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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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RELIABILITY AND PRA SUBCOMMITTEE

+ + + + +

MONDAY

OCTOBER 18, 2010

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ROCKVILLE, MARYLAND

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The Subcommittee convened at the Nuclear
Regulatory Commission, Two White Flint North, Room
T2B3, 11545 Rockville Pike, at 1:00 p.m., John W.
Stetkar, Chairman, presiding.

SUBCOMMITTEE MEMBERS PRESENT:

JOHN W. STETKAR, Chair

DENNIS C. BLEY

MICHAEL T. RYAN

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1 NRC STAFF PRESENT:

2 JOHN LAI, Cognizant Staff Engineer

3 GIRIJA S. SHUKLA, Designated Federal
4 Official

5 SUSAN E. COOPER, RES/DRA

6 Y. JAMES CHANG, RES/DRA

7 ERASMIA LOIS, RES/DRA

8 CHRISTIANA LUI, RES/DRA

9 SEAN PETERS, RES/DRA

10 NATHAN SIU, RES/DRA

11
12 ALSO PRESENT:

13 VINH DANG, PSI, SWI

14 JOHN FORESTER, SNL

15 STUART LEWIS, EPRI

16 ALI MOSLEH, University of Maryland

17 JOHANNA OXSTRAND, INL

18 GARETH PARRY, ERIN

19 APRIL WHALEY, INL

AGENDA

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P R O C E E D I N G S

12:58 p.m.

1
2
3 CHAIRMAN STETKAR: The meeting will now
4 come to order. This is a meeting of the Reliability
5 and PRA Subcommittee. I'm John Stetkar, Chairman of
6 the Subcommittee meeting. ACRS members in attendance
7 are Mike Ryan and hopefully Dr. Dennis Bley will join
8 us.

9 Mr. Girija Shulka of the ACRS staff is the
10 designated federal official for this meeting. The
11 purpose of this meeting is to discuss the status of
12 the Human Reliability Analysis Methods Development, as
13 part of our continuing interactions under SRM M061020
14 in November of 2006. We'll hear presentations from
15 the NRC staff and their contractors.

16 We've received no written comments or
17 requests for time to make oral statements from members
18 of the public regarding today's meeting, but I
19 understand that a representative from EPRI may want to
20 add some comments at some point.

21 MR. LEWIS: Yeah. I do have a few brief
22 things to say.

23 CHAIRMAN STETKAR: Good. So we'll make
24 sure we have time allocated for that. The entire
25 meeting will be open to the public. The Subcommittee

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1 will gather information, analyze relevant issues and
2 facts and formulate proposed positions and actions as
3 appropriate for deliberation by the full committee.

4 The rules for participation in today's
5 meeting have been announced as part of the notice of
6 this meeting previously published in the *Federal*
7 *Register*. A transcript of the meeting is being kept
8 and will be made available as stated in the *Federal*
9 *Register* notice.

10 Therefore, we request that participants in
11 this meeting use the microphones located through out
12 the meeting when addressing the Subcommittee.
13 Participants should first identify themselves and
14 speak with sufficient clarity and volume, so that they
15 may be readily heard.

16 We will now proceed with the meeting.
17 Christina, do you want to say anything?

18 MS. LUI: Okay. Chris Lui, Director of
19 the Division of Risk Analysis, Office of Nuclear
20 Regulatory Research. As John has indicated at the
21 beginning, that the subject today is to address a
22 staff requirement memorandum issued in November 2006.

23 That particular staff requirement memorandum or
24 notice of SRM essentially, in a funny way, that was
25 issued to ACRS by the SRM. It actually indicated that

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1 the SER should work with the staff to address these
2 particular issue.

3 So even though the SRM was in place in May
4 2006, because resource considerations from both sides,
5 that really did not start tackling this issue or
6 planning for the current study until late 2008,
7 beginning of 2009.

8 For example, we were at that particular
9 time that we were focusing on the empirical study, the
10 international empirical study that's coming to a
11 conclusion now, so that we will be able to really
12 start more systematically addressing a lot of the
13 research topics in HRA.

14 So while the SRM explicitly passing both
15 ACRS and the staff on the HRA model and human
16 performance issues, we do appreciate the committee's
17 interest and input on the work. Clearly today that is
18 a work in progress, given that we are -- we really
19 started working on these issues just about a year ago.

20 And because the SRM is passing both the
21 ACRS and staff, in consultation with the committee, we
22 plan to have a series of three to four meetings, more
23 in the form of workshops in the next 12 months or so.

24 That way, you will really facilitate the working
25 together and looking for solutions together type of

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1 interaction.

2 The materials that we have prepared for
3 today's meeting are largely based on the interactions
4 that we had back in April this year. In addition to
5 addressing the questions that we have heard and you
6 have asked us to address, we also want to share more
7 complete thought process with you right up front, so
8 it's more transparent to you regarding all the
9 considerations that have gone into the work so far.

10 As I've indicated, even that it's a work
11 in progress, we value your input and especially those
12 areas where we have identified as challenging topics
13 that we are currently tackling.

14 At the end of today's meeting, we'll visit
15 what we should be focusing on for the next series of
16 interactions, and we also want to acknowledge that we
17 do have a lot of collaborations with industry.

18 You see the EPRI representative here, and
19 we also have international participation in the work
20 that we're doing. Clearly, we also are supported by
21 our very capable contractors. So with that, we'd like
22 to turn the table to you, right.

23 MR. LEWIS: My name is Stuart Lewis. I'm
24 with the Electric Power Research Institute. I'm the
25 program manager for Risk and Safety Management at

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1 EPRI, and that's the program in which all PRA or
2 related activities are undertaken.

3 I wanted to say just a couple of quick
4 words, since this is really the first opportunity I've
5 had to give sort of an EPRI perspective on what our
6 involvement is in this project. We are, we have been
7 essentially the representatives of the industry in
8 terms of participating with the NRC as a stakeholder
9 in the development of or the adaptation of HRA methods
10 to satisfy the SRM.

11 I wanted to very quickly give you a little
12 bit of perspective on where we are, from an HRA
13 research perspective at EPRI. So if you could bear
14 with me, I'll do something very quick.

15 But EPRI did back in the -- especially in
16 the 1980's through the early part of the 1990's,
17 engage in quite a bit of developmental work related to
18 methods for human reliability analysis. The methods
19 that were developed back in the late 80's and early
20 90's are still in widespread use within the nuclear
21 industry, even though they're a little bit long in the
22 tooth.

23 These methods included the SHARP 1
24 framework, which describes what constitutes a human
25 reliability analysis, and identifies the

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1 characteristics of a human reliability analysis,
2 including what, at least are the rudimentary aspects
3 of a qualitative analysis.

4 Then we have two EPRI-developed methods
5 that are still in use for doing further development of
6 human failure events and quantification of those
7 events. Those are the time reliability correlation
8 that you're familiar with, the human cognitive
9 reliability with operator reliability experiments,
10 very conveniently named Method N.

11 It's compliment or cause-based decision
12 tree method. The cause-cased decision tree method was
13 developed primarily because it was recognized that
14 when time wasn't a predominant factor in determining
15 human reliability, other causes need to be addressed.

16 So that this method was put together. Dr. Parry was
17 a primary author of that method back in the early
18 1990's.

19 We really haven't done a lot of work on
20 developing new methods since that time. For about the
21 past ten years, the primary effort related to human
22 reliability analysis is that EPRI has been in the
23 assembly of a tool that we call the "HRA calculator."

24 It's a software tool that's meant to help facilitate
25 performing a human reliability analysis.

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1 Particularly, it was put together because
2 there was a recognition that you can give the same
3 human failure event to six different HRA analysts and
4 get at least six different answers when they analyze
5 the event. So we hope that we can codify the methods
6 to some extent, and eliminate to some degree the
7 variability among analysts addressing essentially the
8 same problem.

9 I think we've been largely successful in
10 that endeavor at least, that we haven't certainly
11 eliminated variability among analysts or among people
12 that probably view this somewhat differently. But we
13 have certainly reduced it substantially and worked
14 more toward a consistent and repeatable process in
15 performing HRA.

16 The HRA calculator actually includes a
17 number of different methods for human reliability
18 analysis. It allows the analyst to address both pre-
19 initiator and post-initiator human failure events.
20 Nothing new on the pre-initiator side. It still has
21 elements of the technique for human error rate
22 prediction, and its simplification that was developed
23 for the ASEP program back in the mid- to late-1980's.

24 The two EPRI methods I just mentioned, the
25 HCR/ORE time reliability correlation and the cause-

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1 based decision tree method are the primary tools used
2 for evaluating the cognitive phase of a post-initiator
3 event, and for evaluating execution. The tool does
4 implement again elements of THERP.

5 So although the methods that are
6 incorporated in the HRA calculator are not very new,
7 the tool itself continues to evolve, continues to be
8 improved in terms of providing additional guidance to
9 users, providing additional capabilities to take more
10 specific aspects into account, and again, continuing
11 to work toward a practical and repeatable process.

12 As it stands right now, the HRA calculator
13 is in use at every nuclear utility in the United
14 States. That's not to say necessarily that if you
15 went to look at each PRA in the country, its human
16 reliability analysis would necessarily have been done
17 using the HRA calculator.

18 But all the utilities now have it. It's
19 available by subscription to EPRI. It's not a free
20 product. You have to pay for it, even if you're an
21 EPRI member. But everybody has it, and presumably
22 those who have not yet implemented it are in the
23 process of implementing it.

24 So it is a -- despite the fact that the
25 methods it incorporates are somewhat long in the

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1 tooth, as I said, it is very widely used and widely
2 accepted among the nuclear industry. We think the
3 methods are pretty well understood by the users at the
4 current time.

5 But we also recognize, looking forward,
6 that these methods are aging, that there hasn't been a
7 lot of review or updating of the methods themselves in
8 a number of years now. In fact, some aspects of
9 what's in the HRA calculator, some of the EPRI methods
10 were set up with the expectation that more work would
11 be done in the future, that more refinement and
12 updating would be done. But in fact, very little of
13 that's been done over the years.

14 So our motivation for being involved in
15 this process is really to take advantage, as fully as
16 we can, of the work that's being done under the
17 auspices of this SRM response. We think it's feasible
18 to work toward an HRA model that has a stronger
19 psychological underpinning than the models that we
20 have now, and that's certainly been a major effort of
21 this response to date.

22 We also think that having a more
23 comprehensive understanding of what can bring about a
24 human failure event is worthwhile and something that
25 we should try to incorporate in the way we do

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1 business. We also think that it's time, possibly past
2 time that we should be thinking about updating the way
3 we do quantification in HRA.

4 That's not the say that we think that the
5 methods that we have now are not serviceable. We
6 think that we're getting useful results and insights
7 on the way we do HRA right now. We think that we're
8 doing effective jobs in applying these methods in the
9 context of PRA, as it's used in a variety of
10 applications these days. But we do think that it
11 would be wrong of us not to think about what we could
12 do to make these tools better going forward.

13 So what we hope that we get out of this,
14 what I guess we're calling now a hybrid model or
15 effort for HRA, from our perspective, we have now a
16 set of tools that we think are very practical for the
17 analysts to implement. I think that's been a very
18 positive development of HRA.

19 We no longer rely on a fairly small set of
20 HRA gurus to do human reliability analysis. Through
21 the use of the HRA calculator, we've been able to
22 socialize a broader set of PRA engineers in the use of
23 some of the methods, and we think that's a positive
24 thing.

25 I mean it makes HRA a more integral part

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1 of the PRA in general, which has not always been the
2 case over the years. But we don't want to lose that
3 practical nature of performing the HRA. So that's one
4 of the things that we will certainly promote in our
5 interactions on this project.

6 We also don't expect that this is going to
7 be a method that will require substantial
8 restructuring of PRAs. This again was a, I guess ties
9 back to being a practical aspect of what we're talking
10 about here. There's an awful lot of effort that's
11 been invested in developing very detailed, very
12 extensive PRA models, and we think at this point that
13 the gain that might be achieved by completely
14 restructuring the model to adapt to a new HRA method
15 is fairly limited. So we would hope that what comes
16 about as a result of this project is something that
17 will be fairly immediately useful, without having to
18 start from scratch with our PRA models.

19 Going back to the objectives that I
20 mentioned before, the HRA calculator itself. We
21 certainly hope that we achieve a set of methods or
22 models that are used as repeatable by different
23 analysts, we achieve a level of consistency in the
24 results and insights that are obtained that are
25 commensurate with what we think we see currently using

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1 HRA tools.

2 So there are other things I hope, I think
3 we hope to see down the road. But these are probably
4 the major points that we're focusing on, in terms of
5 our interactions on this project at the present time.

6 With that, I thank you for giving me a chance to say
7 a few words about that.

8 CHAIRMAN STETKAR: Since you're here, I
9 can put you on the spot. What so far is EPRI's role,
10 you know, as an active participant in this project and
11 are you attending methods and providing insights, or
12 do you have tasks that you're working on?

13 MR. LEWIS: I think our involvement has
14 been a little bit uneven since the project started.
15 Early on, one of our contractors, Jeff Julius, was
16 fairly heavily involved.

17 Early in the process, and this was before
18 I actually joined EPRI, let alone became involved in
19 this project, much of the effort that was spent on
20 this project was partly the -- are now coming from the
21 Halden research activities, in which it was noted that
22 a stronger approach to qualitative analysis was
23 important for an effective HRA, just worked with the
24 NRC and their contractors to help to refine what that
25 meant, and look going forward.

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1 Starting about a year ago, I became
2 somewhat involved in the project, starting to learn
3 what was going on. I tried to understand how the
4 project moved from what I saw in the SRM to what
5 looked like the development of a fairly new HRA
6 method, which wouldn't have been an obvious outcome to
7 me in looking at the SRM. But I think I understand
8 how things have evolved there, and we're going to hear
9 more from John, as I understand today, about that.

10 But we have tried to take a more active
11 role in some of the technical elements of the work as
12 well. In particular, bringing Gareth on board to help
13 out has been a significant asset for us. He's been
14 heavily involved in one aspect in particular, in a
15 number of aspects, but one in particular that's been
16 going on for a few months now.

17 And that is that one of the approaches we
18 decided back in April to take, again moving back to
19 trying to find a practical means to bring all this
20 stuff together, was to use the cause-based decision
21 tree method as a starting point, and we if we couldn't
22 fold much of the research that was being done on the
23 psychological side into the cause-based decision
24 trees, perhaps identify areas where they could be
25 strengthened, modified and possibly where we need new

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1 trees, that sort of thing.

2 Gareth has been working in that area quite
3 heavily. He's also worked with some of the Sandia and
4 INL folks to identify what you'll hear about in terms
5 of proximate causes that might be reflected in those
6 trees, and going back to the factors that could
7 influence performance by the operators. So --

8 CHAIRMAN STETKAR: Since -- I'll interrupt
9 you for a second. Since you have produced Gareth, is
10 he a contractor to the staff, or are you a contractor
11 to EPRI?

12 MR. LEWIS: EPRI.

13 CHAIRMAN STETKAR: Thank you. He's
14 sitting in the corner. It wasn't clear.

15 (Laughter.)

16 MR. LEWIS: You know, I think in Gareth's
17 case, that could have worked either way. I think that
18 one thing you can be sure of with Gareth is you're
19 going to hear what he thinks, and it wouldn't change
20 whether he was working for the NRC or EPRI.

21 CHAIRMAN STETKAR: That's okay. Just
22 curious.

23 MR. LEWIS: But I think his advice can be
24 used and invaluable as his inputs to the NRC staff
25 have been, through the time we've been working

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1 together on this.

2 CHAIRMAN STETKAR: Thanks.

3 MEMBER BLEY: Mr. Chairman, I apologize
4 for being late. I was delayed somewhere in the hall.

5 But I should mention, before we go forward, that I am
6 still a contractor to staff on some of the work we do
7 in this area. So in some areas, I have a conflict and
8 I want to offer clarification.

9 Perhaps in some others I'm not involved in
10 any way, but just as a member, I'd be very careful.

11 CHAIRMAN STETKAR: Thank you for being
12 careful.

13 MEMBER BLEY: You can ask him things if
14 you want.

15 CHAIRMAN STETKAR: Okay. With that,
16 Erasmia, I guess it's yours.

17 DR. LOIS: Thank you very much, and thanks
18 to the Subcommittee for arranging for us to come and
19 talk to you several times, and work with -- I think
20 we've worked together on the SRM. My presentation
21 will be very high level here today, because Dr. Mosleh
22 and I talk to them mostly, and I talk to them as
23 needed.

24 So quickly, we'll cover the outline, how
25 we conducted the SRM, what is our approach and aim at

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1 the moment, and then the interactions we're going to
2 have with the SRA and what would be the objective of
3 today's meeting, who's involved in the project,
4 challenges, scheduling and what would be anticipated
5 routes.

6 I'm not going to read the SRA again for
7 you, but I'd like to note, like Christiana did, that
8 we have had several interactions with the ACRS,
9 actually when the SRM was received by the ACRS.

10 We were invited and also external
11 stakeholders and EPRI came along and were involved in
12 collaborative work, and proposed a plan which we
13 approved and but for several reasons, we didn't start
14 to work until May 2008.

15 The RES has delayed where we work
16 collaboratively with EPRI, and we're looking forward
17 to ACRS input into the work.

18 How we interpret the SRM. The SRM used
19 the word "model." We use it more, we interpret it in
20 a more general sense method. So then we believe that
21 we -- SRM is asking to, indicating that a single
22 method is the most desirable, and if more than one
23 should be used, then it should be justified why, which
24 method should be used for which applications, and in
25 that case, we should develop implementation-specific

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1 guidance for the specific applications, and
2 desirability for convergence of NRC and industry
3 practices.

4 So we tried to achieve this, to establish
5 what we call a consensus approach, by developing a
6 quote-unquote "single, high-level method" or factor,
7 which would ensure consistency throughout the analysis
8 process, and be sufficient in general to support
9 application for different domains, and here I have
10 some examples of our shut down, external hazards,
11 Level 2 analysis.

12 All of these different domains would
13 potentially require adaptation of the overall
14 structure to their specific needs. Also, we hope that
15 we'll gain acceptance from PRA, the HRA and human
16 factors experts, that HRA requires support from both
17 PRA expertise and human performance expertise. This
18 is a very challenging task for us.

19 We start out with focusing on internal
20 event analysis, and converge with EPRI on that
21 specific area, and then expand to more scenarios and
22 in addition to one of the needs is to be able to
23 develop a screening or scoping analysis for -- to
24 address practicality aspects of some of the various
25 users.

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1 So in April 7, 2010, we met with the
2 Subcommittee, in which we presented a hybrid approach,
3 and ACRS members posed many questions, which are
4 summarized as follows:

5 Why not use an existing method? Is it a
6 hybrid, why do we propose? How the initial different
7 domains will be handled? Would the approach be
8 suitable for regulatory applications with using
9 existing PRAs? What could be the impact on the
10 existing PRAs? Would it be suitable for new PRAs?

11 The Subcommittee expressed the need to
12 understand the various facets of the approach,
13 recognizing that there are many facets, and of course
14 how the quantification is going to be handled, and how
15 we will obtain user buy-in. In general, those are the
16 concerns that we've heard, and through informal
17 interactions, we established a plan to have of part
18 of the Subcommittee, so that the members develop, have
19 the opportunity to develop a more in-depth
20 understanding of the technical work, and provide the
21 input, and today is the first of those workshops.

22 So what we are going to do today,
23 hopefully we'll address what I had before, Items 1
24 through 5, which show the rationale leading to the
25 proposed approach. Discuss Quantification 6, which

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1 relates to the building of technical bases for human
2 reliability using results and inputs from cognitive
3 research and expertise, what we call the mid-layer
4 model.

5 So that is going to be discussed in
6 detail, if not the first half of the workshop, the
7 second half.

8 Also, we have, we're going to present
9 another view by, of the current thinking to address
10 quantification, and recognizing that quantification is
11 the area that has several facets. We're going to
12 weigh -- at the moment, we're thinking of a short-term
13 or longer-term approach.

14 Only the current thinking for short-term
15 perspectives are going to be discussed in the
16 discussion of -- also I would like to point out that
17 the discussion of quantification is in very early
18 stages. We will probably present that aspect.

19 We would like to obtain feedback and input
20 from the committee members, and plan for the next
21 meeting, topics and Schedule.

22 So who's involved? As noted, collaborate
23 with EPRI. RES staff directly contribute to the work,
24 and we have NRC-sponsored organizations that are noted
25 here.

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1 The point that I would like to note that
2 this is an interdisciplinary expertise of PRA, HRA,
3 nuclear power plant operations, people who are working
4 in the area and also human factors and cognitive
5 psychology experts. Not all of this are present here
6 today, but actually it's a very big group, about 15
7 people.

8 What are our challenges? Well, because
9 challenges are the high-level concepts are appealing.

10 However, when you get to the details, a lot of issues
11 are showing up and need to be resolved. As a result
12 of that, we have an issue to effectively communicate
13 our viewpoints amongst ourselves and we achieve
14 consensus.

15 As I noted, the project team is comprised
16 of recognized experts in different disciplines, so
17 it's not the easiest work that's being done here.
18 Also, get ACRS input and buy-in, and also facilitating
19 understanding and acceptance by the larger community,
20 both NRC and the industry.

21 So the schedule, quarterly work meetings
22 with the ACRS. We hope that the technical basis will
23 be ready for public view by September 11th. As the
24 same time, I note here a users guide, and this has to
25 do with what we call before practicality. The

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1 technical basis has been intended to be used as the
2 basis for the overall HRA approach.

3 However, we believe that we can encompass
4 the -- let me rephrase. We don't believe that every
5 HRA analyst needs to be a cognitive psychologist to do
6 the work.

7 So we hope that we'll develop tools,
8 technical tools, so that the method is being applied
9 in a more -- at a higher level, and yet provide enough
10 basis and be substantial enough so that the analyst
11 has a good understanding of what is being done and how
12 to do it.

13 Probably we'll be able to also have this
14 methodology ready for evaluation for public review by
15 September. A final report will be ready by 2012.

16 CHAIRMAN STETKAR: Erasmia, unless you're
17 going to go into more details on this schedule, if you
18 want to leave it to the end, we can also do it then.
19 I'm trying to understand a little bit.

20 I think I understand the public or the
21 technical basis of that one entailed. Are you
22 proposing to have pilot applications of the
23 methodology in the 2011-2012 time frame, or have you
24 thought that --

25 DR. LOIS: Actually, we're hoping that

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1 we're doing it, we'll do in a parallel fashion. As
2 part of our overall, of the -- for both approach is
3 being tested or applied, currently with the -- what we
4 call the U.S. nuclear power plant empirical study.
5 But you're right, it may be --

6 CHAIRMAN STETKAR: Well, I'm talking not
7 just piecemeal parts, in terms of trying to estimate
8 human error probabilities, if you think of that one
9 piecemeal. I'm talking about an integrated framework,
10 in other words, to show how the method would indeed
11 support an actual human reliability analysis, not
12 necessary, you know, 25 actions, but two or three
13 different types of actions within the context of an
14 existing PRA model.

15 Is there anything -- if you want to
16 discuss this later in the afternoon in terms of going
17 forward, we can do that.

18 DR. LOIS: Yes. Let's discuss that later,
19 but --

20 CHAIRMAN STETKAR: But I'd like to a
21 little bit understand whether the schedule has any
22 thought of that type of activity.

23 DR. LOIS: It does have. We hope that
24 we'll do everything in parallel, but currently I'm --

25 CHAIRMAN STETKAR: But where in parallel

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1 will that type of --

2 MS. LUI: Maybe I can give a little more
3 insight into the research. Part of the -- another
4 topic that is going to be coming in front of the
5 Subcommittee next month will be the proposed new Level
6 3 PRA. So part of the planning is that we're looking
7 at whether this particular method will be ready in
8 time.

9 If the Commission say that we should go
10 forward and do the pilot on a new Level 3 PRA, is to
11 actually try these method out in the new Level 3 PRA,
12 perhaps in parallel to some of the more established
13 methods.

14 So we are actually looking at a lot of
15 different possibilities, to allow us to actually use
16 this in a very practical and integrated fashion.

17 CHAIRMAN STETKAR: Okay. I guess I can
18 understand that, looking forward. I mean there's some
19 uncertainty about the scope and schedule for that
20 activity. I'm looking more backwards, in the sense
21 that Stuart was talking about, that right at the
22 moment, we do have a large number of PRAs, with
23 varying degrees of sophistication and level of detail.

24 But we do indeed have a large number of
25 PRAs, and a large number of human actions that have

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1 been defined with varying degrees of clarity and
2 description, but defined. It certainly would be
3 useful to see how well anything that comes out of this
4 project dovetails with all of those, because in fact,
5 you know, we as an agency are the principal using
6 those make regulatory decisions, and will continue for
7 the existing fleet to use those going forward.

8 So let's talk more about this again. I
9 want to make sure we have enough time to do all the
10 presentations, because I suspect we'll have quite a
11 bit of discussion on some other topics.

12 DR. LOIS: So to close my presentation,
13 what we hope is that the methodology to be developed
14 will support several activities such as human
15 evaluation, guidance for staff review of risk
16 confirmed license requests, and for current plans and
17 future plans, and of course would be used for new PRAs
18 and especially Level 3, and industry applications.
19 Okay, so with that, we'll close.

20 MR. FORESTER: Okay. Well, I'm John
21 Forester, and while she brings that up, I'll just
22 mention that myself and Vinh Dang at the Paul Scherrer
23 Institute will sort of tag team on this presentation.

24 As you'll note in the title, we are moving
25 towards a hybrid. I think at some of the earlier

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1 meetings, we talked about, you know, concerning use of
2 the tool box or piecing different methods together and
3 so forth.

4 Now some of that may be necessary down the
5 road, but right now our goal is to come up with a
6 hybrid HRA approach. The objective of this is just to
7 inform on approach taken in response to the SRM
8 project.

9 There's an outline of the presentation.
10 Again, I'll actually just reiterate a slide there,
11 rather than put it up.

12 MEMBER BLEY: John?

13 MR. FORESTER: Yes. What's the
14 relationship between the project, NRC and Paul
15 Scherrer Institute in this? How has it been here? It
16 is an interested party or is there some kind of
17 agreement?

18 MR. FORESTER: As a contractor to Sandia.

19 MEMBER BLEY: Contractor to Sandia. Yes,
20 I didn't realize that. Thank you.

21 MR. FORESTER: Okay. Here's just an
22 outline. Again, I'll touch on the interpretation of
23 the SRM and sort of what we're focusing on, which
24 Erasmia has already mentioned that, and talked about
25 our initial process to address the SRM.

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1 What we want to do, you know, part of the
2 SRM directed that we do an evaluation of existing HRA
3 methods. Dr. Dang will give us the results of that
4 evaluation, and then talk about the implication of
5 those evaluations for the SRM project.

6 Then at the end, I'll give sort of an
7 overview of our current thinking on the hybrid
8 approach, and then Dr. Mosleh and Dr. Parry will end
9 up giving you more detail on some of the key pieces to
10 what we're doing.

11 Okay. So then this is a slide you've
12 already seen. Our interpretation again, in fact it
13 says in the SRM that probably a single method is going
14 to be the most desirable. So the notion is you have a
15 basic structure, a single method that can be
16 generalized in some way to most applications. And
17 again, there's a desirability for convergence between
18 the NRC and industry, in terms of the use of those
19 very methods. At times, in different kinds of
20 situations, different teams using different methods
21 will come up in different results.

22 That results in, you know, some degree of
23 conflict or trouble with understanding how to deal
24 with that problem. So if there's a convergence of
25 that and you're confident you have valid methods

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1 that's doing what you want them to do, then that would
2 be the ideal, it would seem.

3 And Erasmia already discussed the last
4 bullet, and I don't think we need to do anything more
5 on that.

6 Okay. So our initial process for
7 addressing the SRM. Initially, we did do a survey of
8 NRC staff, to see that, you know, what are they doing,
9 using the HRA for in terms of regulatory applications,
10 what kind of issues are they coming up with.

11 I think we discussed this at one of the
12 earlier meetings. But you know, again sometimes what
13 they find that is they're a method, the industry's
14 using a method and sometimes there's disagreement
15 possibly in terms of event evaluations.

16 Another point that they wanted to make is
17 they use simple methods that can be practically
18 applied is an important consideration, and that some
19 of the methods also are not being -- some of the
20 existing methods are not generalizing to some of the
21 other conditions, for example, the low power and shut
22 down and so forth.

23 So again, there is a need for methods that
24 can address these different domains. I think that was
25 --

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1 MEMBER RYAN: I guess I get the largest
2 for one question please.

3 MR. FORESTER: Yes.

4 MEMBER RYAN: On the second bullet,
5 desirability for convergence of NRC and industry on
6 HRA methods, is there any kind of analytical approach
7 for that like a certainty analysis or a variability
8 analysis among the models? I guess I'm asking a
9 question. If two models differ, there could be the
10 same answer, but within the variability of the models
11 that overlap for that reason, or they could be
12 different. How are you going to deal with
13 uncertainty, variability and true differences in these
14 sort of models? That's a great question, I guess.

15 MR. FORESTER: That is a great question.
16 But you know, you'd have to argue that if the methods
17 are valid. I mean certainly, there's going to be some
18 variability from time to time. But if just the
19 methods are generally valid, then they should be
20 getting the same general result.

21 MEMBER RYAN: I guess my basic question
22 is, and I can understand how you're going to have to
23 deal with that qualitatively, through extra
24 elicitation or other methods, you know, having the
25 right approach at the table. The other is is there an

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1 analytical component to that, where you do uncertainty
2 or a variability analysis or an outcomes analysis to
3 help you wrestle with that?

4 I ask that as a non-expert, but I am -- I'm curious.

5 MR. FORESTER: Sure, you would try and
6 track how the differences might have emerged,
7 according to the decisions made that led to those
8 differences, to try to get into this thing of why the
9 differences occurred.

10 MR. LEWIS: But if I could, Ricky, a
11 different interpretation of what -- I'm sorry. Stuart
12 Lewis.

13 CHAIRMAN STETKAR: No. As long as you
14 have a name tag, you're okay.

15 MR. LEWIS: Okay, okay.

16 CHAIRMAN STETKAR: Unless you've changed
17 your name, I mean it's just --.

18 MR. LEWIS: I'll try and avoid that. I
19 think ultimately what we were talking about in terms
20 of convergence was convergence on a single model, in
21 which case you wouldn't have --- the question of
22 variability among different models goes away. I mean
23 I think that's whole --

24 MEMBER RYAN: Yes, that's the end point.
25 But I guess I'm curious. Is there, you know, I can

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1 understand how you would converge on that by saying
2 well, this is the right model if I raise your hand,
3 and it's kind of an expert elicitation model that you
4 end up with.

5 The other is you could look at it
6 analytically. If you have three different models and
7 you enter analytic data into any one of those three,
8 are you going to get a different answer? So in that
9 case you could say that all three of the models give
10 you basically the same result. How do you end up with
11 one model is what I'm trying to --

12 MR. LEWIS: Again, I think it's going to
13 be a process of picking pieces out of different models
14 and some new things.

15 MEMBER RYAN: But by what measure?

16 DR. LOIS: We're going to address this
17 issue.

18 MR. LEWIS: We're going to talk about it.
19 We're going to talk about it.

20 MEMBER RYAN: Okay, that's coming up.
21 Great, I'll wait.

22 MR. LEWIS: We'll focus on that criteria.

23 MEMBER RYAN: Right.

24 MR. LEWIS: Right.

25 MEMBER RYAN: Okay. Thank you.

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1 MR. FORESTER: I'll go back one more. I
2 think I just -- we did the survey, and then most of
3 you are aware we had a workshop that involved NRC
4 staff, the laboratories, EPRI staff to sort of obtain
5 their views on what the path forward should be, and
6 there was one thing that came out, what I'll talk
7 about next, is the criteria that we should use to
8 evaluate the HRA methods. There was a general
9 consensus that we'd want to build on the existing
10 methods and experiences that we've had in performing
11 the HRA.

12 Okay. So here is just a summary of the
13 criteria that we wanted to review the methods against.

14 I'll go quickly through this. I'm sure it's nothing
15 new to most people, you know. We're interested in
16 validity, certainly content validity.

17 Are we measuring what we know is
18 important, based on what we know about HRA at this
19 point? We have a construct of validity, so we have
20 good underlying models. We're going to look at
21 psychological models as a big part of this. Do we
22 have accepted models that are relevant to the nuclear
23 power plant domain?

24 So obviously having a method that does a
25 valid analysis is important, and that's one of the

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1 criteria we compare against.

2 Also empirical validity. So how good are
3 the numbers that you get from HRA? What's the
4 empirical basis for those numbers. Obviously, there's
5 not a lot of empirical basis for most of the numbers
6 in human reliability analysis, but some of them
7 certainly have a better basis than others, and they're
8 certainly, you know, not to imply that we don't need
9 to develop better numbers and to use what data is out
10 there.

11 And one of the key things, of course, is
12 the consistency, the variability and the results, and
13 I'll talk about the empirical study a little bit. But
14 there's plenty of evidence that you find a lot of
15 variability in HRA methods. So we're interested in
16 what we see with the different methods in terms of
17 their variability.

18 Useability in resources, having a
19 practical tool is really important. So that's
20 something. Again, we wanted to look at the methods
21 with respect, and then look at issues, like what's the
22 scope of the different methods, and also whether they
23 have, you know, an installed base. Do we have a basis
24 from which to evaluate them in terms of their
25 application and their useability?

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1 So this is just sort of a general overview
2 of the criteria. Obviously, we can go with it. We
3 have a lot more detail than that coming out of the
4 meeting.

5 But so then to perform the HRA method
6 evaluation, we relied on several different inputs.
7 The NUREG good practices document, and the NUREG 1842,
8 where we took, I think, ten different methods or at
9 least nine different methods, and evaluated those
10 methods against the good practices, to see how it, you
11 know, what aspects of HRA they covered.

12 But in addition to that, at that time we
13 also did sort of theoretical scientific evaluation of
14 the methods that we were looking at. So again, we
15 wanted to examine their strength and weaknesses, and
16 what the underlying basis for the models were, and
17 that's documented in 1842, again for ten of more well-
18 known sorts of methods.

19 So that's sort of one approach, one type
20 of the inputs we're looking at. We also looked at
21 applications experience and practicality. The NRC
22 uses methods, the industry uses methods. So we have
23 information about experiences from using the different
24 kind of methods, and what kind of problems that people
25 have and so forth.

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1 And then finally we have the results from
2 the international studies. So we have also a
3 proponents-bases HRA method, evaluation approach.
4 Okay, so essentially different elements of what we're
5 going to do, what we used.

6 For those that may not be familiar, I
7 think we've talked about the international HRA
8 empirical study. But just as a reminder, you know, we
9 have simulator with the Halden Reactor Project, and
10 this was a large international effort, where we had 12
11 different organizations providing HRA teams, had 13
12 HRA methods or somewhere in those types of numbers.

13 Those HRA teams then would take their
14 method and they would look at the scenario. We'd give
15 them information about the scenarios that the crews
16 were going to be performing and what the human failure
17 would be, the conditions and so forth.

18 Then they had to predict crew performance,
19 and we had 14 crews performing those scenarios in the
20 simulator at Halden. And our goal was to assess the
21 strengths and weaknesses of the HRA methods, and
22 again, we have these predictive analyses, that we can
23 actually see how well the HRA methods performed versus
24 the crew data.

25 And another big goal is to, you know, try

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1 and identify the various, the sources of the
2 variability in the results. So if you see one HRA
3 method that's, you know, several methods come up with
4 this kind of an answer and others come up with a
5 different kind of answer.

6 We can actually then trace back and see
7 where the differences, where they occurred in terms of
8 the method application. What was it about the methods
9 that led to those differences?

10 And just while we're here, I'll just
11 mention a few of the major insights from the empirical
12 study. Again, we did see significant variability in
13 results across the different HRA methods. We had --
14 in one case, we had one method applied by two
15 different teams. We saw variability there too. One
16 thing, one of the main --

17 MEMBER BLEY: John, just a clarification
18 for the rest of the committee.

19 MR. FORESTER: Uh-huh.

20 MEMBER BLEY: You mean both quantitative
21 and qualitative results when you talk about results
22 here?

23 MR. FORESTER: Yes, I do. Thank you.
24 Yeah, they would --

25 MEMBER RYAN: Can you give an example of

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1 what you mean by "significant variability"?

2 MR. FORESTER: Sure.

3 DR. LOIS: We'll come to it.

4 MR. FORESTER: It's at the end of this
5 slide.

6 DR. LOIS: Vinh will talk about it or do
7 you want to talk about it.

8 MR. FORESTER: Well, if you just wanted to
9 see a picture of the variability, we have an example
10 of the data.

11 MEMBER RYAN: If it's coming up, that's
12 fine.

13 MR. FORESTER: Well, it's a backup slide
14 actually.

15 MEMBER RYAN: If you want to go do it now,
16 that's fine.

17 DR. LOIS: Yeah, go ahead.

18 MR. FORESTER: Yes, go ahead. Just jump
19 to the end. I think it made it to the last, one of
20 the last two slides, I believe.

21 CHAIRMAN STETKAR: John, the final report
22 is out on the Halden --

23 MR. FORESTER: We have two reports -- we
24 have one NUREG that's done. There's one of the Halden
25 work reports is almost finished. But we still have

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1 the overall final report to do.

2 CHAIRMAN STETKAR: Oh, it's still in
3 progress?

4 MR. FORESTER: It's still in progress.

5 DR. LOIS: Both or --

6 MR. FORESTER: Or we can do one -- this is
7 the loss of feed water. That's one example.

8 DR. LOIS: Okay.

9 MR. FORESTER: Now as Dennis pointed out,
10 we also looked at the qualitative analysis that was
11 done by the different teams, and we see obviously that
12 they were done to different levels.

13 (Simultaneous discussion.)

14 MR. FORESTER: And they would address
15 different things. So the result of the qualitative
16 analysis that used it as an input into the
17 quantitative analysis varied, and you can also see
18 here this shows the mean human error probabilities, or
19 the human error probabilities predicted by the HRA
20 teams for, what we have four of six different events.

21 Actually, there's only four different events in this
22 study.

23 The dots in there are the different HRA
24 HEPs. So for Event 1B, as in the loss of feed water
25 scenario, you can see that the box on the far left

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1 there says "predicted HEPs." That's the variability
2 and the preliminary probability.

3 MEMBER RYAN: And that's like an order of
4 magnitude and a half roughly.

5 MR. FORESTER: Right.

6 CHAIRMAN STETKAR: Those were all
7 characterized as mean values?

8 MR. FORESTER: Yes.

9 MEMBER RYAN: Okay, whatever that means --
10 .

11 MR. FORESTER: This actually was a little
12 tighter than what we saw in this steam generator 2
13 rupture scenario, because there was a little bit more
14 variability there in terms of the prediction that was
15 in --. Do you want to show that one too?

16 MEMBER RYAN: So these vary a little bit
17 in the range of values, from like an order of
18 magnitude to maybe two it looks like?

19 MR. FORESTER: Yes.

20 MEMBER RYAN: And they range in the
21 absolute value of the -- that particular outcome or
22 scenario, whatever you want to call it, by it looks
23 like two orders of magnitude?

24 MR. FORESTER: Well, but they're different
25 scenarios, right.

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1 MEMBER RYAN: Oh, they're different --

2 MR. FORESTER: 1B to 2B to 1A to 2A are
3 different.

4 (Simultaneous discussion.)

5 MEMBER RYAN: That's interesting. What's
6 the other slide look like? That seemed to be a little
7 different pattern just by breezing through it.

8 MR. FORESTER: So again, on the bottom are
9 the different HFBS for the scenario, and then the
10 predicted HEPs from the HRA teams. I believe those
11 are ranked along the bottom in terms of difficulty, as
12 determined by the assessment teams, of how difficult
13 the -- how difficult the different HFBS would be given
14 the scenarios.

15 So you should see some sort of pattern of
16 HEPs going down, and there is that to some extent, I
17 would say.

18 DR. LOIS: And probably a point of
19 interest here is the fact that those that are on the
20 higher end, which is -- I'm sorry.

21 MEMBER RYAN: Sorry, you can go ahead.

22 DR. LOIS: Yes. Well, it's obviously a
23 difficult human action review that we see, tremendous
24 variability among the methods, although analysts were
25 able to assume that it's very difficult to perform.

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1 MEMBER RYAN: That's interesting.

2 CHAIRMAN STETKAR: And you did say you
3 have one, two groups that used the same method?

4 MR. FORESTER: We did.

5 CHAIRMAN STETKAR: And you saw
6 variability?

7 MR. FORESTER: We did see some
8 variability.

9 CHAIRMAN STETKAR: Not just in method to
10 method; it's in analyst to analyst using the same
11 method.

12 MR. FORESTER: At least in that one case,
13 and that's sort of what we wanted to address further
14 in the U.S. studies.

15 So we studied variability, and one of our
16 main conclusions is that the qualitative analyses that
17 were being done just weren't comprehensive enough, and
18 they often weren't structured well enough for people
19 to use them consistently. So that seemed to be
20 something that we really needed to address.

21 CHAIRMAN STETKAR: In lay terms, that
22 means people aren't -- practitioners aren't being
23 instructed well enough what to think about?

24 MR. FORESTER: That's correct, and often
25 what we saw was if you had a really good analysis

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1 team, at least your qualitative analysis could be very
2 good, even if the method itself wasn't guiding that.
3 So if you want a methodology that can be used more
4 generally by a broader range of people, you're going
5 to have to have better guidance.

6 MEMBER RYAN: So there really has to be a
7 lot of process knowledge of the specifics in these
8 reactor cases to get it right? That's what it sounds
9 like.

10 MR. FORESTER: That's true, and that will
11 vary, again, depending on how much guidance you can
12 give the analysts to use and make sure they ask the
13 right question, the right questions to gather that
14 information.

15 But I think, you know, having process
16 knowledge what operations in a control room are is
17 always going to be an important part of this. But
18 we'd like to be able to lessen that to some extent.
19 Okay.

20 Now we're just going to walk through --
21 there are findings from the evaluation of HRA methods,
22 and Dr. Dang will walk you through that part.

23 DR. DANG: So the next slides are not
24 going to go method by method, in terms of evaluation.
25 We're going to cover the main conclusions of this

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1 evaluation, and before I get into some of those, some
2 of the findings that apply across all the methods.

3 Basically, all the methods have some
4 significant shortcomings, and they certainly have
5 different strengths. Part of the reason for that is
6 the originally intended scope of those methods. I
7 think the scope of application that we expect of an
8 HRA method has evolved, and some of the methods are
9 stuck back in the days when the scope was small.

10 The other, of course, relates to trade-
11 offs that were made in the design of the method, I've
12 just given you two examples.

13 One is simplicity versus the ability to
14 represent a broad range of HFEs and performance
15 conditions. So this is the issue of whether, you
16 know, your method is good enough to measure events
17 full power, or whether you can do local actions,
18 maintenance actions.

19 Then another example of the trade-off is
20 the repeatability versus the ability of the analyst to
21 consider, to bring in influences that they consider to
22 be important for that particular HFE. The second
23 point across methods is the qualitative analysis,
24 which was mentioned a little bit in terms of one of
25 the insights, if you want, from the empirical study.

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1 This is a shared weakness, and here we
2 mean in terms of the performance issues and the
3 factors that are considered, how broadly they consider
4 these factors, the guidance for this process for the
5 analyst, and then a key issue is the translation, once
6 you find the issues, into the quantification inputs.

7 Although it's a shared weakness, some
8 methods are definitely better than others in terms of
9 these different aspects, and it's important for us to
10 deal with this, because obviously it impacts the
11 consistency of the estimated HEPs.

12 When that process is loose, you get
13 different issues being identified, and then whatever
14 method you use, you're not going to get the same
15 results if you're not planning the right issues.

16 Secondly, it impacts the validity of the
17 HEPs to the extent that this validity can be
18 empirically verified. In general, the data that we
19 have concerning HEP values is relatively weak, so it's
20 less quantitative an evaluation of validity than we
21 might wish. Next slide, please.

22 CHAIRMAN STETKAR: Let me ask on that
23 aspect, unless you're going to get into this later. I
24 don't want to bog it down, because we covered some of
25 this, I think, on our meeting six months ago.

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1 But I know that EPRI was involved in a
2 number of simulated studies back in the day. It has
3 some catalogue of human error probabilities from those
4 studies that they used to benchmark a particular
5 methodology.

6 I've heard rumors that other international
7 people, most notably the French, claim that they have
8 a large catalogue. Have you, since you're the
9 European representative -- well, to the extent that
10 Switzerland is part of Europe -- that's a good side
11 joke.

12 (Laughter.)

13 CHAIRMAN STETKAR: Have you looked at all,
14 in terms of what other benchmark information might be
15 available on HEPs, you know, because that is a known
16 lack.

17 DR. DANG: I think the key part of your
18 question is on ATPs, and perhaps I'll leave Stuart to
19 comment on the EPRI data. Also for the -- I mean if
20 we turn to the other large source that you mentioned
21 or large repository that you have mentioned, the
22 French have a lot of simulated data. They are
23 continuing to collect it. It is not so HEP oriented.

24 CHAIRMAN STETKAR: Is it? Okay.

25 DR. DANG: So it's more what did we see in

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1 these scenarios? What are the crews doing, and they
2 get quite structured in terms of how they describe
3 that. But actual HEPs coming out of simulated
4 experiments, there isn't a whole lot of that. Maybe
5 for them.

6 CHAIRMAN STETKAR: Are they at all -- are
7 they trying to use that information, though, to
8 structure their own HEP work?

9 DR. DANG: They use the quantitative
10 information to a very limited extent.

11 CHAIRMAN STETKAR: Okay.

12 DR. DANG: They really view it as an input
13 to their qualitative process, to capture the
14 behaviors.

15 MEMBER BLEY: A clarification issue. And
16 correct me, the French were involved in the Halden
17 study.

18 They did have a team, and I thought, I
19 don't remember precisely, that after they laid out
20 their qualitative modeling, that they did in fact to
21 some extent rely on what they had seen in their
22 simulators to help in their quantification. But that
23 might not be true. Maybe you know better.

24 DR. DANG: Well, they also are storing
25 analyses, HRA analyses and their results, and then

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1 they're trying to adapt those when they look at it --

2 MEMBER BLEY: Oh, as data.

3 DR. DANG: As data, exactly. So it's that
4 sort of data. Now maybe Stuart wants to -- or Gareth.

5 DR. PARRY: Yes, I can comment on the EPRI
6 so-called HEP data. Those experiments really were
7 opportunistic in the sense that they did, looked a lot
8 of simulator experiments. But there were, I'm not
9 sure that there were any real failures in the observed
10 experiments. What was generated was in fact time
11 reliability curves. So any HEPs that came out of that
12 would have been subject to the validity of those HEP
13 curves.

14 CHAIRMAN STETKAR: So there too, the
15 purpose of collecting whatever data was collected was
16 a bit different.

17 (Simultaneous discussion.)

18 DR. PARRY: It was to verify the concepts
19 for time --

20 DR. MOSLEH: A quick comment, John. I
21 think you're referring perhaps to the old French data
22 many years back. I'm talking about 20 years or so,
23 where they did collect HEP from simulator exercises.

24 CHAIRMAN STETKAR: That too, but again, I
25 haven't, you know, I have no personal involvement with

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1 what's going in France. So I just hear things, you
2 know, third hand removed at least, which was the
3 source of my comment.

4 I thought that they said that they still
5 had an ongoing program to collect simulator data, but
6 I don't know what that means. I mean I can say those
7 words, but I don't know what it really means in
8 practice.

9 The only I brought it up is to explore the
10 extent to which, you know, the collective team has
11 been looking for, you know, HEP benchmark data, if you
12 want to call it that, because that's always an issue
13 when we talk about the validity of the numbers that
14 you're estimating.

15 Even though everybody might agree that
16 this is the best method possible in the world, if you
17 don't have confidence that it is reasonably
18 predictive, you have problems.

19 DR. PARRY: In comment, I think the
20 French, it's what's been said. The French are using
21 it mainly provide qualitative insights into the modes
22 of behavior of crews and things like that. Even if
23 they had HEPs, I somehow doubt it would be very easy
24 to get it from the French.

25 CHAIRMAN STETKAR: That's a different

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1 practice. That's a different issue.

2 (Laughter.)

3 DR. PARRY: Yeah.

4 DR. SIU: John, if I may. Nathan Siu,
5 Office of Research. Vin, I thought you might comment
6 on the WG Risk workshop. Again, did it say what the
7 state of international data collection is for
8 simulators?

9 DR. DANG: The Working Group on Risk
10 Assessment of the Nuclear Energy Agencies' Committee
11 on the Safety of Nuclear Installations, CSNI, got that
12 through, held a workshop last November on simulated
13 data for HRA purposes.

14 This is really -- well, one of the
15 motivations for the workshop was to see the extent to
16 which the experience, the very positive experience
17 through the empirical study of collecting simulated
18 data and actually using it for evaluating HRA methods,
19 could be extended and used to support HRA practice and
20 HRA method development.

21 There was a lot of interest. There remain
22 issues concerning what we really considered data, what
23 we should share sort of at the full basis, privacy
24 issues, transferability issues if you start to share
25 that kind of data. So it's, I think it's an area that

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1 there's a lot of interest in, and I think we are going
2 to see some developments in this area. But we're not
3 there yet.

4 CHAIRMAN STETKAR: Okay.

5 DR. DANG: Returning back to the slide, we
6 were, to the limited extent that this validity can be
7 empirically verified, I think that in the empirical
8 study we've done a good job of actually managing to do
9 some of the empirical verification.

10 But there's a limit for the highly
11 reliable actions or the less difficult scenarios. The
12 data doesn't say very much quantitatively there. But
13 you can see there are still some qualitative issues.
14 So empirical validation is something that can be done,
15 and we hope to see more that being done, because it's
16 been very informative concerning that.

17 DR. LOIS: Before you move to the next, I
18 wanted to bring a piece of information here. I
19 participated in what is called Israel 2010 Conference
20 in Rhodes, Greece, and I presented the outline of our
21 approach here to address the SRM and the EDF
22 representative of human reliability was there.

23 She noted that MERMOS is pretty much of
24 the same pace and they -- what I was presenting is
25 pretty much what MERMOS is doing. So the point I'm

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1 trying to make is that MERMOS is also on a continuing
2 evolution, and they try to address issues related to
3 consistency, variability in the HRA results.

4 They've pretty much taken advantage of the
5 Halden study. They recognized that they learned a lot
6 and they're continually evolving their thinking
7 towards their simulations.

8 CHAIRMAN STETKAR: I was going to ask, did
9 you get any sense of sort of if they're proceeding on
10 a parallel basis? Parallel is precisely parallel. Is
11 there some sense of convergence or divergence?

12 DR. LOIS: They were --

13 CHAIRMAN STETKAR: Or not enough
14 information.

15 DR. LOIS: I think we are collaborating
16 and we know what we're doing in terms of exchanging of
17 information. Whether or not we will get to the same
18 point, you know.

19 CHAIRMAN STETKAR: Okay.

20 DR. DANG: Returning to findings across
21 methods. So two common practices in HRA that are
22 going to affect this work is the fact that in
23 practice, in many HRAs that are being prepared, you
24 have a mixing and matching of methods.

25 This goes all the way back to THERP, and

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1 it continues today. One split, of course, is decision
2 cognition versus implementation. What we're seeing in
3 THERP, a TRC for the decision part and then tables for
4 the implementation execution part. Practically all
5 the combinations today exist some place.

6 Another reason for mixing and matching
7 methods are the different contexts. So you have
8 different methods for full power and shut down PSA,
9 just because people feel that on a shut down PSA, with
10 the long time windows, a method is not particularly
11 suitable.

12 So you're getting already some sense that
13 the practitioner wants to go in a direction of mixing
14 and matching, to meet the needs of the analysis. The
15 second practice is the, what we'll put in quotes,
16 "adjustments of methods relative to the reference
17 guidance, to the documetns."

18 This is coming from emerging new
19 information since the method was published. One
20 example is people frequently cut off the THERP time
21 reliability curve in terms as you go out towards the
22 long-time windows, because they feel that those low
23 values are no longer realistic, which was not the case
24 when the method was published.

25 Perhaps what's more key is that there's a

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1 great deal of variation in how formalized these
2 adjustments are. In a tool like the HRA calculator,
3 that's a documented set of rules. Use this method and
4 do it like this when you're in this situation, and in
5 other cases, it's really up to analysts' discretion
6 and they actually don't have a document to refer to.

7 That's the way they've implemented it.
8 They'll document that that's how they're doing it, and
9 that will be the extent of the basis for these
10 adjustments. These practices of mixing and matching
11 and of adjusting the method are going to affect the
12 consistency of the estimated HEPs and their validity.

13 In particular, when you compare two HRAs
14 using the same method by name, there could be
15 differences and which adjustments they've chosen to
16 apply.

17 MEMBER BLEY: Vinh?

18 DR. DANG: Yes.

19 MEMBER BLEY: You said it will affect the
20 consistency and validity. Did those two go in the
21 same direction, or does making some adjustments help
22 one and hurt the other, or can you decide about that?

23 DR. DANG: Well, if we're speaking about
24 adjustments to in fact new information, that's going
25 to help validity. If all the analysts decide to do

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1 the same adjustment, then we're going to need a better
2 consistency across analysts.

3 So really we're talking, it depends on
4 whether we're talking about comparing analysts or
5 comparing the results before or after the adjustments.

6 I hope -- I hope that's good enough.

7 MEMBER BLEY: When I first heard it, it
8 sounded as if I was hearing that any time you make
9 adjustments or mix and match, that you are degrading
10 both consistency and validity, and it seems to me
11 you're surely degrading consistency. Perhaps there
12 are good reasons for those things, in which case one
13 would hope it would increase the validity.

14 DR. DANG: Right. What I forgot to add as
15 a footnote to these two points is that there are no
16 value judgments being made for these findings.

17 MEMBER BLEY: That's a good point.
18 Thanks.

19 (Laughter.)

20 DR. DANG: That's the way it is. That's
21 what we're dealing with.

22 MEMBER BLEY: Only observations.

23 DR. DANG: Okay. So now we move into
24 selected method features, because we're now, you know,
25 we're in the frame of mind of well, what can we use

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1 and so on.

2 When we look at time reliability curves
3 for decision diagnosis, we keep getting this feedback.

4 They're easy to use. they're actually fairly
5 consistent in terms of, you know, once you determine
6 the time window you get similar results.

7 But they are difficult. What is
8 challenging about the use of these curves is that when
9 you have other influencing factors, it's very hard to
10 adjust what the time reliability curve outputs,
11 produces as an output.

12 Then some methods are more prescriptive in
13 terms of the analysis, providing work sheets.
14 Obviously, the positive point here is that it supports
15 repeatability, traceability, and it can support
16 validity. However, you need to develop different sets
17 of these rules for each context, and to really
18 consider each context and make all these adjustments
19 in a comprehensive way, in order to have these rules
20 sort of remain compatible and consistent as you move
21 from one application to another.

22 On the right hand side, it's actually sort
23 of contrasting. We have binary quantification inputs
24 in some of the methods, where you're asking yes-no
25 questions or less than greater than questions.

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1 Clearly, binary quantification inputs are going to
2 support consistency.

3 You don't have too many choices. It's one
4 or the other, and you don't have to find that gray
5 area in the middle and define it carefully. the
6 negative side is that depending on what you choose on
7 that yes-no, you get sort of a cliff edge effect, and
8 analysts may not like that too much, being forced to
9 really choose. "I don't really fit the yes condition;
10 can I maybe go to the no condition, where I'm going to
11 get an HEP more to my liking?"

12 In contrast to this type of input are the
13 multiple level, whether it's low-medium-high or full-
14 scale from zero to ten. Here, you can define the
15 input in a more nuanced way, to be able to
16 differentiate. But if you're going to get consistency
17 from such a process, then you need scaling guidance,
18 anchors for the values, so that two analysts will more
19 or less pick the same level on that rating scale, and
20 it should support -- such guidance would support
21 traceability, what is the basis for coming up with a 5
22 on this judgment, and I already mentioned the task.

23 MEMBER RYAN: Those are the quantitative
24 markers?

25 DR. DANG: Yes. You put -- next to the

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1 scale you put what might fit that kind of rating and -

2 -

3 MEMBER RYAN: Yes, thank you.

4 DR. DANG: Okay. Next slide please. The
5 last one concerns we call it different things, a
6 narrative-based failure mechanisms, and maybe I should
7 what we mean there. Most methods implicitly or in the
8 documentation give you some kind of reference to what
9 failure mechanism is driving a certain table value or
10 a certain analysis.

11 What we mean by a narrative-based failure
12 mechanism is that some of the methods, and if we look
13 at ATHEANA and MEMOS in particular, these are methods
14 that do this especially, they will explain the failure
15 of a human failure event, in terms of a very specific
16 way in which that's going to develop.

17 For example, this HFE would fail or could
18 fail because typically, this task is going to be
19 delegated to an auxiliary reactor operator, and he may
20 not be aware of the significance of this information,
21 of some information that he obtains during a task, and
22 communicate it back to the decision-maker.

23 So that kind of very specific mechanism
24 requires, of course, knowing how the task is performed
25 in quite a level of detail, and the practices of the

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1 crews and so on.

2 MEMBER RYAN: So you're really identifying
3 a weakness in the junior reactor operator's training
4 credentials or something that causes him to misjudge
5 something or make a mistake or --

6 DR. DANG: I think the point is that --

7 MEMBER RYAN: How do you translate a
8 junior operator versus a senior into an error?

9 DR. DANG: Right. More than the focus on
10 the qualifications, it's just the mechanism that once
11 you've delegated, you've introduced the need for an
12 extra bit of communication, that you know, if someone
13 else were doing the task, you would not have this
14 issue.

15 MEMBER RYAN: Or it could be that a senior
16 operator has to make sure that person's qualified
17 before he delegates it to him.

18 DR. DANG: Well, we're speaking here in
19 terms of a control room crew, and the tasks that have
20 been delegated are clearly tasks for which the crew is
21 qualified.

22 MEMBER RYAN: All right. So basically
23 you're saying this person may be relatively new, and
24 even though the training is covered, that maybe it's
25 not locked in?

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1 DR. DANG: Or it may just be tangential
2 information to that task. We're not speaking about
3 just reporting back on that task and the outcome of
4 that task --

5 MEMBER RYAN: I understand. Thank you.

6 DR. DANG: So these narrative-based
7 failure mechanisms, they support a very broad set of
8 influences, plan-specific mechanisms, scenario-
9 specific error mechanisms. They require expertise in
10 how these operations are carried out at that specific
11 plant.

12 This broad set -- this possibility to
13 model so many mechanisms make it more difficult to
14 structure the analyses, difficult to review them in
15 terms of well, why didn't they consider this other
16 scenario, or did they consider this scenario, because
17 there is all these possibilities that are being
18 considered.

19 And of course, coming up with these
20 mechanisms for an HFE requires a certain level of
21 effort and expertise, an elicitation that is probably
22 beyond what some of the methods, that have the
23 features from the previous slide, would require. So
24 there's a lot of effort involved here.

25 CHAIRMAN STETKAR: Can I ask a question?

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1 DR. DANG: Yes.

2 CHAIRMAN STETKAR: Something that you
3 mentioned, even peripherally on the third bullet
4 there, where you said not -- analysts might have
5 difficulty understanding whether, at least what I
6 thought I heard, whether there are different scenarios
7 that might be combined into what they're evaluating.
8 Am I understanding that correctly or not?

9 DR. DANG: No.

10 CHAIRMAN STETKAR: Okay.

11 DR. DANG: I mean for example, I think in
12 these methods, you can, of course, you don't have to
13 decide on just one way that all crews are going to
14 carry out the HFE, the task related in the HFE. So
15 you can actually come up with several mechanisms --

16 CHAIRMAN STETKAR: Okay. So this is
17 really in the context of a well-defined scenario?

18 DR. DANG: Right. It is within the
19 context of a well-defined scenario, where maybe what I
20 was trying to say that when you see such an analysis,
21 you can certainly judge the possibility of the
22 scenario that's being presented to you or these
23 several scenarios, and say "okay, that sounds
24 reasonable" and so on.

25 But well, you know, there are so many

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1 other scenarios and maybe across HFEs you see a
2 similar scenario. Well, why didn't you use that
3 scenario here or that kind of mechanism in this HFE.
4 That makes it hard to review.

5 CHAIRMAN STETKAR: Just so I understand,
6 when you say "scenario," do you mean human response to
7 a specific set of stimuli, or do you mean --

8 DR. DANG: Yes, yes.

9 CHAIRMAN STETKAR: --plant behavioral
10 scenario?

11 DR. DANG: No, I was referring --

12 CHAIRMAN STETKAR: Okay. Okay, thanks.

13 DR. DANG: They become --

14 CHAIRMAN STETKAR: That's where I was
15 getting confused. Okay, thanks.

16 DR. DANG: So coming out of these method
17 evaluations, both looking at the -- go on to the next
18 slide.

19 Looking at both the general findings and
20 then what we've learned about some of these features,
21 what we like about them or what maybe gives us some
22 concern, are the following, which become implications
23 for what we want to do in the SRM or what we're doing
24 in the SRM.

25 One is that the guidance for the quality

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1 of analysis needs to be extended and formalized, and
2 that's to make sure that the performance issues,
3 influences, are being addressed comprehensively, and
4 to make sure that this process can be more consistent,
5 meaning that different analysts will cover the same
6 sorts of issues, describe them in the same way, and
7 then provide the quantification of inputs that are
8 similar, when they're looking at the same thing.

9 The second is the need to support, at
10 least for some HFES, failure mechanisms in some detail
11 these narratives that I've mentioned.

12 The third element was rating guidance to
13 support the repeatability and the traceability of the
14 results, and this is now -- once you have formalized
15 your qualitative analysis process, in a way that
16 people are identifying the same issues, we want to
17 make sure that at this interface between the
18 qualitative analysis and the quantitative analysis,
19 meaning the part where you start to use the algorithm
20 to produce numbers, that you're getting consistent
21 inputs.

22 That's where we believe the rating
23 guidance of the questions, that you need to answer in
24 order to make a particular rating or an answer to a
25 decision, is consistent, and finally to improve the

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1 technical basis by linking the HRA to accepted models
2 of human performance.

3 So obviously HRA methods have considered
4 experience and judgment. To a great extent, the
5 models of human performance, for whatever reason, have
6 been maybe not as emphasized, and in this effort, we
7 were trying to balance these two aspects. That would
8 be important for the acceptance of the HR methods.

9 MEMBER BLEY: Vinh, from the standpoint of
10 planning and where you go from here, and I guess
11 everybody, one thing just kind of clicked in what you
12 were saying.

13 We're making an implicit assumption, at
14 least halfway I think it's obvious it's clear, that if
15 we have a good, thorough qualitative description of
16 what's going on in all its aspects, one, we've gotten
17 rid of a major source of disagreements between
18 analyses because we're looking at the same thing.

19 But two, there's an implicit assumption
20 that we'll be more consistent in our quantitative
21 results, and we haven't actually tried that, as far as
22 I know, providing some kind of detailed descriptor of
23 the situation, and then trying these different PRA
24 quantification techniques on them to see what comes
25 out. Has there been discussion of that?

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1 DR. LOIS: Can I jump in here? The
2 assumption is that the qualitative analysis, the
3 quantitative analysis should be able to reflect the
4 qualitative analysis results. So the quantification,
5 we focus on the quantification to address that and
6 that is the way we want to present our first or
7 initial thoughts on how to do it.

8 MEMBER BLEY: I might not have asked it
9 the right way. But what I was suggesting is
10 essentially another, I'll use "benchmark" this time,
11 because now we would have a consistent qualitative
12 description for people to apply using their different
13 methods.

14 CHAIRMAN STETKAR: To meet a consistent,
15 perfect description of the scenario?

16 DR. DANG: Yes.

17 MEMBER BLEY: Thank you. Polite response
18 in that sense.

19 (Simultaneous discussion.)

20 MEMBER BLEY: And people have perceived
21 the business all laid out, where you might go into
22 everything that applies, so that they'd all be working
23 from the same descriptive picture of what's going on
24 and modeling the same thing.

25 DR. PARRY: I can't imagine that that

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1 would give you exactly -- that the different methods
2 would give you the same answer, because they don't
3 have --

4 MEMBER BLEY: But would it be closer than
5 it is now, is the question I have. I hope so, but I -
6 -

7 DR. PARRY: You would hope so, but I
8 wouldn't be convinced, because if the method didn't
9 know how to translate that qualitative information
10 into the quantification --

11 MEMBER BLEY: It might not.

12 (Simultaneous discussion.)

13 DR. PARRY: You can't do it. It might not
14 --

15 MEMBER BLEY: It won't result in any
16 analyst, you know, deciding well I don't have the
17 tools --

18 DR. PARRY: Yeah, I'll fudge the answers -
19 -

20 MEMBER BLEY: I'll fudge the answers
21 somehow, for factors of 10 to 100 on our quantitative
22 analysis. That's my question.

23 MEMBER RYAN: But it seems if you ended up
24 in that place, I would think if, you know, Dennis'
25 scenario was well-defined enough and you ended up in

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1 that place, when you see a range of responses, that
2 would get you to, you know, at least some insight into
3 what my question was, which was uncertainty and
4 variability.

5 And I don't mean variability in an error
6 kind of way; I mean variability among analysts and
7 interpretations and so on. So you know, it would be
8 nice if we could say well, I'll take their brains and
9 say okay, this is the analytical part, this is the
10 interpretive part.

11 We're not going to get to do that, and I
12 think that Dennis' scenario is very well constructed
13 to the point where we would hopefully, and I recognize
14 it's a hope maybe, but to reduce variability among
15 analysts' interpretations of the facts in the
16 scenario. That would be a helpful step.

17 DR. LOIS: I think we have done halfway
18 that experiment, Dennis, with the loss of feed or with
19 the Halden study, where we analyzed the loss of feed
20 scenarios, after we had about at least two workshops
21 with all the analyst teams.

22 Through those workshops, the analyst teams
23 developed a very good understanding of how the tools
24 were performing. In addition to we had the
25 opportunity to communicate the HRA results of the

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1 various methods. So then the teams had the
2 opportunity to learn from each other how to do a
3 better qualitative analysis and how to interpret true
4 performance of how the ATHEANA group did and MERMOS.

5 Both of them did a tremendous job in
6 teaching people how to incorporate those aspects. And
7 yet because the results, the quantitative results that
8 I showed, it shows smaller margins but big enough.
9 The important thing is that even for the most
10 difficult human actions, the variability was pretty
11 big.

12 So it seems that the quantitative tool
13 constrains the analyst to incorporate the
14 understanding into the quantification, and if you take
15 one decision tree, you have, you're dealing with three
16 PSFs, and then the NRC team had recognized actually
17 what would happen.

18 But the result was not able to, you know,
19 one, when they did the quantification, were not able
20 to incorporate their understanding in the method. So
21 but definitely we could do more of those studies --.

22 DR. MOSLEH: I think that obviously part
23 of you're referring to, Dennis, is kind of a control
24 scientific experiment, to show where fixing one aspect
25 of the problem leads to improving the other part, has

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1 not been done, only maybe at best maybe partially.

2 But I can see that through our own
3 empirical validation of what you're doing, we could
4 demonstrate that by improving the qualitative analysis
5 and making it more prescriptive, in the sense that
6 here, we could demonstrate, at least on a limited
7 basis, that the quality of the numerical result
8 moving. That's part of what I think could be the type
9 of test that we should run at this point.

10 DR. PARRY: Well, back to John.

11 MR. FORESTER: Okay. Well, I just wanted
12 to give you then just a quick overview of the
13 presentation. Ali and Gareth will both kind of go
14 into more details of what we're doing. But again, we
15 do want to capitalize on the strengths of the existing
16 methods, and also use what information we have on the
17 psychology, the data and models.

18 So again, there is an emphasis here to
19 build on what we have in cognitive psychology, and,
20 there's a particular kind of activity that we've been
21 trying to accomplish which we're calling now, is to
22 build a human response model, which before we called
23 sort of a mid-layer model.

24 The notion here is that you use the, you
25 know, there's models from psychology. There's also,

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1 you know, explanations about how, you know, cognitive
2 mechanisms can lead to failure. So there's
3 information there, there's data there. It comes from
4 different types of models.

5 We're going to use that information to
6 help us identify, you know, what kind of human
7 failures are going to lead to the human failure. So
8 the notion there's a lot of ways that failures can
9 occur that will lead to the HFP.

10 We want to use the psychological models to
11 help us identify what those are, which we refer to as
12 proximate causes, which is just another way of saying,
13 you know, the easily identifiable kinds of failure,
14 like well, they didn't attend to the data, so they
15 never started the problem, something simple like that.

16 So you use the models to help us identify
17 what are those causes, but then also use the
18 psychological models. If you know what kind of
19 cognitive failures can occur, then you can try and use
20 that information to help you identify what kind of
21 conditions, what plant conditions and the traditional
22 kind of performance shaping factors we consider, could
23 lead those cognitive failures to occur.

24 So you know, I want to build this
25 relationship between those sort of three parts of it,

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1 and again the overall notion here is that that should
2 help us improve the validity.

3 If you understand what parts of the
4 context could facilitate these failure mechanisms,
5 which in turn lead to the most likely forms of the
6 failure, that should improve validity, and Ali's going
7 to give us a detailed discussion on that.

8 We also want to use -- and then given that
9 as a basis, we want to use concepts from ATHEANA,
10 which has a very, you know, comprehensive kind of
11 approach really for identifying the contextual aspects
12 that you should be considering in an HRA. There's a
13 lot of guidance there.

14 To our sense, in terms of wanting to
15 improve consistency, we think that even that guidance
16 as good as it is, in the sense that it covers an awful
17 lot, it probably needs more formal, a little more
18 formalism or a structure that guides the analyst to
19 focus then on the right set of information.

20 It's not a simple thing to do, but that's
21 sort of the goal of what we think needs to be done,
22 and possibly there's some aspects of ATHEANA and
23 MERMOS-type analyses that we haven't addressed yet.

24 So again, we want to use those, that part,
25 those concepts and hopefully improve it, and build on

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1 the validity and the consistency. Then the next part
2 of this, what we're currently looking at, and again,
3 we're still a little bit of the investigative stage
4 here, but we want to structure.

5 You know, the emphasis here is in more
6 formalization and more structure. So one thing we're
7 looking at and another advantage of this, of course,
8 is this is what industry uses. If we could take, you
9 know, the kinds of structures used in the CDBT
10 approach for quantification, or some other kind of
11 approach that provides a structure, you know, the
12 decision tree analysis of working it with the Bayesian
13 belief networks, we're going to take a look at that.

14 But the notion is your quantification, we
15 want to have a structure that we would provide
16 guidance for the qualitative analysis, more structure
17 for that, and then also more structure for the
18 quantification approach. Actually, there should be
19 not a one-to-one correspondence but a pretty direct
20 correspondence between the guidance for qualitative
21 and what you end up quantifying with setting decision
22 trees, for example.

23 So those things should work, should be
24 together. So again, the emphasis here is on more
25 formalism. It should make it easier to apply,

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1 possibly would require less expertise, because again,
2 the type of an ATHEANA analysis without a specific
3 kind of guidance can require a lot of expertise to be
4 able to form.

5 So again, we think this type of approach,
6 trying to have the structure is going to improve
7 validity, consistency, traceability criteria we see as
8 being important.

9 Then finally in one of our earlier
10 presentations, we spent some time talking about the
11 crew response tree, this CRT structure, to help us --
12 there's different views on exactly what they do, but
13 to me at least, they provide a way to represent the
14 different failure paths.

15 So if you looking at a particular HFE and
16 even ATHEANA puts an emphasis on looking for
17 vulnerabilities, where they might take, you know, what
18 might lead the crews to take a different path through
19 the procedures, well that's one of the goals of the
20 CRT, is just trying to help identify those paths, in
21 again a more formal way, and also that would help
22 contribute to the context for the HFEs.

23 So I think that's going to be an important
24 piece to what we have. I do think there are still
25 some issues to work out, to see exactly how these

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1 work. But I think that's going to be an important
2 piece. But that's only one piece to the whole
3 approach, and again, the goal there will be to improve
4 validity and consistency.

5 MEMBER BLEY: Can I ask one question about
6 -- I don't see it on the slide, but you were saying
7 you might not need the level of expertise. I mean
8 currently, there's expertise in cognitive psychology.
9 I mean other human aspects of PRA knowledge,
10 operations knowledge, procedures knowledge. Which of
11 those do you see we might be able to cut back on for
12 the guy that's trying to use this method?

13 MR. FORESTER: Well certainly we don't
14 expect people to be cognitive psychologists. So
15 that's one part of it.

16 MEMBER BLEY: But we'll provide some help
17 for them on that issue.

18 MR. FORESTER: Yes. Essentially, we want
19 to provide the information from that, from the
20 psychological models to the model that we use for
21 searching for conditions and quantifying. So that
22 part of it's not required.

23 I think also, you know, if you know
24 specifically what you're looking for, you may not need
25 as much plant expertise possibly. I think that's

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1 always going to be a part of it, and as you -- the
2 more you know about the operations, that that will
3 help HRA.

4 But again, if you have the specific set of
5 conditions, people are guided --

6 MEMBER BLEY: Where would they come from,
7 if they don't come from --

8 MR. FORESTER: Because we'll give them to
9 them.

10 MEMBER BLEY: The method will tell them
11 the conditions under which --

12 (Simultaneous discussion.)

13 MR. FORESTER: No. It will tell the
14 dimensions they need to look for.

15 DR. PARRY: Yes. I think what John said,
16 the methods should tell them what questions to ask of
17 the right people to get the information that they need
18 to quantify.

19 MEMBER BLEY: Okay, okay. That's helpful.
20 Thanks.

21 DR. DANG: And I think there's another
22 type of expertise of which we hope to have less need
23 for, which is if I know that this is the issue, which
24 PSF can I kind of bend to put that into a
25 quantification? By having a better mapping between

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1 the quality of analysis process and the
2 quantification, we hope that you don't have to go look
3 for that factor so widely.

4 MEMBER BLEY: For the human side of this,
5 we're going to provide lots of helps, and somehow on
6 the systems operation side, we'll provide pointers,
7 but you'll still need somebody at the plant or
8 somewhere to help you out.

9 DR. PARRY: Yes. You still need to know
10 how the plant's behaving and how the parameters are
11 changing.

12 CHAIRMAN STETKAR: Let me ask a sort of
13 fundamental question that I think I've asked a couple
14 of other times, and I'll ask it again, since we're
15 sort of touching on this right now. One of the
16 difficulties that I've seen is that we take an action,
17 let's say manually start feed water.

18 I can give that action a name, and you can
19 say "Well gee, under what conditions?" Okay, well
20 under the conditions that all emergency automatic
21 systems have failed. So an operator is required to
22 manually start feed water.

23 The fundamental question, though, when I
24 look at the billions upon billions, in some
25 constructs, sequences that are created in a typical

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1 PRA model, do I need one human error probability for
2 that that suffices for all? Do I need three? Do I
3 need 50? Do I need 200?

4 In other words, what elements of the
5 actual scenario development? You didn't tell me that
6 I was supposed to do this under a medium loca, for
7 example, where the scenario response is much different
8 compared to a plain vanilla reactor trip, or that it's
9 in response to the biggest earthquake that I've ever
10 seen in my life, or maybe not the biggest, but pretty
11 doggone large, or a fire.

12 Where in terms -- so what I'm asking
13 about, is we're talking about this hybrid methodology
14 in terms of trying to provide consistency and validity
15 in terms of quantifying those HEPs that fill int hat
16 blank, in terms of how likely is the operator to fail.

17 Where, if at all, does this methodology
18 address defining are there one blank to fill in or
19 three or 300 within a PRA model? Some of the early
20 EPRI stuff tried to do that, but not very well.

21 DR. PARRY: I'll give you my opinion right
22 now. We can't answer it right now, but I think the
23 way it could develop is if once we've developed what I
24 would call a quantification model, hopefully that will
25 give us guidance on how to decompose the HFEs into the

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1 right subsets of conditions that you need to address a
2 particular HFE in the different circumstances. I
3 think it should come out of how you develop the PIFs.

4
5 CHAIRMAN STETKAR: It might. The right
6 kind of questions to ask. The only reason, the only
7 thing I'll throw out is I'm not a particular proponent
8 of any one method.

9 The thing that I've always liked about the
10 time reliability correlations, and the only thing, is
11 that it forces, you know, present company excepted, is
12 that it forces the people building the PRA model, the
13 people who are drawing event trees or fault trees or
14 whatever they do to build the PRA model, and the
15 people doing the human reliability analysis, whatever
16 they're doing, and the people doing thermohydraulic
17 analyses, to talk to one another.

18 Because there are a specific set of
19 questions that need to be answered, like how much time
20 is available. The only way to answer that question is
21 somebody running some God-awful thermohydraulics code
22 for a particular scenario has to indeed run that code,
23 and somebody building the model says "Well hey, over
24 here the time might be different because we've got a
25 medium blow going on at the same time that we failed

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1 all feed water."

2 So that's the benefit, you now, of that
3 particular construct, is that it at least gets
4 different people talking to one another. Now we're
5 trying to say the same thing, but by structuring the
6 most appropriate questions, there might be a feedback.

7 DR. PARRY: And there would have to be
8 questions about the relative timing of events included
9 in the model. Otherwise, it's not going to represent
10 the human behavior. So probably we are saying the
11 same thing.

12 DR. MOSLEH: John, on that point, what
13 you're raising is based on the mental and one of the
14 most difficult questions to answer in modeling a
15 representation, and much of the effort so far, I mean
16 a good portion of the effort so far has gone into
17 trying to draw that balance between the various points
18 of view and disciplines that need to enter the
19 picture, in order to identify the right level of, in
20 my opinion, my language, the right level of
21 decomposition, at the level where you capture enough,
22 but it's manageable and practical of the types of the
23 scenarios, the plant scenario and the crew, a response
24 to this scenario.

25 Why we don't have an answer to offer

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1 today, it's something that we hope that the next time
2 we get together, we'll have some concrete ideas how to
3 kind of basically organize an analysis.

4 CHAIRMAN STETKAR: That's good. I'm just
5 trying to keep, infuse that sensitivity, that it can't
6 -- whatever you're involved in can't operate in a
7 decoupled environment, because we're talking about
8 consistency in the overall HRA. It's the integrated
9 stuff in the PRA that we care about, that we don't
10 lose track of that necessarily.

11 DR. MOSLEH: Well, John mentioned that
12 there are a number of pieces to this kind of proposal,
13 and you're going to hear today, or you have heard and
14 you're going to hear more of some of the pieces.

15 But what the topic, the area, the outline
16 has been the subject of many discussions, many
17 exercises and ideas and concepts that have been in
18 part being tested. But we're not the stage where we
19 have a lot of data.

20 CHAIRMAN STETKAR: Yes. I think
21 hopefully, I mean if what I'm hearing, and I guess
22 what we'll hear this afternoon, if it's true, in
23 principle, if you have the right construct of
24 questions, without putting it any other way, to ask,
25 they might prod, you know, those PRA modelers, if I

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1 can call them that, to go out and search for that
2 right information and therefore define the fact that
3 under, you know, this billions and billions of
4 sequences we need 17 different, you know, 17 different
5 enough constructs, if you will, that require an
6 answer. Okay, thanks. Sorry.

7 MR. FORESTER: I think that I'm done.
8 We've talked about the next slide pretty much. So the
9 last thing, I think, is we talked about given the
10 size and the practicality of what we're doing, trying
11 to be consistent with the industry, we do want to
12 structure this applicable cost domain.

13 So again, I don't think, for a particular
14 kind of domain, there may be some special
15 characteristics that you'll have to try and capture.
16 But hopefully the basic structure will work across,
17 will work across domains. So okay.

18 Then the last slide then the next
19 presentations will be Ali's presentation on the human
20 performance, and again that's what we're formally
21 calling the mid-layer model, and then Gareth will talk
22 about use of the decision tree, to try and see if we
23 can use that kind of structure to improve the
24 approach.

25 CHAIRMAN STETKAR: Ali, before you start,

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1 be aware of the time. Is there a -- I don't know how
2 long you planned here. Is there a break time
3 somewhere --

4 MEMBER RYAN: Three o'clock.

5 (Off mic comment.)

6 CHAIRMAN STETKAR: I'm aware of the clock
7 time. I'm worried about --

8 DR. MOSLEH: A natural point to break
9 this, or try to fit this in the next 20 minutes?
10 Which one?

11 CHAIRMAN STETKAR: Huh?

12 DR. MOSLEH: Which one is your question?

13 CHAIRMAN STETKAR: Well yes. We have a
14 break scheduled at three, and I just wanted you to be
15 aware of that. Is there a natural break point, or
16 should we break early and then allow you to continue?

17 DR. MOSLEH: It depends very much on how
18 many questions and kind of what kind of discussion we
19 have. I think that we can do it.

20 CHAIRMAN STETKAR: Okay. You're not
21 starting where you were last time. You're starting
22 beyond that, right? Are you reiterating what you
23 talked about the last time you guys were here? That
24 looks like you're not. It looks like you're starting
25 where you left off and continuing.

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1 DR. MOSLEH: Yes. You mean the kind of
2 depth we didn't show last time, that we've kind of
3 worked since then, in terms of human performance
4 tests.

5 DR. LOIS: But before, before, I think we
6 had structured the discussion so that we had your
7 input on this part of the discussion. So if there is
8 no more, probably we should break now, so that we
9 leave that possibility.

10 CHAIRMAN STETKAR: Let's do that. Let's
11 take our break now. I thumbed through it, and there
12 didn't seem to be a clear break point. So let's do
13 that. Let's recess now until three o'clock, and then
14 we can do continuously until, you know, midnight or
15 whatever.

16 (Laughter.)

17 (Whereupon, a short recess was taken.)

18 CHAIRMAN STETKAR: So back in session.

19 MS. LUI: I need -- well, while resolving
20 the computer issue, we just wanted to stress that for
21 the second half of today's meeting, that we're really
22 going to dive into a fair amount of technical detail.

23 So really we'd like to, we'd like to
24 solicit the input from the members. I know that
25 you're not bashful about asking questions.

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1 CHAIRMAN STETKAR: We'll be less shy than
2 the morning.

3 MS. LUI: And at the same time, the idea
4 of today, we want to get into a position to get your
5 input regarding whether we are at a good position to
6 move forward, whether we have presented a sound
7 technical approach, and clearly, if you have any
8 particular suggestions in terms of path forward, we
9 would like to hear those too.

10 DR. MOSLEH: Okay. Since the chairman
11 hasn't started the session, mostly as you can see on
12 the title of the slide, the title of slide you see a
13 large team of people. Actually, if I list the number
14 of people that have had input to this process, it
15 would be much longer.

16 But I wasn't able to consult everyone on
17 putting their name here. I know this is the core team
18 that looked at a particular aspect of this effort.
19 John mentioned that there are a number of facets,
20 aspects, areas that play an important role in what
21 we're trying to address.

22 This particular one, the team that worked
23 on this particular one is listed. I'm going to be
24 talking about not everything that we have done under
25 the title of establishing a technical basis, but

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1 highlight the areas where you feel more comfortable to
2 summarize and present to you and also to elicit your
3 feedback.

4 There are other aspects that if there is a
5 need and the questions arise in the back of the slides
6 I can go to, and also whatever I need, I will
7 definitely call a friend here, the domain experts,
8 among those present, the domain experts.

9 So the presentation basically is on
10 obvious segments of what are we trying to achieve,
11 that's coming from the titles that are clear on
12 establishing a technical basis for HRA human
13 performance model.

14 While we do that, I will explain, and
15 share with you at least a causal perspective I think
16 that is simple, quite actually popular in the HRA and
17 similar domains, and talk about that and use that to
18 guide us what we found in the literature, and which
19 way define the scope of the focus of the literature
20 research in the psychological literature that is
21 summarized here.

22 Last time we were here, we shared with you
23 a -- or at least provided highlights of some of the
24 results of the search. This takes you a little bit
25 beyond that point, and try to synthesize the

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1 information into something that is closer to what can
2 be used in the HRA.

3 Share with you some findings and examples,
4 so that you get a sense of what you're finding and the
5 developing, and a few words on this, on the expected
6 outcomes.

7 The goal of this particular activity is
8 really trying to just take an aspect of the set of
9 criteria that we established in the beginning of the
10 project, on needed attributes of the credible HRA, and
11 that's a the contemplated view.

12 The content validity of this particular
13 domain, like other domains, depends on theoretical
14 framework of the models that we use, methods and
15 approaches that you get to invoke, and particularly
16 obviously this domain we won't do that, to reflect the
17 current understanding in human sciences, relevant
18 sciences and the psychological and human factors and
19 the related disciplines.

20 Given that where you develop or establish
21 a technical basis, a foundation, a theoretical
22 foundation for the content constructs that you use in
23 your method, you want to basically integrate and then
24 capture the other aspects that are not necessarily
25 obtained from the psychological literature, that we

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1 may need to actually extend and go beyond the
2 psychology that we have done and that's kind of
3 obvious, and to go from that perspective.

4 Just referring to a theoretical basis or a
5 list of theories and ideas that people have published
6 on is not sufficient to establish content validity.
7 You want to also show in more explicit terms how, in a
8 consistent way, how these reflect in the methodology
9 that you're developing or using.

10 Part of what it does is addressing one
11 issue that we have, we see in the current practice of
12 HRA, what you get from the context of a scenario or a
13 situation, or what aspects of human performance you're
14 considering, depends on a large extent to that theme
15 to develop the method, or maybe individual that is
16 applying the method.

17 What we wanted to go is kind of broaden
18 the basis, and provide a much broader basis, consensus
19 agreement by tabbing kind of the literature to see
20 what the broader community of experts, you know,
21 psychologists in human factors say about that.

22 So in that way, you have developed a
23 deeper roots in the community of experts, and then
24 hopefully that helps a consensus, that least in terms
25 of the areas that you're covering in the methodology.

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1 Given that, of course, you know, the next step that
2 you need to take is to formalize the process.

3 Once you capture the essence of what you -
4 - the findings that you have in the literature, and
5 you formalize that in the form of analysis too, our
6 sense is that it reduces the dependency on experts
7 even in applying the method. In other words, you
8 know, basically you capture the essence of the ideas
9 and methods in a formal, structured and visible way.

10 We talked about this in the last session,
11 where it's not really sufficient to provide reference
12 to set of information. What we want to do is to see
13 how that actually helps an analysis, and it's not that
14 it would actually remove the need for the expertise,
15 but it formalizes the process that the expertise and
16 information is captured in the analysis.

17 MEMBER RYAN: Just to understand a little
18 bit, if you don't mind, that formalism would do what?

19 Would it increase reliability, decrease uncertainty -
20 -

21 DR. MOSLEH: It increases the -- decreases
22 the uncertainty in the sense of the existing methods
23 all have some sort of common perspective. But there
24 are differences in perspective as to what aspect of
25 human performance you're looking at. So when you look

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1 at the method to method variability, an element of it
2 is the different perspective of the developers.

3 So that's, if you mean by uncertainty the
4 variability in the results of the method --

5 MEMBER RYAN: Yes.

6 DR. MOSLEH: That's one aspect of the
7 model to model variability, an aspect of it can be
8 captured by broadening the base of understanding of
9 human performance --

10 MEMBER RYAN: So that, I mean so I'm
11 translating what you said a little bit, so I can
12 understand it better. But to me that says that you
13 have a field of outcomes that you're learning more
14 about, that may not become smaller by further study.
15 You may have a wide range of results within that
16 outcome. Is that right? Am I reading that right or
17 understanding that right?

18 DR. MOSLEH: Well, we were going a little
19 bit kind of maybe lower level of or a deeper level of
20 foundation, in the sense that an aspect -- so since
21 there is variability in the different methods, in
22 terms of their foundation, to move toward the
23 consensus model or approach, one needs to go beyond
24 individual perspectives and approaches, and make that
25 a foundation of the methodology.

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1 That way, once you have this so-called
2 consensus method, it meets fewer challenges form the
3 community. And as such, it provides a kind of a
4 content validity. I'll define the term "content
5 validity" in a bit more detail.

6 MEMBER RYAN: Okay, thank you.

7 CHAIRMAN STETKAR: Now just give me an
8 idea. Some methods or two extremes or two examples,
9 one method might say the only thing you need to do is
10 look at every step in an emergency procedure and say
11 what's the likelihood of the operator successfully
12 performing this step or not.

13 Another method might say the steps in the
14 procedures don't make any difference at all. It's
15 simply the amount of time that's available for the
16 operator to process the information. Those are two
17 very, very different constructs and methods.

18 I think what Ali is talking about is just
19 trying to see what elements of those things or --

20 (Simultaneous discussion.)

21 MEMBER RYAN: --put together to say these
22 actions have to occur within this range of times?
23 Could you have a hybrid model, just to pick on John's
24 example?

25 CHAIRMAN STETKAR: Well, that's I think

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1 the way they're trying to --

2 DR. MOSLEH: Yes. The idea is really to
3 cover all aspects, to the extent that kind of the
4 domain sciences allow us, and not to miss important
5 aspects that need to be covered. As such, I think,
6 you know, when you get to the point of analyzing the
7 particular scenario, all relevant aspects, as far as
8 the domain sciences allow us, are covered.

9 CHAIRMAN STETKAR: Sure.

10 MEMBER RYAN: Thanks. That helps.

11 DR. MOSLEH: So the focus of this
12 particular effort is the developing a cognitive
13 framework that links the PRA perspective scenario's
14 context, which we'll define shortly, the psychological
15 processes that are -- that take place in operator mind
16 as well as the crew and team activities, and the
17 resulting performance.

18 In other words, you go from context in a
19 scenario. You go to the context factors,
20 characterization of the environment through the
21 psychological processes to performance. What you want
22 to do is to do this by, supported by psychological
23 literature, and informed by operating experience.

24 In other words, we are doing this in the
25 context of the nuclear power plant and particular

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1 technology, so what do you find from the psychological
2 literature as to development and meaningful data.

3 But by capturing such information in a
4 structured way, the information from psychological
5 literature, we think that one of the core criteria
6 would be met, at least partially, and that is the
7 content validity. What is it that you're covering and
8 why, and what is it that you're leaving out and why.

9 Eventually, if some these things turn up
10 to be maybe too much for the typical analysis, some of
11 these things would go purely into technical basis. In
12 other words, the analyst may not see much of what I
13 say today, but it provides a technical basis to give
14 it much more credibility in the eyes of the
15 development sciences.

16 So I mentioned content validity. It is
17 really a two core ingredients that we need to address.

18 The content and constructs. The content basically is
19 what is it that you're covering in the methodology,
20 what aspects of human performance? And constructs,
21 and how is it covered and what kind of models and
22 abstractions are used or simplifications you're using
23 in order to address the area or domain that you're
24 covering?

25 And the fact that there is really, to say

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1 the obvious in a way, that consider it a kind of a
2 philosophical perspective, that in order to do that,
3 when we talk about capturing information and from
4 different domains and sciences into explaining or
5 describing a phenomena, we're talking about a causal
6 model or a causal perspective.

7 So when we talk about human performance
8 model, we're talking about the causal perspective of
9 human performance model, without which it would be
10 very difficult to actually translate what you see and
11 hear in many different domains into something that is
12 useable.

13 The products of this effort would be
14 ultimately an input to the practical guidelines and
15 the methods for the analysts. But more importantly,
16 at least in this talk, in this presentation, is the
17 technical basis that may go into an appendix to an
18 analyst guide, an analyst would never see.

19 MEMBER BLEY: Ali?

20 DR. MOSLEH: Yes.

21 MEMBER BLEY: When Erasmia introduced
22 everything, she talked about a technical basis
23 document in about a year from now, and a users guide
24 in that same time frame. Are those the two things we
25 see on your slide?

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1 DR. MOSLEH: Yes, yes.

2 MEMBER BLEY: Okay.

3 DR. MOSLEH: I mentioned a simple causal
4 perspective -- yes.

5 MEMBER BLEY: I'm sorry. Just not to pick
6 at how you schedule things, but shouldn't the
7 technical basis be in place some time before you
8 actually were ready to write a users guide for the
9 model, a users --

10 DR. MOSLEH: Yes, absolutely, and that's
11 what e are pushing, although at the same time, we are
12 mindful of what needs to go into kind of the guidance,
13 in order to see what level of practicality and then
14 simplification we need to have.

15 MEMBER BLEY: Last question on this. Have
16 you begun writing the technical basis, and is some of
17 that nearing a point where it could be shared?

18 DR. MOSLEH: Bits and pieces of it,
19 reports that different groups have developed. But
20 they're not in a form that we can -- I mean they have
21 not been internally consolidated and reviewed.

22 MEMBER BLEY: So the development work's
23 still in progress?

24 DR. MOSLEH: Yes.

25 DR. LOIS: So it could be part of the

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1 discussion at the end, what it's going to be discussed
2 in the next workshop, who you call that would be able
3 to provide at least parts of documentation of what we
4 --.

5 DR. MOSLEH: So I mean there are parts
6 that, if you think of them as kind of draft or working
7 documents that can provide, to get feedback more for
8 the view graphs and the slides.

9 DR. LOIS: Yes.

10 DR. MOSLEH: Okay. So this slide shows
11 the simple causal perspective, and it's probably quite
12 a familiar concept to everybody. You see the core
13 ingredients being a human failure event of the type
14 that you see in a PRA or a decomposition of those
15 human failure events that you see in a PRA.

16 What we want to see next, as the next
17 layer of decomposition and the causal delineation, is
18 identification of a set of proximate causes. The
19 proximate causes are effectively, you know, maybe a
20 formal definition, a characterization of the condition
21 that is readily identifiable as leading to HFE, all
22 right.

23 So you're looking at the surface and say
24 what specifically happened that caused the HFE, and
25 what we are aiming at is developing a set of proximate

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1 causes.

2 Now the next level of explicit causal
3 model is the performance influencing factors, think of
4 from the context factors, can think of from the
5 generalization of the performance shaping factors. I
6 use the word "explicit" because you see a list of
7 those, and then you'll see a list of proximate causes
8 and a PRA will show a list of human failure events.

9 What is going to be implicit and part of
10 the technical basis is establishing the relation, the
11 link. On what basis you have a set of proximate
12 causes, what literature and psychology or operating
13 experience supports the proximate causes, and what
14 literature and operating experience supports the list
15 of performance influence and factors.

16 Such links, the indirect ones, of course,
17 will be soft, indirect and often controlled by the
18 state of the art in the related domains, psychology
19 and plant experience.

20 To give you a sense of what we call PIF,
21 you can see as a generalization of the PSFs to include
22 the plant conditions. Generally, maybe one can really
23 call these things a context, a set of context factors
24 that are grouped here. Like some of them are plant
25 and scenario-related, time and rate of change of plant

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1 parameters, the state of the critical safety functions
2 and components, crew mental model and their
3 assessments dynamically as to what is happening in the
4 plant.

5 Other things such as goals that they
6 follow, constraints that they might have, and then
7 finally the usual list of human-machine interface,
8 ergonomics, training, other things that are lumped
9 together as PSFs.

10 Now we do have a list of we're working
11 from, and that list was developed as a result of a
12 dissertation work, Ph.D. dissertation work at the
13 University of Maryland by Katrina Groth.

14 That work has in it a relatively
15 comprehensive literature review of psychology, human
16 factors and nuclear power plant experience, informed
17 by event assessment and event classification from
18 operating experience, and we have also have three
19 international workshops that provided input to that.

20 So it was a reasonable amount of effort
21 that went into developing the list of performance
22 influencing factors that we're working from. That
23 list, although it's a starting point, is still
24 something that is going through some modification, as
25 the group works on finalizing the list of things that

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1 we need to have.

2 CHAIRMAN STETKAR: We're probably not
3 going to see that list today then; is that correct?

4 DR. MOSLEH: We can show you that. It's
5 in the back of the slides. We can -- if you are
6 interested in a --

7 CHAIRMAN STETKAR: Well, probably not in
8 real time, because I want to make sure we have time to
9 finish today. I was more curious about the current
10 size of the list. Does it number in the one's of
11 events, ten's of events, hundreds of, you know,
12 factors? Hundreds of factors?

13 DR. MOSLEH: The structure is
14 hierarchical, and it has two things in mind. One is
15 having enough detail hierarchically so that you can
16 help, what Gareth mentioned, kind of asking the right
17 sort of questions in a qualitative analysis.

18 But also you can collapse them to a higher
19 level of abstraction for quantification, because we
20 know that if you have of, I don't know, 50 or 60
21 context factors or performance shaping factors,
22 quantification will not be very reliable.

23 Okay. So we have that list we can share
24 with you later, if time allows.

25 CHAIRMAN STETKAR: Okay.

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1 DR. MOSLEH: Now let me kind of give you a
2 sense of what we have covered, in terms of
3 psychological review, and this slide is less basically
4 the types of things that have been reviewed, a number
5 of journals, some special issues that summarize many
6 of the findings of the human factors community,
7 cognitive psychology and human factors textbooks, and
8 articles. So the usual search, the usual research in
9 an academic sense.

10 The methodology followed was to look at --
11 so how do you extract information from this? Again,
12 if you look at it, after many, many thousands of
13 articles, papers and books that have been published,
14 and then you scan, you have to have a sense of what is
15 it that you want to use and rely on.

16 One criteria is okay, well there are many
17 people who publish papers, because they need to get,
18 you know, degrees and go to school and all that. So
19 you need to kind of see okay, what level of consensus
20 or agreement is there?

21 You know, what do you see more of than
22 others? And actually the good news is that there are
23 fewer ideas and concepts and methods than the number
24 of papers written. So we can actually capture much of
25 that in a fewer, kind of a representative ideas and

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1 fields.

2 So the degree of community support or
3 consensus in terms of, you know, uniformity and
4 consistency of the ideas was one criteria, and the
5 other one was the critical, of course, is relevance to
6 nuclear power plant. So you have certain things that
7 apply, particularly you know, people study teachers'
8 behaviors or students' behaviors. That has very
9 little relevance.

10 So that relevance to nuclear power
11 operation and complex system operation was another
12 criteria.

13 Given with that, you'll see that there are
14 gaps that are identified. Psychology doesn't support
15 the certain types of things that we know for sure
16 apply to nuclear power plant operation, whether you
17 need to fill those gaps. As such, you end up
18 interpreting, extrapolating and extending from current
19 existing theories. You form a base, you form a
20 foundation, and then you extrapolate from there.

21 That happens to synthesizing some things
22 that seem to be fragmenting basically. You know, you
23 have different ideas that seem to be kind of pointing
24 to different aspects of the same problem. You go
25 through some sort of a synthesis of those, to at least

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1 bring deliberate order into otherwise a very, very
2 kind of a difficult domain, search domain.

3 Lastly, I think is an extremely important
4 and very difficult thing, is to simplify, to take all
5 these things and then reduce to be more manageable.
6 That's why thinking about guidance to analysts is
7 always in our minds, as we go through this thing.

8 So now I'm going to look at the causal
9 perspective that we had in two, kind of two sectors.
10 One is on the left side of the earlier graph. The
11 other one is the right half. What do we mean by left
12 side? Left side means going from psychological
13 theories and models and methods to proximate causes,
14 identifying proximate causes of failure from what we
15 see in the literature.

16 Now the literature, apparently if you look
17 at it, very few -- a smaller fraction of the
18 literature really identifies failure of causes. There
19 are many theories that may provide a hint, and some
20 sense of what proximate causes of human failure might
21 be.

22 But often, you need to just basically rely
23 on extension and extrapolation from areas where the
24 intent was not in the literature to actually identify
25 failures. So the cognitive models and psychological

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1 mechanisms that we identify in the literature were
2 grouped and categorized into initially a list of about
3 130 and so types, and then further reduced to smaller
4 numbers.

5 Remember that this is now going from
6 psychology to identify proximate causes, and not
7 necessarily direct plant talk yet, okay. So that's
8 one side of the literature.

9 In that you can see on the next slide a
10 number of lists, just to give you a sense of the types
11 of methods that we have reviewed, these are titles of
12 these methods, the names. Sensation and perception,
13 information forging theory, situation awareness,
14 sense-making on decision-making and group thinking.

15 You have the recognition prime decision-
16 making, situation awareness and sense making, broad
17 categories of concepts and ideas on the cognitive
18 engineering and aided decision-making. Again, read
19 the list. These are among the literature that we
20 reviewed, so I'm not going to go through the rest of
21 this thing. There's a --

22 MEMBER BLEY: Was that previously done
23 early on or this got finished some time ago, the
24 literature review?

25 DR. MOSLEH: This thing, the initial list

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1 that you saw last time, or this may be some earlier,
2 that hasn't changed in terms of volume significantly.

3 In terms of assessment and reevaluation it has, and
4 some of it needs to continue.

5 One area that we don't have adequate
6 coverage, in my perspective at least, is the purely
7 crew aspect, what if you -- we made a few decisions
8 as to what overarching, kind of a human performance
9 model would be, and then from there, then we see what
10 were the gaps. We saw what were the gaps. We tried
11 to identify the gaps.

12 And there is a difference between the
13 psychology of the real human performance and
14 psychology in terms of group and crew performance. I
15 think what we have is a little bit lighter on the crew
16 as a team than say on the individual psychology.
17 Maybe you can --

18 MS. WHALEY: I would agree with that.
19 April Whaley, Idaho National Lab. The literature
20 review is --

21 CHAIRMAN STETKAR: Please identify
22 yourself.

23 MS. WHALEY: April Whaley.

24 CHAIRMAN STETKAR: Make sure our recorder
25 gets the names

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1 MS. WHALEY: Idaho National Labs, and
2 let's see. The literature review is, I would say
3 largely complete, but as we've been replying and
4 simplifying and developing the structure, some areas
5 where we have some minor coverage have become a lot
6 noticeable. So we're identifying, like Alex said, we
7 need to go in and include some information regarding
8 coordination among the crew.

9 We've got adequate coverage for
10 communications, but not so much command and control
11 issues and you know, delegation amongst the crew. So
12 it's less a broad search and literature review and
13 more targeted to the specific areas that we have
14 unidentified that we're now currently missing.

15 CHAIRMAN STETKAR: Is that because people
16 have not looked at the crew dynamics, or you just
17 haven't looked for the literature yet?

18 MS. WHALEY: The latter. There are --
19 there is research out there about crew dynamics, and
20 it was -- at this point, it was more of we're not sure
21 how to fit this in. So we had to look at it as
22 extensively as we have it now when we're looking at
23 it.

24 CHAIRMAN STETKAR: I'm sorry. It's about
25 the airline industry. It's a somewhat different crew,

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1 but it's still -- there's a history of that dynamic.

2 MS. WHALEY: Yeah. So there is work out
3 there. Yeah.

4 MEMBER BLEY: Has anybody tried to take
5 the research in crew performance and dynamics into a
6 human reliability analysis --?

7 MS. WHALEY: With a specific HRA purpose?

8 MEMBER BLEY: Yes.

9 MS. WHALEY: Not that I'm aware of. I
10 could be, you know, have missed something. But it's -
11 - there's a lot of --

12 MEMBER BLEY: Not that people are doing
13 the HRA development have been aware of that in the
14 picture.

15 MS. WHALEY: Yes. In terms of how to
16 incorporate that into an HRA and how to quantify it, I
17 haven't gone into that yet.

18 DR. MOSLEH: One thing that the literature
19 has verified is really how to address the issue of a
20 control impact of continuous monitoring, where you
21 know, what we tend to do in HRA is discretize that
22 into kind of the simpler subtasks and activities, and
23 very quickly you get into kind of the dynamic
24 situation that has not been the focus of many of the
25 task analyses that we see.

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1 Although the literature of task analysis
2 quite extensive, but breaking or decomposition into
3 something that is practical is very difficult to see.

4 Let me comment further on the criteria that we use
5 for developing, extracting proximate causes of
6 failure, human failure from the literature.

7 One is we wanted to, to the extent
8 possible, have distinct, non-overlapping definitions,
9 and that's with the view on kind of analysts, looking
10 at the analysts and the quantification, having
11 sometimes what we call definitionally --. It's kind
12 of a math term, so that's what we want.

13 The second one is again, looking at the
14 practical, we want those to be observable or at least
15 inferable, so that when you collect data or
16 information, you see that yes, this is a behavior or a
17 cause that I can associate with failure. I can see it
18 and associate it with failure in a practical manner.

19 And in a way, you can see that we really
20 didn't impose a top-down structure on the search. In
21 other words, we said look, given the general
22 guidelines, that we want this thing to be plant-
23 oriented, you know, to speak to the technology we're
24 interested, and that we need to this thing to be
25 practical and all that, we asked the domain experts

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1 to look at the literature and find what they could
2 find. We didn't impose a structure on that.

3 So it's kind of, you can call it a bottom-
4 up approach in that sense, okay. But that obviously
5 is not sufficient. We have to look at complimentary,
6 a complimentary approach to fill the gaps, and I
7 mentioned a few of these things before. Use of
8 synthesis models, to take -- we take from multiple
9 theories and converging to one actually unifying
10 picture, and another technique is to kind of read the
11 psychological literature and say well, you know, in
12 this, in the context of nuclear power plant operation,
13 really this really means this, to interpret it.

14 The other thing it did was kind of try to
15 see if you are looking at a nuclear power plant now,
16 and look at the different aspects of the behavioral
17 response, is there a way of bracketing the problem
18 into kind of distinct set of -- using distinct set of
19 dimensions, to ensure and help us basically assure
20 some level of completeness.

21 And that is, to give you an example, we
22 all know that there's a certain phase that operators
23 collect information, gather information or respond to
24 incoming information. We said okay, you know, the way
25 you would now kind of characterize that environment,

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1 the information, is through three distinct dimension
2 of the problem.

3 One is the source of information, the
4 source. The plant, procedures, what is the source of
5 information. The other one is modality of the
6 information. Is it auditory, is it visual? What kind
7 of form or shape is the information coming? And the
8 response mode of the operator. Is it going to be an
9 active search for information by the operator, or the
10 operators are receiving the information in a passive
11 mode?

12 So that, by crossing different kind of
13 dimensions, you can then develop a fairly complete
14 space of characterizing the types of things that could
15 lead to the identification of proximate causes.

16 So this, together with psychological
17 literature review, helps us develop what I call a list
18 of proximate causes from a generic point of view, kind
19 of in more general terms.

20 We tried to develop this, such that it
21 would apply to a broader range of applications, not
22 just say a power operation, but also hopefully for
23 shut down, ideally for maintenance and other
24 activities. So keep it generic. Keep in generic in
25 that sense, and keep it generic in the sense of really

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1 linking and relating to the psychological literature.

2 Here's an example of the approach, where
3 you see a literature, excerpt from the literature. We
4 can read the words. A particular reference tells us
5 in this particular case, Endsley's 1995 and references
6 are in the back article, that talks about a way that
7 information-gathering could fail, and that's a problem
8 associated with the way you gather the information,
9 sampling.

10 You know, you see a set of incoming cues
11 or information, and you become selective or
12 intentionally, unintentionally. For example, from an
13 -- in an inconsistent and incomplete way. What you
14 take that and say well, these then point to a
15 mechanism for a cue not being perceived, or a cue not
16 being attended to.

17 These key words then lead to
18 identification of the proximate causes that relate to
19 that particular mechanism that I mentioned earlier.
20 So mechanisms being an inadequate sampling, and it
21 says well, if it results in a cue, an important cue
22 not being perceived.

23 MEMBER BLEY: I'm a little curious about
24 what you're showing us, Ali. Is this like an index
25 card in a research project, and you've got hundreds

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1 and hundreds of these from little squibs you pull out
2 of the literature, or is this just an example to tell
3 us this is kind of thing you've done? How has this
4 evolved and how many proximate causes do we now have
5 in a catalogue of some sort, and are they all linked
6 back to the literature like you're showing here?

7 They all link back to either literature or
8 extrapolation from the literature, in the sense that
9 this describes. So if you look at the catalogue of
10 the least proximate causes, there is an explicit
11 reference to where we have, and then if we didn't have
12 any reference to it, either an extrapolation based on
13 the methods that I talked about earlier. So it's not
14 with a catalogue of mechanisms leading to it.

15 MEMBER BLEY: Are we getting a bigger
16 catalogue of these kind of things than we had in, you
17 know, one document I'm familiar with, in the ATHEANA
18 document, or are they different or are we learning new
19 things or just a better way to organize them or just a
20 better way to anchor them back to literature of the
21 one form or another?

22 DR. MOSLEH: Certainly the latter is what
23 might be. But whether they -- I don't know if I can
24 actually tell you what, you know, we haven't done a
25 cross-comparison to the ATHEANA list in a --

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1 MEMBER BLEY: No, I wasn't asking you if
2 you've done that. I'm just trying to get a -- I mean
3 you're showing us an example. But how does it fit
4 into all the work you've done? We were trying to --
5 we were hoping to get a pretty good picture of where
6 you sit in all of this, what this means.

7 CHAIRMAN STETKAR: Let me before, just to
8 help me also, on this simple slide here, you
9 accumulated three possible situations, cues not
10 perceive, cues not attended to and cues misread, as
11 all contributing to, I'm assuming, the same proximate
12 cause.

13 DR. MOSLEH: No, no. Examples of
14 proximate causes.

15 CHAIRMAN STETKAR: Because for example,
16 cues misread to me could be a much different
17 situation.

18 DR. MOSLEH: These are separate, yes.

19 CHAIRMAN STETKAR: Okay, good.

20 MS. WHALEY: Yes. So these, this is --
21 the literature excerpt is when we conducted the
22 search, our goal was well, let's identify ways in
23 which or mechanisms for failure in human cognition,
24 and this was one of the pierces that was identified by
25 Endsley, saying incorrect information sampling is a

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1 way that failure can occur.

2 So this is a mechanism, and this mechanism
3 can lead to several proximate causes, which is not
4 perceived, not attended to or misread. So the end
5 result of the mechanism is a cognizant failure, and
6 that's explaining this specific slide.

7 In terms of how this piece fits into the
8 larger literature search that we've done, if you'll
9 recall from the April meetings, we talked about having
10 a master table of over 130 items. This would be just
11 one of those 130 items. What we found is we have a
12 list of mechanisms were, when activated by the right
13 context, could lead to failure.

14 They tended to kind of cluster together,
15 and those clusters became -- the proximate causes kind
16 of merged out of those categories. So we have less
17 than 30 proximate causes and we're finding it even
18 further. So when you ask about how many proximate
19 causes do you have, I think we're right about 40.

20 (Simultaneous discussion.)

21 DR. MOSLEH: Yes, yes, we have a list here
22 we can show you.

23 DR. LOIS: You want to touch on it, talk
24 about that?

25 DR. MOSLEH: So we have separated the

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1 proximate causes in this list of 30, condensed from
2 130 or so excerpts or content of psychological
3 mechanisms from the literature.

4 MEMBER BLEY: And the arguments for
5 condensing are that they're essentially identical, or
6 that some other argument?

7 DR. MOSLEH: Yes.

8 MEMBER RYAN: Let me ask you another
9 question here on this one --

10 MEMBER BLEY: Can we get this one done
11 first, Mike?

12 MEMBER RYAN: Oh sure, sorry. I was --
13 kind oif it's an add-on.

14 MEMBER BLEY: Oh, okay. Go ahead.

15 MEMBER RYAN: This says "Incorrect
16 information sampling." How about correct information
17 sampled incorrectly. Is that a different case?
18 There's two different things I'm asking about. The
19 first one is incorrect information sample. "I looked
20 at the wrong gauge." How about if I looked at the
21 right gauge and read it wrong?

22 (Simultaneous discussion.)

23 MS. WHALEY: That would be the misread.

24 MEMBER RYAN: That's a separate one, okay.
25 But that's counted. Okay, that was my question.

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1 DR. MOSLEH: Yes, yes. If you look at the
2 list of -- there's a few more that I can -- so this,
3 for instance, the one before.

4 MEMBER BLEY: Do we have a hard copy of
5 this?

6 MS. WHALEY: No. This was in the -- this
7 is the backup slide.

8 (Simultaneous discussion.)

9 MEMBER BLEY: Go ahead and tell us about
10 it, because I can't read it.

11 DR. MOSLEH: It starts with the, on the
12 left, the types of things that relate to failure in
13 the information perception and process a cue or
14 information not sensed or not perceived, not appended
15 to, misperceived, discounted or dismissed, wrong
16 information or cue attended to. That's the first
17 block.

18 MS. WHALEY: And we've actually refined
19 that further. We've condensed it further to not
20 perceived, not attended to and misperceived. So we
21 have three.

22 MEMBER BLEY: Your arguments for this
23 condensation process.

24 MS. WHALEY: Is that we're removing "not
25 sensed" from the list, because from a psychological

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1 perspective, there is a distinction between sensation
2 and perception. But for the purposes of this
3 application, one, you won't be able to identify the
4 difference. It's not observable from, you know, a
5 practical perspective.

6 So from a practical perspective, you can't
7 tell the difference.

8 MEMBER BLEY: And you're building a
9 documentation of this process?

10 DR. MOSLEH: Yes, yes, absolutely.

11 MS. WHALEY: Yes, and for example, then
12 we're also saying "discounted or dismissed" makes more
13 sense to apply when we're talking about
14 understanding, rather than in gathering information.
15 So we're moving discounted/dismissed to a different
16 section.

17 MEMBER BLEY: So under something like an
18 information processing model, you're clumping these
19 things where you think they most belong?

20 MS. WHALEY: Yes, and the wrong cues
21 attended to is actually a specific mechanism or a type
22 of not attending to cues. So it's more specific.

23 DR. MOSLEH: Yes. That is for -- you have
24 asked about whether we are grouping them. It's the
25 grouping that you see here, for instance, a high level

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1 grouping.

2 Okay. So one group on the left, the upper
3 left, the upper left, you see an I and then you have
4 things that relate now to decision-making and
5 situation assessment, and the right-hand side is the
6 action-related proximate causes, and on your other
7 question he gave you the answer.

8 But I just want to emphasize the fact that
9 every step of this thing is document, in other words,
10 the links or as explicit as we can make it.

11 MEMBER BLEY: That will be that technical
12 basis.

13 DR. MOSLEH: That's the technical basis,
14 yes. yes. There's further translation of this generic
15 list to another list, which is even, you know, more
16 plant talk. In other words, if I go to the next slide
17 that you have on your view graphs, it's on 14.

18 So on the left you see the proximate
19 called "generic proximate causes." Say take, for
20 instance, a complete -- deciding on incorrect
21 alternatives. So on this list, you have 14? On this
22 list you see two rows. One rows says "In assessing
23 the situation, you may develop a set of alternatives,
24 alternative explanations that may be incomplete or
25 inadequate.

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1 In other words, you know, I look at the
2 situation in a plant and say well, is it tube rupture?

3 Is it loca? It is something else, and then maybe in
4 that list, you haven't really identified all the
5 possibilities, alternative explanations and accident
6 types. So incompleteness in that sense is a problem.

7 And then once you have a set of
8 alternatives, and the correct alternative is in the
9 list, you make a mistake in actually picking the wrong
10 one from that. So in a generic sense, these are
11 mechanisms leading to incorrect decisions or incorrect
12 assessment of the situation.

13 So make this plant talk, top talk plant,
14 you need to translate that to specific things that can
15 happen and in effect be cause of proximate cause. It
16 could be skipping a step of a procedure or leaving a
17 procedure altogether.

18 So what I meant by going through another
19 layer of translation from the generic proximate causes
20 that are identifiable in the psychological literature,
21 to failed cognitive processes, then you need to go to
22 another layer and say well, how does this now
23 translate to specific things that could affect the
24 plant and be a cause of human failure? Okay, okay.

25 The next step is the other side of the

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1 story. So you have a list of proximate causes, and
2 you have a psychological basis or mechanisms that
3 contribute or would be the background or the
4 contributing factor to cause the proximate cause.
5 These psychological mechanisms can cause the proximate
6 cause if they're involved or triggered by the
7 performance influencing factors.

8 So the next level of the search from the
9 same literature was to see if we can relate the
10 performance influencing factors to the psychological
11 mechanisms, to the proximate causes, going from PIFs
12 to proximate causes.

13 So in this slide, you see, for instance,
14 on the left-hand side, the cue not appended to. If
15 you look at the theory or a concept such as situation
16 awareness and the number of mechanisms that are
17 mentioned in that perspective and theory, you can see
18 a certain sort of mechanisms that one can relate to
19 the PIF.

20 So on the far right, you have the PIFs,
21 three of the PIFs, and then in the middle, you see
22 what the literature or the citation actually refers
23 to, or in this case, narrowing of attention or, for
24 instance, a failure to combine and collapse
25 information or make a final classification to a

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1 distinct, recognizable pattern or assessment.

2 Each of these could point to one or
3 multiple performance influencing factors, the
4 workload, the stress or other things. So the second
5 half of the activity, well kind of happened
6 concurrently, but when you look at the product, you
7 see one leading to proximate causes, and the other one
8 is looking at the psychological mechanism to point to
9 the performance influencing factors.

10 And so similar level of documentation or
11 literature citation is intended there, although in
12 this case, I would say that the literature is much
13 lighter than the previous case. Here, you have to
14 rely more of our understanding of operating experience
15 and the plant, and things that are commonly known as
16 being performance factors in the HRA literature.

17 But there is an attempt, and I think an
18 extensive one to the extent possible, is to do the
19 mapping between the performance influencing factors
20 and the proximate causes, based on literature.

21 So the next slide is a sample of the
22 result of that activity, that you see on the left-hand
23 side a number of the proximate causes, such as cue,
24 for instance, or information not perceived.

25 Right in the middle in this light blue

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1 boxes, a reference to the literature in terms of the
2 mechanisms involved. Then you see the citation next
3 to -- you might find it difficult to see on the
4 screen, but probably on the slides that are clear.

5 So in this case, there's three of them
6 that are highlighted. In the next slide, maybe it's
7 easier to read.

8 MEMBER BLEY: Before you leave this one,
9 the blue boxes are proximate causes. They break down
10 into a subset of some kind of reasons for these
11 occurring.

12 MS. WHALEY: Yes. I wouldn't say they
13 break down, but these are mechanisms that have been
14 identified as ways at which -- ways in which the cue
15 or information could not be perceived.

16 MEMBER BLEY: So there's no argument that
17 this is --

18 MS. WHALEY: I wouldn't say that this is a
19 hierarchical structure.

20 MEMBER BLEY: You wouldn't? So it's just
21 kind of saying we found this in a bunch of places, so
22 it's important?

23 MS. WHALEY: Yes. These are mechanisms
24 that have been identified as ways in which --

25 MEMBER BLEY: And then when you slip over

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1 into the context side?

2 MS. WHALEY: These are the performance
3 influencing factors that we infer or have, you know,
4 been able to directly identify from the literature --
5 that are relevant for this mechanism.

6 MEMBER BLEY: Let me take you up to the
7 top row. If those things in the pale blue column
8 aren't a substructure, then why do they go to
9 different context factors, or whatever you're calling
10 these things? If that's not a breakdown, then I
11 wouldn't expect to see the first one go over to four
12 factors and the second one go to to two different
13 ones. So it looks like it's a structure. I'm
14 confused.

15 DR. MOSLEH: It is a structure. I think
16 what she meant was that, you know, I don't know what
17 the word "hierarchy" was interpreted, but it is really
18 a relation showing the relevance of the factors
19 identified, to say the light blue box, and then
20 relating that to the darkened blue.

21 MEMBER BLEY: Let me try something else.
22 Stay with the top one. "Cue information not
23 perceived." Then there one, two, three, four, five,
24 six, seven things in the next area, "not perceived due
25 to quality, not perceived due to sensor overload."

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1 Now so these seem like different reasons
2 for which it's not perceived. So it does seem like
3 it's structured. Now I don't -- I think what you're
4 saying is you're not arguing that's complete, but
5 those are instances that have been observed, and there
6 could be more instances.

7 DR. MOSLEH: Yes.

8 MEMBER BLEY: For those instances that
9 have been observed, you'd go further, and you haven't
10 told us yet how you do that, to link to these
11 contextual factors, which I still don't know quite
12 where they came from and how you do that linking.

13 DR. MOSLEH: Okay. Go ahead.

14 MEMBER BLEY: But before we -- it is a
15 structure and they are different, so it's not just
16 citations. It's these are instances that you found,
17 either in the literature or including in event records
18 perhaps --

19 MS. WHALEY: This is from the literature.

20 MEMBER BLEY: Strictly from the
21 literature.

22 MS. WHALEY: Strictly the psychological
23 literature.

24 MEMBER BLEY: So it's not from any of the
25 event work you've been doing. But it could include

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1 things from the event work.

2 MS. WHALEY: Yes, I mean and this is just
3 the first -- I mean this is entirely based off of the
4 psychological literature, and we're in the process of
5 identifying areas where we need to add operating
6 experience to complete or enhance.

7 DR. MOSLEH: Let me add on your question,
8 on the pink, light pink side, whether that the list is
9 informed by operating expense or not? Is that --

10 MEMBER BLEY: No. My question was in the
11 blue one, which are the instances for cue information
12 not perceived, that's a list that you pluck from the
13 literature. That could clearly be -- might be
14 expandable from operating experience. It might be
15 complete. We don't know.

16 DR. MOSLEH: Yes, yes.

17 MEMBER BLEY: Now the other question I had
18 was to get from those things that are plucked from the
19 literature over to these contextual factors, I have
20 two questions. One is where do the contextual factors
21 come from, for which you're doing this linking, and
22 how did you do the linking? Or how are you doing the
23 linking? I assume you're not done with all of that.

24 MS. WHALEY: Yes, yes. We're in the
25 process of that. Move to the next slide. We'll show

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1 them. This is the same branch that you were just
2 looking at, only bigger picture, less items.

3 MEMBER BLEY: It's the same stuff.

4 MS. WHALEY: This is the same stuff. This
5 is essentially the top brands, the cue information not
6 perceived.

7 MEMBER BLEY: The right hand side fits in
8 one column instead of two. Okay.

9 MS. WHALEY: Yes, yes. So it's a little
10 bit bigger font. Okay. When you see the references
11 that say, just that they just refer to number one,
12 that means, that's just entirely our inference.

13 So based off of -- we have several
14 references saying that the cue or information cannot
15 be perceived due to some aspect of the quality or the
16 availability of the information source itself.

17 So we have three references there, and the
18 reference is in the back of the presentation.

19 CHAIRMAN STETKAR: Two of those references
20 having the same author, five and nine.

21 MS. WHALEY: Yes. Based off of -- if all,
22 on the context if all it says is "one," that's our
23 inference, saying okay, well based off of this, we
24 think that this is going to be a process, and the list
25 of context factors is the list of PSFs that was

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1 developed in Katrina Groth's dissertation.

2 MEMBER BLEY: But you said that also
3 includes plant conditions or Ali said that.

4 MS. WHALEY: Yes.

5 CHAIRMAN STETKAR: Was that in Katrina's
6 thesis?

7 DR. MOSLEH: No, no. Generic, it kind of
8 as a category it does. But if you're referring to
9 specific plants and areas, of course not, because it
10 is -- those are vague contexts specific to which
11 scenario you're dealing with.

12 Let me show -- maybe we can show Dennis
13 the PIF list. It probably would be difficult. We'll
14 go through view graphs.

15 (Pause.)

16 DR. MOSLEH: Dennis, here is the list of
17 the more usual PSFs, but organized through Katrina's
18 work and all that. So if you look at it, it says
19 something like "machine design PSFs." So HSI --

20 MEMBER BLEY: This is a backup.

21 DR. MOSLEH: So I'm reading it. This is,
22 so --

23 MEMBER BLEY: Can't even see this one.

24 DR. MOSLEH: No, I can't see it. I looked
25 at it for a long time when developing this thing.

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1 It's hard for me --

2 (Off mic comments.)

3 DR. MOSLEH: So look at -- the thing says
4 a system response or HSI on the right-hand side, is
5 more plant factors than say things on the left-hand
6 side. So this is organized by organization,
7 organizational factors on the left. Then it goes to
8 the team factors. It goes to personal or individual
9 factors, and then situation PSFs and then machines.
10 So let me read a few examples of each.

11 On the organizational factors, you have
12 training program, you know, plant programs and
13 activities, resources, procedure, quality and
14 availability, the types of things that are under
15 control of the organization.

16 MEMBER BLEY: These are the things you
17 brought over from Katrina's work.

18 DR. MOSLEH: Yes, right.

19 MEMBER BLEY: Okay.

20 DR. MOSLEH: And this list was what would
21 I think describe as, has looked at the PSFs that you
22 see in HRAs, whereas we had the three workshops that I
23 mentioned and also the HIRA (ph) data activity that
24 Katrina and April spent a few years on, analyzing a
25 number of, I think, 30 or 40 events.

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1 Then also informed by psychological
2 literature, and then separate one that was conducted
3 by Katrina.

4 MEMBER BLEY: And if I go back -- given
5 you had this list, and then if I go back to the slide
6 we had before, which was -- there's no number on it.

7 MS. WHALEY: Seventeen, yes.

8 CHAIRMAN STETKAR: Seventeen.

9 MEMBER BLEY: Seventeen. The one up there
10 says you just had this list and you had this citation,
11 and you said seems reasonable that this is the one,
12 one of the things that could be an instance of that
13 particular cause.

14 MS. WHALEY: Yes.

15 MEMBER BLEY: Okay, and you had four of
16 them, and all of them are 1's, except one of them was
17 a 1 and a 9, whatever a 9 is.

18 MS. WHALEY: Nine is a reference to a
19 specific article, or it's in -- basically, every time
20 you see a 1, it means that we made an inference, and
21 if there -- if the literature itself called out, like
22 this is going to be an issue, like a number of the
23 references to Mike Endsley's work, it called out
24 specifically experience and training. So if the
25 literature --

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1 MEMBER BLEY: Oh, I see.

2 MS. WHALEY: If the literature suggested
3 directly that this is going to be a factor, then we
4 very easily, you know, called that out. If there
5 wasn't a suggestion of what kind of factors could lead
6 to it, then we had to make a judgment or an inference.

7 MEMBER BLEY: Now for Mr. Stetkar's
8 comment that Mr. Endsley's been cited more than once,
9 I think the goal here is to be as complete as you can
10 as you're doing this. So that's not -- it's not that
11 these are orthogonal references; it's just this is a
12 collection of information.

13 MS. WHALEY: Yes. These are -- the list
14 at the back of the presentation of references, that's
15 the current references for the literature review. The
16 literature review, as we were trying to get the big
17 models that have, you know, extensive consensus among
18 the community.

19 DR. MOSLEH: According to the criteria.
20 Now there's kind of the two levels of down-selecting.
21 One was from the literature, to see whether there was
22 a kind of better, more general agreement on the things
23 that the psychologists have said, but another down-
24 selection process was to look at whether it's relevant
25 to --.

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1 MEMBER BLEY: Having skimmed your
2 literature, I have to ask a question. You only cite -
3 - you cite of Reasons' things, but one is his WL, the
4 last book that I know of, on accidents and heroic
5 recoveries. He spends about a third of the book on
6 the good side of human action. Did you try to pick up
7 any of that?

8 MS. WHALEY: Not for this application,
9 because we were looking for mechanisms for failure.
10 But I think that that --

11 MEMBER BLEY: I hadn't thought about this
12 until I started looking through his book, and I'm
13 saying gee, you know, he might be right. We're
14 missing -- we don't have -- these don't get reported.
15 So what we have are anecdotal pieces. But anyway, go
16 ahead. You were starting to say something.

17 MS. WHALEY: Well, yes. I certainly
18 wouldn't disagree with you, that we need to look at
19 opportunities for recovery, and that's something that
20 we continue to mention as amongst our group, within
21 the group, that we need to figure out how we're going
22 to include recoveries in this. So I imagine we'll get
23 there.

24 MEMBER BLEY: Because we run into a lot of
25 comments from people from plants and our committee,

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1 from our folks who came out of the plants, about "Gee,
2 you know. All we hear are operators are bad. What
3 about the other side of it?" Back to wherever you
4 were, say if you can find it.

5 DR. MOSLEH: Also what to add is that
6 there is that -- so we have the list that we have
7 produced, although they have not gone through kind of
8 all the internal cycles of review and consolidation.

9 But there is a list of PIFs. There is a
10 list of proximate causes that speak psychology. There
11 is a list of proximate causes that speak plant, and
12 there's a mapping between these, supported by or close
13 to a completed map. But it's something that the team
14 needs to really review.

15 MEMBER BLEY: The only mapping I've heard
16 so far is I mean the citations from the literature or
17 your own judgment under these. Is there some other
18 kind of mapping --

19 DR. MOSLEH: Okay. Leaving here, we
20 talked about -- I mentioned the tree element model
21 that I showed earlier, the first few view graphs or
22 somewhere in there, it's kind of basically PIF,
23 proximate cause and HFE, is the surface of the causal
24 model.

25 Detail I talked about synthesis models.

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1 The synthesis model, the necessity of the synthesis
2 model is because you have a vast group of literature
3 that's different than, you know, different ideas and
4 concepts and RES.

5 It's hard to synthesize those without
6 having some level of consolidation and the grouping of
7 those into something that would represent at least our
8 perspective of what we learned from the literature.

9 So those synthesis models provide a way of
10 identifying what we -- recognizing what we have found
11 in the literature, also understanding and identifying
12 the gaps, okay. So I mentioned, you know, looking at
13 information perception and processing; talked about
14 looking at three dimensions of the problem.

15 One of the dimensions was whether the
16 activity was a passive information-gathering or an
17 active information-gathering. That, the literature
18 obviously doesn't give us that model, you know, as a
19 consensus model. There's a hint of information
20 forging, as is a theory pointing to this.

21 But we're went a little bit beyond, and
22 that gives us a way of characterizing the proximate
23 causes, in terms of whether they relate information-
24 gathering in a passive way, or information-gathering
25 in an active way, whether the operators are just

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1 receiving information or they're looking for
2 information.

3 So those synthesis models are also kind of
4 under the scheme of this high level construct that I
5 showed you.

6 MEMBER BLEY: As you say that, I'm trying
7 to envision how these connect and work together in an
8 actual model one day. I guess I don't get it yet. I
9 mean everything you saw sounds reasonable and great,
10 but I don't -- I haven't got the idea of how it all
11 really works. If it's at the stage of really working,
12 or if it's --

13 DR. MOSLEH: Working in feeding an HRA,
14 yes. I think we're beginning to feed the HRA process
15 with this. I will mention that the focus of this
16 thing is identifying the ingredients that need to be
17 integrated into an HRA process or procedure, and we're
18 stopping at that level.

19 We can take a couple of steps. Now Gareth
20 is going to talk about how some of these things can be
21 picked up by say a particular way of quantifying an
22 HFE. But the integration of all this into kind of a
23 coherent, cohesive model is something that I can share
24 with you some of the elements. I have a few view
25 graphs. But let me mention this one, so that you see

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1 that.

2 You mentioned earlier or you asked whether
3 your, kind of what the overarching method. Kind of
4 you referred to information processing. Yes, we are
5 using information processing, so that's kind of high
6 level construct, and it's divided into --

7 MEMBER BLEY: You were telling us that you
8 grouped in something like that, but go ahead.

9 DR. MOSLEH: Yes. But you are using that,
10 and that is -- we are providing some supporting -- an
11 argument of why that is useful, relevant and it has
12 support in psychological literature.

13 Once you have that, that gives you an
14 organization of proximate causes. In other words, are
15 these proximate causes relevant or related to the
16 information-gathering phase, or is it relevant to
17 situation assessment and decision-making, or is it
18 really something that gives us a sense of how the
19 actions are executed.

20 So and there's under each of those, there
21 are also other structures. For instance, some of
22 things that is quite -- it's not a dominant theory.
23 But a lot of people refer to an end book, and that is
24 much of the problem-solving in highly structured
25 environments such as control room environment, when

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1 you're procedurized. People are trained and all the
2 things that we know about operator, operating in
3 nuclear power plant operating environment, you know,
4 skill people, procedures and all that.

5 Much of the problem-solving is really
6 either directed pattern-matching, which is directed by
7 procedure, or operator's thinking about, you know,
8 whether they have a solution that has been basically
9 provided to them through training and operating
10 experience.

11 So pattern matching or similarity matching
12 seem to be kind of the dominant mode of operator
13 response in that phase of their response. Now that
14 has roots in a number of theories in psychology. So
15 when we talk about finding proximate causes for that
16 phase of operator response, mainly a situation of
17 assessment and decision-making, pattern matching is
18 the dominant one that we're using. So that's a
19 submodel in that phase.

20 All these things are assembled through the
21 information processing as a model. I mentioned
22 earlier the fact that the information processing
23 model, you can look at it from a crew perspective or
24 an individual perspective, and that's something that
25 we need to finalize. In other words, we are modeling

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1 a crew, but going from psychological literature
2 supporting individual information processing concept
3 with crew information processing is something that we
4 need to spend a bit more time on.

5 MR. FORESTER: I think that maybe one
6 aspect, and I think Gareth will probably touch on it,
7 but there's another aspect of this is that the
8 cognitive mechanisms, when considered in conjunction
9 with the different kinds of PIFs, factors that we
10 expect will influence performance, by looking at those
11 two things again, you get some idea of what you need
12 to measure with respect to the PIF.

13 So PIF might be training, and you can ask
14 about training at sort of a generic level, how good is
15 their training. But you might also, if you have a
16 mechanism like, you know, similarity matching or some
17 sort of confirmation bias or some sort of
18 psychological process, then it tells you what kinds of
19 aspects about training you need to consider to address
20 that particular mechanism. So it goes a little bit
21 further, I think, and that's not an easy thing to do.

22 But that provides us some of what the observables
23 might be.

24 MEMBER BLEY: Let me throw in two things.

25 One, I don't see any references to the folks who have

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1 done the research on crews in your list, and that is,
2 you're just working on that now is what you said. So
3 none of that made it in.

4 I see Gary Klein here two or three times,
5 I think, and in your backup you have stuff on
6 naturalistic decision-making. How are you using that?

7 DR. MOSLEH: Well, so let me go to a
8 couple of view graphs you do not have, and then maybe
9 -- can you go to, I think it's slide -- this is two
10 theories. I will highlight, we will show the slide
11 and I think maybe --

12 DR. LOIS: Which one?

13 DR. MOSLEH: It's Slide 32, I believe.

14 MEMBER BLEY: In the backups?

15 DR. MOSLEH: The backups.

16 MEMBER BLEY: We just got your backups.

17 DR. MOSLEH: Okay, great, good. It says
18 example, frameworks from the literature, and one of
19 them is NDM.

20 MEMBER BLEY: Yes.

21 DR. MOSLEH: So it kind of highlights the
22 elements of NDM, and I'll let April comment to which
23 way or if that has been used in forming the list. I
24 can say something about the other one, the recognition
25 of prime decision-making, either one.

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1 MEMBER BLEY: Which is part the
2 naturalistic decision-making model, I would assume, if
3 you call that a model.

4 MS. WHALEY: There are several -- there
5 are a couple of major camps in the decision-making
6 research in the psychological fields, and the one that
7 is relevant to our purposes is the naturalistic
8 decision-making.

9 The other decision-making work typically
10 does work with college students, and it's choice among
11 alternatives, and it didn't -- I wasn't the one who
12 did this, reviewed this literature specifically.

13 But naturalistic decision-making focuses
14 on decision-making by experts in real world
15 environments, and that makes much more sense too, for
16 our purposes, than some of the other judgment and
17 decision-making work.

18 What we ended up doing is reviewing a
19 couple of the naturalistic decision-making models, of
20 which the one that is by large and far the most
21 published and the most documented is the recognition
22 of prime decision-making, which is Gary Klein's work.

23 The other models haven't had anywhere near
24 as much discussion and research conducted with them.
25 So what we did with this is the same thing we do with

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1 the other literature that we looked at.

2 We identified the stages of the model,
3 because the model has stages and steps, and then tried
4 to either pull explicitly from the source itself, you
5 know, ways in which failures can occur, and we would
6 take a sentence and say okay, well if this doesn't
7 work, we ended up doing a lot of negation. We take a
8 sentence from the article and change the verbal to
9 "not" or "failed to," you know, to identify a way in
10 which it could fail.

11 That became part of our big list of 130
12 mechanisms for failure. It would be part of then our
13 literature for the proximate causes and, you know,
14 connecting to the --

15 MEMBER BLEY: So somehow those things show
16 up in your current list of 130?

17 MS. WHALEY: Yes, yes. That was all
18 integrated in.

19 MEMBER BLEY: It's nice to be able to read
20 how you're putting all this together, because I'm not
21 -- but go ahead.

22 DR. MOSLEH: In this list on this slide,
23 you see that one aspect is, I think, we think it's
24 very relevant. The other aspect is something that one
25 can model things that way, but I'm not sure if that's

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1 really how things happen.

2 One aspect I think is relevant is that the
3 general strategy followed by people in such situations
4 is matching current situation to prototypical kind of
5 situations. So it's a pattern-matching kind of thing.

6 The second one, I'm not sure if it
7 applies, is options are considered sequentially.
8 Operators probably don't go from one option to
9 another, in their mind at least, you know. They do
10 consider various options concurrently. But not
11 apparently in the case of firefighters, which was this
12 was, you know, this type of experiment was based on.

13 So you know, one aspect of it is relevant,
14 the other one is not, and we have to -- that's why I
15 think it's sort of a synthesis model in the sense that
16 I described is important, because we need to extract
17 things that are not part of the theory, combine them
18 with another theory, and step a little bit beyond what
19 the psychology literature is, you know.

20 MEMBER BLEY: It would be interesting to
21 get into this, because what I remember from this stuff
22 is he's essentially arguing that, you know, it's a
23 snap and I'm going this way, and you do it until it
24 doesn't work and then you snap to another way. We've
25 tried to train people not quite to work that way in

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1 power plants, so I'm interested --

2 DR. PARRY: But they still do.

3 MEMBER BLEY: But they still do, because
4 it's --

5 DR. PARRY: They still do.

6 MEMBER BLEY: Because the first thing in
7 your head sticks, and we see that causing troubles
8 often. But it might do a lot of good too. So go
9 ahead.

10 DR. MOSLEH: Okay. So I'm going to
11 quickly summarize the last two slides, and then -- so
12 where we are, and this is Slide 19 on your handout or
13 page 19. So we have a lot of the psychological
14 literature that is in place with the few exceptions I
15 mentioned, taxonomy of PIFs that we have, and it may
16 go through some minor quantification, but I think it's
17 reasonable.

18 The mapping of generic PCs to, those are
19 proximate causes to PIFs, is not as complete as the
20 other reports but it's in reasonable shape. I haven't
21 seen the final kind of round yet from April, but I
22 know that she's been working on it. I've seen it. We
23 have seen an example or two.

24 The mapping of the proximate causes of
25 generic psychology to a plant kind of specific or

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1 plant or a nuclear power plant environment proximate
2 causes, we do have the list or something close to it.

3 The mapping has also been done, but the group has not
4 reviewed that.

5 And then something that I think Gareth
6 will elaborate more on is basically an example or an
7 area where we think we're heading, in terms of
8 establishing guidance for use of the second part only,
9 in an actual HRA. The one element of that is what I
10 have on the next slide, is consideration of logical
11 structure to gather -- the logical structure is really
12 a model or a mapping between the PIFs and the
13 proximate causes in a form --

14 I'm talking now about, you know, how an
15 analyst would use this thing, taking the PIFs, going
16 through some sort of a set of steps to relate those to
17 the proximate causes, and then from the proximate
18 causes to PIFs.

19 In doing so, an example is the decision
20 tree and the variations of that, such as Bayesian
21 belief network, will try to address the relation
22 between PPCs and HFEs, and considerations of what I
23 would call kind of a local recovery.

24 In other words, if you don't perceive any
25 information, there's a chance to recover from that.

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1 Maybe the next cue will tell you go gather some of
2 that information. So there's what I call kind of a
3 local recovery possibilities that might require a
4 different set of logic to be imposed on the model.

5 There's the interdependencies potentially
6 between the proximate causes, because of the common
7 PIFs that apply to, and the PIFs are also not
8 independent. They have interdependencies that need to
9 be considered, at least, in an explicit way.

10 And some of these things we hope that will
11 be subject of the next timer we meet to talk about
12 some of these structures, although Gareth will provide
13 a hint of this as to what we are --

14 MEMBER BLEY: You dropped the phrase
15 "Bayesian networks" in there somewhere.

16 DR. MOSLEH: Yes.

17 MEMBER BLEY: I didn't quite get where it
18 fit and where you were thinking it would be helpful.

19 DR. MOSLEH: Yes. Well, the PIFs are
20 interdependent, and then when they map to the PCs,
21 also there is sometimes a common or set of common
22 factors that point to several PIFs.

23 When you're facing a situation like that,
24 when you know that the influence path is complex, and
25 there are statistical and causal interdependencies,

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1 then the most natural model, the style of modeling I
2 know is influence diagrams. The next step would be
3 the Bayesian influence diagram.

4 Whether we use the Bayesian belief network
5 to explicitly quantify is something that we haven't
6 really explored.

7 MEMBER BLEY: Fair enough.

8 DR. MOSLEH: So the last one is some of
9 the team members are also team members that have
10 current data activities, and that's -- so we're trying
11 to coordinate, at least in terms of exchanging
12 information, in a sense coordinate with the activities
13 such as the one that you're familiar with, and that's
14 similar to data collection as a minimum these two
15 projects.

16 MEMBER BLEY: For the other members,
17 that's time lines for real events and --.

18 MR. FORESTER: Gareth.

19 CHAIRMAN STETKAR: Okay. You're up, sir.

20 DR. PARRY: Okay, thank you. I'm going to
21 talk about developing an HRA quantification model.

22 (Laughter; simultaneous discussion.)

23 MEMBER BLEY: The thing is it's spelled
24 correctly on this.

25 DR. PARRY: I know, I know. But my email

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1 address is incorrect, so drop the 47. Is that right?

2 (Simultaneous discussion.)

3 DR. PARRY: My name's spelled correctly.
4 So Ali's talking about decomposing everything into
5 finer and finer pieces. What I'm going to talk about
6 is the approach we're thinking or an approach we're
7 thinking, of stitching it all back up together again,
8 to come up with an HRA quantification model, okay. So
9 this is the model that we would use.

10 Go to the next slide. This is -- and what
11 we mean by an HRA quantification model is that the
12 model that we use to generate the HEPs for a well-
13 define human failure event. So that's what I'm
14 talking about, is how we're going to develop that
15 model, and this is one concept for doing it.

16 The idea is that the model going to use,
17 as the input, the performance influencing factors and
18 we've used that term a lot, that define the overall
19 context for the HFE, okay.

20 The context is in two parts. We're going
21 to use the plant conditions; it's what's going on in
22 the plant, and also the traditional PSX that typically
23 you don't get directly out of the PRA scenario
24 definition. You have to learn about them from talking
25 to crews and looking at the procedures.

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1 I've got here four like sort of ground
2 rules in this presentation. They're certainly things
3 that I think we would like to have the model look
4 like.

5 First of all, the whole basis for this
6 project is that we want to have the model to have a
7 sound basis that's consistent with cognitive
8 psychology as a behavioral science discipline. So
9 that's the reason we've embarked on this SRM project.

10 The second thing is that we'd like the
11 model to be practical and applicable directly to human
12 failure events that are defined for PRA models. The
13 third thing is that, and I think this is important
14 point, is that the model should provide the user with
15 the tools to identify the crucial elements of context
16 that you need for the quantification.

17 So in a sense, you could almost say that
18 the quantification model developed as it is based on
19 all the work that's been done here, should provide for
20 you the guidance for the qualitative analysis that you
21 need.

22 The fourth thing is that we want to have a
23 model that will enable both intra- and inter-analyst
24 consistency. Okay. So we want the model to be as
25 objective as possible, if you look, in some sense,

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1 given the context.

2 Okay. The theoretical basis for this
3 quantificational model or quantification model is the
4 -- I believe you would have heard about the nested
5 information decision action model before.

6 Okay. The concept behind that really is
7 that the HFE is the failure of a process which is not
8 a point in time process, but it's actually a
9 distributed in time process that if, you know,
10 something happens at the plant, if somebody responds
11 to plant changes.

12 This is an opportunity to recover, as you
13 mentioned Dennis. We have to worry about the recovery
14 factor, and it's the failure of that total package
15 that is the HFE. So we want to basic go on the sets
16 of proximate causes that we're developing as part of
17 this project.

18 And the justification for the
19 quantification tool is really the set of cognitive
20 mechanisms and their links to the PIFs, and back to
21 the proximate causes.

22 MEMBER BLEY: Gareth? Maybe I'll wait
23 until you go a little further, Gareth. But eventually
24 I want to -- I'll telegraph it. Eventually, I want to
25 ask you about the IDA and the nested natural, and I've

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1 seen Ali show that several times.

2 The one place I have a little trouble
3 there is if we're using this in the modeling, the "D"
4 is a big piece. I mean the D has got the kind of
5 mental model and situation assessment. It's got the
6 diagnosis and it's got that plan formulation kind of
7 stuff all embedded in it, which is a lot of stuff
8 going on.

9 So maybe later I'll raise that, but I just
10 wanted to telegraph it. But if we're using IDA and
11 these recycled loops on it.

12 DR. PARRY: Okay. I'll explain that now.

13 MEMBER BLEY: Then I'll want to know a
14 little mor about them.

15 DR. PARRY: I don't think, I mean at least
16 in my mind, that I wouldn't use that explicitly. I'd
17 use that concept, that thought process implicitly in
18 designing the approach for quantification.

19 MEMBER BLEY: Okay.

20 DR. PARRY: But it wouldn't be an explicit
21 loop type model, but I think that it's really too
22 complicated. Okay, the next slide.

23 The approach is that for each of the
24 proximate causes that we've decided, there's two
25 constructive decision trees. Okay, this is -- if

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1 you're familiar with the CBDT, the old EPRI project,
2 it's similar in concept to that. The trees are almost
3 certainly not the same. That was after all done very
4 quickly on the basis of some observations from the
5 EPRI experiments.

6 But the idea is to construct trees, and
7 the headers on the trees will represent the critical
8 PIFs. So that meets ground rule one, if you like.
9 But it helps me with ground rule one, which was to
10 have a sound basis that's consistent with the cog
11 psych and behavioral science discipline, okay.

12 Then for each of the branches, the aim
13 would be to have a set of questions provided to help
14 an analyst determine, as objectively as possible, the
15 existence or not of PIF. So I think this gets to a
16 question that you asked, Dennis, about how do you make
17 sure that the expertise from cognitive psychology and
18 also from the plant people, get into the
19 quantification.

20 And that's the way to do it, is by having
21 the analysts ask the right questions of the right
22 people.

23 A comment on these and what these decision
24 trees represent is that each path through the decision
25 tree essentially represents an explanation of why that

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1 human failure occurred, why that proximate cause
2 occurred, in terms of both the cognitive mechanism.
3 Now that, I've got to say the cognitive mechanism
4 won't be explicit on the trees, okay. But it will
5 underlie the structure of the tree. So in terms of
6 that and the PIFs.

7 This is not dissimilar to the MERMOS
8 approach, where they create what they call little
9 stories. But basically they have a mode of operation
10 of the crew, which could be that they're stuck in this
11 particular mental model, for example.

12 They have performance influencing factors,
13 but they call them something else, which would enable
14 that to exist. But they also have a very important
15 thing, which is the failure to reconfigure their
16 mental model, which is the recovery factor.

17 I think the idea would be to have that
18 recovery factor built into these decision trees,
19 because it's really important in many ways. To give
20 you an example of that would be if there was an issue
21 related to failure to detect a crucial piece of
22 information. That would be perhaps the thing that
23 would kick it off, that they failed to see some cue.

24 But one of the recovery mechanisms could
25 be that there's an alarm that comes in late in the

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1 day, that still gives them enough time to recover. So
2 you want to include that also as a recovery mechanism.

3 So that's the type of thing that we would build into
4 the decision trees. Okay next.

5 MEMBER BLEY: Are you envisioning a
6 standard set of decision trees, or perhaps a set of
7 branches that, depending on the situation, could be
8 reassembled in a tree that fits the particular
9 situation, or have you gotten that far along?

10 DR. PARRY: Well, I think my vision is,
11 okay, and I'm not sure. We haven't all discussed this
12 yet, so it's not perfectly true, but I think my
13 vision would be that we would have a standard set of
14 trees that would be a, if you like, consensus model of
15 what this quantification of models should look like.

16 But that the, for a specific HFE, then the
17 answers to your questions would define which path you
18 were on.

19 MEMBER BLEY: Okay. So you'd be like
20 pruning this thing down to --

21 DR. PARRY: Yes. It would actually take
22 one path through the tree for a particular HFE. Now
23 if it was -- if that HFE and this gets back to your
24 question, John. If it was an HFE that occurred on the
25 different context, then maybe you'd go down a

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1 different branch, okay.

2 So that the trees would be as complete as
3 we could with the knowledge we have, but that they --
4 it would be the conditions and the assessment of the
5 PIFs that would drive you to the right end point for
6 the particular --

7 MEMBER BLEY: Let me dream just a second.
8 This thing could be very big.

9 DR. PARRY: It could be very big.

10 MEMBER BLEY: But you could have a set of
11 questions that as people answer it would automatically
12 simplify this thing, to get down to what you're
13 looking for.

14 DR. PARRY: I think that's something that
15 we've got to be aware of, that it could be very big.
16 Actually, for the few examples that I've tried to
17 construct so far, they're not that big.

18 MEMBER BLEY: No, okay.

19 DR. PARRY: Okay. They're bigger than the
20 decision trees in the current EPRI project, but
21 they're not enormous. Now the approach I think that
22 we're going to try to come up with initially to
23 quantify these trees, so far the only trees I've
24 constructed, what I've done is I've ranked the end
25 points according to my perception of what the HEP

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1 should be.

2 Okay, so the place -- well meaning the one
3 with the worst conditions would have the highest HEP,
4 right.

5 MEMBER BLEY: Right.

6 DR. PARRY: The one with the most optimal,
7 with the optimal conditions would have the lowest
8 HEP, and then each of the end points on the decision
9 tree would be ranked, okay. That's a ranking we'd
10 have to agree on, obviously, amongst ourselves.

11 The idea to use expert judgement to come
12 up with the HEP for each path through the tree
13 ultimately, okay. Now that's not going to be easy.
14 But particularly because, as Ali suggested, that the
15 PIFs are not independent, and furthermore, we don't
16 have an empirical basis really for judging the degree
17 of dependence.

18 MEMBER BLEY: So whatever we come up with
19 is going to be changed, I suspect.

20 DR. PARRY: It could change.

21 MEMBER BLEY: It could do, yes.

22 DR. PARRY: Well, that's true, but I mean
23 I think that's -- that aspect of it should be embedded
24 in the trees, okay. So the idea is that these expert
25 panel that judges these probabilities is going to come

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1 up with these numbers. I see Dennis smiling.

2 MEMBER BLEY: I won't say out loud what is
3 crossing my mind.

4 (Laughter.)

5 DR. PARRY: Okay. I mean it's going to
6 depend on which experts you have to do the trees,
7 right? So I think the only way to get consistency is
8 to have a consensus approach to this. So rather than
9 have each analyst that's applying this model come up
10 with his own probabilities, these end points should
11 have probabilities that have been chosen by consensus,
12 by some group of experts, okay.

13 I mean that's what was done with the
14 original EPRI CBDT effectively. The numbers were just
15 chosen. That, in my mind, is the only way you can
16 have a consensus model. Otherwise, we're back in the
17 situation where everybody who applies it is going to
18 apply his own rules, which are going to be very
19 difficult to unravel, to understand why they got the
20 numbers they got.

21 Okay. So the proposed approach, at least
22 originally we're going to give it a shot anyway, is to
23 rank the end points by the HEPs, and remember what the
24 end points are is this is the HEP under the set of
25 conditions, that's defined by the path through the

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1 tree, okay, by the combination of the PIFs, and then
2 certainly reach consensus on two bounding cases for
3 this tree, and somehow interpolate.

4 So that's one way of reaching a consensus
5 model, in the absence of a database that we can use to
6 quantify these things. We know we don't have one,
7 okay. So let me just make a couple of comments about
8 what this quantification model results in.

9 It's effectively, if we were able to do
10 this, if we are able to do this, and I believe we can
11 up to a point, then what it will be, it will be a
12 consensus quantification model. That's consistent
13 with what we've learned about the psych literature.

14 MEMBER BLEY: Not to pick, but when I look
15 back to find ground rules one and two and four, all I
16 find are ground rules one and three on your slides.

17 DR. PARRY: That's all?

18 MEMBER BLEY: That's all I find.

19 DR. PARRY: Oh. Not on the one I've got.
20 That's on page two.

21 MEMBER BLEY: Ahh. They started sooner
22 than that.

23 DR. PARRY: Oh, those are the --

24 MEMBER BLEY: I'm sorry. I was picking
25 them off later slides.

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1 DR. PARRY: The whole set's there in the -
2 -

3 MEMBER BLEY: Yes, the whole set's there.
4 Pardon me.

5 DR. PARRY: Okay, so -- okay. So the idea
6 is that, you know, that this model would be a
7 practical model to use, and give guidance to the --
8 actually it satisfies probably two, three and four, I
9 think. But the -- well, it satisfies all of the
10 ground rules.

11 But the way you've used this, okay, is
12 that the model will define the minimum amount of
13 qualitative analysis you need to apply -- to estimate
14 the HEPs, okay. Some of that comes from the PRA
15 scenario definition of the HFE. Some of it's going to
16 come from looking at the procedures, talking to
17 trainers, talking to operators, for example.

18 I think this model could be used to
19 directly for existing PRAs. It could also be used to
20 support an ATHEANA type analysis, where you look for
21 deviation scenarios, because you would just -- you
22 might have for one HFE in a traditional PRA, you might
23 have a number of different ones with different
24 subcontexts, if you like, for an ATHEANA-type
25 analysis.

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1 So you would just, for each of those
2 subcontexts, you'd have a different pattern of the
3 tree, but that it would be weighted by the probability
4 of that subcontext within the PRA context, the error
5 fault context in other words.

6 I think if we structure these trees well
7 enough, based on all the information we have, the
8 trees themselves can be used to provide guidance on
9 how to choose the subcontext, how much to subdivide
10 the conditions, if you like, to give you clearly
11 different subscenarios.

12 So I would envisage that the model could
13 be used iteratively with a method like the CRT or
14 ATHEANA, to develop a more detailed HRA/PRA model. It
15 doesn't need to be done that way. You could even do
16 the HFE online, off line I mean, by just looking at
17 the different subcontexts and weight the different
18 HEPs you'd get for the different conditions.

19 So and the way this model would work is
20 that for any scenario, PRA scenario with an associated
21 context, then the HP of the HFE, given that scenario,
22 would be the sum over the probabilities of the
23 proximate causes given that scenario. Okay. That's
24 the way we're suggesting that this model works.

25 The second example is for a place where

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1 the context is broken down into the subcontexts, this
2 just becomes a double sum where, I mean it's a
3 straightforward extension. So that's the idea behind
4 the model. I think the other advantage of using this
5 type of model is, and this advantage is not dependent
6 on whether we eventually choose a decision tree type
7 approach or any other type approach.

8 But we are leaning towards using a causal
9 approach, and any causal approach is probably going to
10 give you a more rationale basis for looking at
11 dependencies between HFEs and the scenario.

12 MERMOS does this by looking at the
13 different relationships between the different what
14 they call human failure scenarios, that are different
15 ways of failing the HFE, if you like. So they look at
16 the perpetuation of the modes of crew operation into
17 another HFE further down the road, for example.

18 So that's the general discussion. I did
19 have some backup slides of a very crude initial shot
20 at a decision tree, if you want to see maybe what it
21 would look like, just to whet your appetite of
22 something.

23 MEMBER BLEY: Why don't you show one?
24 Right now, it's so vague to me, you know. It smells
25 good.

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1 (Simultaneous discussion.)

2 DR. PARRY: Could you back up? I want to
3 see which there we're looking at. No, no. Back up.
4 Yes, I know. This one, okay. Okay, yes. The
5 particular proximate cause in here is that the crew
6 intentionally dismisses information, okay. So in a
7 small subgroup --

8 CHAIRMAN STETKAR: Are these in the
9 backups slides we already got?

10 DR. PARRY: These are different backup
11 slides.

12 (Simultaneous discussion.)

13 DR. PARRY: In a subgroup of the project
14 team, which is John, Katrina, Stacey Hendrickson and
15 myself, we set out looking at a particular -- it's a
16 slightly different set of proximate causes from the
17 ones you've seen. I mean these are the issues we've
18 got to work out obviously.

19 CHAIRMAN STETKAR: You've got to start
20 somewhere.

21 DR. PARRY: And I think that came out from
22 work that Katrina and Stacey have primarily done,
23 based on the work of April and Johanna. So these were
24 the PIFs that we decided were, that were decided were
25 the appropriate PIFs for this particular proximate

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1 cause, given what we could find in the psychological
2 literature, okay.

3 So one of the things -- well, one of the
4 reasons you might dismiss information is from bias.
5 One of them could be conditioning events, past
6 experience with a specific indicator could tell you
7 that it's not reliable.

8 I think in a lot of these information
9 processing things, ambiguity of system responses seems
10 to be a key factor, because I think you have to have
11 some ambiguity; otherwise, why would you even tend to
12 make a mistake. So another one of the traditional
13 PIFs obviously is training, which will induce bias, if
14 nothing else.

15 And then there's knowledge and experience,
16 okay. So these generally are the PIFs that we were
17 working from. So based on that, and I can't even read
18 it now; I'm sure you can't.

19 MEMBER BLEY: You're right. I can't.

20 DR. PARRY: Okay. So this was an attempt
21 to put all that into a decisions structure, okay. So
22 the first branch point is is there a mismatch with
23 expectations? Okay. So this brings in the bias
24 aspect of things.

25 The next question, and don't ask me to

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1 explain why they're ordered this way right now. This
2 was -- I mean obviously it's --

3 CHAIRMAN STETKAR: It's a complete,
4 logical structure.

5 DR. PARRY: Yeah, okay. The things that
6 we have are the indications are unreliable. One of
7 the questions we asked is are they confirmatory
8 information indications. This would be a recovery
9 mechanism of sorts.

10 So the final question is the recovery
11 potential. If there is confirmatory indication, is
12 there a reason why the crew would recognize that that
13 is going to put them on the right path? I mean there
14 is procedural direction to take account of that, for
15 example.

16 So that's the idea of the structure. Then
17 at the end, you've got these rankings here, and
18 basically the way you've structured the tree is that
19 the bad conditions always go up, and the good
20 conditions go down. So they rank from one to ten,
21 with a negligible stuck on the bottom there, because I
22 think wow, you know. This is a perfect situation.
23 Why would he think of dismissing this information?

24 And so the way to -- remember what we said
25 is that we want to have objective guidance on how to

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1 determine whether you go up or down on these branch
2 points. So this is an example of one of the branch
3 points, and again don't take it too literally yet.

4 But the idea is this is the branch point
5 that's concerned with confirmatory information, and
6 can the significance of missing information be
7 validated by other information? Okay. This is the
8 significance of the information that they've
9 dismissed.

10 MEMBER BLEY: I know this is just an
11 example, but from the earlier discussion, it would
12 seem you could have questions that come from the other
13 side, like the Gary Klein stuff. Are you locked into
14 an initial choice here and that's one of the reasons
15 why you might just keep going or something like that,
16 so you could build a larger set of questions that do
17 both sides of the issue, that drive you?

18 DR. PARRY: Well, yes. I think that
19 locked in one would come earlier on.

20 MEMBER BLEY: Oh in the way you compose
21 the tree? That's fine.

22 (Simultaneous discussion.)

23 DR. PARRY: Right, because this is
24 allowing the possibility of recovery. So that the --
25 this question of whether it's confirmatory information

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1 would -- you'd ask things are there additional
2 indications that would typically be used to confirm
3 the plant status.

4 MEMBER BLEY: The place I'm nervous here
5 is in real events we've seen. There are cases -- if
6 you just put these kind of questions, and there are
7 things, well then yeah, they're going to --

8 CHAIRMAN STETKAR: Yes, it is. It's
9 there.

10 MEMBER BLEY: They're going to recover.
11 But you could also have cases where you've got a mind
12 set that's set up and is causing you to miss these
13 things one after another.

14 DR. PARRY: Yes, right.

15 MEMBER BLEY: And maybe you had it earlier
16 and it bypasses all this. If that's true, that kind
17 of works.

18 DR. PARRY: I think what you're going to
19 have to do is to -- and these questions aren't fully
20 developed yet, but you'd have to ask the question is
21 the additional confirmatory indication strong enough
22 that it overcomes any previous biases. Now we can't
23 ask it that way.

24 MEMBER BLEY: And that's though, when you
25 --

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1 (Simultaneous discussion.)

2 DR. PARRY: But I think we'll also find
3 though that for the majority of standard HFES, this is
4 probably not going to be that big an issue.

5 MEMBER BLEY: Oh, I think that's right.
6 But those aren't the ones that -- those are not the
7 big risk factors.

8 DR. PARRY: They're not. Well, I'm not
9 sure. I mean I think the -- that remains to be seen,
10 whether they really are big risk factors.

11 MEMBER BLEY: You and I may disagree, but
12 accidents tell a tale here.

13 DR. PARRY: Well, accidents are a little,
14 I think are a little different though, because the --
15 particularly I think in the -- I think there has to be
16 something quite significantly wrong with the
17 procedures for them to lead into a major accident.

18 I mean not that the procedures are wrong,
19 but that they're not structured for the particular
20 scenario that you're dealing with.

21 DR. MOSLEH: This could be forcing him
22 into the situation that Dennis is talking about. I
23 think that's --

24 MEMBER BLEY: Right, and if all your
25 instruments are working right and all that sort of

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1 thing. There's other stuff.

2 DR. PARRY: Right, okay. I mean I
3 understand about your concerns, and it's clearly
4 something we've got to think about. I also think that
5 at least for an interim step in this process, it's
6 worth looking at this type of path, because it will be
7 a model that is more in tune with current thinking
8 than, say, the previous ones.

9 MEMBER BLEY: No argument.

10 DR. LOIS: Dennis is not going to argue
11 about that. I think his argument is about with
12 respect to other questions, and the matter of the path
13 is that got produced these questions, and that there's
14 very little --

15 (Simultaneous discussion.)

16 DR. MOSLEH: No, I understand. We're like
17 a style like analysis than a project, and I think your
18 point is well taken, that it has to be a merger of the
19 types of questions that come from this side --

20 MEMBER BLEY: That's right.

21 DR. MOSLEH: The psychology and the --

22 MEMBER BLEY: And experience. And looking
23 at real experience, to make sure that from both sides,
24 those questions are developed. I don't know if
25 they're a different thing. Accidents are a thing we

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1 need to worry abo ut.

2 CHAIRMAN STETKAR: That's why we're doing
3 this.

4 (Laughter.)

5 MEMBER BLEY: I don't disagree with that.

6 (Simultaneous discussion.)

7 CHAIRMAN STETKAR: Usually we're thinking
8 the same thing but saying it so differently we don't
9 recognize it. So go ahead.

10 DR. PARRY: So really all I wanted to do
11 by this example, remember these are just strawmen that
12 haven't been structured. So I want to show you the
13 concept of that translating the PIFs that we have
14 determined are relevant, because of understanding of a
15 mechanism, a covenanted (ph) mechanism if you like,
16 and using those as decision points in a tree, and then
17 asking a set of questions which we --

18 And this will be a challenge, is to come
19 up with a set of questions that are clear and can be
20 objectively applied to help you decide which way you
21 go on the decision tree. If we have to have multiple,
22 you know, multiple point branches on a decision tree,
23 that's something we might have to look at.

24 MEMBER RYAN: I'm reading the final
25 conclusion, and at the end it says "yes to both

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1 questions." Let's say the answer is no to the second
2 question, and yes to the first question. What have we
3 got then?

4 DR. PARRY: I think you'd go down the
5 branch. I'm sorry, you'd go up the branch, not down
6 it.

7 MEMBER RYAN: Yes.

8 DR. PARRY: Yes. Remember, this is an
9 example, okay.

10 MEMBER RYAN: Oh no. I'm just trying to
11 think about the mechanics of it.

12 DR. PARRY: The mechanics of it would be
13 that the set of questions would be structured such
14 that, and we'd have to be careful about saying do I
15 mean all of these or do I mean one of these, because
16 that's something.

17 MEMBER RYAN: Okay. That's the point I'm
18 looking for, that you have to be very careful in the
19 language.

20 DR. PARRY: We do.

21 MEMBER RYAN: You can get mixes of yes and
22 no's that might not give you any sort of information
23 on where to go next.

24 DR. PARRY: Right, and --

25 MEMBER RYAN: Is that a fair point?

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1 DR. PARRY: So that's a very fair point, I
2 mean, because even in documents like the PRA standard
3 that have been produced, there's some ambiguity in
4 some of those requirements, as to whether you meet all
5 or one of them. It's a good point, and I think that's
6 the type of feedback we have to incorporate into this
7 model.

8 MEMBER RYAN: I guess I think Dennis and
9 John can correct me, but I would think that operator
10 experience in those sorts of language choices would be
11 very helpful, to really understand how operators use
12 the language as opposed to us.

13 DR. PARRY: I don't think this is an
14 operator issue as such.

15 MEMBER RYAN: Well they could certainly
16 inform how that language gets used, you know. I mean
17 do they use the same language in the same way to mean
18 an acceptance or a denial or data, you know, or this
19 is important versus this isn't.

20 DR. PARRY: Well, okay. I think that's a
21 good point, but the questions we ask, we should also
22 have in mind the audience to which the question is
23 addressed.

24 MEMBER RYAN: Exactly.

25 DR. PARRY: To make sure that we're

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1 talking about -- well, some of this is the operators.
2 Some of this is not. Some of this is procedures,
3 some of this is training, and some of these are plant
4 conditions even.

5 So I think the question has to be phrased
6 in such a way that the person to whom it's being asked
7 can answer it in a positive way, or a negative way,
8 whichever.

9 MEMBER RYAN: Whatever the convention is,
10 you have to kind of line up with the conventions.

11 DR. PARRY: Right, right.

12 MEMBER BLEY: You know, I think this going
13 to be really interesting to see where it goes. I
14 guess one thing I'd urge, having been off to see some
15 of the new control rooms and other things, and knowing
16 what folks are doing in computer programs these days
17 is if keeping it simple enough to keep it on a sheet
18 of paper might not be as important as having a tool
19 that lets you selectively identify things and shrink
20 it down to get to the essence that you're after.

21 I'm not saying that very well, but
22 automated tools might be necessary to make this a
23 useful process.

24 DR. PARRY: I tend to be a bit of a
25 Luddite on this side.

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1 (Laughter.)

2 MEMBER BLEY: I do too. I've been doing
3 it myself. But I think we're trying to take some
4 fairly complicated ideas and bring them to an
5 application point for people who probably need that
6 kind of help, so that they don't lose track of the
7 important things we're trying to force through this
8 model.

9 DR. PARRY: Well, I think that's why
10 embedding this into something like the HRA calculator
11 would be a good thing to do, I think.

12 DR. MOSLEH: There are two aspects of what
13 you're talking about, Dennis. One is really to have a
14 method that captures the information in an accurate
15 and then consistent way.

16 That method may be something that's too
17 complex for an analyst actually to kind of use. You
18 need to hide it behind a computer, an algorithm --,
19 and therefore the idea of embedding some of these
20 things into a computer code, to analyze, to help to
21 aid the analyst.

22 A second thing is, in terms of routine
23 applications, some of these things seem to, are going
24 to require, you know, sequence, a series of questions
25 that need to be asked in an organized and consistent

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1 way.

2 It may be difficult to fit it in the usual
3 paper and pencil version, and the analyst might be
4 easier guided by a computer, to go through this
5 sequence.

6 (Simultaneous discussion.)

7 MEMBER BLEY: You're talking about
8 prompts, different prompts depending on preceding
9 questions.

10 DR. MOSLEH: So that's kind of basically,
11 just typically use their interface, using the computer
12 to help the analysis, rather than simplifying it to
13 the point that you cannot sacrifice some of the key
14 points that you want to capture.

15 DR. PARRY: Yes, as is somewhat accounted
16 to that. I think we also have to recognize the fact
17 that really we only want the model to be good enough.
18 We don't have to have such a fine-tuning of these
19 HEPs that we, you know, start believing them.

20 I mean they really are going to be pretty
21 crude estimates. So sort of fine-tuning a crude
22 estimate into two even more crude estimates doesn't
23 seem to me to be all that productive.

24 So I think there's a balance here between
25 doing the thing in such a way that you get as much of

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1 the relevant qualitative information out of people as
2 possible, and force them into creating a story of
3 what's going on at the plant and perhaps recognizing
4 the different ways people can fail.

5 So that you could use it for lots of
6 reasons, one of the reasons being is you could look
7 for improvements for the way that -- you could look
8 for improvements in procedures or methods of training
9 or even plant.

10 CHAIRMAN STETKAR: Sorry he walked out.
11 He'll be back.

12 MEMBER RYAN: It wasn't anything you said.

13 (Laughter.)

14 CHAIRMAN STETKAR: I think, Gareth, you
15 know, that that phrase "relevant" that you tossed
16 around a few times is really important, and I think
17 some of the things that Dennis was talking about, and
18 I can't speak for him, but the relevancy of some
19 information, as far as trying to estimate human
20 performance, may not be as clear as this simple
21 construct, the absolute yes or absolute no.

22 And that's -- I don't know how to, you
23 know. I don't have any ideas. It's just that the --
24 I go back to the example, and this is a simple
25 example, but came from actual operating experience.

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1 It's not an accident. It's just a simple example, and
2 there are things in the literature, I'm sure, that
3 mirror this.

4 A well-trained, probably the best operator
5 I had on my shift was cooling down the plant and was
6 turning the knob clockwise. It was cooling down too
7 fast and he kept turning it clockwise and it kept
8 cooling down faster and faster and faster.

9 He immediately knew that there was
10 something wrong with the instrumentation controls,
11 that something was wired backwards, and he wanted
12 somebody to call out the instrument techs and replace
13 this faulty thing, because we're violating technical
14 specifications.

15 He didn't think that maybe he had
16 completely the wrong mental model. He didn't even
17 think to turn it counter-clockwise, to see if it fixed
18 the problem.

19 MEMBER RYAN: Right.

20 CHAIRMAN STETKAR: Now he had a procedure.

21 I'm not quite convinced that he actually ever looked
22 at the procedure, which was a pretty simple activity.

23 But if you asked him a lot of these questions
24 abstractly, you would have concluded he would have
25 never done that. He was the best guy. He would have

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1 never done that.

2 DR. PARRY: Yes, I know. Right. Well and
3 I think you can't really ask operators whether they
4 will make mistakes, because they will always tell you
5 --

6 CHAIRMAN STETKAR: Well no, but even just
7 ask them, you know, different cues that he had
8 available and things like that.

9 DR. PARRY: And I think there's an element
10 of that. Well, part of that would be that when you're
11 looking at recovery, you're not necessarily always
12 looking at the same crew member, right. You could be
13 talking about somebody else.

14 CHAIRMAN STETKAR: Not necessarily, that's
15 right. In fact, the crew solved the problem. The
16 crew solved the problem by asking somebody else gee,
17 why don't we turn this counter-clockwise and see what
18 happens?

19 DR. PARRY: Yes. I think you have to
20 build that picture of bearing in mind what's going on,
21 and bearing in mind what failure mechanism you have in
22 mind for that person, like the wrong mental model,
23 okay.

24 Then I think you have to look for fairly
25 convincing recovery mechanisms to make that mental

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1 model be changed. If it comes from somebody else, so
2 be it. It's probably more difficult for somebody to
3 alter his own mental model.

4 CHAIRMAN STETKAR: The only sense that I
5 had is looking at the simple logic model we had up
6 there which, you know, you couldn't read, but the
7 observation was that it had all of the possible
8 logical branches on it. Perhaps a logic model that
9 indeed was hierarchical and had some structure to it.

10 DR. PARRY: Well, I think there is method
11 in the madness of ordering the questions. They are
12 structured to some sense logically. All the recovery
13 stuff comes right --

14 CHAIRMAN STETKAR: Right.

15 DR. PARRY: But I think in trying to do
16 them, I think that's going to be challenge, as like
17 maybe putting the -- perhaps it's even senseless.

18 CHAIRMAN STETKAR: You're just bimodal,
19 right. The answer is either yes or no. Is it 70
20 percent yes and 30 percent no.

21 DR. PARRY: No, no, no. There's no
22 percentage involved at all in this, right?

23 DR. MOSLEH: Just looking at the
24 combinations.

25 DR. PARRY: It's looking at the

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1 combinations. So there's no probability associated
2 with those branches. The probabilities are only
3 associated with the HEP, given the set of conditions.

4 But yes, it doesn't need to be bimodal.

5 I find it easy to write that way. But I
6 think the, you know, my guess would be that the first
7 questions in the tree might actually be more to do
8 with plant conditions rather than traditional PSFs,
9 for example.

10 Like you might argue one of the questions
11 might be is this accident scenario fairly similar to
12 another one, okay. That's probably not a very good
13 example.

14 CHAIRMAN STETKAR: Oh, we know.

15 DR. PARRY: You know what I mean. If
16 we're asking questions about the availability of
17 instrumentation, for example, or the reliability of
18 it, it would be up front, not further down, because
19 that would certainly give you different means of
20 failing.

21 DR. MOSLEH: I think, John, what we're
22 convinced of is there needs to be a structure, some
23 sort of a logic in our hierarchical or some other
24 relation, maybe to many, and some way of including a
25 non-binary kind of --

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1 CHAIRMAN STETKAR: I don't know right at
2 the moment.

3 DR. MOSLEH: But yes. We're looking at --
4 but I think this is the simplest of structures you can
5 think of, as a starting point, to see okay, how do we
6 go from the pieces to some aggregate picture.

7 MEMBER RYAN: Yeah, and I mean I've got
8 two basic choices. You can either have different
9 branching arrangements, a yes, no, a maybe, or maybe
10 five maybes with different pathways or a whole more
11 complicated set of yes-no questions.

12 DR. PARRY: Yes.

13 MEMBER RYAN: You want to kind of get to
14 one or the other of those two solutions.

15 DR. PARRY: You know, if you're going to
16 use expert judgment to come up with the end point
17 probabilities, I don't think you want a million end
18 points. You want them to be relatively small in
19 number. So I think the argument should be that the --
20 have better questions as you go down the branches.

21 CHAIRMAN STETKAR: I think the notion of
22 this construct is not to assign, you know, five
23 probabilities to the various gradations, versus no or
24 yes, because --

25 MEMBER RYAN: Yes. I guess to get to

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1 that, the questions have to be very artfully created.

2 DR. PARRY: Right. I mean that's a big
3 challenge. You know, I think whatever we use,
4 ultimately, you know, Ali and Katrina are very keen on
5 using the Bayesian belief networks, for example, and
6 that might, you know, it certainly has the advantage
7 of being more mathematical in some sense.

8 But even there, you're going to have to
9 put in, I think, choices that are a lower level of the
10 correlations between PIFs and things. I think in this
11 construct, that is not -- you still talk about it, but
12 it would be the experts that would have to come up
13 with will be a consensus set of experts, and it would
14 be while they're, I guess their rationale isn't so
15 obvious, certainly the results of what they said would
16 be.

17 I think if you bury it too deeply into a
18 model, then you do get into a bit of the black box
19 syndrome, and I mean there's -- we're always going to
20 have a black box problem, because I think we just
21 don't have the data to enable us to do this stuff in a
22 more scientific way or objective way.

23 DR. MOSLEH: If I could add one more point
24 to something that was brought up earlier regarding the
25 degree of realism that we have in the branches of the

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1 decision tree, when it's set up, informed by operating
2 experience.

3 In a parallel project that I'm involved,
4 you're looking at characterizing the situational
5 factors that were informed from operating experience,
6 and one idea that might work is to map those to say a
7 decision tree, a path through a decision tree, to see
8 if you're capturing what we see in operating
9 experience in a more explicit way.

10 So if you have analyzed 30 events and
11 grouped them into like five or ten situational
12 characterizations, do they map to the decision trees?

13 That's sort of a sanity check regarding that.

14 CHAIRMAN STETKAR: Anything else from the
15 presenters? We're a little bit over time, but this is
16 I think a useful interchange. So I certainly don't
17 want to cut it off because of an arbitrary clock.

18 (No response.)

19 CHAIRMAN STETKAR: No? I'd like to thank
20 you all. I think this was really, really good. I
21 think what I'd like to do is see --

22 MEMBER RYAN: Just one thing. Chris asked
23 in the beginning, I'm sorry.

24 CHAIRMAN STETKAR: What I wanted to say is
25 do you have any more focus questions on what we've

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1 seen?

2 MEMBER BLEY: No, I don't.

3 CHAIRMAN STETKAR: Okay. Thank you very
4 much, sir. And do you sir?

5 MEMBER RYAN: No sir, I do not.

6 CHAIRMAN STETKAR: Okay, thank you very
7 much, sir. Now what I was going to say, to answer
8 kind of Chris' question about where do we go from here
9 and sort of input and guidance for our next meeting, I
10 will then ask now do you have any input on those
11 areas, or did I cut you short too quickly, sir?

12 MEMBER BLEY: Well Chris actually asked us
13 if we were, could say is this stuff right? Is it
14 going in the right direction. Everything we've heard
15 today I found very useful and interesting, and it
16 sounds very good.

17 There are some of the stuff that holds it
18 all together and the details are going to tell whether
19 it's useful and appropriate to use some other times.
20 So I don't think we're at the point yet to say yeah,
21 this is great.

22 But it's encouraging and I need to see
23 some more. I need to see some things written on the
24 modeling aspects, the first half, and on the
25 quantification approach. It just needs a lot of work

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1 before anybody knows how well it's going to work, I
2 think.

3 MS. LUI: Yes. We're taking a phased
4 approach. What we really want to do is to say, okay,
5 we established the foundation, and then to get your
6 buy-in and get your input, and if you feel that we're
7 at the right place, then we'll continue to move
8 forward and clearly, in the next meeting, we'll bring
9 forward more detail.

10 So whatever that you feel that has been
11 most useful for you to hear, as well as our work to
12 support that, we will absolutely be happy to come
13 forward with that type of information next time.

14 MEMBER BLEY: On the first half, on the
15 modeling work, you know, tying all these factors
16 together, the mid-level model as you folks call it. I
17 think we're nearing the point that seeing something
18 written down, to be able to study it, would be
19 important.

20 On the quantification approach, I think
21 whatever evolves between now and a few months from now
22 would be very useful, seeing it in whatever state it's
23 in.

24 CHAIRMAN STETKAR: The sense I have is I
25 think the discipline or writing up that linkage model

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1 might also help some of the thoughts that we were
2 discussing right here at the end, in terms of, you
3 know, what the structure of that quantification might
4 look like.

5 You know, does it need some sort of logic
6 structure, a different type of logic structure or not.

7 So I think I'd like -- as Dennis mentioned, from my
8 perspective, there isn't anything that I've heard
9 today that says, you know, change course or stop or,
10 you know, there's something, there's a fatal flaw
11 hidden anywhere.

12 I think that a key element is to -- let me
13 just put it this way. Stop the literature search, if
14 you will, and start documenting and provide some
15 substance to that framework, because without that,
16 it's really difficult for us to quite understand
17 enough of the information to really see how it's going
18 to work. Anything else?

19 MEMBER BLEY: No.

20 MEMBER RYAN: Yes. We talked a little bit
21 about uncertainty and variability and those kinds of
22 things, and I guess if I had to try and pick one word
23 to sum all up what I'm trying to reach for, is the
24 robustness of the model. How well does it actually
25 describe what could be a real circumstance or set of

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1 real circumstances?

2 So you know, I think if you go through the
3 exercises that Dennis and John sort of described,
4 maybe some of that will fall out. You know, the
5 questions are sort of -- I mean just for presentation
6 purposes today and the detailed questions will give
7 you some more insights about, you know, variability
8 and uncertainty.

9 If, for example, you had two plants built
10 the same way with a different operating staff, would
11 you have exactly the same set of questions about the
12 plants? It depends on how they were trained and what
13 procedures they had, and how they were written versus
14 the others.

15 So that's part of the fidelity, the
16 robustness and the uncertainty aspects of any model.
17 So believe me, it's not a calculational kind of
18 uncertainty but more of a variability kind of concept
19 that we're reaching for here.

20 But if you can think about a little bit
21 and maybe react to that down the line, that might be
22 interesting to hear what your insights are there.

23 DR. PARRY: I could give you an immediate
24 reaction as far as the questions. I think the
25 questions in my mind would be the same. The answers

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1 might be different.

2 MEMBER RYAN: Okay. What does that mean?

3 I'm asking you to sort of --

4 DR. PARRY: Well, because I think the
5 intent of the questions and the structure is to look
6 for the variances in PIFs that would lead --

7 MEMBER RYAN: But the intent that you have
8 for the question may not be the way three different
9 respondents react to the question. You can't
10 guarantee their response. You can only guarantee the
11 intent of the question, not the answer.

12 MR. FORESTER: Is it them misinterpreting
13 the question or having different nuances?

14 MEMBER RYAN: Or interpreting it in a way
15 that you didn't think of.

16 MR. FORESTER: Yes, that's true. They
17 have to be carefully written.

18 MEMBER RYAN: Carefully written can still
19 be misinterpreted, and I -- well that's one person
20 handing off to another, you know, and there's always a
21 chance for misinterpretation. Even though it might be
22 a small chance or a small misinterpretation, it's not
23 impacting. Or a big interpretation change that could
24 be impacting.

25 That's part of, you know, what happens if

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1 at some point in this process you get the wrong
2 answer, wrong interpretation, miscommunication? How
3 does that flow through the model? Does it worry,
4 screw up your ability to interpret the model, or is it
5 something you can live with? Does it have enough
6 fidelity that one small misinterpretation is not going
7 to be enough? I guess that's a measure of how good's
8 the question. I'm trying to distinguish --

9 DR. PARRY: I think Ryan will like it.

10 MEMBER RYAN: Well, but it's the same kind
11 of thing. I mean how -- when are you going to know
12 the question's good enough.

13 CHAIRMAN STETKAR: Are you -- I want to
14 use a simple example, that if I chose as experts five
15 crews of operators, I mean that's sort of the thought
16 process that I'm hearing here a bit to, you know,
17 march through the decision tree.

18 You might have, depending on the
19 interpretation of the questions and, you know, time of
20 the day, day of the week and yadda-yadda-yadda, you
21 might have five different sets of answers, even among
22 the same, you know, five different crews at the same
23 nuclear power plant.

24 Have you thought about that, or is this a
25 process that's not geared toward operating crews?

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1 DR. PARRY: I don't think that the
2 question should be written in such a way that's an
3 unlikely thing to happen.

4 CHAIRMAN STETKAR: So you wouldn't expect,
5 you know, three crews to say yes and two crews to say
6 no to a particular question?

7 DR. PARRY: It's possible. It would hope
8 to not have that happen, but yeah, I don't know. I
9 mean we haven't thought about the questions well
10 enough yet.

11 DR. DANG: But I think the intent is not
12 to give these questions to the crews. I mean I think
13 we're staying with the good practices of having a team
14 for the PRA/HRA that covers the disciplines that are
15 needed, and that get the respective inputs to answer
16 these questions. We're not handing over the HRA to
17 plant experts, to --

18 CHAIRMAN STETKAR: Oh, is that right? I
19 guess I'm troubled a bit by that, that you're not
20 planning to have any input from people who understand
21 the plant?

22 (Simultaneous discussion.)

23 DR. DANG: No. Get the input but not in
24 the form of answering these questions directly.

25 CHAIRMAN STETKAR: That's a good point.

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1 That's a good point.

2 DR. DANG: The questions that are placed
3 here, of course, they make reference to the plant and
4 the operations, but they're not meant for them to
5 answer themselves. It's an aggregate and make a
6 consensus.

7 CHAIRMAN STETKAR: That's a good point. I
8 think the question is to help the analyst who's doing
9 the HRA, to find out what he can from the plant
10 people, to help him answer the question. Okay.

11 DR. MOSLEH: But of course if that
12 requires that they go ask five crew and they --

13 CHAIRMAN STETKAR: Then you have one of
14 these that three of them say "yes, I do" and two of
15 them say "no, I don't." What do you do with that?

16 DR. PARRY: That tells you something.

17 DR. MOSLEH: Again, I think this is
18 something that is difficult, in the sense of
19 structuring a methodology and a model that is detailed
20 enough and is prescriptive, so that we get, you know,
21 consistent answers, as opposed to giving flexibility
22 so that you're uncovering things that you need to
23 know, to have a more realistic assessment of the
24 situation.

25 CHAIRMAN STETKAR: And many times you

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1 don't understand that until your replies come back.

2 DR. MOSLEH: So that balance, that
3 optimization is something that we are not -- although
4 we have explored many different styles of analysis,
5 and we have a team here that has spent a lot of time
6 to see how we can structure the analysis, such that we
7 get consistent results with a certain level of detail
8 that would be at that level of consistency. But these
9 things we need to kind of try ourselves, before we can
10 share with you.

11 MEMBER RYAN: Thank you. That's critical.

12 CHAIRMAN STETKAR: One last thing. I
13 guess we ought to -- it's probably premature to think
14 about when we'll meet again, but given the fact that
15 you've sort of targeted getting things out on the
16 street by about a year from now, let's say, we should
17 certainly, in the introduction, I think Erasmia said
18 quarterly meetings, our particular constraints on
19 subcommittee meetings and things like that.

20 I think we should probably target for, you
21 know, March, no later than April time frame. That's
22 not quite a quarter, but since we're -- we generally
23 don't meet in January, and even if we do, our January
24 schedule is already full, and we're out into February
25 already. We're looking at probably early March is the

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1 earliest. But I think we ought to reconvene some time
2 in that time frame.

3 DR. LOIS: And by that time, you would
4 like to see some of the --

5 CHAIRMAN STETKAR: We would certainly, I
6 think I would say that we should not reconvene and
7 perhaps my colleagues here could correct me, until we
8 have a reasonably coherent documentation of that mid-
9 level model, if that's what we're calling it. I think
10 that more sort of philosophical discussions, if I can
11 call it that, about that, would not necessarily be all
12 that productive.

13 So I think you need to look at when that
14 might be available. It doesn't have to be polished.
15 I mean these are not final committee meetings. But it
16 ought to have some prose attached to it and rationale.

17 I think whatever else on the quantification part of
18 it might fall out.

19 But I think without that basic
20 documentation that we can actually have, and remember,
21 what I'd like to do is have that available
22 traditionally a month, you know, 30 days before our
23 subcommittee meeting, so that we actually have a
24 chance to digest it. That may dictate, you know, when
25 you need to come back to us. You can just coordinate

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1 with John as far as setting the schedule.

2 The message is think about it sooner than
3 later, because our schedules these days are miserable.

4 I'll just throw that out.

5 MEMBER RYAN: No they're not, John.
6 They're full of fun and wonderful things to do, all
7 day, every day.

8 CHAIRMAN STETKAR: They are. That too,
9 and with that, unless Christina is -- before we miss,
10 is there anybody, members of the public? I don't see
11 anyone here, but I always have to ask for that, that
12 wants to say anything?

13 (No response.)

14 CHAIRMAN STETKAR: With that, Christina?

15 MS. LUI: Well yes. We certainly
16 appreciate you spending time with us this afternoon,
17 and we would aim to get back to you by March time
18 frame. I know my project team may not agree with me,
19 but that's my issue.

20 CHAIRMAN STETKAR: One message is we
21 probably can't -- we can't get a meeting in before
22 March. I'd like to get one in kind of in the March to
23 April time frame, if you can support it, so that we
24 don't drag it too far.

25 MS. LUI: Yes absolutely, because I would

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1 like to probably schedule another meeting prior to any
2 documentation goes out on the street. So March time
3 frame would be the right time frame before we actually
4 would be able to squeeze in another interaction with
5 you before the final set of documentations.

6 I do have one question for you guys. I
7 understand that you'll be meeting with the Commission
8 next month.

9 CHAIRMAN STETKAR: Yes.

10 MS. LUI: Do you need anything from us to
11 support any type of discussion in this area?

12 CHAIRMAN STETKAR: No.

13 MEMBER RYAN: I don't think that's on our
14 agenda.

15 CHAIRMAN STETKAR: No. Nothing on our
16 agenda in this area at all.

17 MS. LUI: Okay, all right.

18 MEMBER RYAN: And the questions and
19 answers, we may get a question from at least one of
20 the Commissioners.

21 CHAIRMAN STETKAR: We might, but probably
22 not. I'm betting no. Given the other topics on the
23 agenda, I'm betting no. Anyway, with that, we're
24 adjourned.

25 (Whereupon, at 5:29 p.m., the meeting was

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1

adjourned.)

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EPRI

ELECTRIC POWER
RESEARCH INSTITUTE

Development of a Hybrid Model for Human Reliability Analysis

EPRI Perspective

Stuart Lewis

Program Manager

Risk and Safety Management

ACRS PRA Subcommittee Meeting

October 18, 2010

Status of HRA Research at EPRI

- Basic HRA methods developed by EPRI in late 1980s/early 1990s still in wide use within nuclear industry
 - SHARP1 framework for HRA (including guidance for qualitative analysis)
 - 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

Role of the HRA Calculator®

- Focus for past ~10 years has been on development of the HRA Calculator®, a software tool
- Objectives of the tool
 - Facilitate performance of human reliability analysis
 - Promote consistency among different analysts addressing the same problem
- Tool implements methods for
 - Assessment of pre-initiator human failure events (HFES): THERP, ASEP
 - Assessment of post-initiator HFES: HCR/ORE and CBDT for cognitive failure, THERP for execution
 - Evaluation of dependencies among post-initiator HFES

Status of the EPRI Methods/Tools

- HRA Calculator® is now used by every nuclear utility in the US
- Methods are generally well-understood by users, but
- There is recognition that the methods
 - Are aging, without significant review or update for 18+ years
 - Included elements that were meant to be examined further over time

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

Expectations for the hybrid model

- Practical to implement
- Not requiring major restructuring of current PRA models in the near- to mid-term
- Achieving consistency and repeatability in results

Together...Shaping the Future of Electricity

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

October 18, 2010

Outline

- Background
- Interpretation of the SRM
- Approach and Aim
- Focus
- Interactions with the ACRS
- Objective of Today's Meeting
- Who is Involved in the Project
- Challenges
- 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 initiated work to support addressing the SRM
- ACRS input into the work
- Collaborative with EPRI

Interpretation of SRM-061020

- Interpret “model” in the more general sense of “method”
- 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 on HRA methods

Approach and Aim

- Establish a consensus approach by developing a “single” high-level method/structure that ensures
 - consistency through out 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 may require adaptation of the overall structure for addressing domain-specific needs
- Gain acceptance from PRA/HRA and human factors experts and practitioners

Focus

- Current focus
 - Start with addressing the issue for a detailed internal event/at power PRA/HRA
 - Converge with EPRI on HRA methods(s) and practices
- Future
 - Expand to other scenarios
 - Modify for screening/scoping analyses

Interactions with the ACRS

- Subcommittee briefing, April 7, 2010 during which we presented a “hybrid” approach and ACRS members posed many questions summarized as follows
 1. Why not choose an existing method
 2. Is it a “hybrid”
 3. How the needs of different domains (e.g. LPSD) will be handled
 4. Would the approach be suitable for regulatory applications using existing PRAs
 - What could be the impact on existing PRAs
 5. Would it be suitable for new PRAs
 6. Need to understand the various facets of the approach
 7. How quantification will be handled
 8. How will obtain user buy-in
- Current plan for quarterly meetings with the Subcommittee
 - Need for ACRS members develop an in-depth understanding of the technical work
 - Different aspects of the work to be discussed in different workshops
 - 1st workshop today, Oct.18, 2010

Objective of Today's Meeting

- Discuss items 1-5, showing the rationale lead to the proposed approach
- Discuss part of question 6 related to building a technical basis for HRA using results and inputs from cognitive research and expertise—what we called before mid-layer model
- Present an overview of the current thinking to address quantification—bullet 7
 - Recognizing that quantification is the area that has many facets needed to be addressed we are going forward with short term and longer term activities.
 - Only the short term perspectives will be discussed today
 - The discussion on quantification shows early stages of the work
- Obtain feedback and input on the work being performed
- Plan for the next meetings
 - Topics to be discussed
 - Schedule

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

Schedule

- Quarterly working meetings with the ACRS subcommittee
 - First scheduled for October 18
- Technical Basis for public review—Sept 2011
- User's Guide—Sept 2011
- Application on event evaluation for public review—Sept 2011
- Final report—2012
- Computerized capability—TBD

Anticipated Uses

- The tools developed should support NRC staff risk-informed activities
 - Event evaluations (significant risk determination)
 - Guidance for staff review of risk-informed licensee requests
 - Current plants—e.g., risk-informed licensing changes
 - Future plants—reviews of PRAs/HRAs for new plant operation licensing and practices
 - New PRAs and especially the Level 3 PRA planned by the staff for the next few years
- Industry applications in the same areas

Basis for Use of a “Hybrid” HRA Approach to Meet SRM-M061020

ACRS PRA Sub-Committee Meeting

October 18, 2010

Presented by
John Forester (SNL) and Vinh Dang (PSI)

Objective

- Inform on the approach taken to address SRM-M061020

Presentation Outline

- Interpretation of SRM and initial process
- Results of evaluation of HRA Methods
- Implications for SRM
- Current thinking on a “hybrid” approach

Interpretation of SRM-061020

- A single method is the most desirable
- Desirability for convergence of NRC and industry on HRA methods
- 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

Initial Process for Addressing SRM-M0601020

- Survey of NRC staff to identify regulatory applications in which HRA plays an important role and what issues the staff is dealing with when applying HRA
- Workshops with NRC, national laboratory and EPRI staff to obtain their views on the path forward (April and June 2009)
- The need to build on existing methods and experience was emphasized

From the Workshop - Review Methods Against Evaluation Criteria

- **Validity – content, construct**
 - *models*
- **Empirical validity and quantitative performance**
 - *quality of numbers*
- **Reliability, consistency, traceability**
 - *variability*
- **Usability and resources—**
 - *Having a **practical** tool is key*
- **Scope of applicability**
 - *From scoping to detailed HRA*
 - *For different PSA scopes*
- **Experiences with method; installed base (users and applications)**

Inputs to HRA Method Evaluation

- NUREG-1792, Good Practices
- NUREG-1842, Evaluation of HRA Methods vs. Good Practices
 - Theoretical/scientific considerations - examined their strengths, weaknesses, and underlying basis
- Experiences from NRC and other reviews of HRAs
 - Applications experience/practicality
- International HRA Empirical Study (additional methods addressed)
 - Performance-based HRA method evaluation

The International HRA Empirical Study (2006-2010)

- **Simulator study at the Halden Reactor Project**
 - 12-organizations; 13 methods; 14 crews
 - Assess strengths and weaknesses of HRA methods based on predictive analyses vs. crew data
 - Evaluate and identify sources of variability in results
 - **Major insights from the Empirical study**
 - Significant variability in results across HRA methods and within teams for one method
 - Need for more comprehensive/consistent qualitative analysis – to allow consistent identification of correct issues
 - Ability to incorporate the issues into quantification
-

Evaluation of HRA Methods

Findings across methods

- **On evaluation, all methods have some significant shortcomings and different strengths**
 - Relates in part to originally intended scope of methods
 - Relates to trade-offs
 - e.g. simplicity vs. ability to represent broad range of HFEs and performance conditions,
 - e.g. repeatability vs. ability of analysts to consider specific influences
- **Qualitative analysis is a shared weakness** - some methods much better than others
(scope - issues and influences considered, guidance for analysts, translation into quantification inputs)
 - **Impacts the consistency** of estimated HEPs
 - **Impacts validity of HEPs**, to the limited extent that this validity can be empirically verified

Findings across methods (cont.)

- **Two common practices in HRA are**
 - **Mixing and matching of methods**
 - e.g. decision/cognition vs. implementation/execution
 - e.g. different methods for full-power vs. shutdown PSA
 - Motivation is to allow consideration of different performance influences
 - **“Adjustments” of method relative to reference method guidance**
 - Variation in how formalized the adjustments are
 - From a documented set of rules to apply to analyst discretion

These practices also affect consistency of estimated HEPs and their validity.

Evaluation of selected method features

- **Time Reliability Curves for decision/diagnosis**

- easy to use
- difficult to adjust for other influence factors

- **Prescriptive rules for analysis, including worksheets**

- supports repeatability, traceability, and can support validity
- need to develop different sets for each context, e.g. full-power vs. shutdown PSA

- **Binary quantification inputs, e.g. yes/no**

- may support consistency
- “cliff-edge” effect of assigned inputs

- **Multiple-level quantification inputs, e.g. L-M-H, 0-10**

- allows more nuanced factors
- scaling guidance (anchors) needed to support repeatability, traceability, inter-analyst reliability

Evaluation of selected method features

- **Narrative-based failure mechanisms**
 - supports broad set of influences, plant- and scenario-specific error mechanisms
 - requires expertise in plant-specific operations
 - difficult to structure analysis, to review
 - effort and expertise in elicitation

HRA Method Evaluations - Implications for SRM to Address Criteria

(e.g., validity, consistency, traceability)

- **Extend guidance for qualitative analysis**
 - Important to address a comprehensive set of performance issues and to obtain consistent quantification inputs
 - **Support for analysis and representation of failure mechanisms in some detail**
 - As in ATHEANA, MERMOS, and other methods that explicitly link performance conditions to potential behaviors and failures
 - **PSF rating guidance to support comprehensive analyses, repeatable and traceable results**
 - Consistent inputs to quantification, i.e. *qualitative-quantitative interface*, once key performance issues are identified
 - **Improve technical basis by linking the HRA to accepted models of human performance**
 - *In addition to consideration of experience and engineering judgment*
 - Importance for acceptance of HRA methods and their results
-

“Hybrid” Approach

Capitalize on Strengths of Existing Methods and Psychological Models/Data

- The hybrid is (currently) building on
 - Information from cognitive psychology to build an explicit connection (human response model) between:
 - the human failures leading to a human failure event (HFE) (proximate cause)
 - the underlying psychological failure mechanisms
 - the factors driving the failure mechanisms (PSFs and plant/scenario conditions)
 - **Improves validity** – helps identify what we need to measure and what specifically we need to predict
 - ATHEANA concepts for identifying and incorporating contextual aspects associated with human performance
 - Needs more structure for capturing relevant context and may need to be extended to be more comprehensive
 - **Improve validity and consistency**

“Hybrid” Approach

(Continued)

-
- The hybrid is (currently) building on:
 - The causal structure of the Cause Based Decision Tree (CBDT) method for quantification or some other structured approach (e.g., Bayesian Belief Networks)
 - Key is to have a concrete, **structured** approach for quantification that capitalizes on psychological information and incorporates critical drivers of performance
 - Provides clear guidance for what information needs to be collected, what decisions need to be made, and how to make those decisions
 - **Improves validity, consistency, transparency, traceability**
 - **Requires less analyst expertise and fewer resources**
 - Use of a PRA-type explicit structure (CRTs) to support identification of potential failure paths and associated context for HFEs
 - **Improves validity and consistency**

“Hybrid” Approach

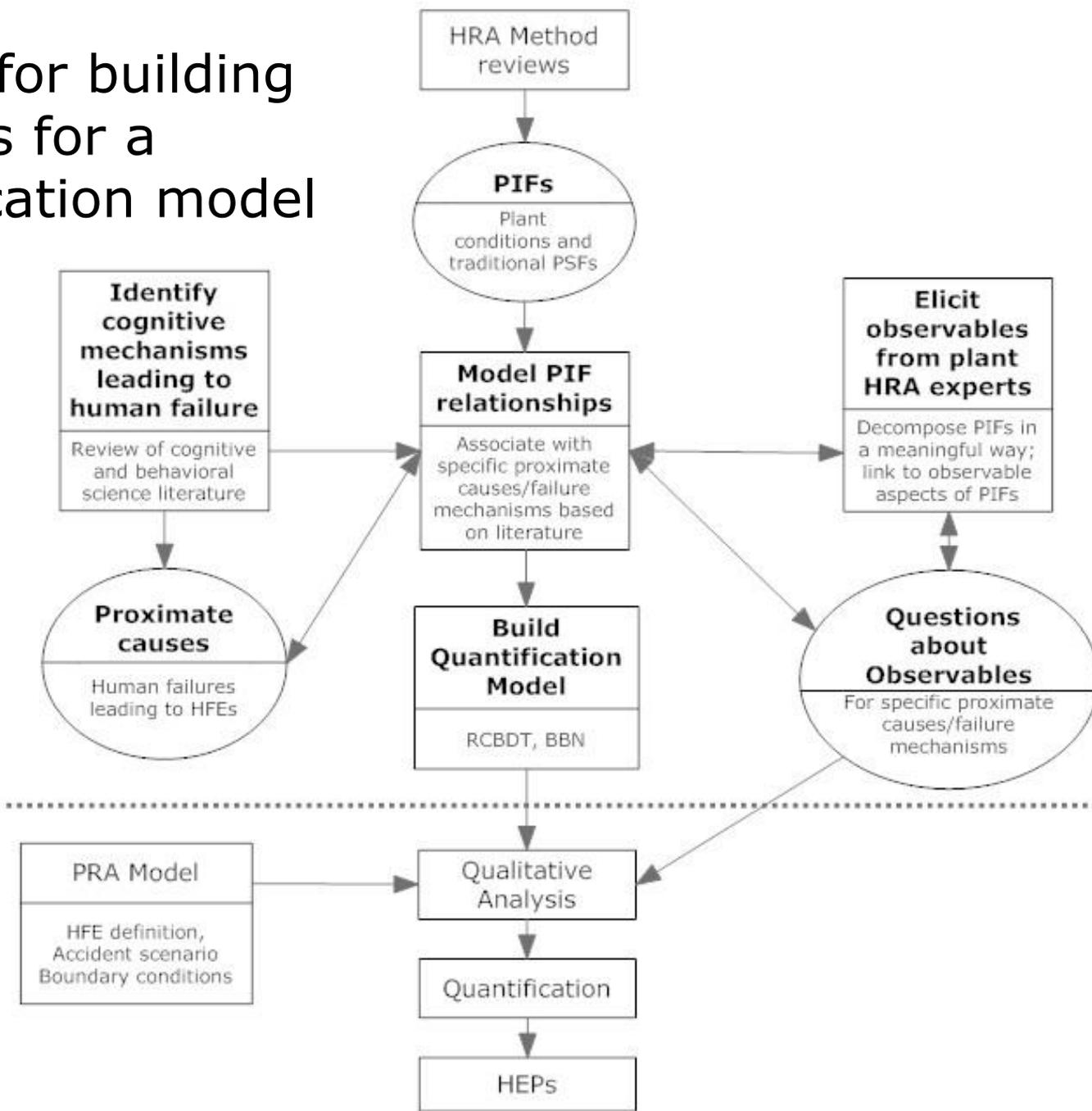
- Incorporating in the method an explicit process for capturing current understanding of human behavior from both the literature, NPP operations, and PRA/HRA experience
- The method should provide a structure to guide the analysts to ask/identify the right issues during the information collection and qualitative analysis task and at the same time is:
 - Improved scientific basis
 - Structure applicable cross domains
 - Consistent with industry (another driver supporting use of CBDT type structure)
 - **Practical**

Next Presentations

- Human performance model from psychological models/data (formerly mid-layer model) to support HRA
- Experimentation with use of decision tree approach for quantification

Back-Up

Process for building the basis for a quantification model



Key Strengths & Weaknesses (1)

	Strengths	Weaknesses
THERP	<p>designed to address large set of NPP tasks included in PSAs</p> <p>several validations of execution models</p> <p>large installed base</p>	<p>limited treatment of cognitive demands after event identification and in execution basis for diagnosis model (for TRCs)</p> <p>very few PSFs and limited guidance for their assessment</p> <p>no review of execution model with respect to modern HMIs</p>
ASEP	<p>more specific rules for analysts (relative to THERP)</p> <p>ease of use</p>	<p>same weaknesses as THERP due to common basis</p> <p>more limited than THERP in modeling failure mechanisms (proximate causes), but can in principle be combined with THERP as needed</p>
CBDT	<p>specifies failure mechanisms and their relation to plant and PSF context</p> <p>explicit set of causal factors and failure mechanisms</p> <p>binary assessment of factors avoids need for fine-grained judgments, advantage for consistency</p> <p>ease of use</p>	<p>basis of the decision tree branch HEPs</p> <p>limited set of causal factors and failure mechanisms</p> <p>binary assessments of causal factors (can be modified but introduces more branches)</p>

Key Strengths & Weaknesses (2)

	Strengths	Weaknesses
SPAR-H	<p>highly traceable worksheets</p> <p>scaling guidance for rating of PSFs</p> <p>ease of use</p>	<p>ambiguous and inadequate guidance for some PSFs</p> <p>limited set of factors and influences considered</p> <p>limited ability to model specific (narrative-based) failure mechanisms</p> <p>limited ability to consider cognitive demands of execution</p>
HCR/ORE TRCs	<p>curves derived from simulator data (but not validated)</p>	<p>no validation of TRCs</p> <p>no limit on relation of response time to available time (accounting for magnitude of time window)</p> <p>lack of support for assumption that slow performance is poor performance (may not credit crews' deliberate use of available time)</p> <p>in practice, median response times are frequently estimated without simulator data (not based on plant-specific and scenario-specific simulator data)</p>
FLIM	<p>PSF scaling guidance for 7 key PSFs, relating PSFs to failure mechanisms</p> <p>comprehensive and broad definitions of PSFs</p> <p>structured elicitation of NPP operator inputs</p>	<p>need for external calibration values</p> <p>PSFs may compensate each other unrealistically (additive model of PSF effects) / underrepresent of impact of very poor individual PSFs</p> <p>other quantification issues (grouping for calibration, updating of HRA)</p> <p>resources for elicitation, impact on PSA model development and updates</p>

Key Strengths & Weaknesses (3)

	Strengths	Weaknesses
ATHEANA	<p>encourages consideration of broad set of influences and failure mechanisms</p> <p>qualitative analysis guidance more extensive than many methods, based on psychological models of cognition and human performance in complex domains</p> <p>encourages holistic view of influences and their interrelationships, including dependences</p> <p>evaluates a range of conditions, more explicit consideration of aleatory influences</p> <p>uses plant-specific operations information elicited from plant staff</p>	<p>“open” set of factors and failure mechanisms</p> <p>requires dedicated expertise for plant staff elicitation</p> <p>reliance on expertise on integration of influences to consider in qualitative analysis (and on interview approaches)</p> <p>external review may be hindered by reliance on plant-specific expertise</p> <p>repeatability of qualitative and quantitative analysis (may call for more structure)</p> <p>expert judgment in quantification</p> <p>level of resources and required expertise</p>
MERMOS	<p>identification and evaluation of multiple, detailed failure mechanisms (narratives)</p> <p>evaluates a range of conditions, more explicit consideration of aleatory influences</p> <p>flexible but consistent structure for failure narratives</p> <p>uses plant-specific operations expertise</p> <p>accounts for observed performance in NPPs and structure of NPP operators’ task</p> <p>quantification uses context features that are</p>	<p>“open” set of factors and failure mechanisms</p> <p>reliance on operations expertise</p> <p>difficult to review plausibility / completeness of failure narratives without specific expertise concerning on plant operators and how they work</p> <p>expert judgment in quantification</p> <p>level of resources and required expertise</p>

Method Evaluation Criteria – details (1)

- **Validity – content, construct**
 - Addresses performance issues and factors/influences accepted to be important
 - Based on an accepted model of human performance, relevant to NPP emergency operations
 - **Empirical validity and quantitative performance**
 - Bases for the method's values (tabled values, nominal HEPs)
 - HEPs estimated with the method are consistent with data and operating experience
 - **Reliability**
 - Consistency among analysts and across applications by an analyst
 - Reproducibility
 - Traceability (qualitative and quantitative)
-

Method Evaluation Criteria – details (2)

- **Usability and resources**
 - **Scope of applicability**
 - Support for scoping, coarse/fine screening, and detailed analyses
 - Extensibility beyond full-power internal events PSA (ability to incorporate elements to address performance issues and factors arising in other PSA scopes)
 - **Insights from practical experience with method (applications, HRA reviews), installed base**
-

ASEP Comparison Against Criteria (EXAMPLE)

Criterion	Positive	Negative
Content Validity	<ul style="list-style-type: none"> • Cognition and Action covered • Dependency between HFEs covered through THERP • EOO included • Limited coverage of recovery • Accounts for uncertainty 	<ul style="list-style-type: none"> • Minimal coverage of context • Cognition can be ignored • No PSF interaction • Minimal inclusion of EOC • No coverage of failure mechanisms • Minimal task decomposition
Empirical Validity	Origin is THERP	
Reliability		Inter-analyst variability in level of modeling detail in specifying HFE and in how each PSF is assessed
Traceability	Mathematical tracing possible	Qualitative tracing possible, but dependent on level of analysis and documentation
Level of Analysis	Screening and scoping level	No detailed level
Usability	Fairly straightforward application	

HRA Methods Evaluated Against Criteria

ATHEANA	A Technique for Human Event Analysis
CBDT*	Cause-Based Decision Tree
SPAR-H	Standardized Plant Analysis Risk - HRA
THERP	Technique for Human Error Rate Prediction
ASEP	Accident Sequence Evaluation Program

*CBDT was evaluated with the understanding that it addresses only the cognitive failure probability

ATHEANA Comparison Against Criteria

Criterion	Positive	Negative
Content Validity	Fairly complete qualitative analysis – covers all elements	
Empirical Validity	HEPs based on expert judgment – could be seen as positive or negative	
Reliability		Mathematical reproducibility difficult
Traceability	Qualitative traceability possible (dependent on documentation by analyst)	Mathematical traceability difficult
Level of Analysis		Does not offer a screening or scoping option
Usability		Time and resource intensive

CBDT Comparison Against Criteria

Criterion	Positive	Negative
Content Validity	<ul style="list-style-type: none"> • Plant and PSF context • Cognition and Action covered • EOO included • Failure mechanisms explained 	<ul style="list-style-type: none"> • No crew context • No PSF interaction • Partial dependency between HFEs • No EOCs • Partial coverage of recovery • No quantification of uncertainty • No guidance on task decomposition
Empirical Validity	Based on THERP and adapted by expert judgment	
Reliability	Quantitative analysis reproducible as long as qualitative analysis is same	May be significant differences in the qualitative analyses between analysts
Traceability	Mathematical traceability possible	Qualitative tracing possible, but dependent on level of analysis and documentation
Level of Analysis		Does not offer a screening or scoping option
Usability	Fairly straightforward application and fairly easy to use within HRA Calculator	

SPAR-H Comparison Against Criteria

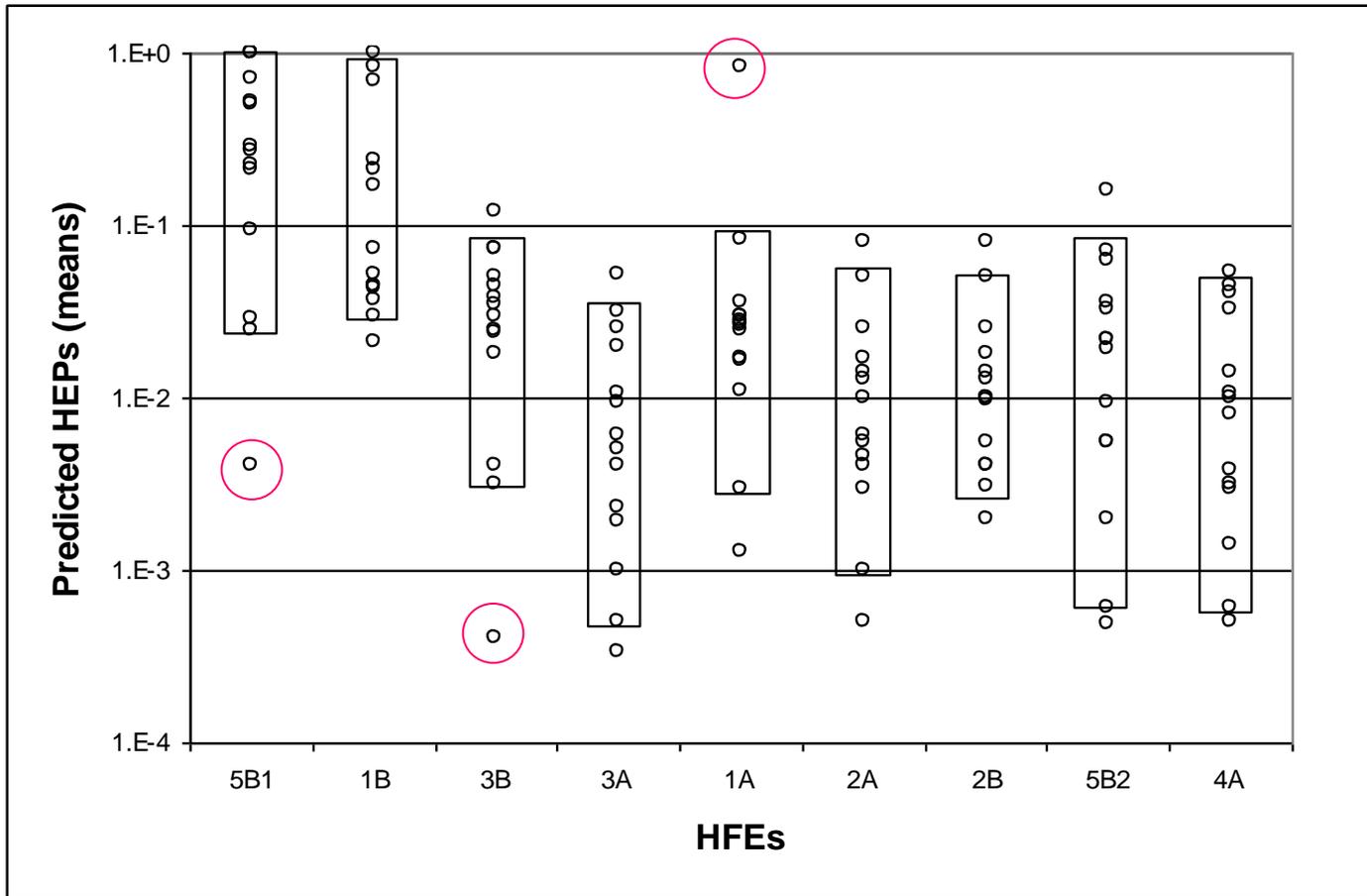
Criterion	Positive	Negative
Content Validity	<ul style="list-style-type: none"> • Cognition and Action covered • Dependency between HFES covered • EOO included • Failure mechanisms explained • Accounts for uncertainty 	<ul style="list-style-type: none"> • Minimal coverage of context • No PSF interaction • Minimal inclusion of EOC • Partial coverage of recovery • No coverage of failure mechanisms • No task decomposition
Empirical Validity	Compared multipliers uses to assess effect of PSFs to other PSF-intensive methods	
Reliability		<ul style="list-style-type: none"> • No guidance offered on checking reasonableness of final HEP • Possible differences in selection of important PSFs and impact of PSFs
Traceability	Mathematical tracing possible	Qualitative tracing possible, but dependent on level of analysis and documentation
Level of Analysis	Somewhat scoping and detailed	No screening option
Usability	Easy to use	

THERP Comparison Against Criteria

Criterion	Positive	Negative
Content Validity	<ul style="list-style-type: none"> • Cognition and Action covered • Dependency between HFEs covered • EOO included • Recovery included • Accounts for uncertainty 	<ul style="list-style-type: none"> • Minimal coverage of context • No PSF interaction • Partial coverage of HFE dependency • Minimal inclusion of EOC • No coverage of failure mechanisms • Partial task decomposition
Empirical Validity	Mix of empirical data and expert judgment	
Reliability		Reproducibility reliant on task analysis done – variability possible in level of detail of task analysis
Traceability	Mathematical tracing possible	Qualitative tracing possible, but dependent on level of analysis and documentation
Level of Analysis	Screening and detailed level	
Usability	Screening level fairly easy to apply	Detailed level more resource intensive

Range of predicted mean HEPs - SGTR

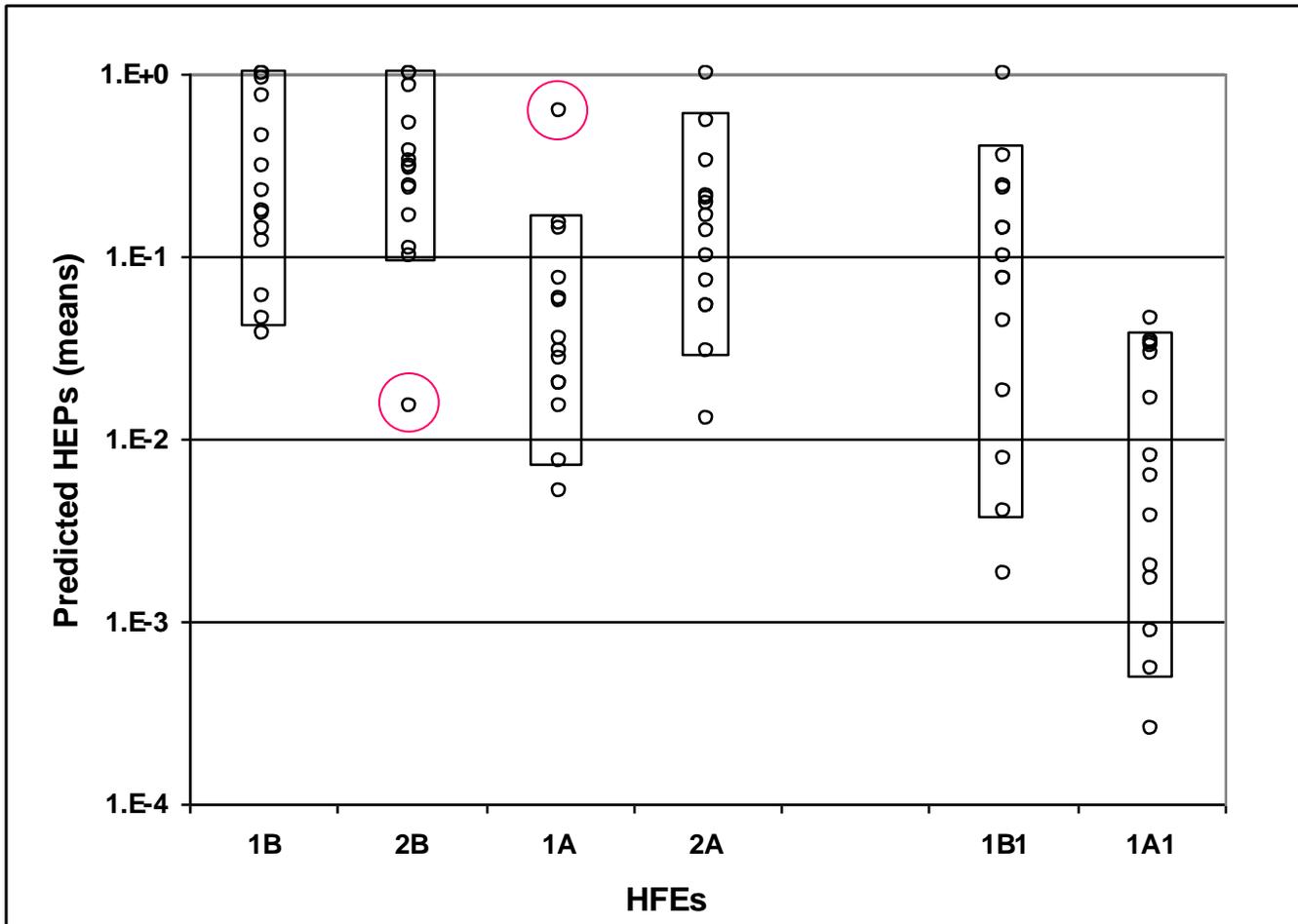
Boxes drawn around range, 1 maximum value and 1 minimum value excluded from each range.



- After exclusion, most ranges span < 2 orders of magnitude
- Many outliers relatively close to the range.
- Exceptions are highlighted.
- Exceptions explained in terms of inconsistent assumption, and method application

Range of predicted mean HEPs - LOFW

Boxes drawn around range, 1 maximum value and 1 minimum value excluded from each range.



- After exclusion, ranges span < 2 orders of magnitude
- Many outliers relatively close to the range.
- Two exceptions are highlighted.
- These are being examined to determine causes
 - method or assumption or combination

Establishing a Technical Basis for Crew Performance Model in HRA

Ali Mosleh

ACRS PRA Sub-Committee Meeting

Oct 18, 2010

Team:

April Whaley, Ron Boring, Johanna Oxstrand, Dana Kelly (INL)

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Song-Hua Shen, Jing Xing, James Chang (NRC)

Ali Mosleh (UMD)

Outline

- **Background and Goals**
 - Establishing a Technical Basis for HRA Crew Performance Model
- **Simple Causal Perspective**
 - Guiding the psychological literature search
- **Literature Search and Scope**
- **Findings and Examples**
- **Current Status**

Background and Goals

- Addressing issues related to “Content Validity” is needed to address variability
- Content validity depends on the theoretical frameworks and models utilized by methods and the extent to which they reflect the current understanding of human performance
 - Need to incorporate findings from current psychology and operations experience
- Content validity also depends on an accurate and consistent use of the frameworks and models employed
 - Current practices depend on analyst expertise for content validity
 - Need to formalize the process to reduce dependency on analyst expertise and expert judgment

Background and Goals

- This effort aims to provide a cognitive framework that establishes links between PRA scenarios, context, operator psychological processes, and resulting performance
 - Supported by psychological literature
 - Informed by operating experience
- Further improve content validity through formalization
- Address practicality and consistency through tools in which a sound technical basis underlies the tool

Background and Goals

- Relation to Evaluation Criteria:

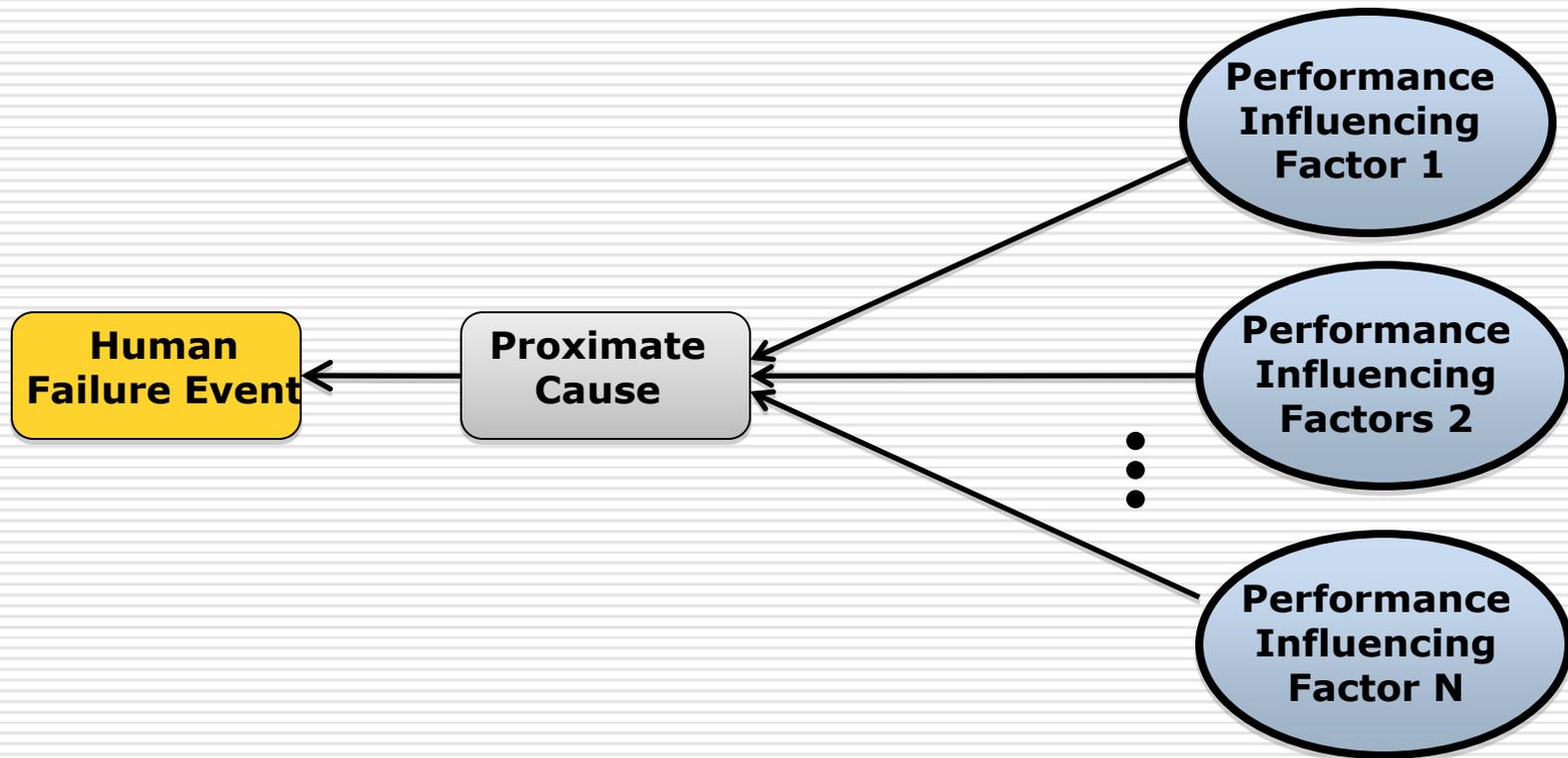
Validity – content, construct

Models

A causal perspective with empirical or theoretical basis for its constructs (elements and relations) is a key scientific approach to creating valid predictive or descriptive models

- Products of the effort
 - Practical Model for Use in HRA
 - Technical Basis (theory, literature support, ...)

A Simple Causal Perspective for Guiding the Psychological Literature Search



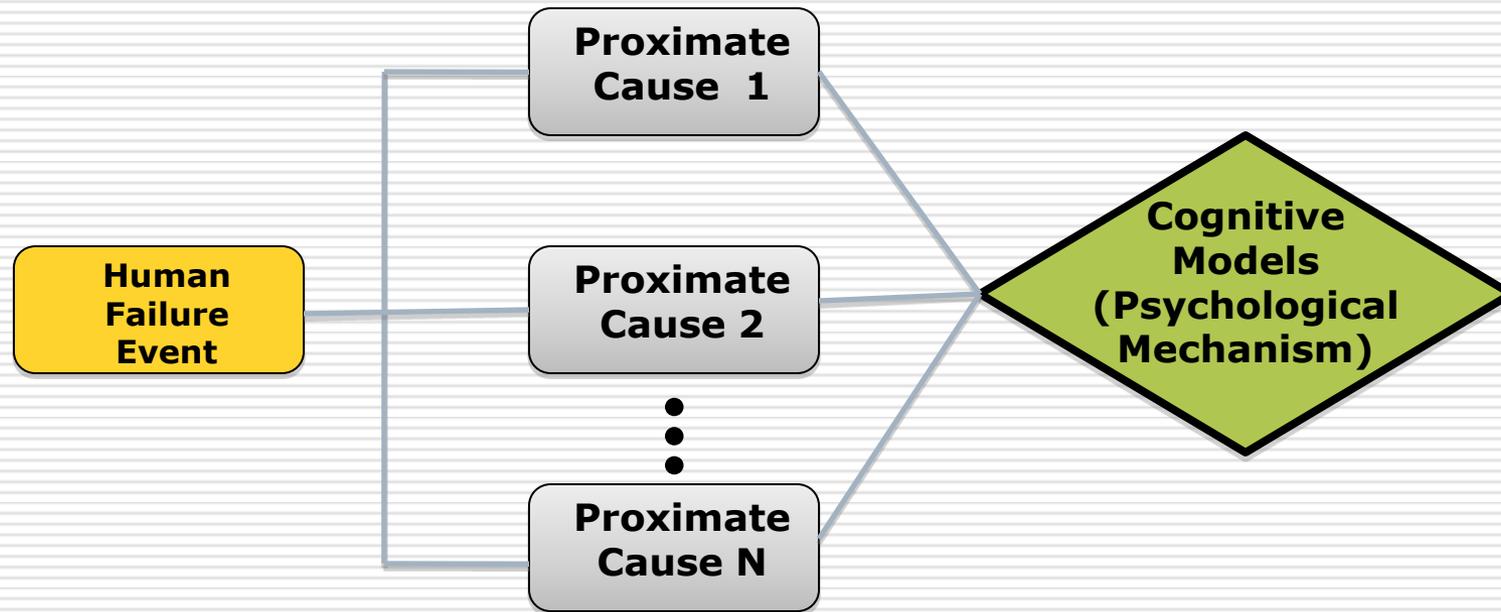
Context Factors (PIFs)

- Plant
 - Status (past and current) of
 - Critical safety functions
 - Relevant systems/components/equipment
 - Dynamics
 - Rate of change/speed of event evolution
 - Time
- Crew Mental model
 - Where the crew thinks the plant is headed
 - Crew understanding of the event
 - Goals
 - Related to the plant and event, both general and event-specific
 - Organizational goals
 - Action history
- Human-Machine interface/ergonomics, training, procedures, and other typical PSFs

Psychological Literature Review

- Reviewed relevant psychological, human factors, and human performance literature
 - Past 10 years of *Annual Review of Psychology*
 - The 50th Anniversary Special Edition of *Human Factors*
 - Cognitive Psychology and Human Factors/Human Performance textbooks
 - Related peer-reviewed articles and sources
- Methodology
 - Identify appropriate models based on
 - Degree of community support/consensus
 - Relevance to NPP operating environment
 - Fill Gaps, interpret, extend, generalize
 - Synthesize and Simplify

Search for Proximate Causes in Psychological Literature



Psychological Literature Review

- Sample Models, Frameworks, and Theories Reviewed
 - Sensation and Perception, Information Foraging Theory, Situation Awareness and Sensemaking
 - Recognition-Primed Decision Making, Situation Awareness and Sensemaking, Aided Decision Making, Cognitive Biases, IDAC, Cognitive Engineering
 - Human Performance Models, Contextual Errors, Omission-Provoking Factors (e.g., James Reason's work on slips, lapses, and maintenance errors)

Use of Psychological Literature for Proximate Causes, Mechanisms, and PIFs

- Criteria used was that to the extent possible Proximate Causes should
 - have distinct non-overlapping definitions
 - be observable or inferable in a practical manner
- Search approach
 - PCs, Psych Mechanisms and PIFs identified by various theories and models, absent any top-down structure

Use of Psychological Literature for Proximate Causes, Mechanisms, and PIFs

- Complementary approach applied
 - Using “synthesis models” or extrapolation from main psychological model adopted
 - Applying a top-down structure of relevant dimensions in NPP context
 - Example: For information gathering dimensions included were
 - Information Source (plant, procedure ...)
 - Information Modality (Auditory, Visual, ...)
 - Response Mode (Active vs Passive information gathering)
- Proximate cause and psychological mechanisms were defined in more general terms to allow application over wider range of situations

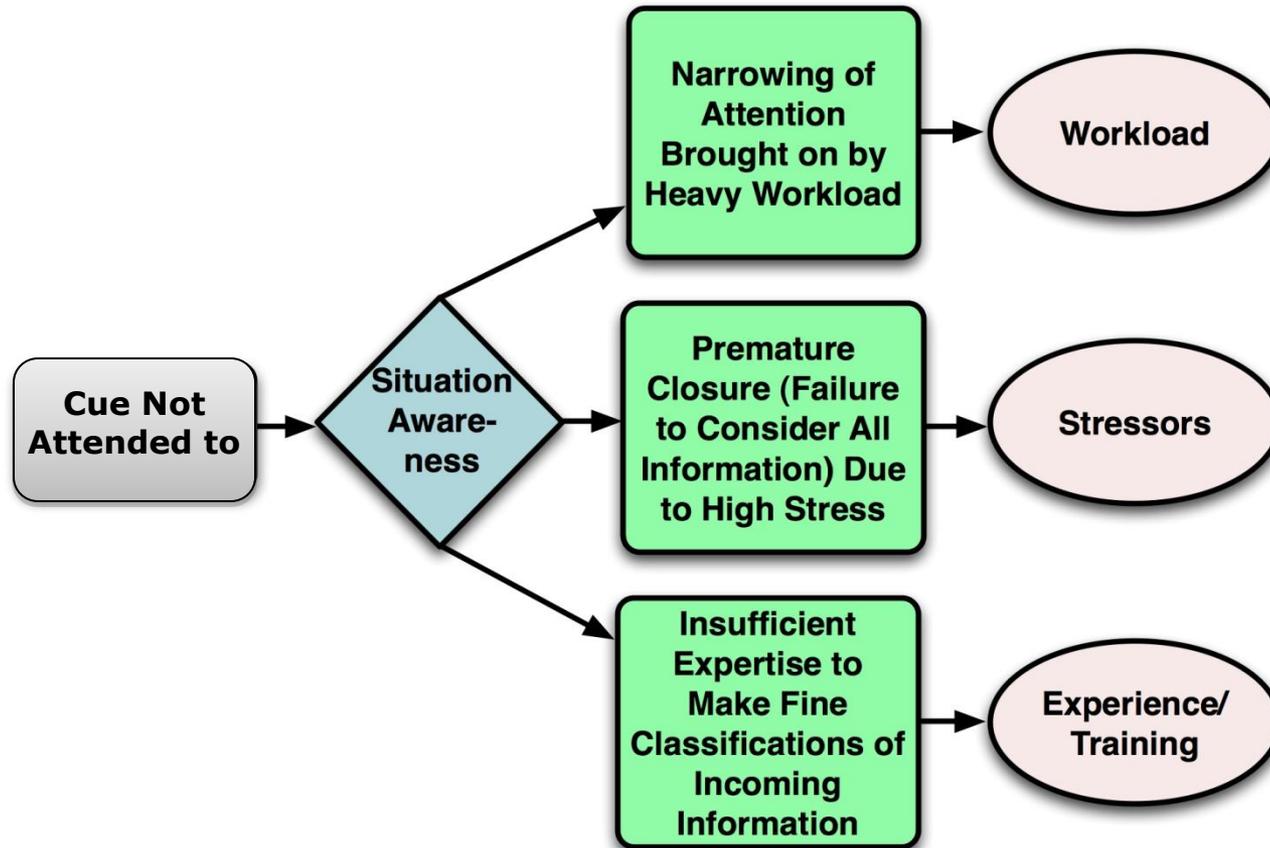
Process Example

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. ⁴ Error identified by Endsley, page 41, 55.]
Question:	What is the end result of this?
Answer:	<ul style="list-style-type: none">• Cues not perceived• Cues not attended to• Cues misread 

More Context-Specific Instances of Generic Proximate Causes (Examples)

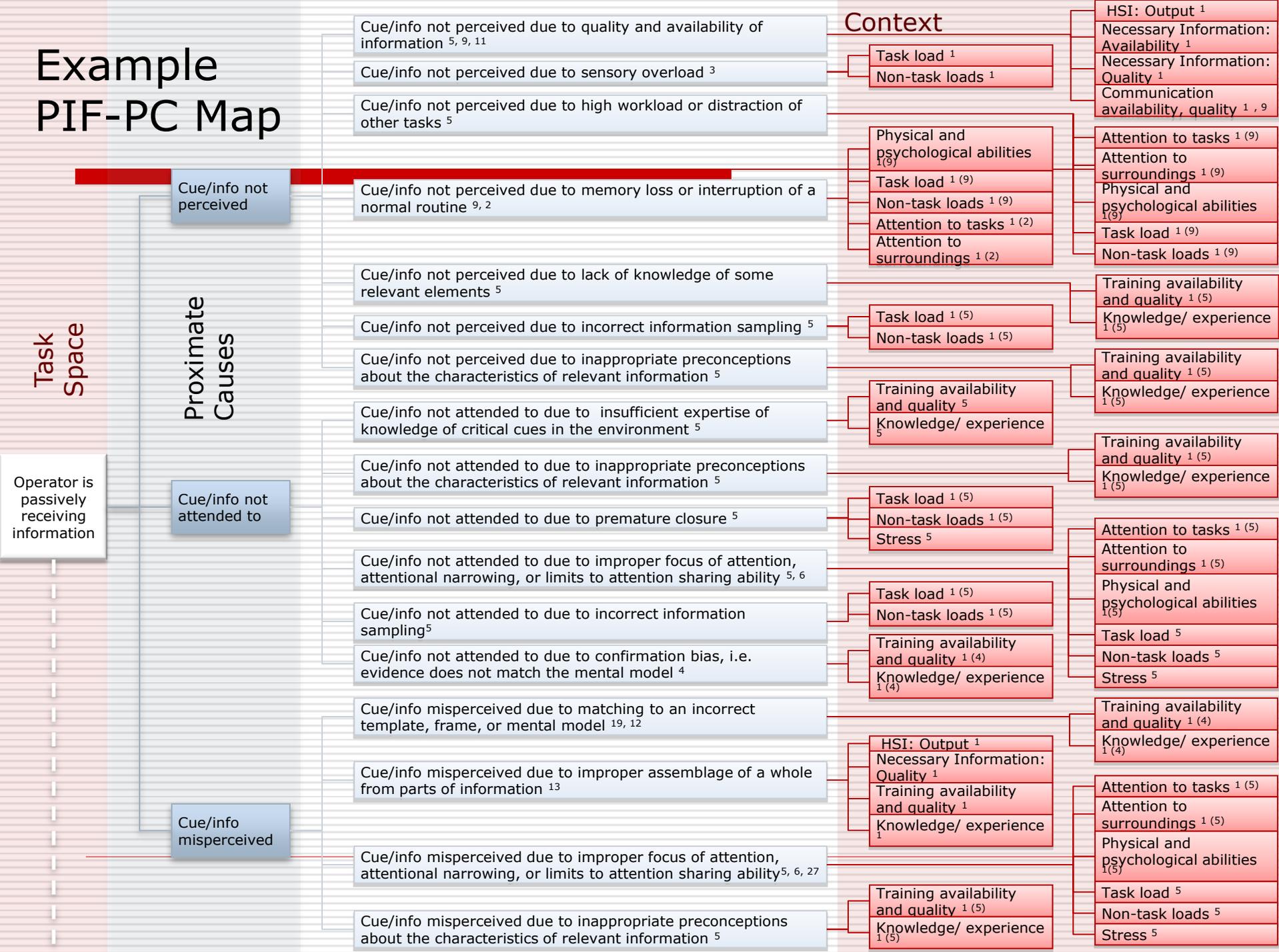
Generic Proximate Cause	Notes
Incomplete/inappropriate list of alternatives (information/explanations/courses of action)	This refers to an incorrect evaluation of alternatives, be it information, diagnoses, or courses of actions. This may include: <ul style="list-style-type: none">• Failure to consider all relevant information/explanations/actions• Inappropriately including irrelevant alternatives
Decide upon incorrect alternative (information/explanation/course of action)	This refers to making a choice, often among alternatives. Specific examples that fall into this category of proximate cause include: <ul style="list-style-type: none">• Incorrect strategy selected for achieving goal(s)• Decision to skip procedure step(s)• Decision to deviate from procedure• Decision to wait for more information• Decision to take alternate action(s)• Decision to delay action/step(s)• Decision to not collect information

Assignment of PIF to PCs through Psychological Mechanisms

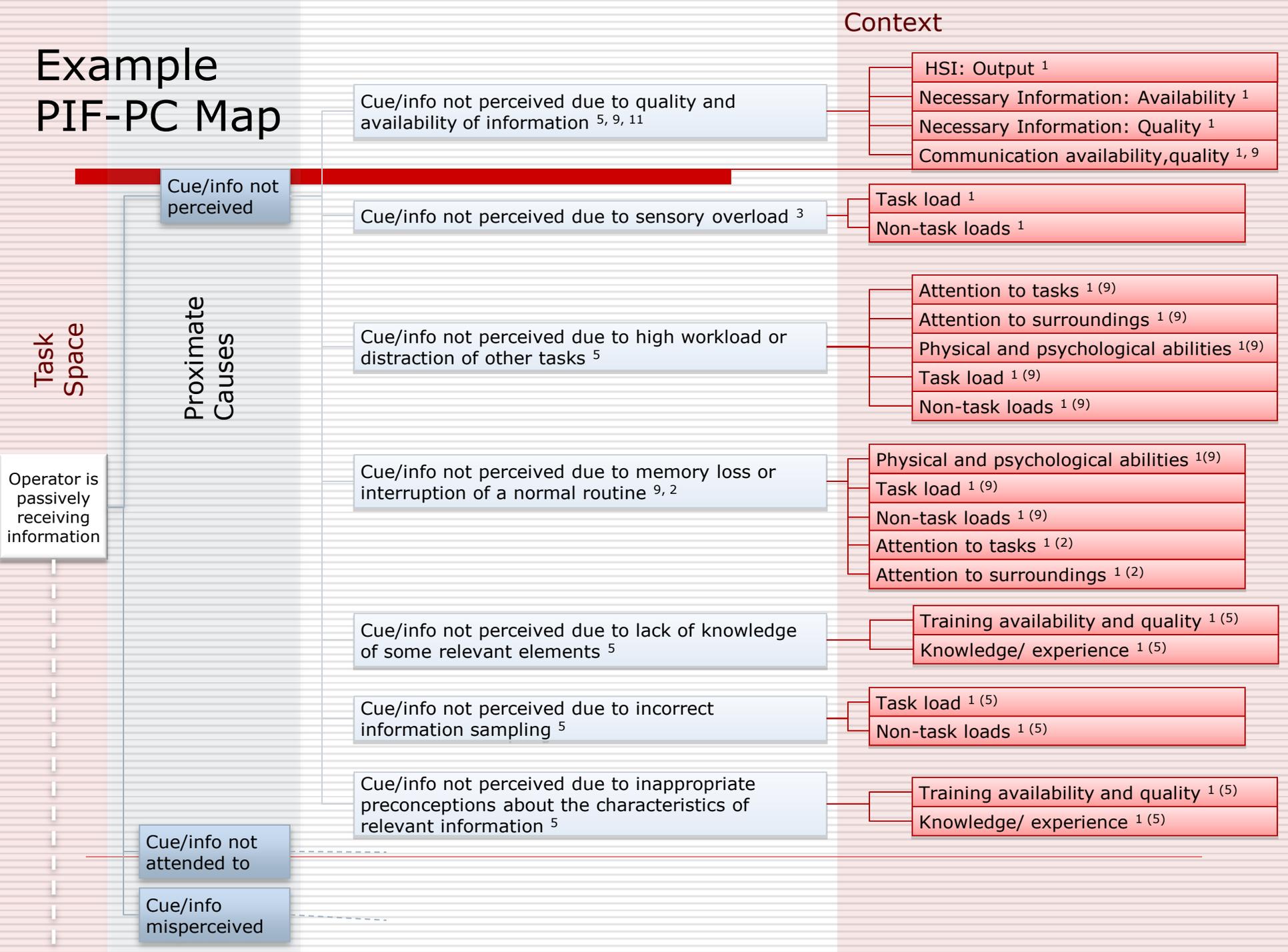


A single proximate cause is explained by different facets of a cognitive model with corresponding different PSFs

Example PIF-PC Map



Example PIF-PC Map



Psychological Literature Referenced in Example PC-PIF Assignment

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Status

- Psychological literature nearly completed
- Taxonomy of PIFs completed
- Mapping of generic PCs to PIFs nearly completed
- Identification of specific instances of generic PCs (more relevant to control room operations) nearly completed
- Establishing guidance for use of the model for Qualitative and Quantitative Analysis
 - Parts already in place

Status

- We are developing a logic structure to complete the causal model and support quantitative approach
 - Relation between PCs and HFE (in part to treat “local recovery” of PCs)
 - Treating interdependencies of PCs due to common PIFs
 - Treating PIF interdependencies
 - Potentially a subject for next ACRS Subcommittee meeting
- Coordination with other projects to examine absorbability of PCs in (a) operating experience in coordination with HRA data base development activities, and (b) simulator data collection and analysis

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Back-Up Slides

Main Cognitive Framework

Information Processing Framework

- Adopted as the overarching framework
- Represents generalization of multiple cognitive models
- Model is used in existing HRA methods
- 3 stage human information processing model
 - Includes all relevant aspects of human performance
 - Maps to more complex models
 - Offers More distinct lines based on cognitive demands
- Not intended to be used by practitioners

I-D-A Stages

- “I” includes (a) sensing and (b) perceiving information.
- Information perception in this stage includes:
 - assigning meaning in a generic sense (e.g., observed color is red),
 - generic, not context-specific “light chunking” of the information (e.g., flashing light plus siren=alarm)
 - initial classification and grouping of incoming information.
- It stops short of further inference and conclusions based on processed information as a whole.

I-D-A Stages

- “D” covers the operator response phases of “situation assessment / diagnosis”, and “response planning.” It contains problem solving through goal setting, selection of and approach to achieve the goal(s), and corresponding decisions*
- “A” refers to the execution of the actions decided upon. The actions are skill-based, and of relatively low cognitive complexity

* The complexity and exact nature of the activities within “D” depends on the levels of task decomposition

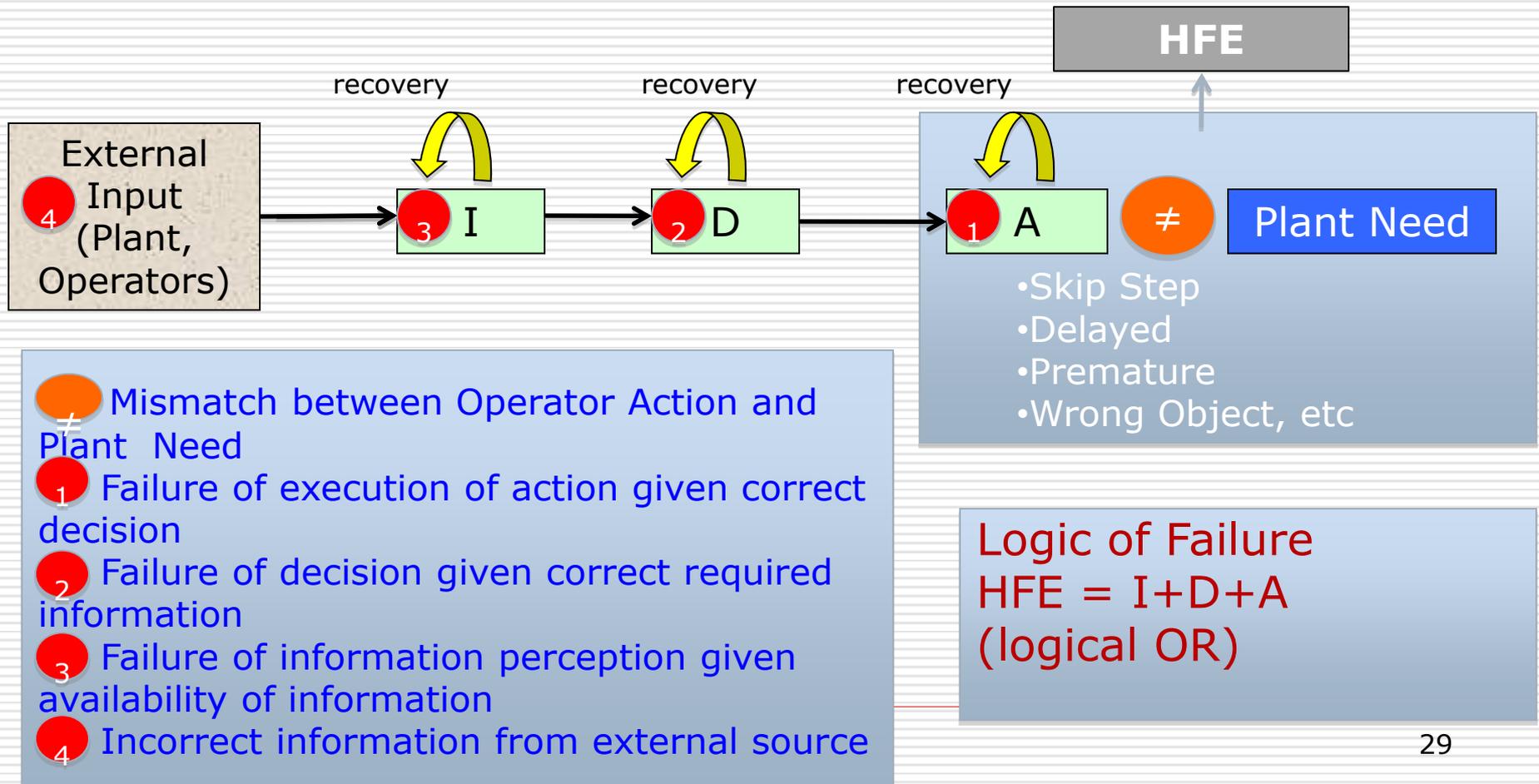
Information Processing Framework

- Why is using an information processing framework (i.e., I-D-A¹) appropriate?
 - Simple model that covers all aspects of human performance of interest for HRA
 - Aids in model development by guiding literature review to identify relevant areas of psychology
- IDA is useful both as way of “tasks decomposition” as well as an overarching simple model of cognitive response
- With some modification the model is applicable irrespective of whether “unit of analysis” is *crew* or an *individual operator*

Causal Model of Error

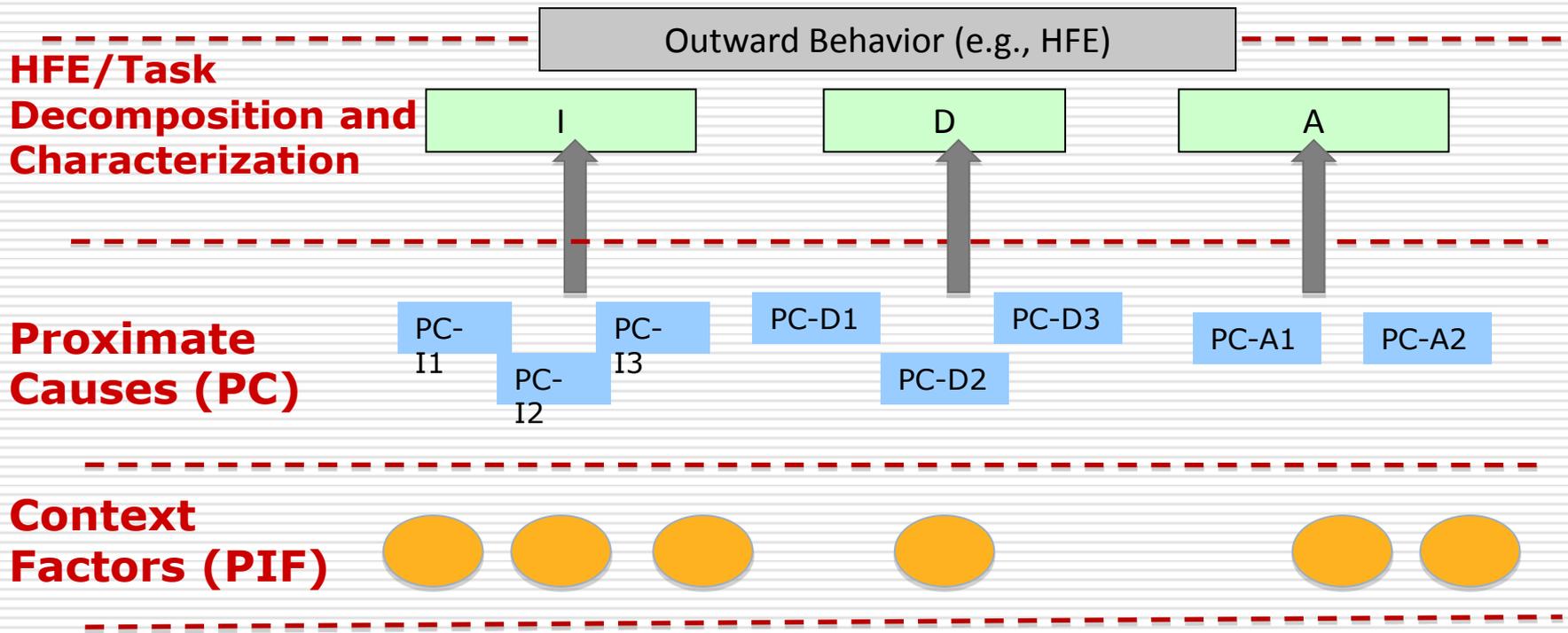
Human Error in IDA Framework

- Error defined in terms of the operator failing to meet a plant need. Cause of errors is traced through the IDA phases



Simplified Causal Model

- A simple three-tiered causal model is used to represent the path from context to outward behavior (e.g., a HFE as defined in PRA)



Model Structure

- The model distinguishes between:
 - Task Space
 - used as a task decomposition to describe the type of activity in the event response
 - Cognitive Space (Macrocognitive Functions):
 - describe the cognitive activity related to the task
- The macrocognitive function is always assessed in relation to the task
 - Cognition occurs in context of the task
 - Any or all of the macrocognitive functions can occur for each of the task types

Examples Frameworks from Literature

Naturalistic Decision-Making (NDM)

- Attempts to model how people make decisions in familiar, real world contexts
- Decisions characterized by:
 - Uncertain, dynamic environments
 - Ill-defined problem and goals
 - Action feedback (previous decisions affect future options)
 - Time stress
 - High stakes
 - Multiple players

Example Frameworks from Literature

Recognition Primed Decision-Making

- NDM strategy based on decision-making behavior of experienced firefighters
 - Rarely did decision-makers consider even two options concurrently
 - A search for an optimal choice could delay action long enough to result in loss of situational control
- General strategy is to match current situation to a prototypical situation drawn from experience
- Options considered sequentially

Emphasizes the need to develop an accurate situational assessment (information perception is important...)

Example Frameworks from Literature

- “Cognitive Engineering” Perspective ⁸
 - Human behavior is goal-driven, actions are selected in support of a goal, involves iterative cognitive cycles
 - Human behavior may be better modeled as ‘multi-level’ nested goal-driven actions.
- IDAC Model ³
 - Operator “problem solving” behavior is
 - Rational (has an explanation),
 - Goal-Oriented (single/ multiple, parallel/sequential)
 - Use identifiable “problem-solving strategies”
 - Dynamic
 - Operator “decision making” (choice among alternatives) is
 - Rational (has an explanation)
 - Risk-Benefit Based

More on “D” Model

- Possible crew goals are context/scenario-specific
- Most-likely problem solving strategy in Full Power scenarios
 - Knowledge-Supplemented Procedural Response
- All problem solving and decision making strategies identified for NPP crew response can be constructed in terms of Reason’s
 - Basic Similarity Matching (BSM)
 - Frequency Gambling (FG)

Back up on Results

"I" Proximate Causes of Failure

Proximate Causes	Passive (Receiving I)	Active (Seeking I)
Cues/Inf Not Sensed	X	—
Cues/Inf Not Perceived	X	—
Cues/Inf Not Attended To	X	—
Cues/Inf Misperceived	X	X
Cues/Inf Discounted/ Dismissed (as irrelevant or unimportant)	X	X
Wrong Cues/Inf Attended To	X	X
Internationally Not Gathered	—	X

“D” Model and Proximate Causes

- “D” Covers Two (Cognitively) Distinct Activities
 - **Problem Solving** (e.g., Diagnosis, Develop Action Plan)
 - **Decision Making** – making choice among alternatives (The problem-solving process involves a series of decisions to be made or solutions to be selected based on available alternatives)
 - Follow EOPs vs. CSF-procedures
 - Restoring AFW flow vs. performing Feed & Bleed in Loss of Heat Sink scenarios
- Possibility subject to different influencing factors

“D” Generic Proximate Causes

Generic Proximate Cause	Notes/Mechanisms
Incorrect understanding/diagnosis of the situation	<ul style="list-style-type: none">• Cues/info misunderstood / misinterpreted<ul style="list-style-type: none">~ Single piece of information~ synthesizing multiple pieces of information• Incorrect/incomplete mental model• Incorrect/incomplete projection of future status/ mental simulation• Incorrect/inappropriate mapping of information/cues to a mental model• Failure to change incorrect mental model• Inappropriate change of mental model• Failure to deviate from or change procedures when the situation warrants it• Inappropriate deviation from or change of procedures (these last two items may fit better elsewhere)
Inability to develop diagnosis from available	<ul style="list-style-type: none">• No mental model exists that matches the information, no pattern with which to interpret the data

“D” Generic Proximate Causes

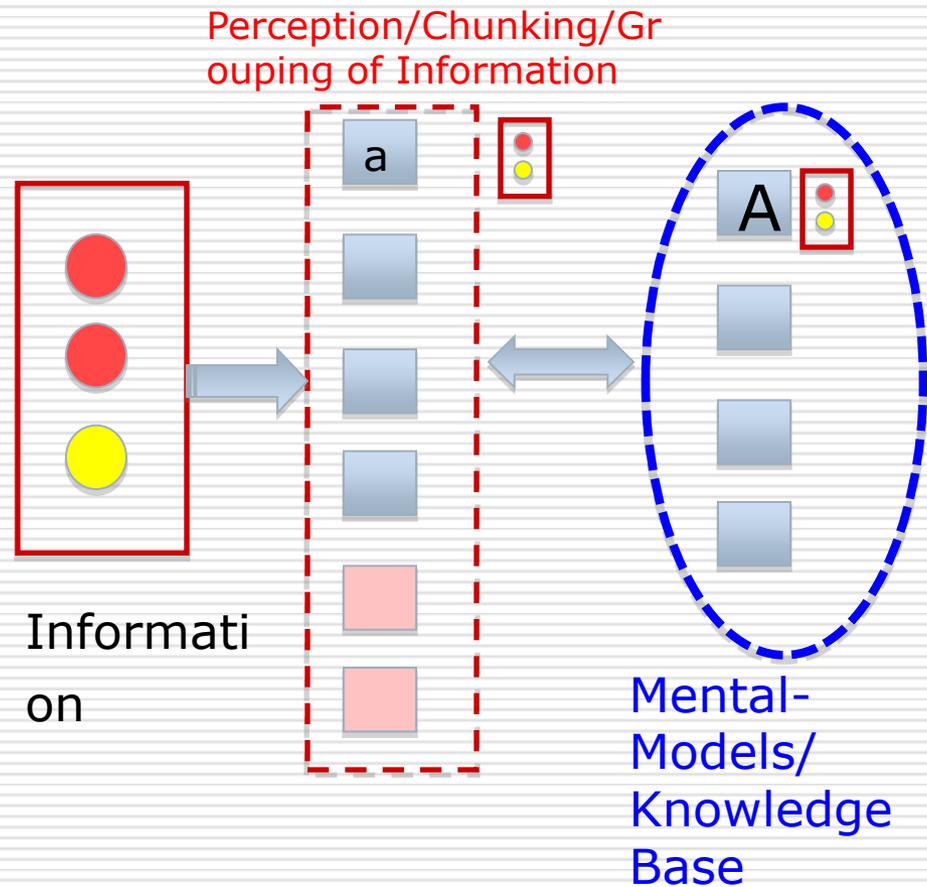
Generic Proximate Cause	Notes/Mechanisms
Inappropriate goal/priority selected	<p>Specifically, in using the term <i>goal</i>, we're referring to <i>functional goals</i> (i.e., plant functions, such as establishing AFW).</p> <p>Reasons for not selecting the correct functional goal may include:</p> <ul style="list-style-type: none">-- Administrative goals/rules/policies-- Cost/benefit/risk/safety prioritization-- Personal goals (e.g., don't be wrong, avoid embarrassment, ego issues, competition, etc.)
Failure to properly maintain/balance multiple goals/priorities	Involves assigning improper priorities to multiple goals or tasks.

"D" Generic Proximate Causes

Generic Proximate Cause	Notes/Mechanisms
Consideration of incomplete/inappropriate list of alternatives (information/explanations/courses of action)	This refers to an incorrect evaluation of alternatives, be it information, diagnoses, or courses of actions. This may include: <ul style="list-style-type: none">• Failure to consider all relevant information/explanations/actions• Inappropriately including irrelevant alternatives
Decide upon incorrect alternative (information/explanation/course of action)	This refers to making a choice, often among alternatives. Specific examples that fall into this category of proximate cause include: <ul style="list-style-type: none">• Incorrect strategy selected for achieving goal(s)• Decision to skip procedure step(s)• Decision to deviate from procedure• Decision to wait for more information• Decision to take alternate action(s)• Decision to delay action/step(s)• Decision to not collect information

Pattern Matching (Similarity Matching) Cognitive Mechanism

- Pattern Matching is a prominent mode of cognition in much of the literature
 - Leads to operators forming mental models/beliefs
 - Judged to be applicable to “Knowledge-supplemented procedure following” strategy



Use of BSM in identifying failure mechanisms

- This characterization helps to identify some key failure mechanisms.
 - Failure of BSM due to memory recall failure: operator does not recall the memorized match to cue
 - Failure of BSM due to poor training: operator's knowledge base (from training) lacks match to cue
 - Failure of BSM due to regency of a cue-situation match (failure because current situation is different)
- Such rules apply to I, D, and A elements

I-D-A Generic Proximate Causes

- I:**
 - Cues/info not sensed
 - Cues/info not perceived
 - Cues/info not attended to
 - Cues/info misperceived
 - Cues/info discounted/dismissed
 - Wrong cues/info attended to
 - **D:**
 - Incorrect understanding/diagnosis of the situation
 - Inability to develop diagnosis from available info (no diagnosis, failure to diagnose)
 - 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)
- A:**
 - 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 communicate information verbally or nonverbally
 - Incorrectly communicate information verbally or nonverbally

PSF Taxonomy and Properties

Organizational PSFs	Team PSFs	Personal PSFs	Situation PSFs	Machine Design PSFs
<ul style="list-style-type: none"> ● Training Program <ul style="list-style-type: none"> – Availability – Quality ● Corrective Action Program <ul style="list-style-type: none"> – Availability – Quality ● Other Programs <ul style="list-style-type: none"> – Availability – Quality ● Safety Culture ● Management Activities <ul style="list-style-type: none"> – Staffing <ul style="list-style-type: none"> * <i>Number</i> * <i>Qualifications</i> * <i>Team composition</i> – Scheduling <ul style="list-style-type: none"> * <i>Prioritization</i> * <i>Frequency</i> ● Workplace adequacy ● Resources <ul style="list-style-type: none"> – Procedures <ul style="list-style-type: none"> * Availability * Quality – Tools <ul style="list-style-type: none"> * Availability * Quality – Necessary Information <ul style="list-style-type: none"> * Availability * Quality 	<ul style="list-style-type: none"> ● Communication <ul style="list-style-type: none"> – Availability – Quality ● Direct Supervision <ul style="list-style-type: none"> – Leadership – Team member ● Team Coordination ● Team Cohesion ● Role Awareness 	<ul style="list-style-type: none"> ● Attention <ul style="list-style-type: none"> – To Task – To Surroundings ● Physical & Psychological Abilities <ul style="list-style-type: none"> – Alertness – Fatigue – Impairment – Sensory Limits – Physical attributes – Other ● Morale/Motivation/Attitude (MMA) <ul style="list-style-type: none"> – <i>Problem Solving Style</i> – <i>Information Use</i> – <i>Prioritization</i> <ul style="list-style-type: none"> * <i>Conflicting Goals</i> * <i>Task Order</i> – <i>Compliance</i> ● Knowledge/Experience ● Skills ● Familiarity with Situation ● Bias 	<ul style="list-style-type: none"> ● External Environment ● Hardware & Software Conditioning Events ● Task Load ● Time Load ● Other Loads <ul style="list-style-type: none"> – Non-task – Passive Information ● Task Complexity <ul style="list-style-type: none"> – Cognitive – Task Execution ● Perceived Situation: <ul style="list-style-type: none"> – Severity – Urgency ● Perceived Decision: <ul style="list-style-type: none"> – Responsibility – Impact <ul style="list-style-type: none"> * Personal * Plant * Society 	<ul style="list-style-type: none"> ● HSI <ul style="list-style-type: none"> – Input – Output ● System Responses <ul style="list-style-type: none"> – <i>Ambiguity</i>

Italicized elements are behaviors or metrics associated with the parent PIF.

Generic Proximate Causes Identified

- Cues/info not sensed
- Cues/info not perceived
- Cues/info not attended to
- Cues/info misperceived
- Cues/info discounted/dismissed
- Wrong cues/info attended to

- Incorrect understanding/diagnosis of the situation
- Inability to develop diagnosis from available info (no diagnosis, failure to diagnose)
- 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)

- Omission (Failure to perform action)
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- Commit incorrect action (specifically an accidental or unintentional incorrect action, e.g., habit intrusion, interference error, perseverations)
- Failure to communicate information verbally or nonverbally
- Incorrectly communicate information verbally or nonverbally

Developing an HRA Quantification Model

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Workshop

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What is the HRA Quantification Model?

- For the purposes of this presentation, the HRA quantification model is the tool that generates the human error probability (HEP) associated with a human failure event (HFE)
- The model will use as input the performance influencing factors (PIFs) that define the overall context for the HFE
 - Plant conditions
 - PSFs

Groundrules for Construction of HRA Model

- The model should:
 - 1. have a sound basis consistent with the cognitive psychology and behavioral science disciplines
 - 2. be practical and applicable directly to the HFEs defined in the PRA.
 - 3. provide the user with the tools to identify the critical elements of context (PIFs) used for the quantification of HEPs
 - 4. facilitate intra and inter analyst consistency and reliability

Theoretical Basis for the Quantification Model

- Nested Information-Decision-Action (IDA) framework
- Set of proximate causes for human failure in the NPP environment
- Cognitive mechanisms linking PIFs to proximate causes

Approach

- For each proximate cause, construct a decision tree:
 - The headers on the tree represent critical PIFs (groundrule 1)
 - For each branch, a set of questions is provided to determine as objectively as possible the existence or not of the PIF (groundrule 3)
 - Each path through the tree represents an explanation of the human failure in terms of a cognitive mechanism and the PIFs (groundrule 1)

Approach (Cont'd)

- Use expert judgment (SRM team) to associate an HEP with each path through the tree
- The PIFs are not independent - they may reinforce one another or counteract one another. There is no empirical basis to guide the experts other than their general understanding
- Proposed approach. For each decision tree:
 - rank the paths by HEP
 - reach consensus on two bounding case HEPs
 - Interpolate

Quantification Model

- The intent is that the model will be a consensus model, thus satisfying groundrules 2 and 4
- Use:
 - defines the required qualitative analysis to complement that provided in the definition of the HFEs
 - can be used for existing PRAs or to support an ATHEANA type analysis of deviation scenarios
 - can provide guidance on choice of subcontexts to explore deviation scenarios
 - could be used iteratively with a CRT or ATHEANA approach for developing a more detailed PRA/HRA

Quantification

- For a scenario S with an associated context

$$HEP(HFE|S) = \sum_i Prob(PC_i|S)$$

- For an HFE with the context broken into subcontexts

$$HEP(HFE|S) = \sum_j \sum_i Prob(PC_i|S_j) \cdot Prob(S_j|S)$$

Dependency

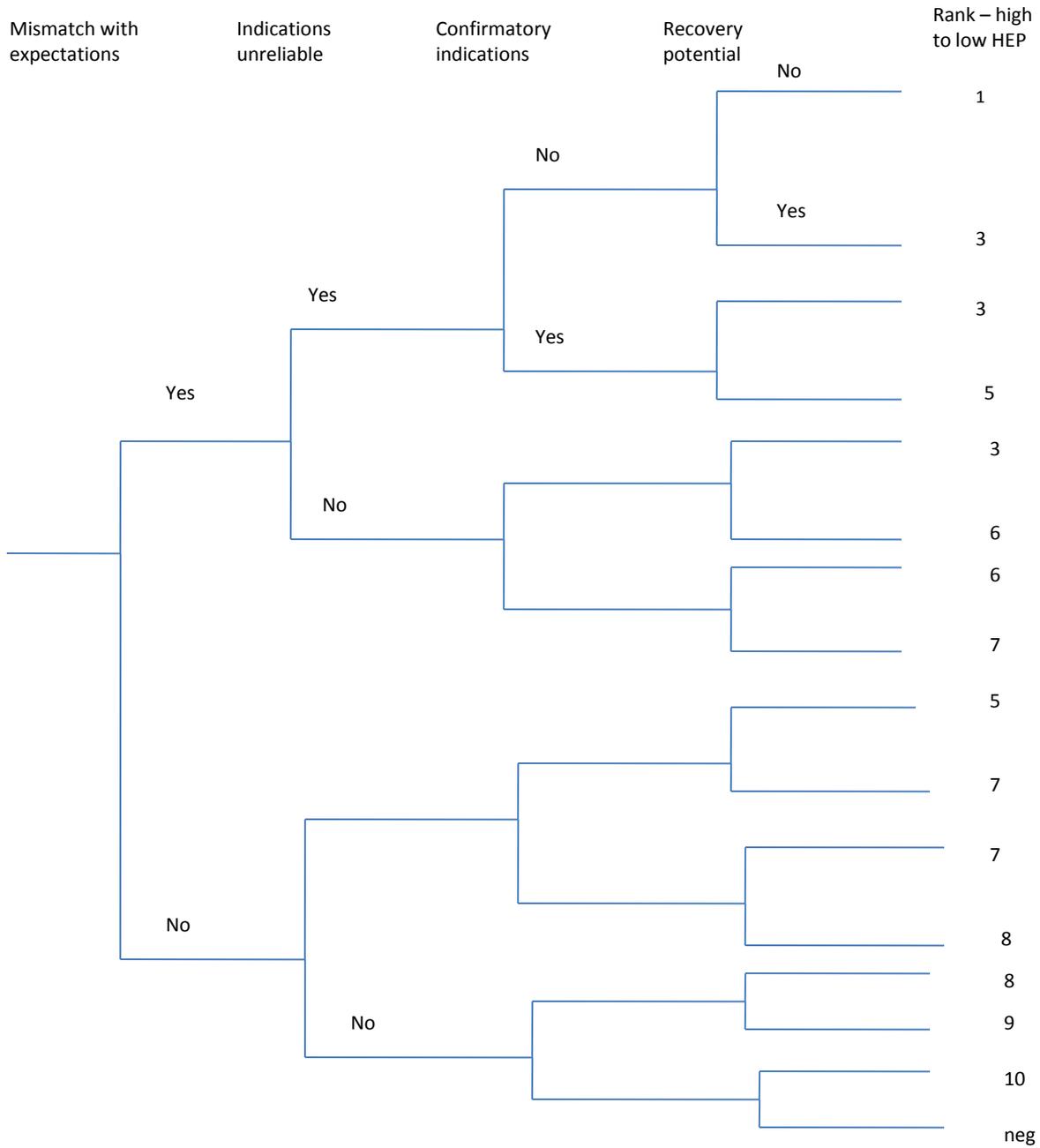
- The focus on causes provides a more rational basis for addressing dependency between HFEs occurring on the same accident sequence cut set.

Back-up Slides

Example of a decision tree for the proximate cause: Intentionally dismiss information

PIFs

- Bias (incl. from training)
 - Confirmation of theory/preconceived notion
 - Against a specific information source
 - (e.g., they think the indicator is wrong because of previous experience, or because maintenance has repeatedly tried to fix the indicator, etc)
- Conditioning Events
 - Past experience with specific indicator
- Ambiguity of system responses (this is one of main driver for this proximate cause)
 - Must be an ambiguous situation or they don't have the option to discount data
- Training,
- Knowledge & Experience
 - Failure to recognize the relevance of the additional data
 - Misperceive the utility of the information
 - Misranking of solution alternatives



Example questions

- BP3: Confirmatory information – can the significance of the missing information be validated by other information?
 - If this is possible, this provides a defense against dismissing the information. Note that this is a procedure/knowledge driven PIF.
 - Are there additional indications that would typically be used to confirm the plant status indicated by the information (e.g., pump amps to confirm a pump unavailable)?
 - Is checking these additional sources emphasized in training?
- If the answer is YES to both these questions, there should be a lower likelihood of dismissing the information.