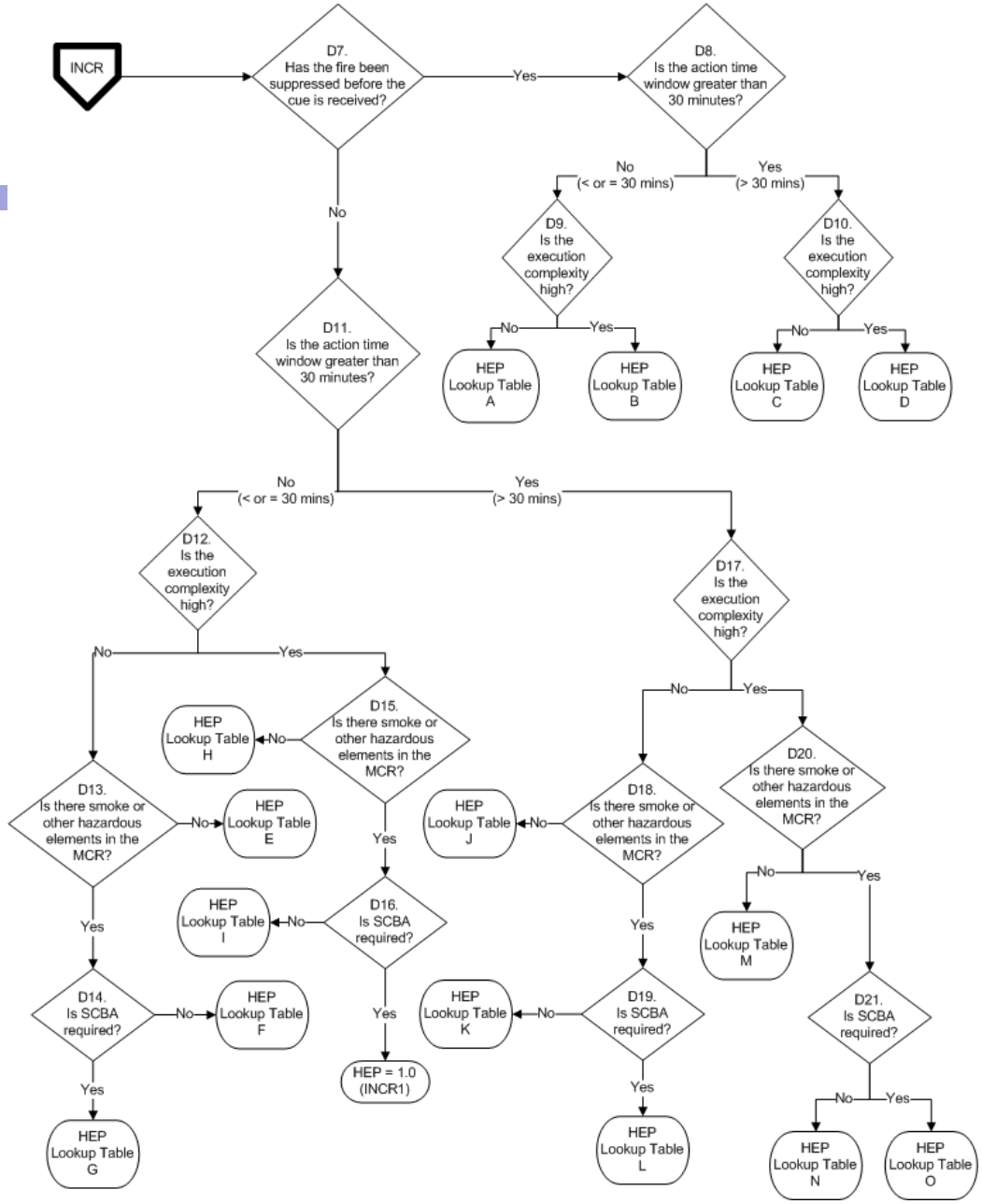
Search Scheme

- Directs analyst to correct quantification flowchart



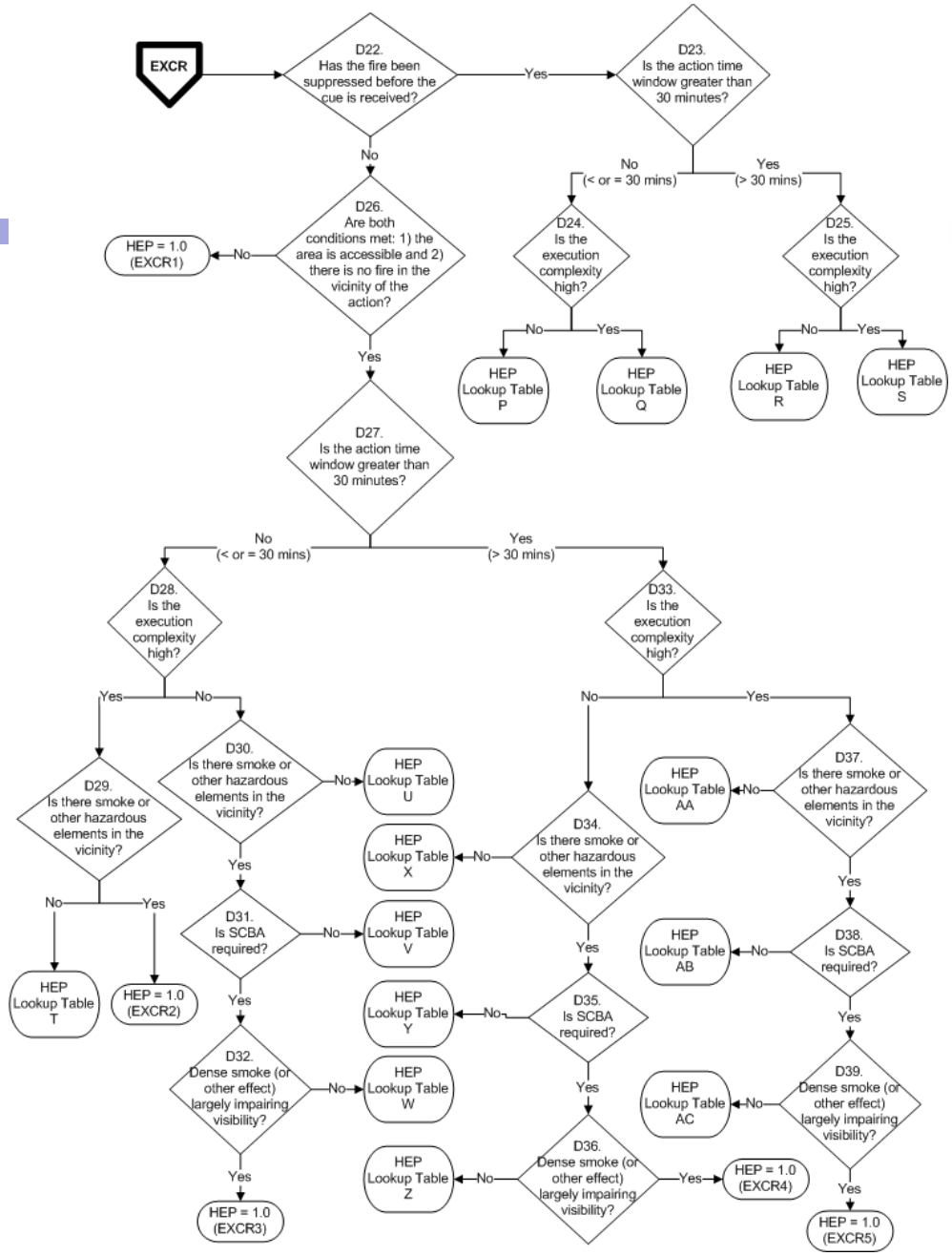
INCR

- Scoping HRA for in MCR Actions



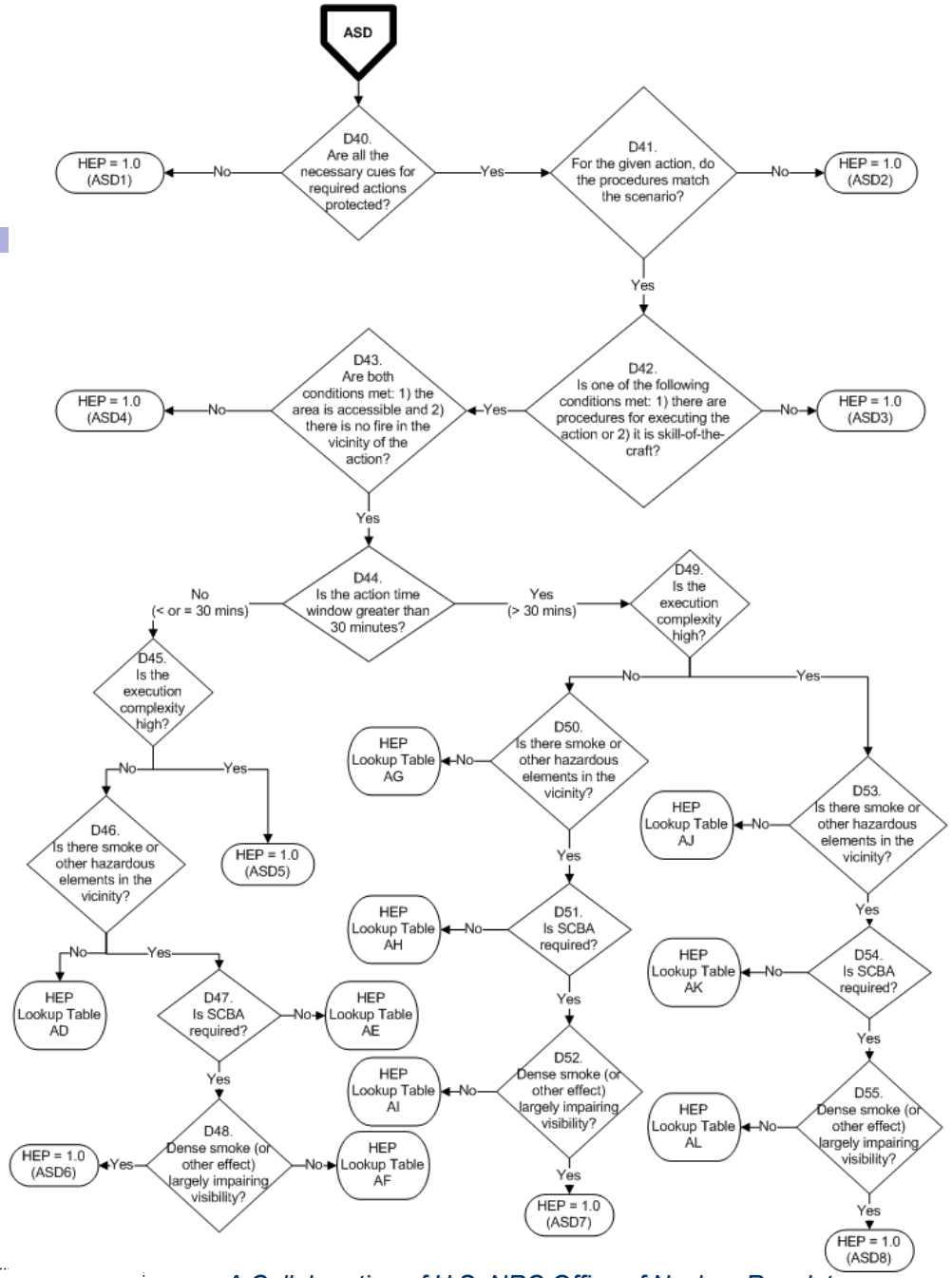
EXCR

- Scoping HRA for ex-MCR Actions



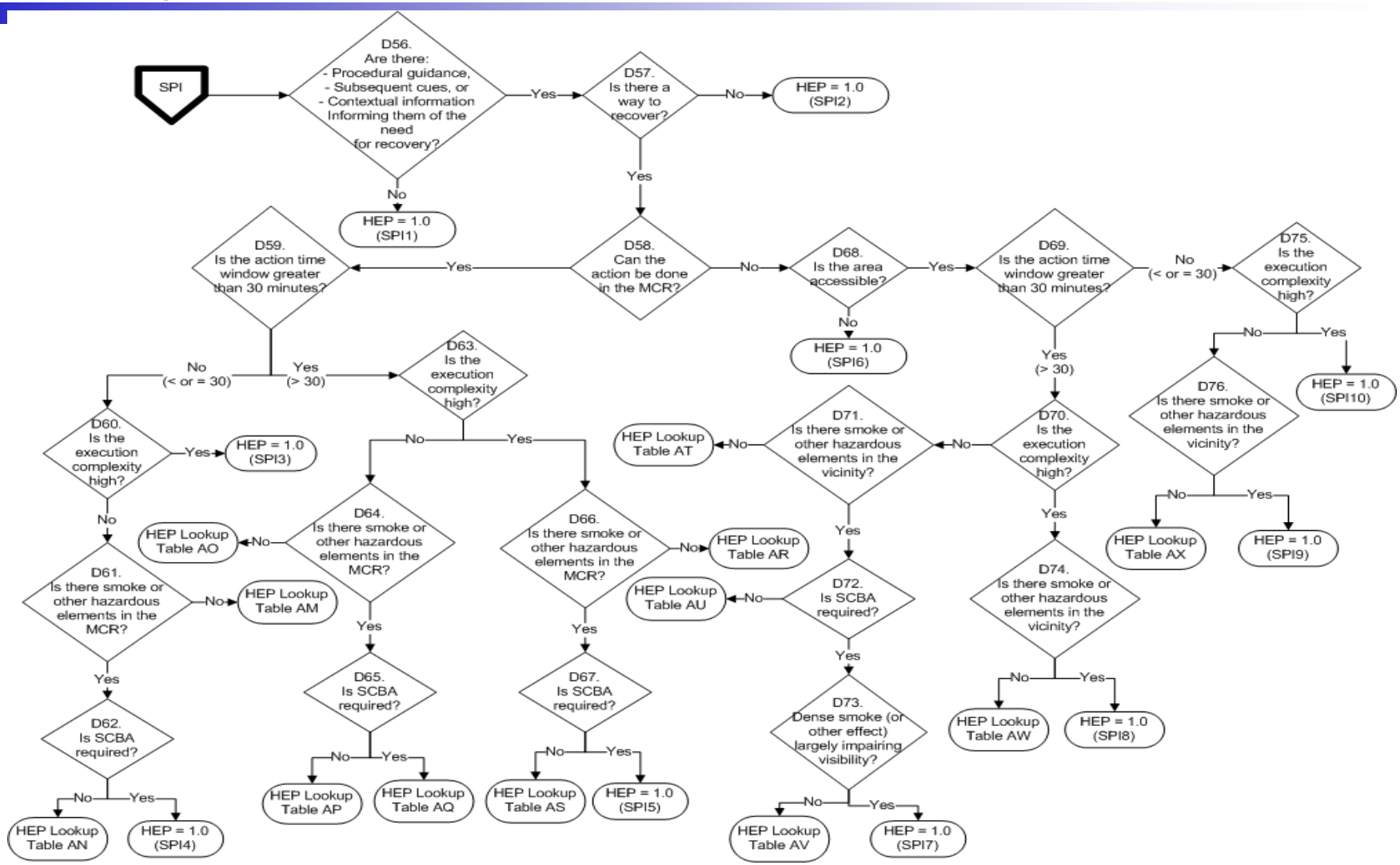
ASD

- Scoping HRA for Alternative Shutdown Actions



SPI

Scoping HRA for EOC or EOO due to spurious instrumentation



INCR Look-up Table

HEP Lookup Table	Time Margin	HEP	HEP Label
A	≥ 100%	0.005	INCR2
	50 – 99%	0.025	INCR3
	< 50%	1.0	INCR4
B	≥ 100%	0.025	INCR5
	50 – 99%	0.125	INCR6
	< 50%	1.0	INCR7
C	≥ 100%	0.001	INCR8
	50 – 99%	0.005	INCR9
	< 50%	1.0	INCR10
D	≥ 100%	0.005	INCR11
	50 – 99%	0.025	INCR12
	< 50%	1.0	INCR13
E	≥ 100%	0.05	INCR14
	50 – 99%	0.25	INCR15
	< 50%	1.0	INCR16
F	≥ 100%	0.1	INCR17
	50 – 99%	0.5	INCR18
	< 50%	1.0	INCR19
G	≥ 100%	0.2	INCR20
	< 100%	1.0	INCR21
H	≥ 100%	0.25	INCR22
	< 100%	1.0	INCR23
I	≥ 100%	0.5	INCR24
	< 100%	1.0	INCR25
J	≥ 100%	0.01	INCR26
	50 – 99%	0.05	INCR27
	< 50%	1.0	INCR28
K	≥ 100%	0.02	INCR29
	50 – 99%	0.1	INCR30
	< 50%	1.0	INCR31
L	≥ 100%	0.04	INCR32
	50 – 99%	0.2	INCR33
	< 50%	1.0	INCR34
M	≥ 100%	0.05	INCR35
	50 – 99%	0.25	INCR36
	< 50%	1.0	INCR37
N	≥ 100%	0.1	INCR38
	50 – 99%	0.5	INCR39
	< 50%	1.0	INCR40
O	≥ 100%	0.2	INCR41
	< 100%	1.0	INCR42

Note that some tables (e.g., G) “absorb” the 50-99% TM into one <100% because multiplying the >100% TM by 5 already causes HEP=1

EXCR Look-up Table

HEP Lookup Table	Time Margin	HEP	HEP Label
P	≥ 100%	0.01	EXCR6
	50 – 99%	0.05	EXCR7
	< 50%	1.0	EXCR8
Q	≥ 100%	0.05	EXCR9
	50 – 99%	0.25	EXCR10
	< 50%	1.0	EXCR11
R	≥ 100%	0.002	EXCR12
	50 – 99%	0.01	EXCR13
	< 50%	1.0	EXCR14
S	≥ 100%	0.01	EXCR15
	50 – 99%	0.05	EXCR16
	< 50%	1.0	EXCR17
T	≥ 100%	0.5	EXCR18
	< 100%	1.0	EXCR19
U	≥ 100%	0.1	EXCR20
	50 – 99%	0.5	EXCR21
	< 50%	1.0	EXCR22
V	≥ 100%	0.2	EXCR23
	< 100%	1.0	EXCR24
W	≥ 100%	0.4	EXCR25
	< 100%	1.0	EXCR26
X	≥ 100%	0.02	EXCR27
	50 – 99%	0.1	EXCR28
	< 50%	1.0	EXCR29
Y	≥ 100%	0.04	EXCR30
	50 – 99%	0.2	EXCR31
	< 50%	1.0	EXCR32
Z	≥ 100%	0.08	EXCR33
	50 – 99%	0.4	EXCR34
	< 50%	1.0	EXCR35
AA	≥ 100%	0.1	EXCR36
	50 – 99%	0.5	EXCR37
	< 50%	1.0	EXCR38
AB	≥ 100%	0.2	EXCR39
	< 100%	1.0	EXCR40
AC	≥ 100%	0.4	EXCR41
	< 100%	1.0	EXCR42

ASD Look-up Table

HEP Lookup Table	Time Margin	HEP*	HEP Label
AD	≥ 100%	0.2	ASD9
	< 100%	1.0	ASD10
AE	≥ 100%	0.4	ASD11
	< 100%	1.0	ASD12
AF	≥ 100%	0.8	ASD13
	< 100%	1.0	ASD14
AG	≥ 100%	0.04	ASD15
	50 – 99%	0.2	ASD16
	< 50%	1.0	ASD17
AH	≥ 100%	0.08	ASD18
	50 – 99%	0.4	ASD19
	< 50%	1.0	ASD20
AI	≥ 100%	0.16	ASD21
	50 – 99%	0.8	ASD22
	< 50%	1.0	ASD23
AJ	≥ 100%	0.2	ASD24
	< 100%	1.0	ASD25
AK	≥ 100%	0.4	ASD26
	< 100%	1.0	ASD27
AL	≥ 100%	0.8	ASD28
	< 100%	1.0	ASD29

SPI Look-up Table

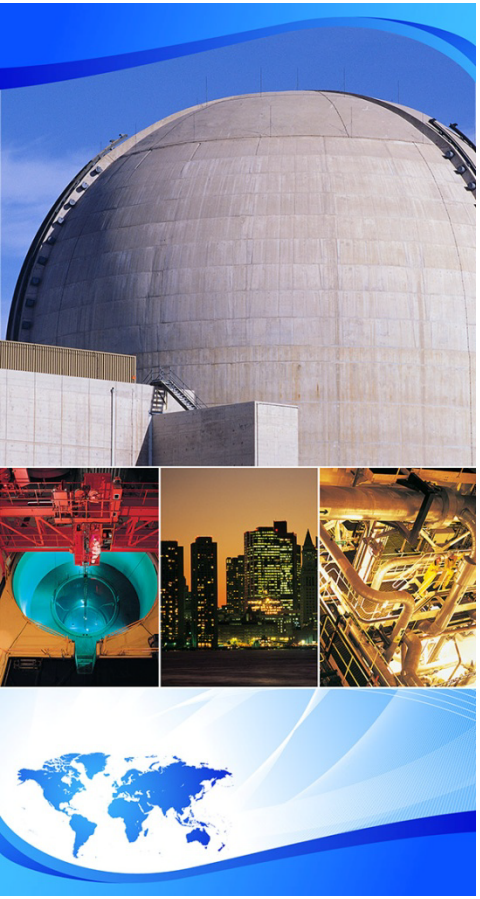
AM	≥ 100%	0.25	SPI11
	< 100%	1.0	SPI12
AN	≥ 100%	0.5	SPI13
	< 100%	1.0	SPI14
AO	≥ 100%	0.05	SPI15
	50 – 99%	0.25	SPI16
	< 50%	1.0	SPI17
AP	≥ 100%	0.1	SPI18
	50 – 99%	0.5	SPI19
	< 50%	1.0	SPI20
AQ	≥ 100%	0.2	SPI21
	< 100%	1.0	SPI22
AR	≥ 100%	0.25	SPI23
	< 100%	1.0	SPI24
AS	≥ 100%	0.5	SPI25
	< 100%	1.0	SPI26
AT	≥ 100%	0.1	SPI27
	50 – 99%	0.5	SPI28
	< 50%	1.0	SPI29
AU	≥ 100%	0.2	SPI30
	< 100%	1.0	SPI31
AV	≥ 100%	0.4	SPI32
	< 100%	1.0	SPI33
AW	≥ 100%	0.5	SPI34
	< 100%	1.0	SPI35
AX	≥ 100%	0.5	SPI36
	< 100%	1.0	SPI37

Multipliers Applied to HEPs Across Flowcharts

HEP in Base Flowchart	Adjustment Value	HEP in Scoping Flowchart
INCR	2	EXCR
EXCR	2	ASD
INCR for in-MCR actions; EXCR for ex-MCR actions	5	SPI

Change in PSF	Scoping Approach Multipliers
Fire effects ongoing (i.e., < 70 minutes from the start of the fire)	10
Action time window ≤ 30 minutes	5
High execution complexity	5
Increases in smoke level	2
Decreases in time margin: from ≥ 100% to 50%-99% from ≥ 50% to < 50%	 5 Set HEP = 1.0

Item # 10



EPRI/NRC-RES FIRE HRA Guidelines

Quantification – Detailed Method
EPRI Fire HRA Approach

Jeff Julius (Scientech)

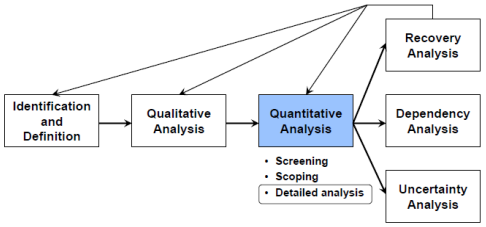
ACRS Meeting – PRA Sub-Committee
April 20, 2011
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Agenda Overview

1. Introduction
2. Summary of Reviews, Tests & Comments
3. Updates to the EPRI/NRC Fire HRA Guidelines
   A. Identification and Definition
   B. Qualitative analysis
   C. Quantitative analysis
      1) Scoping
      2) EPRI approach (detailed)
      3) ATHEANA (detailed)
   D. Recovery, Dependency & Uncertainty analyses
   E. Other Appendices
4. Project Status and Path Forward

Quantification – NUREG-1921 Detailed Approaches



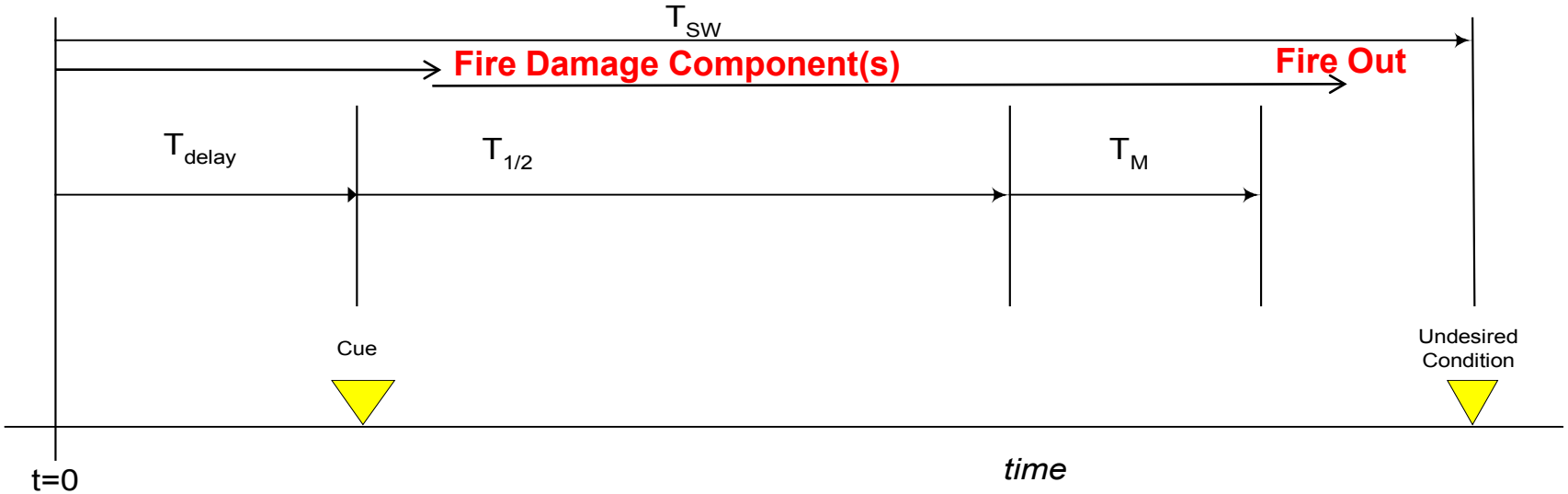
Two options for detailed analyses:

- EPRI methods, (e.g., as implemented in HRA Calculator®)
  - Cause-based decision tree method and/or HCR/ORE time reliability correlation for failure in cognition
  - THERP for failure in execution
  - Limited changes, primarily to guidance on Stress, but extensive guidance for implementation for fire context
- NRC's *A Technique for Human Event ANAlysis* (ATHEANA): designed to be adapted to different contexts

Detailed Fire HRA Summary – EPRI Approach

- Consists of HRA tasks that develop human error probabilities (HEPs) for the modeled human failure events (HFEs)
  - HEP used in FPRA quantification
  - HEP development provides qualitative insights on results drivers
- Follows the **HRA Process**
  - Identification & Definition
    - Definition is the PRA context: initiator, sequence, procedure and time window.
    - Qualitative analysis
      - Integrated timeline & timing impacts, and
      - Fire impacts PSFs/CBDT failure mechanisms
        - Impact on cue/instrumentation
        - Workload
        - Procedure
        - Stress

EPRI Timeline for a Post-initiator HFE



1) Thermal-Hydraulics Time Line: Provides $\mathbf{T_{SW}}$ = System time window (time available).

2) Fire Growth Time Line: Time to target damage, models growth & suppression (fire out).

3) Plant Response Timeline: Includes Fire Brigade, MCR and local manual actions.

$\mathbf{T_{delay}}$ = Time from start of transient until cue is reached (start of cognition)

$\mathbf{T_{1/2}}$ = Median response time (cognition = detection, diagnosis, & decision-making)

$\mathbf{T_M}$ = Manipulation time (includes transit, tools, PPE & execution of each task including valve stroke time if applicable)

Summary of Changes to EPRI Approach

- Identification & Definition:
  - Definition benefits from simplification & additional clarity on "what is the PRA context"
- Qualitative Analysis:
  - Integrated timeline & timing impacts – no changes.
  - Recognition that some factors are directly tied to quantification and others are not, but they contribute to the narrative.
  - Stress guidance – changed to eliminate "fire stress".
  - 92-18 valves – added to the list of factors affecting manipulation & feasibility.

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BACKUP SLIDES

Summary of Detailed Fire HRA (EPRI) - Changes

- Consists of HRA tasks that develop human error probabilities (HEPs) for the modeled human failure events (HFEs)
  - HEP used in FPRA quantification
  - HEP development provides qualitative insights on results drivers
- Uses most of the steps in the **HRA Process**:
  1. Identification & Definition of HFE
  2. Qualitative analysis – context & performance shaping factors
  3. Quantitative analysis – **method selection** & quantification of HEP
     a) Screening
     b) Scoping
     c) Detailed HRA
        a) EPRI approach (CBDTM or HCR/ORE & THERP)
        b) ATHEANA
  4. Provides input to subsequent Fire HRA tasks
     - Dependency analysis & Uncertainty analysis

Outline of the EPRI Approach to Detailed Fire HRA Module

- Overview of Quantitative Methods in the EPRI Approach:
  - Cause-Based Decision Tree Overview (Cognitive)
  - HCR/ORE Overview (Cognitive for Time-Critical)
  - THERP (Execution)
- Definition & subsequent Qualitative Analysis
  - Fire Context
  - Performance Shaping Factors
- Method Selection & Quantification
- Summary

What is *Detailed Fire HRA*?

Consists of HRA tasks that develop human error probabilities (HEPs) for the modeled human failure events (HFEs)

- HEP used in FPRA quantification
- HEP development provides qualitative insights on results drivers

Typically done to PRA Standard Capability Category II

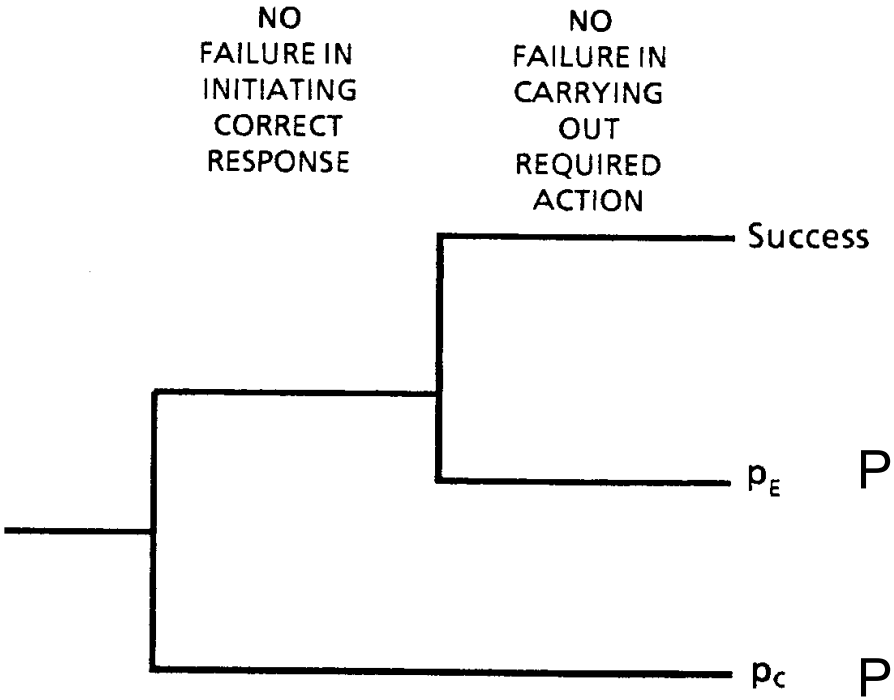
Uses most of the steps in the **HRA Process**:

1. Identification & Definition of HFE
2. Qualitative analysis – context & performance shaping factors
3. Quantitative analysis – method selection & quantification of HEP
   a) Screening
   b) Scoping
   c) Detailed HRA: EPRI approach or ATHEANA
4. Provides input to subsequent Fire HRA tasks
   - Dependency analysis
   - Uncertainty analysis

EPRI Quantification Methods

- CBDTM (Cause Based Decision Tree Method)
  - 8 Decision trees based on simulator experiment insights
  - Default method for cognitive portion (detection/diagnosis)
- HCR/ORE Correlation (Human Cognitive Reliability / Operator Reliability Experiment)
  - Used for time-critical operator actions
  - Normalized time reliability correlation (function of $T_{available}$ / $T_{required}$)
- THERP (NUREG/CR-1278) for execution
- Methods are implemented in EPRI *HRA Calculator*® software, but can be quantified on paper

Post-Initiator HFE Representation: EPRI TR-100259



Pe = Execution is quantified using THERP

Pc = Cognitive is quantified using

CBDTM (default)

HCR/ORE (time critical HFEs)

CBDTM Overview – Cognitive Method

- Analytical approach based on identification of failure mechanisms and compensating factors
- Applicable to rule-based behavior, such as when procedures are used
- Two high-level failure modes:
  - Plant information-operator interface failure
  - Operator-procedure interface failure
- Each failure mode is decomposed into contributions from several distinct failure mechanisms
- Default method, especially if not time-critical

CBDTM - Summary of Failure Mechanisms

Type	Designator	Description
Failures in the Operator–Information Interface	p_c a	Data not available
	p_c b	Data not attended to
	p_c c	Data misread or miscommunicated
	p_c d	Information misleading
Failures in the Operator-Procedure Interface	p_c e	Relevant step in procedure missed
	p_c f	Misinterpret instruction
	p_c g	Error in interpreting logic
	p_c h	Deliberate violation

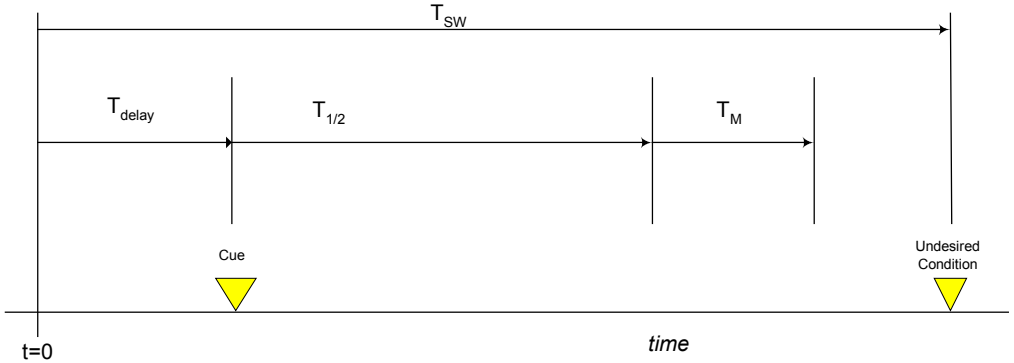
CBDTM - Recovery Factors

Recovery Factor	Time Effective
Self Review	At any time there is a subsequent cue, other than the initial cue that would prompt the operator to revisit the decision OR Is there a procedural step that either returns the operator to the initial step where the error was made, or that repeats the initial instruction?
Other (Extra) Crew	At any time that there are crew members over and above the minimum complement present in the CR and not assigned to other tasks
Shift Technical Advisor	10 to 15 minutes after reactor trip.
Emergency Response Facility/ Technical Support Center	1 hour after reactor trip – if constituted
Shift Change	6 hours after reactor trip given 8 hour shifts 9 hours after reactor trip given 12 hour shifts

Quantification: Fire HEPs for HFEs

- If HFE has been quantified using the EPRI HRA Approach for internal events, quantification for fire is a relatively simple modification in following areas:
  - **Timing**
  - **Cue** and indications impacts
  - Increase in **stress**
  - Increase in **workload**
  - Use of multiple **procedures**
  - For local actions, consider alternate **routes** if fire impacts the normal or ideal travel path

Fire Impacts on Timing



T = 0 is considered the start of the fire – For existing HFEs T=0 is typically reactor trip. In most cases, the FPRA assumes the fire and reactor trip coincide.

T_{delay} = Time from start of transient until cue is reached. If the cue is considered to be procedure step the **fire may cause delays in the procedure implementation**.

$T_{1/2}$ = If the fire impacts some but not all of the **instrumentation** $T_{1/2}$ will be increased from the internal events case to account for the time required for the operators to asses the situation & determine which instrumentation is correct or diagnose based on secondary cues.

T_m = For **main control room** actions in which there is no fire in the control room, T_m is considered to be the **same for the internal events case and the fire case**.

For **local actions, T_m will account for any detours caused by the fire**. If the exact fire location is not known, it is suggested that T_m be increased by 10 minutes from the internal events case to account for travel delays. T_m must also account for PPE & tools.

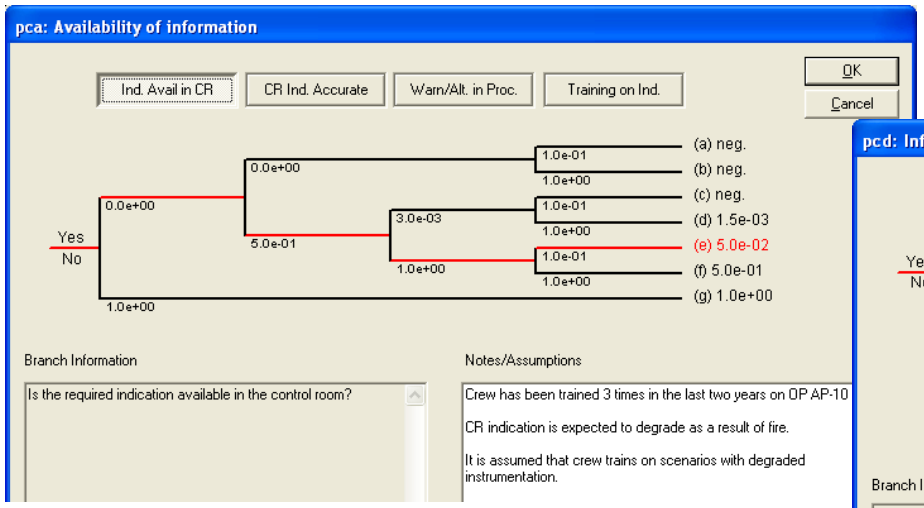
Fire Impacts on Timing (cont'd)

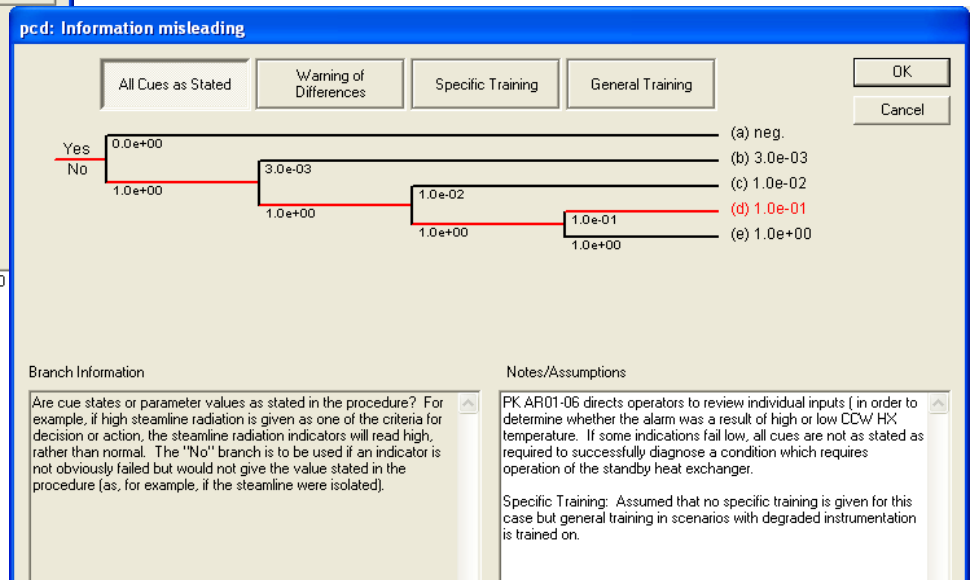
- If time available for recovery is reduced due to fire impacts on timing, then the recoveries previously credited in the internal events PRA within the CBDTM are to be revisited.

- If time-critical action and cues/indications are impacted, then the Tdelay is increased.

Fire Impacts on Instrumentation

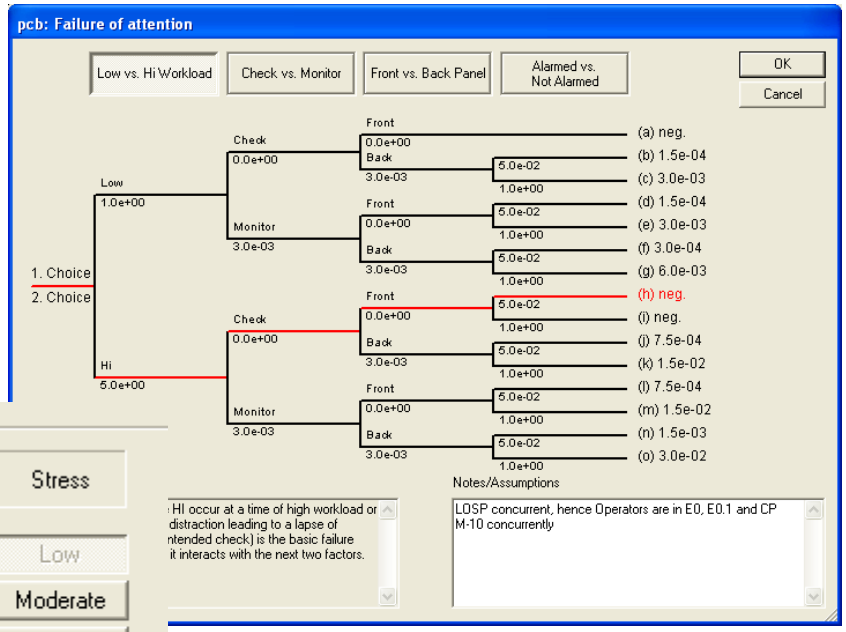
- If all **instrumentation is impacted** and there are no cues for diagnosis then HEP =1.0
- **Partial instrumentation** impacted is modeled in decision tree **Pc-a & Pc-d** (HEP range 1E-2 to 1.0)
- If the fire causes **no impact on instrumentation** then Pc-a and Pc-d typically evaluate to “Negligible”

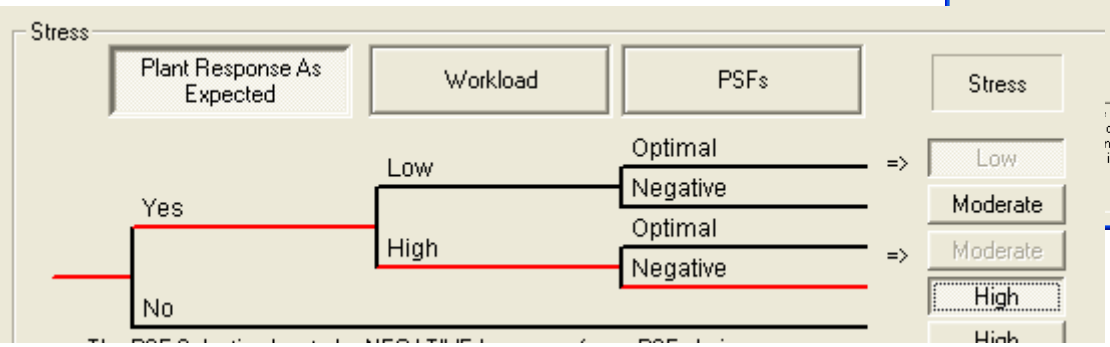




Fire Impacts on Workload

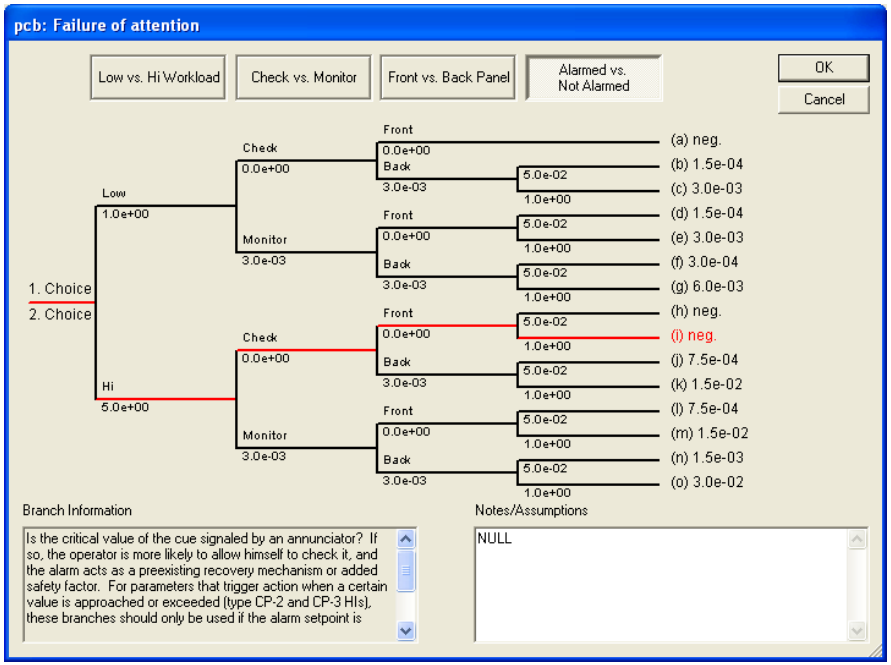
- Increase in workload is
  - modeled explicitly in decision tree **Pc-b** by selecting high workload if applicable during fire, for cognitive phase
  - also considered in determining the **stress level, for execution**





Fire Impacts on Procedure Usage

- If EOPs are implemented in parallel to fire procedures, then multiple procedures are used
- If EOPs are suspended while fire procedures are being used, then only one procedure is credited and any time delays are accounted for in the timeline



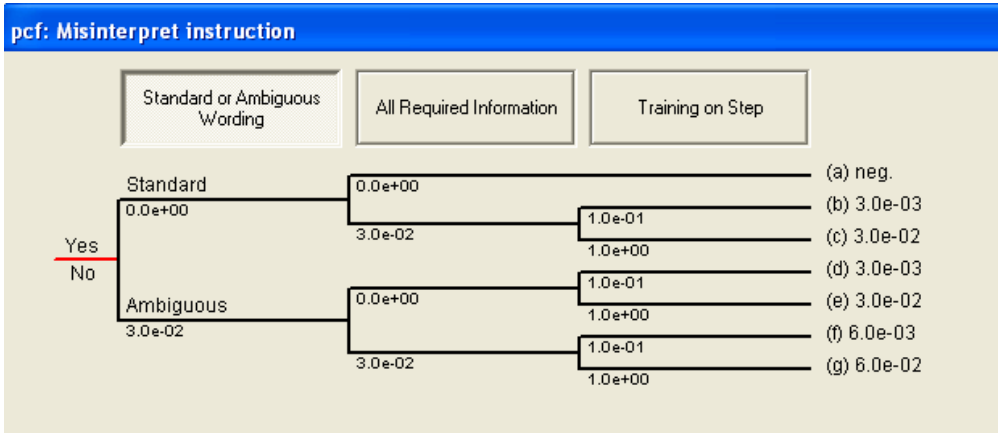
Fire Impacts on Execution

- Stress is the primary PSF for THERP

- Stress is often increased from internal events case
  - Except for control room actions when operator actions occurring more than 65 minutes after the fire started, because
    1. 99% of fires are extinguished within 65 minutes per Appendix P of NUREG/CR-6850 (EPRI 1011989), and
    2. On average, a fire is extinguished in 13 minutes

Fire Response HFEs

- Same considerations as internal events actions and the following **additional considerations**
  - **Ambiguously worded procedures**: Fire procedures are typically not standardized like EOPs. Modeled in decision tree P_cf. For internal events HFEs P_cf typically evaluates to negligible.

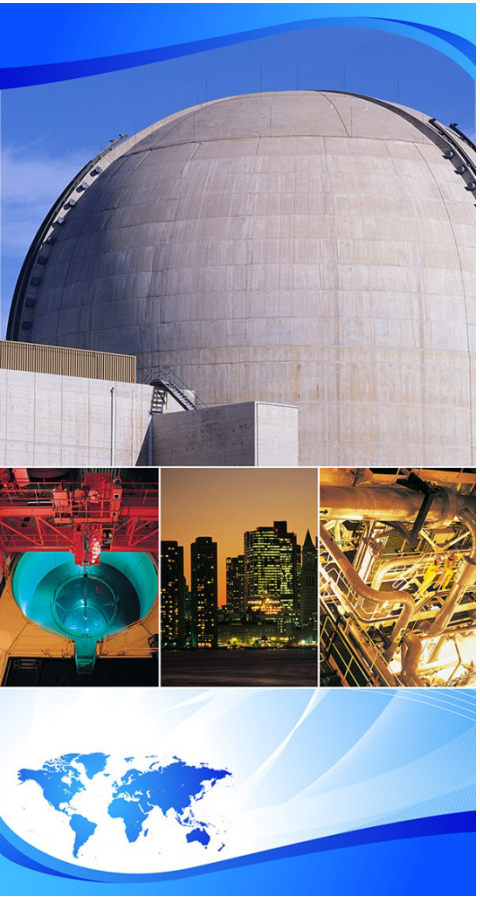


  - **Local controls** may not be as easily accessible and as well trained on as for internal events actions. In this case, higher Error of Omission is selected from THERP
  - **No base case** from which to build the analysis, so entire analysis must be developed

Fire Response HFEs

- Method selection depends on timing
  - CBDT approach to quantification applied first
  - HCR/ORE for time critical fire response actions
    - Use upper bound based on sigma value
- Ex-control room actions required due to loss of control are not substantially different from other local actions (e.g., during SBO) provided that local actions are not credited in close proximity to fire location
- No additional guidance for MCR abandonment at this time
  - MCR typically is completely abandoned due to uninhabitability, not due to loss of control/functionality initial results show that frequency is low enough to not be a concern
    - If required, additional decision trees may be developed to model locus of control moving outside the control room

Item # 11



EPRI/NRC-RES FIRE HRA GUIDELINES

Quantification – Detailed Method ATHEANA

Susan E. Cooper (NRC/RES)

ACRS PRA Subcommittee Meeting
April 20, 2011
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

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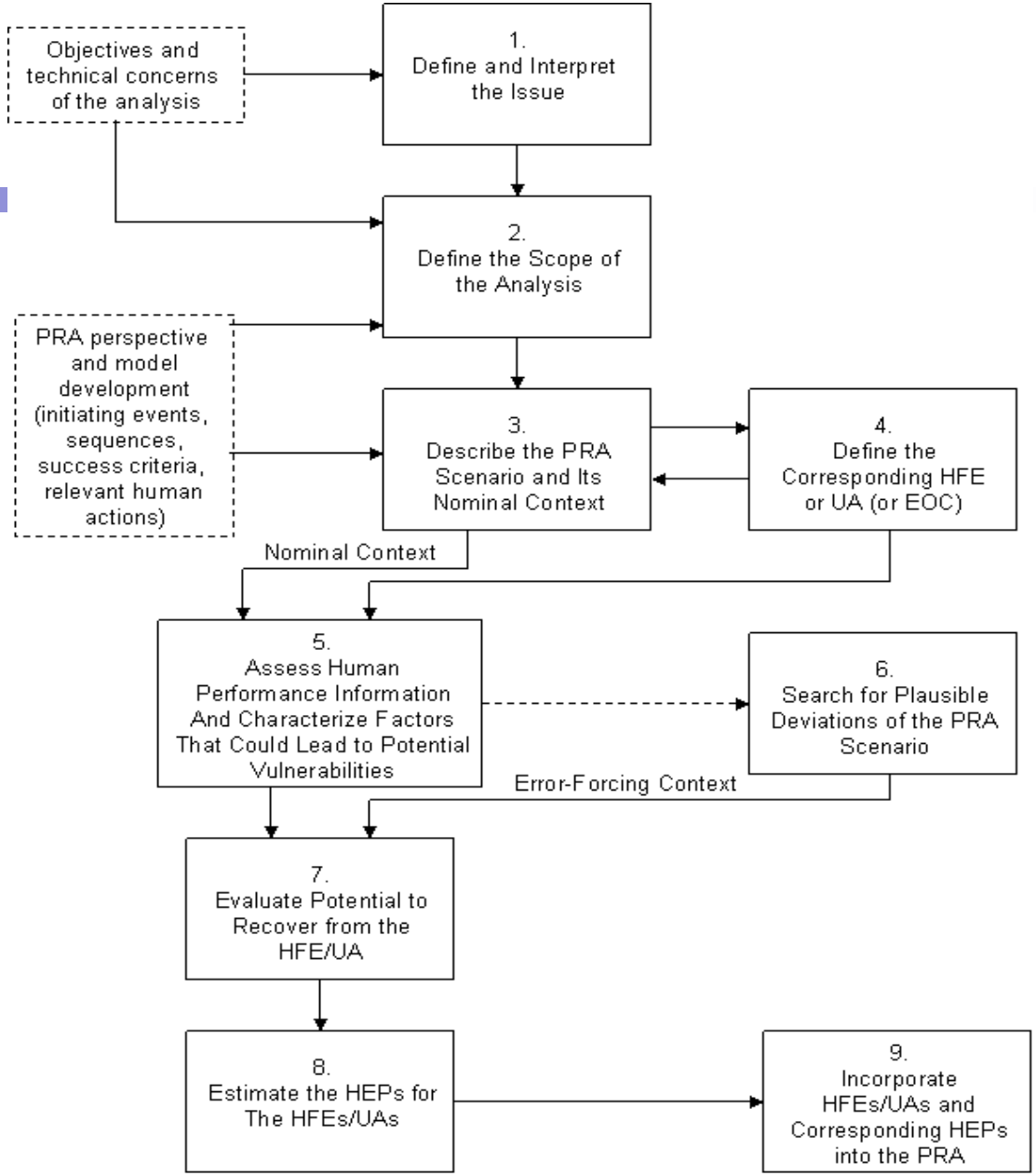
Key characteristics of ATHEANA

- Focuses on the **error-forcing context** (i.e., the context that sets up operators), but also addressed the nominal context
- Uses a structured search for problem scenarios (i.e., **error-forcing contexts**) and associated unsafe actions (i.e., operator failures)
- Links plant conditions, performance shaping factors (PSFs) and human error mechanisms through the **context**
- Open-ended set of influencing conditions (i.e., analyst uses whatever driving conditions, PSFs, etc. that are relevant to operator performance)
- Is experience-based, both in its development and application (e.g., uses knowledge of domain experts such as operators, pilots, trainers)
- Uses multidisciplinary approach and underlying cognitive model of operator behavior
- Explicitly considers operator dependencies (including recovery actions) by developing entire accident sequences
- Uses a facilitator-led, expert elicitation approach for quantification (that allows the plant-specific experience and understanding from operators, operator trainers, and other operations experts to be directly reflected)

Steps in the ATHEANA Process



Mapping ATHEANA Process Steps to Fire HRA Guidelines Process

ATHEANA Process Step	Fire HRA Guideline Process Step
Steps 1 & 2: Define issue & scope of analysis	Defined by fire PRA & its scope of analysis – **no additional work needed**
Step 4: Define HFEs and unsafe actions (UAs)	**Covered*** by Chapter 3: Identification and Definition
Steps 3 & 5: Describe PRA scenario & assess human performance information, etc.	Some additional information needed for detailed HRA; but, **mostly covered** by Chapter 4: Qualitative Analysis
Step 6: Search for deviation scenarios	**Probably not needed**; fire scenarios are already "deviations"
Step 7: Assess potential for recovery	Similar to Chapter 6: Recovery
Step 8: Quantification (explicitly addresses dependencies & develops uncertainty distributions)	Different approach than scoping trees (Chapter 5) or CBDT (Appendix C); different approach to dependency & uncertainty (Chapters 7 & 8)

Updates to ATHEANA approach for fire

- No changes to how ATHEANA would be applied
- Further guidance was added on how to apply ATHEANA for fire, e.g.,
  - More discussion on how to address fire using ATHEANA
  - Tips for applying ATHEANA carried over from Fire PRA Training Course 2010
- In order to illustrate the guidance, references have been added that point to ATHEANA analysis examples developed in Appendices B, C, and D of NUREG-1624, Rev. 1
- An illustrative example was added

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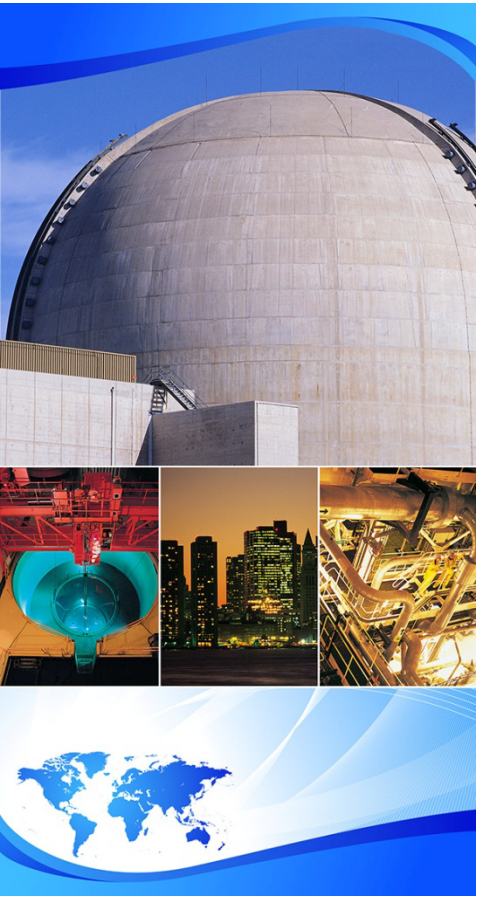
Item # 12



EPRI/NRC-RES FIRE HRA GUIDELINES

Recovery, Dependency, and Uncertainty Analysis

Erin Collins (SAIC) and Stuart Lewis (EPRI)

ACRS PRA Subcommittee Meeting
April 20, 2011

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Recovery, Dependency & Uncertainty Analyses

Contents Summary

- Fire HRA process described in PRA Standard addresses these elements:
  - Recovery analysis
    - Modeling of recovery actions that have cues, provided operators know what to do through procedure or training/skill, and are feasible.
  - Dependency evaluation
    - Identification of multiple human actions in an accident sequence or cutset be identified, assessment of degree of dependency, and calculation of a joint HEP.
  - Uncertainty analysis
    - Development of a representation of confidence in state of knowledge about parameter values and models used in constructing PRA

Recovery, Dependency & Uncertainty Analyses
Update Summary

- These were formerly independent chapters of the Guidelines document but have since been consolidated as subsections of Chapter 6
- Recovery and Uncertainty chapters have been significantly changed based on public review comments
- Discussions have been pared down to essentials and now refer to other Guidelines chapters or sources for details

Recovery at the Cutset Level

- PRA Standard definition – "Restoration of a function lost as a result of a failed system, structure, or component (SSC) by overcoming or compensating for its failure. Generally modeled by using HRA techniques."
- Adding cutset level recovery actions is common practice in PRA
- Credits other reasonable actions the operators might take to avoid severe core damage and/or a large early release that are not already specifically modeled

- Corresponding PRA Standard SRs: Part 4, HRA-D1 and –D2

Recovery Actions

Relaxation from original 6850 guidance

- Reconsider Internal Event PRA assumptions (e.g., HRA recoveries of systems or components previously assumed failed)
  - re-evaluate WHY the component was assumed failed for internal events. If it was for conservatism, then may want to consider it for fire HRA
- Non-proceduralized HFEs can be credited, provided they meet the requirements of ASME/ANS SR HRA-H2
  - operator training includes the action, or justification for lack of procedures or training is provided
  - "cues" (e.g., alarms) exist to alert the operator to the recovery action
  - attention is given to the relevant PSFs
  - there is sufficient manpower to perform the action

Recovery Actions

Not to be Credited (per NUREG/CR-6850 [EPRI 1011989])

Actions should not be credited as recoveries that:

- require significant activity and/or communication among individuals while wearing SCBAs (unless SCBAs contain internal communication devices)
- require performing numerous and strenuous actions wearing SCBAs
- require operators or other personnel to travel through fire or areas where fire effects (e.g., smoke, heat) are severe
- involve restoring systems or equipment damaged by fire
- have insufficient time available

Recovery Analysis

Update Summary

- Cut down to only one page of material in response to public comments
- Removed extraneous discussions of intra-HFE recovery
- Clarified that analysis process is similar to that for other fire HFEs, so now refers to other sections on Feasibility Assessment and Quantification
- Noted that recoveries can be modeled in fault trees, event trees, or as cutset events, so incorporation into Fire PRA Model is project-specific

Dependency Analysis

Contents Summary

- For Fire PRA, dependency analysis is performed in combination with NUREG/CR-6850 (EPRI 1011989) Task 11, Detailed Fire Modeling and finalized as part of Task 14, Fire Risk Quantification
- Focuses on post-initiator HFEs occurring in the same cutset (i.e., pre-initiator HFEs are not affected by fire context)
- Tasks are to:
  - Identify combinations of multiple operator actions in fire scenario (**regardless if screening, scoping or detailed quantification**)
  - Evaluate dependencies within scenario
  - Incorporate dependency evaluation into Fire PRA model

Dependency Analysis

Basic Dependency Rules

- Dependence impact is one-directional in chronological order
- The THERP positive dependence model is adopted, i.e., failure of an event increases the probability of failure of a subsequent event
- The first HFE in a sequence is always independent
- In a chronological sequence, an HFE depends only on the immediately preceding HFE (given no common cognitive element)
- An HFE is independent of an immediately preceding success

Dependency Analysis

THERP Dependency Formulas

Dependence Level	Equation	Approximate Value for HEP < 0.01
Zero (ZD)	HEP	HEP
Low (LD)	(1+19 X HEP) / 20	0.05
Medium (MD)	(1+ 6 X HEP) / 7	0.14
High (HD)	(1 + HEP) / 2	0.5
Complete (CD)	1.0	1.0

Dependency Analysis

Levels of Dependence

- **Dependency Factors**
  - Same Crew
  - Cognition (cues/procedure)
  - Simultaneity
  - Resources
  - Location
  - Timing
  - Stress

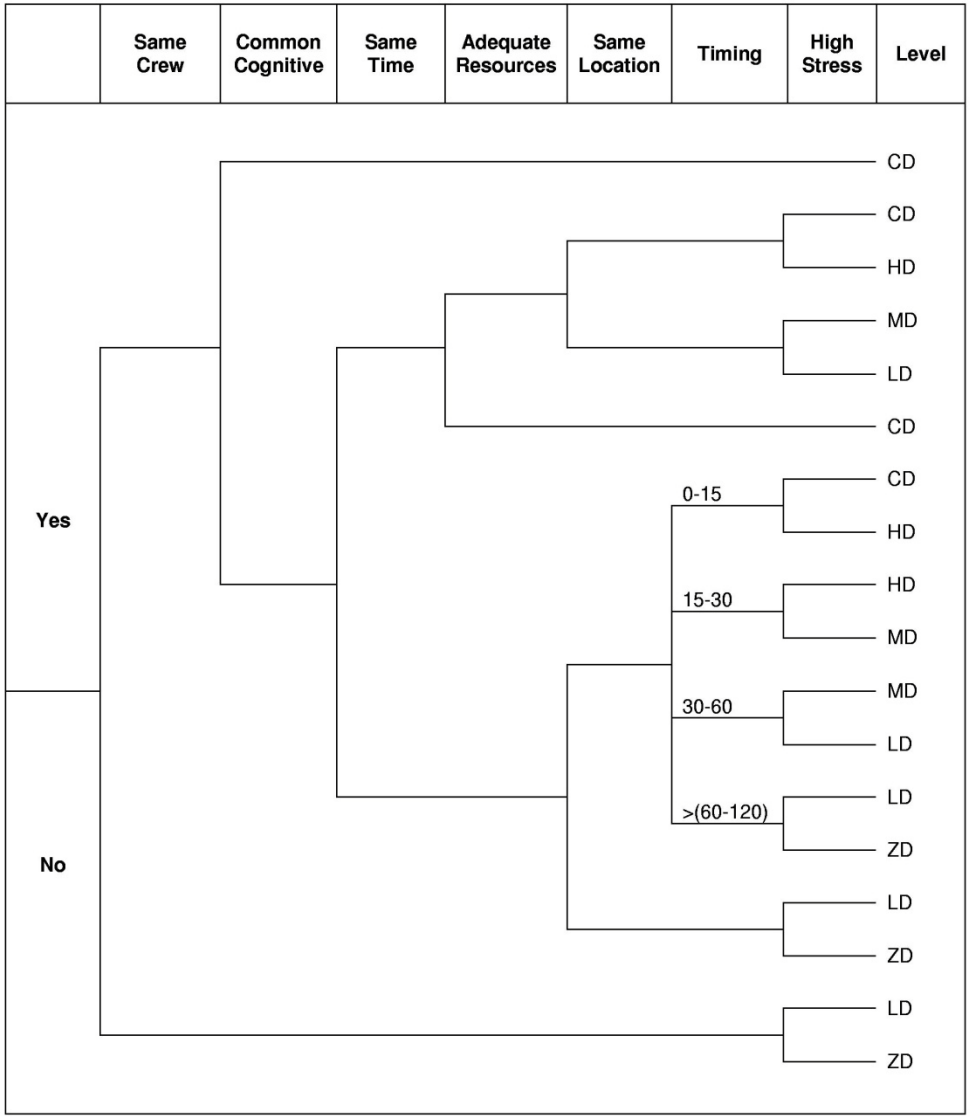


Figure 1: HRA Dependency Rules for Post-Initiator HFEs

ATHEANA Consideration of Dependency

- Unsafe Action (UA): Actions inappropriately taken (~ EOCs), or not taken when needed (~ EOOs), by plant personnel that result in a degraded plant safety condition
- In ATHEANA, the potential for multiple UAs contributing to a particular HFE is considered
- Modeling and analyzing at the UA level provides the means to explicitly investigate the potential impact of different UAs on the plant response, as well as on other human actions
- ATHEANA considers dependency when there is a significant perceived dependency between a particular UA associated with the HFE and some other human failure modeled in the PRA (either upstream or downstream in the chain of events depicted by the PRA sequence)

Dependency Analysis
Update Summary

- Added the following points:
  - Dependency assessment of the applicable HFEs in the Internal Events PRA should be performed to ensure that dependencies are accounted for in the fire PRA
  - Potential dependencies created either by the fire effects or the associated introduction of new HFEs into the model also need to be addressed
  - New fire HFEs added to the model should be evaluated to ensure that any strong dependencies have been addressed during screening, so that accident sequences/cutsets are not artificially removed because of multiplying many supposedly independent HEPs together

Uncertainty Definitions
per the PRA Standard

- Uncertainty in the context of PRA and HRA is defined as the representation of the confidence in the state of knowledge about the parameter values and models used in constructing the PRA
- Uncertainty analysis: the process of identifying and characterizing the sources of uncertainty in the analysis, and evaluating their impact on the PRA results and developing a quantitative measure to the extent practical
- Guidance now available via NUREG-1855 and EPRI 1016737 on parameter and modeling uncertainties in PRA

Uncertainty Analysis

Qualitative Issues Contributing to FHRA Uncertainty

- Operators dealing with fire scenarios may use multiple Emergency and Abnormal Operating Procedures (EOPs and AOPs) at the same time to deal with multiple failure conditions, such as loss of inventory and loss of heat sink due to electrical cable failures
- In case of fire, the MCR instrument response can degrade the flow of information to the operators
- Procedures dealing with fire are accurate in addressing Appendix R concerns, but can be complex for specific fire areas and may require some counterintuitive steps for the operators

Uncertainty Analysis
Update Summary

- Confined discussion to the following points:
  - For fire HRA, uncertainties are addressed in the same manner as for internal events HRA
  - The HRA should characterize the uncertainty in the estimates of the HEPs consistent with the quantification approach, and provide mean values for use in quantification
  - In fire HRA, key assumptions may include timing or selections of performance shaping factors
  - References for internal events HRA uncertainty also apply to fire HRA

Uncertainty Analysis References

- NUREG-1855, “Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making,” March 2009
- EPRI 1016737, “Treatment of Parameter and Model Uncertainty for Probabilistic Risk Assessments,” December 2008
- NUREG-1880, “ATHEANA User’s Guide,” June 2007
- EPRI 1009652, “Guideline For Treatment of Uncertainty In Risk-Informed Applications,” December 2005
- NUREG-1792, “Good Practices for Implementing Human Reliability Analysis (HRA),” Sandia National Laboratories, 2005
- NUREG/CR-1278, "Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications," (THERP) Swain, A.D. and Guttmann, H. E., August 1983

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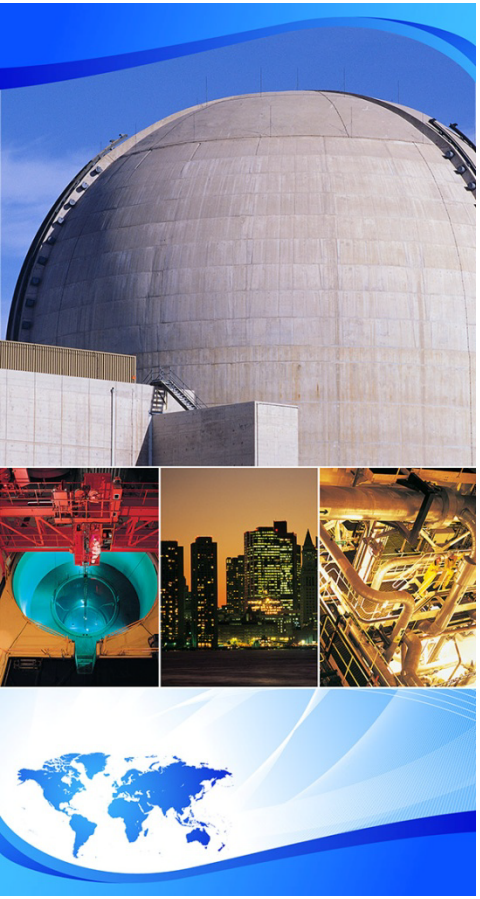

EPRI/NRC-RES FIRE HRA GUIDELINES

Project Status and Path Forward

Susan E. Cooper (NRC/RES) and Stuart Lewis (EPRI)

ACRS PRA Sub-Committee Meeting
April 20, 2011
Rockville, MD

A Collaboration of U.S. NRC Office of Nuclear Regulatory Research (RES) & Electric Power Research Institute (EPRI)

Fire HRA Project Status

- Review, testing, and public comments, e.g.,:
  - Peer review: June 2008
  - Testing at 2 plants: Summer/Fall 2008
  - Review by NRR & NRO
  - Piloting by PWR Owner's Group: Summer 2009
  - Public comments on December 2009 draft report (March 2010)
  - Feedback on trial use by authors
- Various revisions to report:
  - First integrated draft: May 2008
  - Revised draft: April 2009 (based on peer review & testing)
  - Issued for public comment: December 2009
  - April 2011 draft for ACRS review
- Publication of final report: Summer 2011

Fire HRA Project Status (continued)

- Joint EPRI/NRC-RES Fire PRA Training
  - ½ day, “for information only” presentation on fire HRA (June/October 2009)
  - Development of a new “track” for fire HRA in EPRI/NRC Fire PRA Course (Summer 2010)
  - Full-track, Fire HRA Training presented (September and October 2010)
  - Full-track, Fire HRA Training to be repeated in Fall 2011 (August and November 2011)

Fire HRA Guidelines Path Forward

- We expect the final Fire HRA Guidelines report to be issued by Summer 2011.
- It is anticipated that this guidance will be used by the industry as part of transition to NFPA 805 and possibly in response to other regulatory issues.
- This is the first report addressing fire-related HRA for fire PRA that goes beyond the screening level.
- As the methodology is applied at a wide variety of plants, the document may benefit from future improvements to better support industry-wide issues being addressed by fire PRA.

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