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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

NOVEMBER 19, 1999

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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MEETING: HUMAN FACTORS

U.S. NRC
Conference Room 28-1
Two White Flint North
11545 Rockville Pike
Rockville, Maryland

Friday, November 19, 1999

The committee met, pursuant to notice, at 8:30 a.m.

MEMBERS PRESENT:

GEORGE APOSTOLAKIS, Chairman, ACRS
DANA A. POWERS, Member, ACRS
THOMAS S. KRESS, Member, ACRS
JOHN J. BARTON, Member, ACRS
JOHN D. SIEBER, Member, ACRS
MARIO V. BONACA, Member, ACRS
ROBERT E. UHRIG, Member, ACRS
ROBERT L. SEALE, Member, ACRS

P R O C E E D I N G S

[8:30 a.m.]

DR. APOSTOLAKIS: The meeting will now come to order.

This is a meeting of the ACRS Subcommittee on Human Factors. I'm George Apostolakis, chairman of the subcommittee. The ACRS members in attendance are Mario Bonaca, John Barton, Robert Seale, Dana Powers, Jack Sieber and Tom Kress.

The purpose of this meeting is to review a proposed revision to NUREG 1624, Technical Basis and Implementation for a Technique for Human Event Analysis, ATHEANA, period and assist staff research activities related to human reliability analysis, pilot application of ATHEANA to assess design basis accidents and associated matters. The subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for deliberation by the full committee.

Mr. Juan Piralta is the cognizant ACRS staff engineer for this meeting. The rules for participation in today's meeting have been announced as part of the notice of this meeting previously published in the Federal Register on October 14, 1999. The transcript of this meeting is being kept and will be made available as stated in the Federal

Register notice. It is requested that speakers first identify themselves and speak with sufficient clarity and volume so that they can be readily heard.

We have received no written comments or requests for time to make oral statements from members of the public. We have to recess at 11:45, because I have to go to another meeting, and then, we will reconvene again at maybe 12:45, okay? So, if you can plan your presentation around that schedule, that will be good.

We will now proceed with the meeting, and I call upon Mr. Mark Cunningham, for a change, to begin.

[Laughter.]

DR. APOSTOLAKIS: Was there ever a meeting where Mr. Cunningham was not the first speaker?

[Laughter.]

DR. APOSTOLAKIS: We all ask.

MR. CUNNINGHAM: Probably one or two in the last 20 years; not much beyond that, it seems.

Good morning.

DR. APOSTOLAKIS: And Dr. Uhrig just joined us, for the record.

MR. CUNNINGHAM: All right; on the agenda, I've got a couple of items to begin with this morning. First is just an overview of what we're doing. The second is topics related to international efforts. I'd like to put the international efforts, to delay that a little bit and discuss it after the ATHEANA presentation, because I think the context is much better after you've heard more about ATHEANA and the way we're treating human errors and things, unsafe acts, I'm sorry, that sort of thing.

But anyway, by introduction, we have I guess by and large one big topic and a couple of smaller topics to discuss this morning. The big topic is the work we've been doing over the last year or so to the ATHEANA project to respond to the peer review that we had in Seattle awhile back, June, okay? That's the main topic for the day, so we'll talk about that; we'll talk about the structure of ATHEANA, what the objectives of the project are and then have an example.

One of the things we've been doing over the last year is demonstrating the model in an analysis of a fire accident scenario in a plant that gets involved with this self-induced station blackout, a SISBO plant, if you will. After that, we'll come back and talk about two smaller topics. One is a base proposal, which are basically our international efforts in the human reliability analysis. We had some work underway for the last couple of years with CSNIs, PWG-5, Principal Working Group 5, and you had errors of commission; we also had a CUPRA program related to trying to relate risk -- bring into risk analysis the impact of organizational influences. So, I'll talk briefly about those later on in the morning or right after lunch or something like that.

DR. APOSTOLAKIS: Oh, I forgot to mention that Mr. Sorenson, a fellow of the ACRS, will make a presentation on safety culture after lunch, and we would appreciate it if some of you guys stay around and express comments and views. This is an initiative of the ACRS, and certainly, your views and input would be greatly appreciated. So don't disappear after the ATHEANA presentation.

MR. CUNNINGHAM: We won't. Most of us won't.

DR. APOSTOLAKIS: Good.

MR. CUNNINGHAM: With that, I'll turn it over to Katharine Thompson. Katharine is the project manager of the ATHEANA project in the office built by two support people, John Forester from Sandia and Alan Kolaczkowski from SAIC. We've got some others in the audience, too, but we'll get back to that in a minute.

DR. THOMPSON: Good morning, and it's my pleasure to be here this morning to discuss ATHEANA with you for the first time, I guess. I know you've heard a lot about it.

DR. APOSTOLAKIS: We should invite you more often, Katharine.

[Laughter.]

DR. POWERS: Well, George, I will point out that the first speaker before the committee usually gets asked a fairly similar question.

DR. APOSTOLAKIS: Yes; go ahead, Dana.

DR. POWERS: What in the world qualifies you to speak before this august body?

[Laughter.]

DR. THOMPSON: I have orders from my manager.

[Laughter.]

DR. POWERS: No, I'm serious; could you give us a little bit of your background?

DR. THOMPSON: Oh, sorry; I have a Ph.D. in industrial and organizational psychology. I've been at the NRC for about 10 years. I was in NRR and human factors for a few years, and then, I went as a project manager for the Palo Verde plant. I've been over here in the research and assessment branch for about 5 or 6 years, and I've been working on ATHEANA for the past about 5 years.

DR. POWERS: What in the world makes you think that this body will understand anything you have to say?

[Laughter.]

SPEAKER: We'll be slow in delivery.

DR. THOMPSON: Okay; just a brief outline of the presentation. I'm going to be discussing the overview and a brief introduction. Dr. John Forester will be going through the structure of ATHEANA and how it's done. Alan

Kolaczkowski will be talking about the fire application, and then, I'll be back to talk about some conclusions and some follow-up activities.

We're not going to talk about the peer review in the interests of time, but in the back of your handout, you have all of the slides and discussion of the peer review, so you can look at that in your own time.

DR. APOSTOLAKIS: Unless we raise some issues.

DR. THOMPSON: Unless you raise some issues.

I guess the first question that always comes is why do we need a new HRM method? And so, we've talked about this and looked at accidents that happen in the industry and other industries, events that have happened, and certain patterns and things come to the surface. What we're finding is that a lot of problems involve situation assessment; that scenarios and the events deviate from the operator's expectation. Perhaps they were trained in one way on how to approach a situation, and the scenario didn't happen that they were trained on.

We've seen that plant behavior is often not understood, that multiple failures happen that are outside the expectations of the operators, and they don't know how to respond to this or how to handle it properly. They weren't trained on how to follow these scenarios. And we also know that plant conditions are not addressed by procedures. A lot of times, these things don't match. The procedures tell them how to go through a scenario, but yet, the scenario isn't matched with the procedures at hand, so that they may do something that's not in the procedures; that could, in fact, worsen the conditions.

And these types of things aren't handled appropriately in current ERAs and HRAs, and so, we need to address these problems with situation assessment and how the plan is understood by the operators.

DR. APOSTOLAKIS: Now, this thing about the procedures is interesting. Isn't it true that this agency requires verbatim compliance with procedures, unlike the French, for example, who consider them general guidelines?

DR. POWERS: Guidance.

DR. APOSTOLAKIS: Yes; it's like traffic lights somewhere else.

So how -- what are we going to do with this? I mean, should the agency change its policy?

MR. CUNNINGHAM: We are probably not the best people to say, but I don't think that's the policy of the agency, to follow -- require verbatim compliance with the procedures.

DR. BARTON: George, the agency requires that you have to procedures to conduct operations, to handle emergencies, et cetera. Some procedures are categorized in different categories: continuous use, reference, stuff like that. But there really isn't --

DR. APOSTOLAKIS: There is no --

DR. BARTON: -- a requirement that you do verbatim compliance.

DR. BONACA: Although the utilities --

DR. BARTON: Utilities have placed compliance, strict compliance, on certain groups of procedures, and they have also policies that say if you can't comply with the procedure, what you do: stop and ask your supervisor, change the procedure, et cetera. But I don't think there are any regulations that say you have to follow procedures verbatim.

DR. APOSTOLAKIS: Although we have been told otherwise, though. What's that?

DR. BONACA: Control room procedures, however, in an emergency, EOPs, for example, there is following verbatim to line by line.

DR. APOSTOLAKIS: But these are the ones that Katie is talking about, right? EOPs?

DR. BONACA: Yes.

DR. APOSTOLAKIS: Not procedures for maintenance. I mean, you're talking about --

MR. CUNNINGHAM: Again, I don't know that it's a requirement of the agency that they follow line-by-line the procedures. It's my understanding that it's not.

DR. UHRIG: It was 20 years ago at one point, but that was believed.

MR. CUNNINGHAM: Okay.

DR. BONACA: Well, the order in which you step through an emergency procedure is very strict. I mean, at least -- I don't know if it is coming from a regulation, but it is extremely strict. You cannot -- I mean, the order of the steps you have to take; that's why you have the approach in the control room with three people, and one reads the procedure; the others follow the steps.

DR. APOSTOLAKIS: Yes, that's true.

MR. CUNNINGHAM: Again, I think all of that is very true. I just don't think it's a requirement -- it's not in the regulations that they do that is my understanding.

DR. APOSTOLAKIS: You say you are not the appropriate people. Who are the appropriate people who should be notified?

MR. CUNNINGHAM: I'm sorry?

DR. APOSTOLAKIS: Maybe that will do something about it.

MR. CUNNINGHAM: Who --

DR. APOSTOLAKIS: Who in the agency is in charge of the procedures and compliance?

MR. CUNNINGHAM: It's our colleagues in NRR, obviously, and where exactly in the last reorganization this ended up, I'm not quite sure.

DR. APOSTOLAKIS: Okay.

MR. CUNNINGHAM: But the issue of whether or not there is verbatim compliance is an NRR issue that --

DR. SEALE: It might be interesting to discuss this with some inspectors in the plant.

DR. KRESS: Whenever we've heard -- one of these things that always seems to show up. I'm sorry; I can't talk to them and listen at the same time, but it seems to me like there was almost an implied -- on these procedures.

DR. APOSTOLAKIS: Yes.

DR. KRESS: Whether it's real or within the regulations or not.

DR. BONACA: But that certainly has been interpreted by now by the licensees. I mean, for the past 10 years, especially -- even the severe accident guidelines, in some cases, where you look at the procedures, they are very strictly proceduralized, I mean. And you check to see that people do not even in the simulator room do not invert the order of the stuff.

DR. THOMPSON: Yes, but a lot of that came from the analysis, because following the procedure requirement, it's the next step that you must deal with, I don't ever recall a regulation requiring verbatim compliance. We had company policy about certain procedures.

DR. APOSTOLAKIS: Okay.

DR. THOMPSON: Okay; so what we know from all of these reviews of accidents and events is that situations in the context creates the appearance that a certain operator action is needed when, in fact, it may not be and that operators act rationally; they want to do the right thing; they try to do the right thing, and sometimes, the action is not the appropriate action to take. The purpose for ATHEANA, then, is to provide a workable, realistic way to identify and quantify errors of commission and errors of omission.

There are three objectives of ATHEANA. First is to enhance how human behavior is represented in accidents and near miss events. We do this by looking at the decision process involved, how people -- their information processing abilities and how they assess a situation, and we also integrate knowledge from different disciplines. We look -- we have technology factors, engineering risk assessments. We try to incorporate many different areas of knowledge there.

DR. POWERS: I guess I'm struck by how this view graph would have been written by somebody -- who developed human error analysis methodologies they use now. They probably would use this view graph and just change the title, right? Everybody that advances the human -- our reliability analysis program says he's going to make it realistic; he's going to integrate perspectives of ERA with plant engineering, operations training, psychology, risk-informed and have insights. I mean, this is true of any conceivable human error analysis.

MR. CUNNINGHAM: In theory. Now, we could go back perhaps in another session and talk about how much did other methods really accomplish this, and I think what you see, and you hear stories of how, in the poorer qualities HRAs, if you will, how this is implemented in a way that, in fact, the issues such as psychology and operations and training and things like that are handled on a rather -- one way to put it is a crude way, and one way would be just a mechanical way or something like that.

DR. POWERS: You know, I mean when you look for things like your hallowed Navier Stokes equations, people come up with --

DR. KRESS: Hallowed, not hollowed.

DR. POWERS: That's right, hollowed.

[Laughter.]

DR. POWERS: The fount of all wisdom, and you call it the big bang; everything else was just thermohydraulics.

[Laughter.]

DR. SEALE: And a little chaos thrown in.

[Laughter.]

DR. POWERS: You know, in your equations, you say, well, we'll make an approximation. We may have zeroeth Ns, and you can see that there is no dimensionality in the zeroeth approximation, and then, you have first order ones and second order ones and third order ones, and it's very clear when somebody is getting more realistic and incorporating more terms. How am I going to look and see that this ATHEANA program is more realistic? You know, what is it that says clearly that this is more realistic than what was done many, many years ago for the weapons programs?

MR. CUNNINGHAM: I guess in my mind, there would be a couple of clues. I guess one would be how well we can mimic, if you will, or reproduce the real world accidents that Katharine started talking about, and again, those are the accidents that are, if you will, I think of them as the more catastrophic accidents. If you look back and see, investigate human performance in catastrophic accidents, how well does this model -- I don't want to say predict but work with those types of events?

DR. KRESS: You're not talking about neutral.

MR. CUNNINGHAM: No, I'm talking about in general. I can think of --

DR. KRESS: Can you transfer that technology to technology?

MR. CUNNINGHAM: Yes, I think you can, and that's kind of one of the subtle, underlying presumptions is that the human performance in catastrophic accidents can be translated across different industries, highly complex, high-tech industries, if you will: aircraft, chemical facilities and that sort of thing.

DR. APOSTOLAKIS: I think there is a message here, Katharine: use your judgment as you go along, and skip the view graphs that are sort of general and focus on ATHEANA only. Do not raise anything until you come to the specifics. Otherwise, you're going to get discussions like this.

[Laughter.]

DR. APOSTOLAKIS: So can you go on, and we'll come back to these questions?

DR. THOMPSON: Skip the next one, John.

This is just to show you the basic framework of ATHEANA and to underscore again -- well, we use different ones here; that's the left part. Psychology, engineering -- this is something we've been working on. The left-hand side shows you the elements of psychology, human factors engineering that are folded into the framework.

DR. APOSTOLAKIS: Go ahead.

DR. THOMPSON: And then, it flows into the PRA logic models and the rest. You've seen this before. John is going to talk more about this in the future, so I don't want to spend too much time on this right now.

DR. APOSTOLAKIS: I have a couple of comments.

DR. THOMPSON: Okay.

DR. APOSTOLAKIS: I have complained in the past that error-forcing context is a misnomer, and then, I read your chapter 10, which tells me that there may be situations where the error-forcing context really doesn't do anything. So I don't know why it's forcing. I notice that some of the reviewers also said that it's probably better to call it error-producing, error -- I don't know, some other word than forcing, because you, yourselves say in chapter 10 that the probability of error, given an error-forcing context, is not one, may not be one.

DR. THOMPSON: Right.

DR. APOSTOLAKIS: Second, I don't understand why you call them unsafe actions. I fully agree that the human failure event makes sense, but until you go to the human failure event, you don't know that the action is unsafe. I mean, you insist -- in fact, you just told us -- that people aren't rational, and I'm willing to accept that. So the poor guy there took action according to the context, which led to a human failure event. So I don't think you should call it unsafe. I mean, human actions -- don't you think that that would be a better terminology?

And then, finally, coming back to Dr. Powers' question, I give you my overall impression of the report. I think the greatest contribution that ATHEANA has is the extreme attention it paid to the plant, at the plant conditions; that there is an awfully good discussion of how the plant conditions shape the context. But I must say that chapter 10 was a disappointment. The quantification part, I didn't see anything there that really built on the beautiful stuff that was in the previous chapters. In fact, it just tells you go find a method and use it.

It's a little harsh, but, I mean, in essence, that's what it says. I mean, I have this context. I spent all this effort to find the error-forcing context. And then, all you are telling me is now, you can use half. You can use, you know, slim model if you like. I thought I was going to see much more. I mean, this thing of error mechanisms has always intrigued me, why you bother to use it. And then, in chapter 10, you don't use it, which is sort of what I expected. I mean, I can't imagine anybody quantifying error mechanisms.

So I don't know if this is the proper place to discuss this, because it's jumping way ahead, but I'm just letting you know that chapter 10, I thought, was a let-down after the wonderful stuff that was in the previous chapters.

MR. CUNNINGHAM: Yes, I think we are getting a little ahead of --

DR. APOSTOLAKIS: Yes, okay.

MR. CUNNINGHAM: I mean, after John and Alan talk for awhile, we can come back to this.

DR. APOSTOLAKIS: But, I mean, one part of the answer to Dr. Powers is that this is really the first HRA approach that really paid serious attention to the plant conditions, and I think that is very, very good, very good, but we are really -- we are not just speculating now. You guys went out of your way to see how this circle there, plant design, operations and maintenance and plant conditions shape the context. I've always had reservations about the error mechanisms, but I deferred to people more knowledgeable than I.

But chapter 10 now makes me wonder again. So, but the terminology, I think, is very important. I'm not sure that you should insist calling it error-forcing context when you say in chapter 10 that -- I don't remember the exact words but, you know, sometimes, you know, it doesn't really matter. How can it be forcing it?

Yes, John?

MR. FORESTER: Do you want me to comment on it?

DR. APOSTOLAKIS: I want you to comment on this.

MR. FORESTER: I suggest we come back and --

DR. APOSTOLAKIS: Great.

MR. FORESTER: -- the natural progression of the talk will get us to chapter 10.

DR. APOSTOLAKIS: Okay; fine, fine.

MR. FORESTER: Sometime today so --

DR. APOSTOLAKIS: Do you have any reaction to the comments on the terminology? I mean, last time, you dismissed me. Are you still dismissing me?

[Laughter.]

DR. THOMPSON: We'll come back to it.

MR. FORESTER: We will come back to it.

MR. KOLACZKOWSKI: The answer is yes.

DR. APOSTOLAKIS: Well, then, that gives me time to find your exact words in chapter 10.

[Laughter.]

DR. APOSTOLAKIS: Okay.

DR. THOMPSON: This slide going real fast. I wanted to just briefly recognize the team, because they all did a wonderful, wonderful job, and it, again, underscores the different disciplines we've brought to this program. We've got psychologists, the first three, specifically.

DR. APOSTOLAKIS: Always pleased to see names that are more difficult to pronounce than my own.

[Laughter.]

MR. KOLACZKOWSKI: I don't see any such names here.

[Laughter.]

DR. THOMPSON: He's referred to as Alan K., because I can't pronounce it either.

[Laughter.]

DR. THOMPSON: Engineers, risk assessment experts, psychologists, human factors, so we've brought all of the disciplines to this project that we need.

DR. APOSTOLAKIS: By the way, I hope you don't misunderstand my comments. I really want this project to succeed, okay? So I think, you know, being frank and up front is the best policy. So I must tell you that it was not a happy time for me when I read chapter 10.

MR. CUNNINGHAM: We appreciate that over the years, we've gotten a lot of good advice from the various subcommittees and committees here, and we appreciate that and take it in that vein, even though we may take your name in vain occasionally.

[Laughter.]

DR. POWERS: We are probably in good company.

DR. APOSTOLAKIS: Now, you know why Mr. Cunningham is always there --

[Laughter.]

DR. APOSTOLAKIS: -- every time we meet. He knows how to handle situations like this.

[Laughter.]

MR. FORESTER: Yes; I am John Forester with Sandia National Laboratories, and I'm, I guess, the project manager, the program manager. I work for Katharine, and I'm the project leader for the team.

DR. APOSTOLAKIS: She's not Kitty anymore? Is it Katharine now?

MR. FORESTER: Katharine, yes.

DR. APOSTOLAKIS: Okay.

[Laughter.]

MR. FORESTER: For this part of the presentation, I'm going to discuss the structure of ATHEANA, and what I'd like to do is focus on the critical aspects and processes that make up the ATHEANA method.

DR. APOSTOLAKIS: So, you skipped the project studies.

DR. THOMPSON: I'm sorry; I'll get back to that at the end when we talk about the completion.

DR. APOSTOLAKIS: Okay.

MR. FORESTER: Okay; ATHEANA includes both a process for doing retrospective analysis of existing events and a process for doing prospective analysis of events.

DR. KRESS: A retrospective? Is that an attempt to find out the cause?

MR. FORESTER: Right, an analysis of the event to find out what the causes were and, you know, ATHEANA has had a process or a structure, at least, for doing that for quite awhile, to be able to analyze and represent events from the ATHEANA perspective so that you can understand what the causes were and also, by doing that in this kind of formal way, you'd have a way to maybe identify how to, you know, fix the problems in a better way.

DR. KRESS: And you can use that retrospective iteratively to improve some of the models in the ATHEANA process?

MR. FORESTER: Yes; you know, the idea was that by doing these retrospective analyses, we learn a lot about the nature of events that had occurred and then can take that forward and use it in the prospective analysis.

DR. APOSTOLAKIS: But today, you will focus on prospective analysis.

MR. FORESTER: That is correct; yes, I just want to note that one of the recommendations from the peer review in June of 1998 was that we had the structure for doing the retrospective, but we did not have an explicitly documented process for doing the retrospective, and we have included that now, okay? And we do see that as an important part of the ATHEANA process in the sense that, you know, when plants or individuals go to apply the process, they can look at events that have occurred in their own plant and get an understanding of what the kinds of things ATHEANA is looking for, sort of the objectives of it, and that way, it will help them be able to use the method, in addition to just learning about events in the plant and maybe ways to improve the process or improve the problem, fix the problem.

Okay; now, we do see in terms of the prospective analysis, as George said, we're going to focus on that mostly today. We do see the process as being a tool for addressing and resolving issues. Now, those issues can be fairly broadly defined in the sense of we're going to do an HRA to support a new PRA, but we also see it as a tool to use more specifically in the sense -- for example, you might want to extend an existing PRA or HRA to address a new issue of concern; for example, maybe, you know, the impact of cable aging or operator contributions to pressurized thermal shock kind of scenarios or fire scenarios. So it can be used in a very effective manner, I think, to address specific issues.

Also, maybe, to enhance an existing HRA or, you know, upgrade an existing HRA to be able to -- for purposes of risk-informed regulation submittals and things like that. So it can be a very issue-driven kind of process.

The four items there on the bottom are essentially sort of the major aspects of the tool, and I'm going to talk about each one of those in detail, but in general, the process involves identifying base case scenarios; sort of what's the expected scenario given a particular initiator and then trying to identify deviations from that base case that could cause problems for the operators.

Another major aspect of the --

DR. KRESS: Are those the usual scenarios in a PRA that you're talking about?

MR. FORESTER: The -- well, no, the base case is sort of -- I'll go into more detail about what the base case scenario actually is, but it is what the operators expect to occur, and it's also based on detailed plant engineering models, okay? So maybe you'll lift something from the plant FSAR, but I'll talk about that a little bit more.

And again, another major aspect of the revised method is that we try to clarify the relationship between the deviations, the plant conditions and the impact on human error mechanisms and performance shaping factors. So we tried to tie that together a little better, and I think we've created at least a useful tool to do that with. And then, finally, the other major aspect is the integrated recovery analysis and quantification, and I would like to say Kitty has already pointed out that I'll kind of go through the general aspects of the process, and then, Alan is going to give us an illustration of that process, okay?

[Pause.]

MR. FORESTER: Okay; I think as we mentioned earlier, sort of the underlying basis for the prospective analysis is that most serious accidents occur when the crew sort of gets into a situation where they don't understand what's going on in the plant.

DR. APOSTOLAKIS: Is this Rasmussen's knowledge-based failure?

MR. FORESTER: Yes, I guess it would be. It's where the procedures don't maybe fit exactly; they may be technically correct, but they may not fit exactly, and, well, even in the aviation industry or any other kind of industry, what you see in these kind of serious accidents was that they just didn't understand what was going on. Either they couldn't interpret the information correctly. I mean, in principle, I guess it could have been responded to in a rule-based kind of way, but they didn't recognize that, so it did put them into a knowledge based kind of situation.

DR. KRESS: When I read that first bullet, I'm thinking of nuclear plants because it comes from the broad plan.

MR. FORESTER: Yes; that's true, but there have been some events. I mean, they haven't led to serious events, necessarily, and even beyond TMI and --

DR. KRESS: Yes, but that's one data point.

MR. FORESTER: I mean, there are other events, though, that haven't gone to core damage or, I mean, that haven't really led to any serious effects.

DR. KRESS: But you're getting this information from --

MR. FORESTER: Yes, yes; okay.

DR. KRESS: Because in designing nuclear plants, we talk about conditions not understood. We've gone to great pains to get that out. I'm sorry; I'll just quit talking.

[Laughter.]

MR. FORESTER: It does seem, even in the nuclear industry, you know, there are times where people do things wrong. I mean, it doesn't lead to serious problems, but people do, you know, they bypass SPASS --

DR. SEALE: You know, it really goes back to George's comment about human error. Human error is a slippery slope. It's not a cliff. And, in fact, when human error occurs, the angle of that slope will vary from error to error, and while you may talk about TMI as a case where you led to an accident, I bet you you could find a dozen where people did something, recognized that they were on a slippery slope, and recovered, and that seems to me, that should be just as useful an analysis, an identification to do in your ATHEANA process as was the TMI event, because it's the process you're trying to understand.

MR. CUNNINGHAM: No, I think that's right; you learn from your mistakes. You also learn from the mistakes you avoid.

DR. SEALE: And the ability to recover is important knowledge.

MR. CUNNINGHAM: Yes; there's a lot of work that's been done about TMI; an operator response to initial events, and as you said, there is still the residual that they don't understand, and that's where we can get into very severe accidents, even after all that training.

DR. POWERS: It seems to me that a double-ended guillotine pipe break, that's a severe accident that a crew would understand absolutely what it was doing in a double-ended guillotine pipe break.

DR. KRESS: So we are never going to have one.

[Laughter.]

DR. POWERS: If we had one, you would damn well know what happened.

[Laughter.]

DR. POWERS: You wouldn't be able to mistake it for much. It seems like what you're saying may be true for accidents that are of real concern to us, but it's going to run counter to the DBAs. The DBAs, you know what's going on, and it doesn't seem like it applies to the DBAs.

MR. CUNNINGHAM: DBAs are obviously very stylized accidents. DBAs themselves are very stylized accidents, and the training, you know, 25 years ago was fairly stylized to go with those accidents. We've made a lot of progress since then in taking a step back from the very stylized type of approach, but you can still have accidents or events. The one that comes to mind for me is the Rancho Seco event of -- I don't know -- the early eighties or something like that, where they lost a great deal of their indication; another indication was confusing and that sort of thing. It's not a design-basis accident, but it was a serious challenge to the core, if you will.

DR. APOSTOLAKIS: Isn't, John, I don't see anything about the values of operators, the references; again, the classic example is Davis-Bessie, you know, where the guy was very reluctant to go to bleed and feed and waited until that pump was fixed, and the NRC staff, in its augmented inspection team report, blamed the operators that they put economics ahead of safety. The operators, of course, denied it. The guy said, no, I knew that the pump was going to be fixed, but isn't that really an issue of values, of limits? It's a decision making problem.

MR. CUNNINGHAM: Right.

DR. APOSTOLAKIS: Where in this structure would these things -- are these things accounted for? Is it in the performance shaping factors, or is it something else?

MR. FORESTER: Well, one place it comes through is with the informal rules. We try to evaluate informal rules. And if there's sort of a rule of, you know, we've got to watch out for economics, I mean, in their minds, it may not be an explicit rule, but in their minds, they're not going to do anything that's going to cost the utility a lot of money. That's one way we try to capture it.

There's also -- we try and look at their action tendencies. We have some basic tables in there that addresses both the BWR and PWR operator action tendencies, what they're likely to do in given scenarios.

DR. APOSTOLAKIS: But if I look at your multidisciplinary framework picture that you showed earlier, I don't see anything about rules. So the question is where, in which box, you put things like that.

MR. FORESTER: Well, I guess it would probably be sort of part of the performance shaping factors.

DR. APOSTOLAKIS: I'm sorry, what?

MR. FORESTER: Well, overall, the impact of rules would sort of be -- or of what you're describing here, and I used informal rules as how we get at that in terms of the framework, it would certainly be covered under part of the error forcing context, essentially.

DR. APOSTOLAKIS: But this is the performance shaping factor, part of the performance shaping factor?

MR. FORESTER: I think it -- I guess it would also -- I'm not sure we'd directly consider it as a performance shaping factor.

DR. APOSTOLAKIS: What is a performance shaping factor in this context? Give us a definition.

MR. FORESTER: Well, procedures, training, all of those things would be -- the man-machine interface, all those would be --

DR. APOSTOLAKIS: Technological conditions? Is that performance-shaping factors?

MR. FORESTER: Stress and --

DR. APOSTOLAKIS: So the error forcing context is the union of the performance shaping factors and the plant conditions. Is that the correct interpretation of this?

MR. FORESTER: That's a correct interpretation.

DR. APOSTOLAKIS: So clearly, values cannot be part of the plant conditions, so they must be performance-shaping factors. I mean, if it's the union --

MR. KOLACZKOWSKI: I'm Alan Kolaczkowski with SAIC. Yes, if you want to parcel it out, if you want to actually put tendencies of operators or roles into a box, it would best fit in the performance shaping factors, yes, but the reason why I think we're struggling is that we recognize that to really define the error-forcing context, you have to think about the plant conditions and all the influences on the operator in an integrated fashion, and it's hard to parcel it out, but if you want to put it in a box, I would say yes, it's affecting the performance shaping factors.

DR. APOSTOLAKIS: That's what the box says: all of these influences --

MR. KOLACZKOWSKI: I understand.

DR. APOSTOLAKIS: -- are the PSFs, because there's nothing else.

MR. FORESTER: Well, it could be more specified, I would say, in the sense that part of what you're bringing up is augmented in the organizational factors, maybe even team issues, things like that, which are going to be -- which are certainly going to contribute to the potential for error. Those are not explicitly captured. In some sense, they could be looked at as part of the plant conditions, and they could also be looked at as performance shaping factors.

DR. APOSTOLAKIS: Now, this sector on the left, what do you mean by operations?

MR. FORESTER: Just the way they do things there, the procedures, their modus operandi, I guess, as to the way they run the plant.

DR. APOSTOLAKIS: Is what other people call safety culture there?

MR. FORESTER: I think that's more --

DR. APOSTOLAKIS: No, but that's part of it.

there's an error there on the left, plant design, operations and maintenance. I remember the figure from Jim Reason's book, where he talks about line management deficiencies and valuable decisions. Are you lumping those into that circle, or are you ignoring them? I mean, the issue of culture --

MR. FORESTER: We have not explicitly tried to represent those yet.

DR. APOSTOLAKIS: But this is a generic figure, so that's where it would belong, right?

MR. FORESTER: I'm not sure I would normally necessarily pigeonhole it there. It's all part of that whole -- the whole error force in context and what feeds into the error force in context.

DR. APOSTOLAKIS: But the error force in context is shaped by these outside influences. It does not exist by itself. You have these arrows there.

MR. FORESTER: Right.

DR. APOSTOLAKIS: So this is an outside influence, so, for example, if I wanted to study the impact of electricity market deregulation, that would be an external input --

MR. FORESTER: Yes.

DR. APOSTOLAKIS: -- that would affect the performance shaping factors and possibly the plant condition.

MR. FORESTER: Yes; that is correct.

DR. APOSTOLAKIS: Okay.

MR. CUNNINGHAM: That is correct.

DR. APOSTOLAKIS: So all of these are external influences that shape what you call error force in context.

MR. CUNNINGHAM: That's right. This is a very conceptual description of the process.

DR. APOSTOLAKIS: Yes.

MR. CUNNINGHAM: And it's probably a little broader than ATHEANA is today, but again, if we could go back and get into ATHEANA as it is today, it might help --

DR. APOSTOLAKIS: Okay.

MR. CUNNINGHAM: -- some of the others understand what we're going through here.

MR. FORESTER: Well, given what we've identified as the nature of serious accidents, we think a good HRA method should identify these conditions prospectively, and we have several processes that we use to do that. Mr. Chairman, I'm going to talk about these in more detail, to identify the base case scenarios, and again, these are conditions that are expected by the operators and trainers given a particular initiating event.

They may want to identify potential operational vulnerabilities, and these might include operators' expectations about how they think the event is going to evolve. It could include vulnerabilities and procedures; for example, where the timing of the event is a little bit different than what they expect. The procedure could be technically correct, but there could be some areas of ambiguity or confusion possibly.

And then, based on those vulnerabilities, at least part of what we use is those vulnerabilities, then try and identify reasonable deviations from these base case conditions, to sort of see if there are kinds of scenarios that could capitalize on those vulnerabilities and then get the operators in trouble.

DR. APOSTOLAKIS: So I think it's important to ask at this point: what were the objectives of the thing? It's clear to me from the way the report is structured and the way you are making the presentation that the objective was not just to support PRA.

MR. FORESTER: Not just to support PRA, no; I guess that's maybe how we started out, but I think the method itself can be used more generally than in PRA. I think it needs to be tied to PRA because of some of the ways we do things, but no, certainly, it could be used more generally.

DR. APOSTOLAKIS: What other uses do you see?

MR. FORESTER: You can do qualitative kind of analysis, so if you're not doing a PRA, you don't need explicit quantitative analysis. So with, for example, in the aviation industry, there is not a whole lot of risk assessment done as far as I know on what goes on in the airplane cockpits, but that doesn't mean that you couldn't use this kind of approach to develop interesting scenarios, potentially dangerous scenarios, that you could then run in simulators, for example, or in the nuclears, you can run these things as simulators and give operators experience with them and see how they handle the situation.

DR. APOSTOLAKIS: So this would help with operator training?

MR. FORESTER: I believe it would, yes, because there is a very explicit process.

DR. BONACA: I think we have the fundamental elements of root cause, for example, and so, that would help with that.

MR. SIEBER: I think it also helps in revising procedures, because you have a confusing procedure, and it doesn't really give you the -- but this technique helps you pinpoint --

DR. APOSTOLAKIS: This is an important point that I think you should be making whenever you make presentations like this, because the sole objective is to support the PRA, and I think a legitimate question would be are you sure you can quantify that? Maybe you can't, but if your objective is also to develop health of operator training and other things, then, I think it's perfectly all right.

DR. BONACA: I think the value of this, you know, when I looked at this stuff is that -- was in part, I mean, some of the issues are based on the mindset that the operators have. Here, you have a boundary where they believe they have the leeway not to follow procedures; for example, the issue of not going to bleed and feed was very debated in the eighties, because it seemed like an option was that severe accidents, something, and if you look at the procedure, before 1988 or so, there was no procedure to do bleed and feed. I mean, simply said, if you have a dry steam generator, do something. One thing you could do was bleed and feed.

Well, then, leave it to the judgment of the operator to do so. Well, today, you go into it. We learned that that was a mistake. So we said the only thing you can do is bleed and feed, so do it, and you put it in the procedure now, and they follow it now, but it took a long time for the operators to convince them to go into it. I mean, they didn't like that.

So I'm saying that in a model like this, it would help to talk about some of the shortcomings.

MR. SIEBER: I'm pretty well convinced that even if you didn't have a PRA, you could profit from looking at how --

DR. APOSTOLAKIS: And all I'm saying is that those statements should have been made up front, because the review, then, doesn't say what you are presenting, and I would agree. I agree, by the way, that this is a very valuable result.

DR. SEALE: It's interesting, because the utility of this method actually begins in terms of influencing procedures and so forth before it gets terribly quantitative, and yet, it's the ultimate objective, presumably, or let's say the most sophisticated use of it is when it gets quantitative so that you can use it in the PRA, but it strikes me that it might be when you talk about these other uses to actually identify the fact that in its less quantitative form, it's still useful --

MR. CUNNINGHAM: Yes.

DR. SEALE: -- in doing these other things, and that supports the idea, then, that you can evolve to your ultimate objective, but you have something that's useful before it ever becomes the final product.

MR. CUNNINGHAM: That's very useful. We've talked about that and those types of benefits, but we could make it clearer.

DR. APOSTOLAKIS: Okay; can we move on?

DR. KRESS: Before you take that slide off --

DR. APOSTOLAKIS: We have two members who have comments.

Dr. Kress?

DR. KRESS: The three sub-bullets under two, if I could rephrase what I think they mean, you start out with some sort of set of base case scenarios, and you look at that scenario and look at places where the scenario could be described wrong, and it could go a different way somehow all through it, so those are the vulnerabilities or place where it could go differently than you think or might even go different. And then, the abbreviations are the possible choices of these different directions a scenario might go; it looks a whole lot to me like an uncertainty analysis on scenarios, which I've never actually seen done. So it looks to me like a continuum. I don't know how you would make this a set of integers.

MR. CUNNINGHAM: We'll talk about that later.

DR. KRESS: You'll talk about that later?

MR. FORESTER: Yes.

DR. KRESS: Okay.

MR. CUNNINGHAM: We want to get to that later.

DR. KRESS: Okay, so I'll wait until you do.

DR. APOSTOLAKIS: Mr. Sieber?

MR. SIEBER: I have a question. When I read through this, I had a sort of an understanding of what the performance shaping factors were. It's all the things that go into the operator, like training, the culture of the organization, mission of the crew, formal and informal rules, et cetera. That to me makes this whole process unique to each utility, because the performance shaping factors are specific to a unit. And this stuff is not transferable from one plant to another; is that correct?

MR. FORESTER: That is absolutely correct.

MR. CUNNINGHAM: The process would be transferable but not the results. That is correct.

MR. SIEBER: So you just couldn't take some catalog of all of these potential possibilities for error and move them into your PRA, and anything that had any relevance to anything --

MR. CUNNINGHAM: The potentials and the experience base are useful inputs, but they are not substitutes for the analysis of an individual plant.

MR. SIEBER: Well, when you're doing, then, a retrospective analysis, you have to do it with the crew who was actually on the shift, and you will reach a conclusion based on that crew, not necessarily that plant; certainly not some other plant; is that correct?

MR. KOLACZKOWSKI: That would be the best track, correct.

MR. SIEBER: Thank you.

MR. FORESTER: So, sort of the next critical step after the issue has been defined and the scope of the analysis is laid out is to identify the base case scenario. So we've got to go into a little bit more detail about exactly what we mean by base case scenario.

Usually, the base case scenario is going to be a combination of the expectations of the operators as to how the scenario should play out given a particular initiating event.

DR. APOSTOLAKIS: So these are key words. You're analyzing response to something that has happened.

MR. FORESTER: Yes.

DR. APOSTOLAKIS: You have a nice description in chapter 10 of the various places where human errors may occur. Essentially, they're also saying there that we recognize that the crew may create an initiating event, but that's not really the main purpose of ATHEANA.

MR. FORESTER: Right; that's -- yes, the crew could certainly create an initiating event, but they still have to respond to it once they create it.

DR. APOSTOLAKIS: Right; so, the understanding is what an event three, now, in the traditional sense, and the operators have to do something.

MR. FORESTER: Right.

DR. APOSTOLAKIS: Okay.

MR. FORESTER: Okay; so, we're looking at that kind of scenario, and it is the expectations for operators and trainers as to how that scenario should evolve, what, sort of, their expectations are, combined with some sort of reference analysis. Again, that could be some sort of detailed engineering analysis of how this scenario expected to proceed, and again, that could be something from the FSAR.

DR. KRESS: Would the structure of ATHEANA allow you to do essentially what George says it doesn't do, and that is go into how an initiating event is created in the first place, if it's created by an operator acting of some kind?

MR. FORESTER: Well, certainly, we could --

DR. KRESS: Because you're starting out with normal operating conditions.

MR. FORESTER: Right; well, in terms of what the process does right now, it doesn't really matter whether the initiating event was caused by an operator or someone working out in the plant or some sort of hardware failure.

DR. KRESS: I know, but I was trying to extend it to where we could do some control over initiating events by looking at the --

MR. FORESTER: Well, we didn't explicitly consider that, but certainly, you could, you know, begin to examine activities that take place in the plant and sort of map out how those things could occur and then sort of use the process to identify potential problems with those processes that take place in the plant that could cause an initiating event, so it certainly could be generalized in that way.

DR. SEALE: That's an interesting point, because we always worry about completeness of the PRA, and this is another way to cut into the question of what are the possible scenarios that can be initiated and do my intervention mechanisms, cross-cut those scenarios to give me relief.

DR. KRESS: Well, my concern was initiating event frequencies are kind of standardized across the industry, and they're not plant specific. They probably ought to be.

DR. APOSTOLAKIS: I think this operator-induced initiate is more important for low-power and shutdown point.

DR. KRESS: Yes, that's where I had -- that's what I was thinking of.

DR. APOSTOLAKIS: But anyway, if they do a good job here, that's a major advance, so let's not --

DR. KRESS: Let's don't push it yet.

MR. KOLACZKOWSKI: I was just going to comment that, for instance, if you could have as the base case scenario how an operator normally does a surveillance procedure, and then, you could look at the vulnerabilities associated with that in terms of how well is he trained? How well is the procedure written? Et cetera. And then, the deviations would be how could the surveillance be carried out slightly different, such that the end result is he causes a plant trip, so we still think the process could apply. It is true that in the examples right now provided in the NUREG, we don't have such an example, but we don't see why the process would not work for that as well.

DR. APOSTOLAKIS: Because in those cases, the fact that you have different people doing different things is much more important, and ATHEANA has not really focused on that. Dr. Hullnager observed that, too. So, I mean, the principles would apply, but it would take much more work, which brings me to the question: what is the consensus operator model? Are you talking about everybody having the same mental model of the plant?

MR. FORESTER: Yes; well, and the same sort of mental model of how the scenario is going to evolve. So, if you ask a set of operators and trainers how they would expect a particular scenario to evolve in their plant, you would get some sort of consensus. We try and derive -- the analysts would try to derive what that consensus was.

DR. APOSTOLAKIS: Now, again, one of the criticisms of the peer reviewers was that you really did not consider explicitly the fact that you have more than one operator, that you sort of lumped everybody together as though they were one entity. So in some instances, you go beyond that, and you ask yourselves do they think, do they have the same mental model of a facility, but the so-called social elements or factors that may affect the function of the group are not really explicitly stated; is that correct?

MR. FORESTER: It is in some ways, in the sense that when you look at a crew perform, you can identify characteristics of how crews tend to perform at plants.

DR. SEALE: You can find the alpha mayo, huh?

DR. APOSTOLAKIS: By the way, John, you don't have have to have done everything.

MR. FORESTER: And I was going to say, we have not explicitly considered --

DR. APOSTOLAKIS: Okay; good; let's go on.

MR. FORESTER: -- the two dynamics, okay?

[Laughter.]

MR. FORESTER: But it's not totally out of it is what I'm -- the point I was --

DR. APOSTOLAKIS: I agree.

MR. FORESTER: Okay.

DR. APOSTOLAKIS: Because you're talking about consensus over the model.

MR. FORESTER: That is correct.

DR. APOSTOLAKIS: So it's not totally --

MR. FORESTER: Right.

DR. KRESS: I am still interested in the consensus operator model. Excuse me for talking at the table but --

MR. KOLACZKOWSKI: That's okay; we understand why.

DR. KRESS: But, you know, I envision you've got two or three sets of operators, so you have maybe -- I don't know -- 10 people you're dealing with, and they each have some notion of how a given scenario might progress. My question is really, do you have a technique for combining different opinions on how things progress into a consensus model? Do you have some sort of a process or technique for doing that that you can defend or an interim entropy process or something?

MR. FORESTER: We don't have an explicit process for that. I think the analysts were going to base their development of the base case scenario on what they understand from what the operators are saying; from what trainers are saying; what they see done in the simulators when they run this kind of initiator in the simulator, how does it evolve? Again, you have reference case.

DR. KRESS: It's a judgment.

MR. FORESTER: It is a judgment.

DR. KRESS: Of who is putting together --

MR. FORESTER: Yes, it is.

DR. KRESS: -- your model.

MR. FORESTER: Yes.

DR. KRESS: Okay.

MR. FORESTER: Okay; well, there's what we see as the critical characteristics of the base case scenario, the ideal base case scenario is going to be well-defined operationally; the procedures explicitly address it; those procedures are in line with the consensus operator model; well-defined physics; well-documented. It's not conservative, and it's realistic. Again, we're striving for a realistic description of expected plant behavior, so that then, we can try and identify deviations from those expectations.

One thing I do want to note, that part of what is done usually in developing the base case scenario is to develop parameter plots, so that if a given initiating event occurs, we try and map out how the different parameters are going to be behaving, but the expectations of the parameter behavior will be over the length of the scenario, because that's what the operators deal with. They have parameters; they have plant characteristics that they're responding to. So we try and represent that with the base case. And not every issue allows that, but in general, that's the approach we want to take.

DR. POWERS: You have based those ideal scenarios on the FSAR, you have you looked at how they deviate from the FSAR?

MR. FORESTER: That's right; okay; the next step, then, is to see if we can identify potential operational vulnerabilities in the base case. The idea is to try and find sort of areas in the base case where things are not perfect, and there could be some potential for human error to develop. We look for biases in operator expectations, so if operators have particular biases, maybe they train a particular way a lot, and they've been doing that particular training a lot; the idea is to look at and try to identify what it is they expect and see if those expectations could possibly get them to trouble if the scenario changed in some ways, if things didn't evolve exactly like they expect them to.

DR. APOSTOLAKIS: So you are not really trying to model situations like the Brown's Ferry, where they did something that was not expected of them with the control rod drive pumps to cool the core? You are looking for things that they can do wrong, but you're not looking for things that they can do right to create -- because I don't know that that was -- what was the base case scenario in that case, and what it is it that made them take this action that would raise the core?

MR. FORESTER: I'm not sure I understand the -- no, no, yes, the Brown's Ferry fire scenario.

DR. APOSTOLAKIS: Yes, the fire. They were very creative using an alternative source of water.

MR. KOLACZKOWSKI: George, like PRA, this is basically, yes, we're trying to learn from things that the operator might do wrong. This is in PRA; we try to -- we treat things in failure space and then try to learn from that. But we certainly consider the things that the operator could do right, and particularly when we get to the recovery step, which we'll get to in the process, in the case of the Brown's Ferry fire, one of the things that the -- if we had now -- were doing an ATHEANA analysis, if you will, of that event, a retrospective analysis, one of the things you would recognize is that there was still a way out, and that was to use the CRD control system as an injection source, and that would be a recognized part of the process.

But, yes, just like PRA, we are basically trying to find ways that the scenario characteristics can be somewhat different from the operator's expectations, such that the operator then makes a mistake or, if you will, unsafe act, as we call it, unsafe in the context of the scenario, and ends up making things worse as opposed to better, and then, we hope to learn from that by then improving procedures or training or whatever, based on what the analysis shows us the vulnerabilities are. So --

DR. APOSTOLAKIS: The emphasis here is on unsafe acts.

MR. KOLACZKOWSKI: That's what I ended up trying to figure out is what could be the unsafe acts? What could be the errors of commission or omission? How might they come about, and then, what can we learn from that to make things better in the future?

DR. SEALE: But it still would be useful to understand what it takes to be a hero.

MR. KOLACZKOWSKI: I agree it's still part of the recovery.

DR. BONACA: In all of the power plants, that's what people refer to as tribal knowledge, especially discussions of the operators in the crews and among themselves: what would you do if this happens and so on? That would demonstrate the ways to get there, and in some cases, they lead you to success, like, for example, the example you made here, they would proceduralize and yet, they succeeded.

In the other cases, I've noticed things that they have that they were talking about that would never lead to success; for example, the assumption that, you know, you dry your steam generator, and now, you do something to put some water in it; well, it doesn't cool that way. You've got to recover some levels before you can do that. So the question

I'm having is is there any time to -- or is there any possibility? I guess you can incorporate the type of information into this knowledge, right? You would look for it. Is there any extended process to look for it that you would model with ATHEANA?

MR. CUNNINGHAM: I think we'll come back to that.

DR. BONACA: The reason that I mentioned it is that that is -- you know, if you look at a lot of scenarios we have in accidents, it has a lot of that stuff going on. As soon as you get out of your procedures, it comes in, and people do what they believe that --

DR. APOSTOLAKIS: In other terms, this is called informal culture.

MR. FORESTER: That's right, and we are taking steps to address those things; we certainly do.

DR. KRESS: I'm sorry to be asking so many questions, but I'm still trying to figure out exactly what you're doing. If I'm looking at, say a design basis accident scenario, what I have before me is a bunch of signals of things like temperatures, pressures, water levels, maybe activity levels in the various parts of the plant as a function of time. This is my description of the progression of events. Now, when you say you're looking for deviations that might cause the operator to do something different than what -- are you looking for differences that might exist in those parameters? The temperature might be this at this time, or the water level might be this?

MR. FORESTER: It might change at a faster rate than this.

DR. KRESS: It might change at a faster rate than you expect. So, those are the indicators you are looking at.

MR. FORESTER: Exactly.

DR. KRESS: And you're looking at how those might possibly be different from what he expects and what he might do based on this difference.

MR. FORESTER: Right.

DR. KRESS: Okay; thank you.

MR. FORESTER: Okay; so, there are essentially several different approaches for identifying the vulnerabilities is what we have up there. Again, we want to look for vulnerabilities due to their expectations. We also want to look at a time line or the timing of how the scenario should evolve to see if there is any particular places in there where time may be very short, so if the scenarios are a little bit different than expected, then, there should be some potential for problems there, again, focusing on the timing of events and how the operators might respond to it.

We also then tried to identify operator action tendencies, so this is based on what we call standardized responses to indications of plant conditions. Generally, for PWRs and BWRs, you can look at particular parameters or particular initiators, and there are operator tendencies given these things. We try and examine places where those tendencies could get them in trouble if things aren't exactly right.

And then, finally, there is a search for vulnerabilities related to formal rules and emergency operating procedures. Again, if the scenario evolves in a little bit different way, the timing is a little bit different than they would expect, there is some chance that, again, even though the procedures may be technically correct, there may be some ambiguities at critical decision points. Again, we try and identify where these vulnerabilities might be.

And once we've identified those vulnerabilities, we go to the process of identifying potential deviation scenarios. And again, by deviations, we're looking for reasonable plant conditions or behaviors that set up unsafe actions by creating mismatches. So again, we're looking for deviations that might capitalize on those vulnerabilities, and we're looking for physical deviations, okay, actual changes in the plant that could cause the parameters to behave in unusual ways or not as they expect, at least.

In this step of the process, we're also developing what we call the error-forcing context. We're going to identify what the plant conditions are. We want to look at how those plant conditions may trigger or cause to become operable certain human error mechanisms that could lead them to take unsafe actions and also begin to identify performance shaping factors like the human-machine interface, recent kinds of training they had that could have created biases that could lead them, again, to take an unsafe action. So part of the deviation analysis is to begin to identify what we call the error-forcing context, and ATHEANA has search schemes to guide the analysts to find these real deviations in plant behavior, and again, we are trying to focus on realistic representations.

Part of the deviation analysis does involve, also, again, developing parameter plots that try and represent what it is the operators are going to be seeing and what is going to be different about the way this scenario would evolve, the deviation scenario would evolve relative to what they would. So these four basic search schemes that we use to identify potential characteristics for a deviation scenario, there are similarities between these searches; there is overlap. They use similar tools and resources. There are a lot of tables and information in the document to guide this process, but in general, we recommend that each step is done sequentially, and by doing that, some new information could come out of each step.

DR. APOSTOLAKIS: John, this is a fairly elaborate process, and shouldn't there be a screening process before this to decide which possibly human actions deserve this treatment? This is too much. Am I supposed to do it at every node of the event three? If I look at an event three, for example, and it has some point, you know, go to bleed and feed, I know that's a major decision, major human action. I can see how it deserves this full treatment, but there are so many other places where the operators may do things here or there.

Surely, you don't expect the analysts to do this for every possibility of human action. So shouldn't there be some sort of a guideline as to when this full treatment must be applied and when other, simpler schemes perhaps would be sufficient? Because as you know very well, one of the criticisms of ATHEANA is its complexity. So some guidelines before you go to the four search schemes, so right after, as to which human actions deserve this treatment --

MR. FORESTER: Correct.

DR. APOSTOLAKIS: -- would be very helpful.

MR. FORESTER: Well, just a couple things. One is there is an -- you know, if you identify a particular issue that you're concerned with, then, you can identify what particular human failure events you might be interested in, okay, or unsafe actions, so the issue may help you resolve some of that in terms of what you would like to respond to. If that's not the case, if you are dealing more with a full PRA, you're trying to narrow down what it is you want to look at, then, we do provide some general guidance in there for how to focus on what might be important scenarios to initially focus your resources on.

DR. APOSTOLAKIS: But you're not going to talk about it.

MR. FORESTER: No, I hadn't planned on talking about that explicitly. It's -- you know, I mean, you can say that, you know, it's the usual kind of things, I guess, in terms of looking for -- trying to prioritize things, you know, do you have some short time frame kinds of scenarios? We have a set of characteristics; they're not coming to mind right at this second, but a set of characteristics that were used to prioritize those scenarios to focus on.

On the other hand, I think that the process itself, the search for the deviation scenarios, you are reducing the problem, because you're trying -- you're narrowing down to the problem kind of scenarios. Okay; once you've identified, you know, an initiator, for example, and maybe you're going to focus on several critical functions that the operators have to achieve to respond to that initiator, then, what the process does is it focuses the analyst in on the problem scenario. So the process itself reduces what has to be dealt with. We're not trying to deal with every possible scenario; we're trying to deal with the scenarios that are going to cause the operators problems.

MR. KOLACZKOWSKI: Let me also add, George, though, I think if you were going to apply this to an entire PRA, if your issue was I want to redo the HRA and the PRA, I would say that no matter what HRA method you used, that's a major undertaking.

DR. APOSTOLAKIS: Yes, but you are being criticized as producing something that only you can apply.

MR. KOLACZKOWSKI: I was going to say -- thanks, Ann -- I think you'll see, as we go through some more of the presentation and show you the example, the method now has become much more -- excuse me, methodical, and the old method that you saw in Seattle, it has changed actually quite a bit from that method now. It's far quicker to use as long as you don't want to get caught up in all of the little minute documentation. You can actually do an entire scenario, set of sequences, probably in a matter of hours to a day kind of thing.

MR. FORESTER: Once you've done a little bit of front end work on this.

[Laughter.]

MR. FORESTER: So again, though, I do think the process itself -- you're looking for the deviation scenarios; I think that narrows the problem solving. Is that -- you know, the prioritizations -- okay; okay, we have four basic searches. The first search involves using HAZOP guide words to try and discover troublesome ways that the scenario may differ from the base case. So again, we try and use these kinds of words to ask questions like, well, is there any way the scenario might move quicker than we expect it to or faster? Could it move slower? Could it be more, in some sense, than what they expect, given a particular initiator? For example, maybe given one initiator, you also have a loss of instrument error. So now, it's more than it was.

Another example might be in one of our examples in the document is we're a small loca, close to a small loca, but it's actually more than a small loca; yet, it's not really a large loca either. So, again, we begin to look -- one way is to use these HAZOP guide words simply as ways to investigate, you know, potential ways that the scenario might deviate from what is expected, and the -- we're interested in the behavior of the parameters, once again: are the parameters moving faster than we expected in things like that? So that's one way we do the search.

Another search scheme is then to identify that given the vulnerabilities we already identified, maybe with procedures and informal rules, are there particular ways that the scenario might behave that could capitalize on those vulnerabilities? Should the timing change in some way to make the procedures a little bit ambiguous in some ways? That type of thing.

Third, we look for deviations that might be caused by subtle failures in support systems, so this is sort of the way the event occurs and the way something else happens might cause the scenario to behave a little bit differently. They might not be aware that there is a problem with the support system. So again, a subtle failure there could cause them problems in terms of identifying what's happening.

DR. APOSTOLAKIS: Are you also identifying deviations that may be created by the operators themselves, by slips?

MR. FORESTER: Yes, I don't see why we couldn't do that. I mean, to arbitrarily examine what kinds of slips are possible at this point in time, I'm not sure we've done that explicitly, but that's certainly an option in terms of doing the deviation search.

DR. APOSTOLAKIS: Because it has happened.

MR. FORESTER: That's going to get pretty complex but --

DR. APOSTOLAKIS: It has happened.

MR. FORESTER: It has happened; that's true.

DR. APOSTOLAKIS: That isolated systems simply by their own problem, but then, it takes about a half an hour to recover.

MR. FORESTER: Yes; I guess, you know, if we found some vulnerabilities or we found some inclinations or some situations where they might be focusing on particular parts of the control room or something or on the panel, part of what we do examine are performance shaping factors like the human-machine interface that could contribute to the potential for an unsafe action, and in examining those things, we would determine that there is some poor labeling or something that creates the potential for a slip, that would certainly be figured into the analysis.

DR. APOSTOLAKIS: So it could be, but it's not right now.

MR. FORESTER: No; I guess I shouldn't have said it that way. I think it is. As I'm saying, once you've identified potential deviations, part of the process is involved in looking at the human-machine interface; looking at other performance shaping factors that could contribute to the potential of the unsafe action. So, and that is part of the process. That is explicitly part of the process, to examine those things. So you might, then, identify, you know, it would take someone knowledgeable about the way the control room panels and so forth should be designed to maybe identify those problems, but presumably, you'll have a human factors person on the team.

DR. KRESS: I'd like to go back to my question about the continuous nature of deviations. Let's say you have a base case scenario, and you've identified in there a place along the time line that's a vulnerability and that the operator might do something, and then, when he does that something, it places you in another scenario that's different than your base case.

MR. FORESTER: Right.

DR. KRESS: And then, there are things going on after that, and there may be different vulnerabilities in that line than there were in the base case.

MR. FORESTER: That's true.

DR. KRESS: And there's an infinite number of these. I just wonder how you deal with that kind of --

MR. FORESTER: Well, we try and deal with it during the recovery analysis, when we move to quantification, when we try and determine whether -- what the likelihood of the unsafe act might be. Once they've taken that action, we then try and look at what kind of cues would they get, what kind of feedback would they get about the impact that that action has had on the plant; you know, what other things; how much time would be available; what other input could they receive in order to try and recover that action.

DR. KRESS: So you did tend to follow the new scenario out --

MR. FORESTER: Right.

DR. KRESS: -- to see what he might be doing.

MR. FORESTER: Exactly.

Okay; and before I go to the last search scheme, I'd like to go to the next slide. Actually, we sort of cover it on the next slide anyway so --

DR. KRESS: When you say search, what I'm envisioning is a person sitting down and looking at event trees and things and doing this by hand. This is not automated.

MR. FORESTER: It's not automated at this point, no.

DR. KRESS: You're actually setting --

MR. FORESTER: It could be automated, yes, and we hope to be able to automate it, provide a lot of support for the process.

DR. BONACA: You know, I had just a question. You know, it took a number of years to develop the symptom-oriented procedures, and they really went through a lot of steps from what you're describing here. In fact, it was a time-consuming effort that lasted years, and they had operators involved. Have you looked at them at all to try to verify, for example, the process you are outlining here? Because they did a lot of that work that could be useful.

DR. KRESS: It sounds very similar to that.

DR. BONACA: Yes; I mean, they have to go through so many painstaking steps; you know, is this action or recommendation in the procedure confusing? I wonder if you had the opportunity --

MR. FORESTER: Well, part of our process involves doing flow charts of the procedures, specifically investigate where the ambiguities could occur. So we go through that process.

Now, in terms of have we actively tried to look at, you know, validating the existing procedures? No, we haven't taken that step. But I think the general consensus is is that there are -- the procedures are not perfect; that things don't evolve exactly -- I mean, there can be timing kinds of issues, and there can be combinations of different kinds of parameters that can be confusing.

DR. BONACA: So I think that probably, they would exercise at one point with one set of procedures is what rules would be a good foundation for a code like this and furthermore would give you some indication of the strengths you may have in the process here of identifying things or only the key points that -- for example, the key points that were then central to the discussions of an owners' group, so that they can identify in this process what they were, and they actually go through the same situations. So there is a lot that can be learned to verify the adequacy of a tool like this.

MR. CUNNINGHAM: No, that's a good point. We'll follow up with that somewhere along the line here.

MR. FORESTER: Okay; on the next slide, one thing I wanted to emphasize that a major part of the first three searches while we're looking for the expectations, and they're using the guide words to sort of characterize the way the scenarios could develop, we're also trying to evaluate what the effect of those deviations, what the effect of the deviations could be on the operators. What we wanted to determine is the way particular parameters behave or the way the scenario was unfolding, could that trigger particular human error mechanisms that could contribute to the likelihood of an unsafe act?

Also, are there other performance shaping factors that could then, based on the characteristics of the scenario and potential human error mechanisms, are there performance shaping factors that could also contribute to that potential for an unsafe act? So we're doing that at the same time we're developing the actual deviations, and one thing we've done, which I'll talk about here somewhere, I think -- maybe not -- is to try and tie particular characteristics of the scenario: are the parameters changing faster than expected? Or are two of them changing in different ways? And try to identify how the characteristics of the scenario could elicit particular types of error mechanisms: could it cause the operators to get into a place where they're in kind of a tunnel vision kind of state? They're focused on the particular aspects of the scenario, or do they have some kind of confirmation bias developed, or based on their expectancies, they have, you know, a frequency bias of some sort.

And then, we try and tie the behavior of the scenario, the characteristics of the scenario, to potential error mechanisms and then relate specific performance shaping factors to the potential for the error. We have tried to provide some tables that make that process a little easier, so we have -- essentially, we have made an effort to try and tie those factors together much more explicitly.

So getting that process, then, the fourth scheme, the fourth search, is to sort of do a reverse process. If once you identify potential error types and tendencies or operator tendencies that could cause the human failure events or unsafe facts of interest, then, you simply use conjecture to try and ask are there any kind of deviations that could make these things occur, that have the right characteristics that could make these things occur. So it's sort of coming from the other direction rather than starting with the physical characteristics; you just kind of start with the human tendencies and see if there are deviations that could cause that.

So with those four searches, we think we do a pretty good job of identifying a lot of potential deviation kinds of characteristics. Then, once that's --

DR. APOSTOLAKIS: Does everyone around the table understand what an error mechanism and an error type is?

MR. FORESTER: Well, error types are fairly straightforward, in the sense that it's just things that they could do that could lead to the unsafe fact, like make a wrong response; skip a step in a procedure; normal kinds of -- it's not a real sophisticated kind of concept there; it's just things that they could do.

Error mechanisms, we're referring to, you know, essentially things within the human, general processing, human information processing characteristics, what their tendencies are, maybe some processing heuristics that they might use; not everything is going to be a very carefully analyzed, completely systematic kind of analysis. They'll use bounded rationality, so people have sort of general strategies for how they deal with situations. Now, most of the time, those kinds of situations, those kinds of strategies can be very effective, but in some situations, the characteristics of the scenario that may, where those particular tests may apply, may lead to an error, because they're misapplied. So that's how we're characterizing error mechanisms.

DR. APOSTOLAKIS: Is the inclusion of error mechanisms in the model what makes it, perhaps, a cognitive model? I've always wondered about these things. Because you have included these error mechanisms, you can claim that now, you have something from cognitive psychology in there?

MR. FORESTER: Well, we have the error mechanisms. We also have the information processing model, you know, the monitoring and detection process; the situation assessment. The human error mechanisms, to some extent, are tied to those particular stages of processing, so, you know, we try and include all of that. In fact, the use of the tables that address the error mechanisms is broken down by situation assessment and monitoring.

DR. APOSTOLAKIS: We are going very slowly.

MR. FORESTER: Okay; well, I'm just about done.

Once you have identified all of the deviation characteristics, basically, you've got to put them all together and identify the ones that you think are going to be the most relevant, okay?

We can look to that. And the final slide is, again, we just want to emphasize that once we have identified what we consider a valid, a viable deviation scenario that has a lot of potential to cause problems for the operator, and we analyze that, we want to quantify the potential for the human failure event to occur or the unsafe actions. We can directly address the frequency of plant conditions; standard systems analysis to calculate that. We can get the probability of unsafe act and the probability of nonrecovery at the same time given the plant conditions and the performance shaping factors.

We look at this thing in an integrated way, and we do want to emphasize that, that we carry out the scenario all the way out to the very end, in a sense, to the last moment, when they can have a chance to do something. We consider everything that's going on, and then, ideally, in my mind, in terms of quantifying that, we have the input of operators and trainers. Once you -- for example, if you can set up the scenario on a simulator, you can run a couple of crews through that. You may not necessarily -- you're not using that to estimate the probability, but what I like to look for is what it is the operators and trainers, what they think will happen when their crews in the plant are sent through that scenario.

If everyone pretty much agrees, oh, yes, you know, if that happened like that, we would probably do the wrong thing, then, you have a very strong error-forcing context, and quantification is simple. For situations where that is not the case, where there are disagreements about what happened or not or a lot of high expectation that the actual unsafe actions would take place, then, we do not have a new or a special approach for dealing with that problem for a couple of reasons: one, none of the existing approaches are completely adequate as they are. For one thing, we have no empirical basis from psychology to support those kinds of quantifications, those kinds of estimates. It just doesn't exist.

Nor do we have an adequate existing database of events that we can base it on. So, getting that situation, our suggestion for now is to try and use existing methods. However, I think there are some things that we could do to improve our existing quantification process. You know, part of what we're recommending is maybe use SLIM. Well, the problem with SLIM, of course, is you don't have adequate anchors. It's hard to determine what the anchors might be so you can actually use a SLIM kind of process.

So one thing we'd like to investigate, I think, is how we could identify some maybe anchor kinds of events; we could characterize the events that we could pretty substantially determine what the probability of that event was; characterize that event in some way, at least maybe a couple of events on the continuum, so that then, when we characterize events using the ATHEANA methodology, we would know roughly where they fit along that continuum. Okay; so, that's one improvement that we could make that we haven't made right now.

DR. BONACA: One question I have is that in your presentation, you are discussing the operator, but there are operators who operate. One thing is to talk about the operators in the control room who have been trained on system-oriented procedures, and there, it's pretty clear how you can define the problem. The problem is that they're following a procedure to the letter, and then, if there is some area where we have misdesigned the procedures, then, we mislead them, and they may have to initiate something that they're not used to, and that's all kind of stuff.

Life is pretty clear that in the operators in the plant, they follow procedures to do maintenance, for example, it seems to me that the way you would train those kinds of operators would be very different from the ones in the control room, because there, they have their options on the procedures, on how you use them and so on and so forth. Also, the operators are at the mercy of other operators doing other things with other systems. I think even if you talked about how they would --

DR. APOSTOLAKIS: They haven't done that.

MR. FORESTER: No.

DR. BONACA: So when you're talking about operators, you're talking about the ones --

DR. APOSTOLAKIS: A single entity. A single entity.

DR. BONACA: Yes.

DR. APOSTOLAKIS: In the control room.

MR. FORESTER: In the control room, that is correct.

DR. APOSTOLAKIS: I have a few comments. This is the only slide on quantification?

MR. FORESTER: Yes.

DR. APOSTOLAKIS: So I will give you a few comments.

MR. KOLACZKOWSKI: Except for the example.

MR. FORESTER: Yes, we do have the example.

DR. APOSTOLAKIS: Okay; on page 10-7, coming back to my favorite theme, item two, the error-forcing context is so non-compelling that there is no increased likelihood of the unsafe act. If you really want the error-forcing context, the error-forcing context is so non-compelling that there is no increased likelihood -- I really don't understand your insistence on calling it forcing.

MR. FORESTER: Well I guess --

DR. APOSTOLAKIS: You don't have to comment.

MR. FORESTER: We've also been criticized for using the term error at all, okay? But the point we want to make is operators are led to take these unsafe actions.

DR. APOSTOLAKIS: Forcing -- and later on, you say that the probability, even if it's very relevant, will be something like 0.5.

MR. FORESTER: Yes; I know Strater uses error-prone conditions or error-prone situations, so there are other terms.

DR. APOSTOLAKIS: You saw here the HEART methodology. Have you scrutinized it? I'll give you some things that bother me. On Table 10-1, there are generic task failure probabilities, so that first one is totally unfamiliar; performed at speeds with no real idea of likely consequences, and there is a distribution between 0.35 and 0.97.

Then, it says that in Table 10-2, HEART uses performance shaping factors to modify these things, and the first 10-3 is unfamiliarity. So now, I have a generic description of a totally unfamiliar situation that I have to modify because I'm unfamiliar with it, and the factor is 17. It's the highest on the table. So I don't know what that means. Either I was unfamiliar to begin with, and second, there is a distribution in Table 10-1. Am I supposed to multiply everything by 17? What am I doing? Am I multiplying the 95th percentile by 17? Am I multiplying the mean by 17?

MR. FORESTER: It's just the action. It's just the probability for the action.

DR. APOSTOLAKIS: It's not explained.

MR. FORESTER: We didn't really claim to completely explain HEART in there. We're trying to provide some guidance.

DR. APOSTOLAKIS: You need to scrutinize it, I think, a little better.

MR. FORESTER: I think you're right, and a lot of the categories are not always easily used. It's not a perfect method.

DR. APOSTOLAKIS: And then you say that one of the modifiers is a need to unlearn a technique and apply another that requires the application of an opposing philosophy. I'm at a loss to understand how you make that decision, that somebody has to unlearn something and apply something else.

And then, there is a modifying factor of five if there is a mismatch between the perceived and the real risk. I don't know what that means, risk. If I were you, I would throw this out of the window. You don't have to take all these great stuff you presented in the first 18 view graphs and then present this thing. You should do your own work here, in my view.

As I said earlier, I thought that the quantification part is not at the same level of quality as the rest of the report.

MR. FORESTER: Agreed.

MR. KOLACZKOWSKI: Agreed.

DR. APOSTOLAKIS: You are throwing away a lot of the details that you took pains to explain to us. There are no error mechanisms here anywhere. And I fully agree, by the way, with what you said about the difficulty and, you know, there has to be some sort of a judgment here. There is no question about it, and this committee will be very sympathetic to that, but not this kind of thing. And this is old, right? The reference is from 1988, way before ATHEANA came into existence.

The thing that is really startling is that it is not very clear how the error-forcing context is to be used. They mention SLIM. I thought I was going to see here an application of SLIM with the problems that you mentioned. Everybody has those problems; where you would remedy one of the difficulties or weaknesses of SLIM, namely, which performance shaping factors one has to consider. And I think your error-forcing context or whatever you call it in the future is ideal for producing those. I mean, you have done such a detailed analysis. Now, you can say, well, a rational application of SLIM would require perhaps a set of independent ESFs or mutually exclusive -- I don't know what the right term is -- and these are derived from the error-forcing context we just defined in this systematic way, and no one will blame you for that, because, I mean, if you've worked in this field for a month, you can realize that the numbers will never be, you know, like failure rates, where you can have data and all of that, and the anchors, I think you pointed out, is an extremely important point, and perhaps you can do something about it to give some idea.

But this guy who developed HEART had no heart.

[Laughter.]

DR. APOSTOLAKIS: His task is unfamiliar, and then, they modified because I'm unfamiliar with the situation? I mean, what is this? And a factor of 17, right? You increase the probabilities by approximately 17.

[Laughter.]

MR. FORESTER: The only advantage to that method is this guy did claim that a lot of these numbers were based on empirical data.

DR. APOSTOLAKIS: And you know very well --

MR. FORESTER: Yes, well, okay --

DR. APOSTOLAKIS: -- what that means.

[Laughter.]

DR. APOSTOLAKIS: Now, another thing -- so I'm very glad that you are not willing to really defend to the end chapter 10.

MR. FORESTER: No.

DR. APOSTOLAKIS: It's probably something you wouldn't be working on. Okay; I'm very happy to hear that, I must say, because I was very surprised when I saw that.

Now, the -- actually, some discussion is really great. The figures there, there is some type of figure 10-1 is repeated twice. Well, that's okay. There was one other point that I wanted to make which now escapes me -- oh, this -- all the information processing paradigm is not here, right? You are not really using that.

MR. FORESTER: Well, we're using --

DR. APOSTOLAKIS: All of this stuff, I didn't see it playing any role, at least the way it is now.

MR. FORESTER: It's not explicitly represented; you're right.

DR. APOSTOLAKIS: The way it is now; okay.

MR. FORESTER: In our minds, it's represented.

DR. APOSTOLAKIS: Oh, I know that the mind is a much broader term.

Okay; I'm very glad for that.

Okay; the dynamic element, and I believe Hullnagel commented on that, too. We were doing in a different context some retrospective analysis recently at MIT of two incidents. One was at Davis-Bessey; the other was the Catawba. And what you find there is that there are some times, critical times, when the operators have to make a lot of decisions. There's no question about it. That's why you ask about the training, and, I mean, you don't really want to attack each one with a full-blown analysis.

MR. FORESTER: Right.

DR. APOSTOLAKIS: But in one of the incidents, I think it was the Catawba, there were two critical points. One was 6 minutes into the accident; the other 9 minutes. Where they had to make some critical decisions, and the contexts were different, there was a dynamic evolution. In other words, at 9 minutes, they had more information; they were informed that something was going on, so now, they had to make an additional decision. This specific element, the dynamic nature of the EFC, is not something that I see here, and perhaps it's too much to ask for at this stage of development, but it appears to be important, unless I'm mistaken.

In other words, is the error-forcing context defined as a deviation from what's expected? And for this sequence, it's once and for all?

MS. RAMEY-SMITH: No.

MR. CUNNINGHAM: No.

DR. APOSTOLAKIS: No, so you are following the evolution and the information that is in the control room, and you may have to do this maybe two or three times at two or three different --

MR. KOLACZKOWSKI: Exactly, George. We present this as a very serial type of process. Your point is well taken. You really have to iterate and iterate. I think in one of the examples that we have for the loss of main feed water event, one of our deviation scenarios is X minutes into the event, all of a sudden, the spray valve on the pressurizer is called for, and it sticks.

DR. APOSTOLAKIS: Right.

MR. KOLACZKOWSKI: That changes the scenario; it changes the operator's potential response, and that's carried through. So I think we try to do that.

DR. APOSTOLAKIS: Okay.

MR. KOLACZKOWSKI: But clearly, we're still discretizing the situation into pieces of time, yes.

DR. APOSTOLAKIS: Okay; good, so, the dynamic nature of that is recognized; that's good.

Now, a recovery in this context, my impression is it means recovering from errors that they have made, not recovery in the sense that the average person or the plant person will use it to recover from the incident. They are two different things, aren't they?

MR. KOLACZKOWSKI: Well, ultimately, we're worried about it. The core damage is the situation we're worried about. We're ultimately worried about recovering the scenario. So, as I said, it will go back to a success path. But part of that recovery may be overcoming a previous error or unsafe act that the operator has performed. So now, something has to come in that changes his mind about what I did an hour ago, I now recognize was a mistake, and now, I need to do this. So, that could be part of the recovery, but ultimately, we're looking at recoveries of the scenario, yes.

DR. APOSTOLAKIS: So both.

MR. FORESTER: Both.

DR. APOSTOLAKIS: Okay; well, fine; if the main thing was to realize that you, yourselves felt that chapter 10 needed more work, so I have no more questions.

DR. POWERS: But I may still.

DR. APOSTOLAKIS: I'm sorry; yes.

DR. POWERS: As you're willing to say that the system is more complicated, how do we decide that it's better?

DR. APOSTOLAKIS: In my view, as I said earlier, the emphasis on context, the extreme attention that they have paid to context is a very good step forward. Other HRA analyses, they do some of it but not -- the quantification part, I am not prepared to say that it is better, but I am glad to see that they are not saying that either. But I think this detailed analysis that you see, there are other argumentations in scope, but that's expected.

I think it's a good step forward. It's a very good step forward. If I look at the --

DR. POWERS: Maybe the question is just different. The analysis is more complicated. Therefore, you wouldn't have to be sparing in your application of it. How would we know when this complicated system --

DR. APOSTOLAKIS: I asked them that question and unfortunately, they got upset.

[Laughter.]

DR. POWERS: And when can I do something else, and what is that something else that I should do?

DR. APOSTOLAKIS: I think the message is very clear, gentlemen, that you have to come up with a good screening approach. You can't apply this to every conceivable human action.

MR. CUNNINGHAM: That's right, and if we need to better describe how to do that and take that on, we've already talked about that as an issue in terms of next year's work or this year's work, that sort of thing.

DR. APOSTOLAKIS: Speaking of years, Hullnagel points that out, and I must say I'm a little disturbed myself. This project started in 1992, 7 years. Do all the members feel that this is a reasonable amount of time for the kind of work they see in front of them?

DR. KRESS: Well, we'd have to know whether this work was continuously done and how many people --

DR. APOSTOLAKIS: Mr. Cunningham is here. He can explain that to us. Were there any --

DR. POWERS: Well, come on, George. It's difficult, is it not, to manage the NRC? And besides, on the performance that they want --

DR. APOSTOLAKIS: No, but on the other hand, if I'm presented with a piece of work, I mean, how much effort has been expended on it is a factor in deciding whether the work is good or not.

DR. POWERS: It is? That stuns me. It certainly is not in the thermal hydraulics community.

[Laughter.]

DR. APOSTOLAKIS: After such a powerful argument --

[Laughter.]

DR. APOSTOLAKIS: I defer humbly to -- I withdraw my question.

DR. SEALE: The thing is that the entropy is always increasing, whether you do a damn thing about it or not.

[Laughter.]

DR. KRESS: Only in closed systems.

DR. BONACA: One thing that I'd like to -- I like the process, et cetera. Still, it seems to me that the process doesn't distinguish, for example, between the French situation and the American situation. In the U.S., we have extremely detailed procedures that the operators will live by, and literally 10 years were expended to put them together, going through a process which was as thorough as this and involved all kinds of people, from the operators to engineers to everybody else. And it seems to me that -- I'm trying to understand if I go to review a possible situation that develops in an accident under the French plan, where, in fact, there isn't a structural procedure; I understand how I would have used it.

In fact, I would use it to see if the operator was discussing the elements and what kind of errors he will make. I would make a hypothesis. But in the U.S., I would tend to say that applied in a way to review the procedures that they followed to see what errors he would make in the U.S. and to eliminate all of those elements that are then focused purely on the many possible -- see what I'm trying to say? I don't see any of the --

MR. KOLACZKOWSKI: Yes.

DR. POWERS: It seems to me that it would be that way because of the tie to the DBAs. When you tie them to the DBAs, you've only got one measure. You say, gee, I can use this just to make sure my -- but I think that when you go into the severe accident space, and you have multiple failures, this network of deviations, there is an infinite net that they show, and it changes character.

DR. BONACA: It does. There are new procedures. It's totally different. They're not at all looking at these DBAs. They're looking at the air pressure, temperature condition, et cetera, is moving in this direction; what are you going to do?

DR. BARTON: And you still have underlying error.

DR. POWERS: But still you have underlying a failure, and when you go to multiple failures --

DR. BONACA: You do, and it makes an assumption that, you know, you are going to a key procedure, because you have conditions that will require your ECCS to come up, for example, so there are some entry decisions you make, but then, especially for the EPGs, for BWRs, they're extremely symptom-oriented. I mean, at some point, you forget where you came from.

DR. POWERS: Even with the symptom-oriented, you do things that apply to an area that ultimately get you to what's wrong.

DR. BONACA: I understand, but again, if it was a plant X, and they would use this, the first thing I would do, I would go through this process to understand where my procedures were invested billions of dollars; you're correct. That's really what happened. I mean, if it followed literally, then, it would be different in certain respects from the application that we make for -- where I have no prescribed way, and so, I may discover that that's why I led the operator in the situation we are in.

Now, I don't know if this had to have a different perspective when you apply it to our plants, which are going through very structured procedures. It seems to me every scenario would be still open if you review it in a way where everything is possible, and yet, you're ignoring the existence of the framework, which is exactly the pattern of the steps you're suggesting here.

MR. CUNNINGHAM: I guess my reaction is that I think we would have to kick that around among the team as to implications of the French style versus the American style and that sort of thing. I just -- I don't think we've thought much about that.

DR. APOSTOLAKIS: It may require a designer approach.

We will recess for 12 minutes, until 10:35.

[Recess.]

DR. APOSTOLAKIS: We have about an hour and 5 minutes, so you will decide how best you want to use it. It's yours.

MR. FORESTER: Okay; I think what we'd like to do is present an example of application of the method to some fire scenarios. This is part of another task that we have to apply ATHEANA to fire scenarios. We want to sort of do a demonstration of the methodology for fire applications, and Alan Kolaczkowski is going to present this.

DR. APOSTOLAKIS: We have this or we don't have this? We don't have it. No, we don't have the report.

MS. RAMEY-SMITH: It hasn't been written.

MR. KOLACZKOWSKI: My name is Alan Kolaczkowski. I work for Science Applications International Corporation. George, I'm one of the new team members. I've only been around for about a year and a half so --

DR. KRESS: You're saying we can't blame you.

MR. KOLACZKOWSKI: Blame? No, I guess you can't.

Okay; well, you've heard at least in the abstract now what the methodology involves, and again, I think the important points is that -- and I think George articulated this very well -- is that we're really trying to look at the combination of how plant conditions can, based on certain vulnerabilities either in the operator's knowledge about how the scenario might proceed, weaknesses in the procedures, whatever, how those two things may come together in a way that if the scenario is somewhat different from, if you will, the base case scenario that maybe the operator is prone to perform certain actions which would be unsafe in light of the way the scenario is actually proceeding.

I want to demonstrate now, actually, the stepping through the process that will make some of these things and some of these abstract ideas perhaps a little bit more concrete, step through it by actually showing you an example, and as John pointed out, what I want to do is take you through a set of a couple of fire analyses that we've done, and as Ann pointed out, this report is currently in process in terms of being put together.

So, the first slide, what I'd like to point out here really is focus primarily on the third bullet, unless you have questions on the others, and that is if you look at current HRA methods and the extent that they look at fire events, and certainly, this had to be done as part of the IPEEE program by the licensees, et cetera, what you find is that a lot of the current HRA methods look at the human reliability portion of the issue pretty simplistically. Most of the IPEEEs, if you look at them, what they've done is they've taken their human error probabilities from the internal events, and they might put a factor of five on it and say, well, the stress is probably higher because there's a fire going on, and there's a bunch of smoke, et cetera, and that's what we're going to use for our human error probabilities.

And there really is, for the most part, not a hard look at what is the fire doing? How is the equipment responding? Might some of those responses be erratic? How might that change the way the operator responds during the scenario, et cetera? That kind of look at what the human is doing is typically not looked at. It's treated pretty simplistically, for the most part. And so, we thought that this was an error that would be very fruitful for ATHEANA to look at in order to look at the context of fires and how scenarios from fire initiators might affect the way the operators will respond as the fire progresses and so on and so forth. So that's kind of why we looked at this.

DR. APOSTOLAKIS: What is SISBO?

DR. POWERS: Self-induced station blackout.

DR. APOSTOLAKIS: What?

DR. POWERS: Self-induced station blackout.

MR. KOLACZKOWSKI: I'm going to describe that in the next slide, I believe.

So we decided that this was a pretty fruitful area to look at, and that's why we chose this one as a good example to present here in front of the committee.

DR. POWERS: Do we have a good phenomenological understanding of how the fire affects equipment and other things?

MR. KOLACZKOWSKI: I guess I don't know how to measure good. I think we have some general ideas, but that's part of the problem is that fires can affect equipment in many, many different ways, which can, therefore, make scenarios be somewhat different than what we expect, and it's these kinds of deviation scenarios that we're talking about.

MR. CUNNINGHAM: In parallel with our work on human reliability analysis, we have a separate program that's looking at the issue of modeling of fires in risk analyses.

DR. POWERS: They repeatedly tell me that they can't really predict what -- that that's why their research needs to go on --

MR. CUNNINGHAM: Yes.

DR. POWERS: -- is because they don't know what kinds of things will happen to equipment.

MR. CUNNINGHAM: That's right; both are viable subjects, reasonable subjects for research.

DR. POWERS: And I have had the licensees in saying the vicious and evil thing about the NRC staff, because they take too conservative a position on fire-induced changes and things like that.

MR. CUNNINGHAM: Again, we have another program. Part of the reason for picking the fire example was to try to bring some of these -- bring the two programs a little closer together.

MR. KOLACZKOWSKI: The next slide, as you're going to see in a moment, we picked two particular scenarios to look at, but first, you have to understand a little bit what the plant design is like, at least in a general sense, for dealing with fires and what this SISBO concept is, because we did decide to look at a so-called SISBO plant.

This cartoon, if you will, is meant to at least show you what the separation is typically like in a nuclear power plant for dealing with fire, and then, as I said, I want to introduce the SISBO concept. You can see here that if you look at the cabling equipment in the plant and so on, typically, for Appendix R purposes and so on, in a very simple, two-division kind of plant, you end up with separating the cables in the various cable trays and having certain walls and rooms and fire barriers, et cetera, between equipment such that all the division A equipment is located somewhat separately and at least are protected from a fire standpoint from division B equipment, and we see that displayed in this cartoon.

Of course, plants have now a remote shutdown panel associated with them. Usually, that remote shutdown panel has a limited amount of instrumentation and controls associated with it for controlling one of the divisions of equipment for shutting down the plant safely should the operators have to leave the main control room, which might be the case for fire in the control room area as well as, as you'll see in a moment, if it's a SISBO plant, there are other reasons why they may leave the main control room as well.

So anyway, we have this standard separation between the two divisions, and that separation, to the extent possible, is maintained all the way up through the cable spreading room, the relay room, the main control room, where we have the various fire barriers and so on and so forth. As I indicated, we have this remote shutdown panel, the idea being that if we need to leave the main control room, we go down to the remote shutdown panel as well as other local areas in the plant, and we operate this -- what's called dedicated areas of equipment or division A equipment, and typically, what's done is that there is a set of switches there on the remote shutdown panel, and that's just shown as one switch in this little cartoon, that are thrown such that we become now isolated from the main control room so that shorts, hot shorts or other electrical problems that might be propagating up through the main control room won't come down to the remote shutdown panel.

And now, we hook in the remote shutdown panel directly with the equipment out in the field, and then we safely shot down the plant from there. What's unique about the SISBO idea is that some plants, in order to respond to various requirements in Appendix R and other fire-related requirements for dealing with potential hot shorts and so on, have taken on this so-called self-induced station blackout approach, in which basically, what happens is the plant, once the fire gets so severe that they feel that they are losing control of the equipment because of erratic behavior, potentially because of hot shorts, whatever, they essentially de-energize all of the equipment in the plant, and at the same time, energize only either the alternate area equipment if the fire is in a dedicated area zone, or they would go down to the remote shutdown panel and operate the dedicated area of equipment if the fire is in an alternate equipment zone and then re-energize that equipment off that diesel. And then, they operate just that particular set of equipment to safely shut down the plant.

So essentially, they put the plant into a loss of power situation and then re-energize either A-bus or B-bus and then use just selected equipment off of that bus that they think is not being affected by the fire. Of course, the advantage of that is that now, hot shorts can't occur in the A equipment, let's say if that's where the fire is, because you've got it all de-energized, and so, you won't have a spurious opening of the PORV or something like that that could make the scenario much worse. So that's kind of the concept behind the SISBO idea.

Next slide. Now, for illustrating the ATHEANA process, what we've done is we've reanalyzed two fire scenarios that have been previously analyzed in an existing PRA. This just highlights what the two fires are and what the potential effects of the fires are for this particular plant. One is an oil fire in the auxiliary feed water system pump B room. This is for their classification, a so-called alternate fire area, and you can see that if the fire does become significant, the effects are quite severe. Four out of four of the non-safety busses become affected and would potentially have to be shut down. You also potentially lose the division B 4160-volt safety bus. That's the safety bus for the various safety loads.

Of course, you lose, obviously, pump B of auxiliary feed water, and it turns out in this particular plant, because of where the cabling is located, if you had a severe fire in this room, you would also affect the ability to operate and control the turbine pump. This is a three-pump system that has two motor pumps, A and B, as well as a turbine pump. This fire would affect one of the motor pumps as well as the turbine pump.

If this situation got this severe, the expectations, according to the procedures, would be that you would leave the main control room, and then, you would shut down using limited division A, that is, dedicated equipment, from the remote shutdown panel, and there is an EOP, so called FP-Y, that governs how this is actually implemented.

The other fire is, as I indicated there, a fire concerning certain safety busses, and it turns out these safety busses are located in the same area, room, if you will, that the remote shutdown panel is located. So this is a so-called dedicated area fire, and again, if this fire got severe, such that the feeling was that the operators were losing control of the plant, the expectations, per the EOP, would that -- well, first of all, you would lose the division A busses and the ability to use that diesel and its various loads, and the expectations would be you would shut down using division B equipment or so-called alternate equipment.

In this case, they would stay in the main control room to operate that equipment, but they're still going to de-energize everything and then only energize the B busses and then use the B equipment. So you're still going into a self-induced loss of power situation.

Lastly on this slide, I wanted to indicate what the current PRA insights are about the human reliability performance in these two fires. And if you look at what are the sort of dominant lessons learned from the HRA analysis for this existing PRA, those are highlighted there on the third slide, that there is a potential for a diagnosis error to even enter the right EOP, either EOP-Y if it's an alternate area fire or EOP-Z if it's a dedicated area fire, so notice that one of the things they have to know is where is the fire in order to know which EOP to enter.

And the reasons why the existing human reliability analysis technique says that a diagnosis error might occur are indicated here: either the operator would misread or miscommunicate the cues to enter the procedure, or he might just plain skip the step and not enter the procedure or might misinterpret the instruction regarding when to enter the procedure. Those were highlighted in the PRA as possible reasons for why he might make this diagnostic error.

The more dominant errors, however, in the HRA, if you actually look at the quantified results: they claim that it's much more likely the operators will make mistakes in actually implementing the EOPs themselves, just because they're very complex and so on and so forth. There are a lot of steps involved.

Most of the errors, they claim, will be as a result of switch positioning errors or just because of the fact that they may omit certain steps because they're in a high stress situation. So that's kind of what you learn from the existing PRA if you look at the human reliability analysis for these two fires.

DR. POWERS: The regulation is that they're required to be able to shut this plant down, so you're going to look at carrying out that requirement.

MR. KOLACZKOWSKI: That is correct; we don't look at the errors associated with still safely shutting down, but look at it now from an ATHEANA perspective and say that if we think about the context of these fires a little more, what might we learn that might be new, more lessons learned that we could apply to ways to make the operators better-prepared for dealing with these fires than just simply, well, they might skip the step. Well, what are we supposed to do about that? I guess we could say increased training, maybe, but we want to see if ATHEANA can provide some additional insights as to how the operator may not bring the plant back to a safe condition.

Yes?

DR. APOSTOLAKIS: Who did the PRA you are referring to?

MR. KOLACZKOWSKI: I'm sorry?

DR. APOSTOLAKIS: The PRA, the existing PRA. Is that the utility?

MR. KOLACZKOWSKI: It is a -- yes, it's an IPEEE from a licensee.

DR. APOSTOLAKIS: Okay.

MR. KOLACZKOWSKI: Now, John indicated that one of the first things we do after really defining the issue, which, in this case, is how can we learn better how the operators might make mistake given these two kinds of fires and, therefore, take from that lessons learned and ways to improve operator performance given these kinds of fires, once we're able to identify that issue, one of the first things we have to do is try to understand how does an operator, how does he think these two fires would normally proceed?

This is that defining the base case scenario step. This is trying to come up with that collective operator mindset as to what his expectations would be given that these fires actually occurred, and our base case is essentially summarized in this and the next slide, and let me just kind of quickly go through this, and then, if you have any questions, we can proceed to those.

Of course, one of the first things that would eventually occur most likely is once the fire has happened, let's assume for the moment that it happens without a person being in the room at the particular time, et cetera; it's going to start to affect some equipment, et cetera, but one of the first things that will probably occur is that we will eventually get a fire detection alarm. There are, at this plant, multiple alarms for detecting smoke, et cetera, in these rooms and so on, so we would expect that fairly early in the scenario that one of the first indications would be this fire detection alarm.

The operators then enter what is called EOP FP-X upon a fire detection alarm, which basically provides the initial things that they do for dealing with once a fire has been detected in the plant. One of the first steps in that procedure is they ask another operator out in the plant to go and visually validate that there actually is a fire, that this is not a spurious or false alarm, and the procedure almost reads as though the intent is that they don't do too much more until that validation comes back.

Let's assume they do get the validation. Then, the fire brigade is then assembled. It's called on. And one of the things they do is they unlock the doors to the suspected area to make sure that the fire brigade is going to have fairly easy access to that area, et cetera, and there's a general notification over the Gaitronic system that there is a fire in the plant and those kinds of things.

Now, during this time, especially if the fire is not yet all that severe, the plant is still running. It's just humming along, running along fine, and, in fact, the main control room staff are attempting to just maintain the plant online and under proper control while the fire brigade is now getting assembled and getting ready to do their thing.

We expect that as time proceeds, and let's say the fire brigade is finally getting down there, perhaps entering the room, et cetera, but if the fire is getting to the point where it's approaching the severities that I talked about in the previous slides, then, we're going to start seeing erratic operation of some of the normally-operating equipment. Perhaps we're going to start seeing flow acting erratically; maybe if you have current indications on certain pumps, like the AFW pump, you might begin to see erratic indications of the current or maybe voltages on certain busses, depending, again, on which cables are affected and when that occurs.

DR. POWERS: Isn't it much more likely that the things that are going to be affected are the instrumentation and not the core itself?

MR. KOLACZKOWSKI: That is true, too. I mean, it depends on, looking at in each individual room, how much control and power cables there are versus how much instrumentation cables. Certainly, the AFW pump is instrumented to some degree, but the flow instrument for flow going to the steam generator might be in an entirely different room, and it's unaffected at all.

So it's very, very plant-specific, obviously, as to what the specific effects are, but we would generally say erratic operation of equipment, and certainly, your point is well-taken, Dana, of some indications may be possible. But the point is the plant isn't necessarily going to trip right away, and in a lot of small fires, as we know, the plant ran through the entire scenario just fine. They put the fire out, and that's it.

Now let's assume for the --

DR. POWERS: There is nothing at this point to indicate to trip this plant.

MR. KOLACZKOWSKI: I'm sorry?

DR. POWERS: There is nothing at this point --

MR. KOLACZKOWSKI: No, FP-X does not require them at this point yet to trip the plant. And, in fact, they will try to maintain plant operation per their procedure at this plant.

So we have potential erratic behavior of some of the normal operating equipment, perhaps some of the indications. Notice that certain standby equipment may also be affected; for instance, that turbine pump, the turbine auxiliary feed water pump, and it may also, maybe, have cables associated with that pump's control that are burning, and yet, they will have no necessarily idea that that pump has been affected, because they haven't asked it to try to work yet. They're still running the plant; feed water plants are still on. They'd have no idea that the AFW turbine pump has now become inoperative. They won't know that until they try to use it.

So just recognize that there is some missing information with their situation assessment as to how bad this fire is, okay? Now, also during this time; let's assume the fire brigade is trying to do its job. There is going to be some diversion of attention as well, because there's going to be periodic communication between the fire brigade and the main control room staff. One of the things they do is hand out radios, et cetera, and there's going to be talking back and forth: how are you coming? What's the situation?

Maybe the brigade is saying, well, we haven't entered the room yet; there's an awful lot of smoke, et cetera, et cetera. There's going to be some diversion of attention dealing with the fire brigade as well as trying to just make sure that the plant is okay. That's part of the overall situation.

Let's assume for the moment that the conditions get even worse. Either the fire brigade is having trouble getting out the fire or whatever. At some point, if enough erratic behavior is occurring, and we're actually beginning to have a lot of difficulty in actually controlling the plant, maintaining pressurizer level, maintaining feed water flows, whatever, that's when the judgment occurs for the operators to then enter either EOP-FP-Y if the fire is in an alternate zone or EOP-FP-Z if the fire is in a dedicated zone, and at that point, one of the first steps in that procedure is, yes, trip the plant, okay?

Secondly, then, what they do after that is they, in the procedures, is they basically isolate the steam generators, and then, they leave -- if they have to, if they're in EOP-FP-Y, they have to actually leave the main control room, and then, they start the de-energization process, and that's when they actually are pulling fuses, pulling breakers out locally in the plant, et cetera, and essentially putting the plant into a self-induced blackout.

Simultaneously, they are -- and they actually take the crew and separate them up into about three or four different areas of the plant, so you have to also recognize that the crew is no longer working as a unit in one room anymore; they're now located in various areas of the plant talking on radios. One guy is over pulling fuses in a DC panel; another person is over pulling breakers in an AC bus, et cetera. So they're acting now certainly still in communication but as separate entities.

They de-energize the various buses in the plant, and then, they bring on the appropriate bus, depending on whether the fire is in an alternate or dedicated zone, and then begin to bring on manually the equipment they're going to use to safely shut down the plant. Now, in the base case scenario, even if the fire got this bad, the expectations of the operator would be, okay, we enter the right EOP procedure; we go through its implementing steps; we carry it out; we eventually restabilize the plant. Sometime during this time, the fire eventually gets extinguished, and the scenario is over.

So in a general sense, this would be sort of the expectations, even if the fire got fairly severe, as to what the operators' expectations would be as to how the scenario would proceed, and that's going to be our starting point to then build deviations on that scenario.

One of the things we'll also do early on in the process is we try to focus on, well, what human failure event or events and what particular unsafe acts are we really interested in analyzing for? And this slide is meant to attempt to try to summarize really the specific human failure event that we're looking at, which is really failure to accomplish heat removal. Let's say we get to the point where they have to trip the plant, and now, they have to bring it back into a stabilized, cooled state, recognizing they may have to leave the main control room and go through this de-energization process and so on, and what if they fail to carry that out correctly for one reason or another?

Taking that overall human failure event and really breaking it down into, as we have here, three separate unsafe acts that we're really going to be trying to analyze and determine, if we can, the probability of that occurring. UA-1 is really very much closely associated with that diagnostic error I talked about in the original PRA; that is, one unsafe act could be the failure to enter the right EOP or wait too long to enter that EOP, to the point where, perhaps by that point, so much equipment damage has occurred; maybe hot shorts have also occurred that they have essentially lost all control of the plant and the ability to even bring it back to a cooled and safe and stable safe.

DR. APOSTOLAKIS: What's too long? Who determines the length of fire?

MR. KOLACZKOWSKI: For purposes of this illustration, we haven't tried to necessarily answer that question, George. It would obviously depend on the specific plant; how big the fire grows; how fast the equipment gets affected. You know, you could do that by doing various com burn runs for that room and so on and so forth. It would be very plant specific. I mean, I could try to give you some general ideas, I suppose, but we have not tried to address that specifically in this illustration.

DR. APOSTOLAKIS: Okay; but in terms of the base case scenario --

MR. KOLACZKOWSKI: Yes?

DR. APOSTOLAKIS: -- do you have an idea as to how much time they have? I thought that was one of the premises of defining the base scenario.

MR. SIEBER: It depends on how big the fire is.

DR. APOSTOLAKIS: Well, okay, but they have to have some sort of an idea how quickly they have to do it.

MR. KOLACZKOWSKI: I agree that as part of the base case scenario, you would describe for a specific plant how long do they think it would take before this fire would get that large and so on, and that's going to be a very plant-specific answer.

DR. APOSTOLAKIS: I see Jack is shaking his head here.

MR. SIEBER: I don't think you can do it.

DR. APOSTOLAKIS: So how will the operators act?

MR. SIEBER: You act as quickly as you can without making any mistakes.

[Laughter.]

DR. POWERS: What's happening in reality is that you've got something, the fire alarm or something. You've got some people doing things. They're talking to you about what they're finding. In the mean time, you're going to have instruments that are telling you something is going on, and the urgency, well, it's urgent to get the fire out, but it's not urgent to take the plant, to trip the plant until you get something urgent. Who says that? It's the instrumentation board or the people that are talking about it. They say the fire is very big, and we can't get it out with the people we've got; you're going to trip the plant.

DR. APOSTOLAKIS: And this is now on the order of minutes?

DR. POWERS: Minutes.

MR. KOLACZKOWSKI: It could be.

DR. POWERS: Yes; I know. I mean, some of us are more incredulous than others, but maybe that's just an area that somebody is going to have to work on. It's in the area of most extreme abuse, I think; what's already a very laborious process.

DR. APOSTOLAKIS: I think that's related also to the problem of screening at the beginning. In other words, you really have to try to make this not to look like it's an open-ended process that only a few select people can apply.

I have another question. I'm confused there by the second paragraph.

MR. KOLACZKOWSKI: Okay; I was going to get to that, George.

DR. APOSTOLAKIS: I think we have to hurry.

MR. KOLACZKOWSKI: Okay; go ahead.

DR. APOSTOLAKIS: Triggered error mechanisms include no entry to procedures. And then, it says tends to lead to unsafe acts, including taking no action. I thought the mechanism was something different. I agree with the last statement, but if they delay or they take no action, that's an unsafe act. I just don't see how it is an error mechanism.

MR. KOLACZKOWSKI: Yes, it looks like maybe that is miscategorized and should be down as an error type.

DR. APOSTOLAKIS: Okay; so it shouldn't be classified as a trigger mechanism.

MR. KOLACZKOWSKI: I think I would agree with you, George.

DR. APOSTOLAKIS: Okay; I think we've got the flavor of the search.

MR. KOLACZKOWSKI: Okay.

DR. APOSTOLAKIS: Unless the members want to see two, three -- do you want to continue on to the deviation scenario development now?

MR. KOLACZKOWSKI: That's fine; that's fine.

DR. APOSTOLAKIS: Number 30?

MR. KOLACZKOWSKI: That's fine.

So we go through various searches to try to come up with credible ways a scenario could be different, such that they trigger certain error mechanisms that we think will lead to the error types of interests, okay? Now, we actually -- once we've gone through those searches, and we have some idea of credible ways that the scenario might deviate from the base that really sets up the potential for the unsafe acts that we're interested in, we then summarize those characteristics into a troublesome scenario or scenarios; it might be more than one, okay?

In this particular case, based on what we learned on the searches in this illustration, we selected the following time line of events that would be somewhat different. Imagine, if you will, that the fire detection for whatever reason was delayed, either because of perhaps some of the fire detection equipment not working and/or the fire develops very slowly, which is getting sort of to the next bullet but progressively.

Also, let's say the fire brigade has trouble putting out the fire, although perhaps it reports back to the main control room that it is almost under control. Obviously, with the kinds of things that that's going to do, it's going to delay the decision process; allow the potential for more equipment to be damaged before, in fact, the operational staff take action; and if they're getting reports back by the fire brigade saying we've just about got it out, again, the feeling is going to be one of almost relief and say well, we're just about out of this thing.

Now, beyond the initial fire conditions, also some other later deviations that we're going to include in this "deviation scenario" is that suppose that the fire duration and progression is such that it gets so severe that it actually has cross-divisional equipment effects. Perhaps it lasts longer than two or three hours, and eventually, fire barriers get defeated or whatever, and/or other good equipment, that is, the equipment they're going to try to use to safely shut down the plant, what if it fails to function, like the diesel doesn't start? Those that we think are credible, realistic deviations in the scenario that could make the scenario much more troublesome. Next slide.

DR. APOSTOLAKIS: So where are you using the fact that they may be reluctant to abandon the control room?

MR. KOLACZKOWSKI: Well, again, that's been recognized as part of one of the vulnerabilities, and the fact that we have a scenario now that is going to develop slowly, and also, they're going to be getting good reports from the fire brigade, we're basically saying that's going to strengthen that reluctance. They're going to be less willing to leave the main control room given that's the situation, because they think the fire is just about out, and they're not sure what all the effects of the fire are, in fact, because it's progressed so slowly.

DR. APOSTOLAKIS: So that's not part of the deviation scenario?

MR. KOLACZKOWSKI: It is a reason why the deviation scenario is what it is. We're saying that this kind of a scenario, as described, is going to strengthen or increase the reluctance factor. The scenario is not the PCF. The scenario is described in an equipment sense.

DR. APOSTOLAKIS: What's the PCF?

MR. KOLACZKOWSKI: I'm sorry; I said PCS; PSS. The scenario is going to strengthen certain performance shaping factors. In one case here, one of the performance shaping factors, one of the negative ones, is this reluctance.

DR. APOSTOLAKIS: So if one asks now what is the error forcing context --

MR. KOLACZKOWSKI: Yes.

DR. APOSTOLAKIS: How many do you have, and which ones are they?

MR. KOLACZKOWSKI: Okay; in this case, I guess we would say we're describing one overall context. What you have before you on this deviation scenario slide, the previous slide, is essentially the plant conditions part of it. The actual performance shaping factors, I don't think I have a slide on that, but the performance shaping factors which make up the other part of the context would be things like unfamiliarity with such a situation; reluctance to want to deenergize the plant and/or if necessary leave the main control room and so on and so on.

And so, you would then describe those performance shaping factors, and then, together, if you say given those performance shaping factors and this kind of a scenario, we think we have an overall context which may lead to higher probabilities of not entering the procedure in time or carrying it out incorrectly, et cetera, those three UAs that I talked about.

DR. APOSTOLAKIS: I mean, I thought that the error forcing context is central to all of this. So I sort of expected the view graph that said this is it.

MR. KOLACZKOWSKI: Probably should have stressed the performance shaping factors; you're right. We only presented this --

DR. APOSTOLAKIS: Is it the performance shaping factors or the context? Or these are part of the context?

MR. KOLACZKOWSKI: Yes; if you go back to the framework, you'll notice that the error forcing context box has in it two things: the plant conditions --

DR. APOSTOLAKIS: Yes.

MR. KOLACZKOWSKI: -- and the operator performance shaping factors, and what we're saying is suppose the plant conditions are as I've described in this deviation scenario. That's going to trigger a lot of those other vulnerabilities that we talked about in the previous step, which really become the performance shaping factors; that is, he's going to have a reluctance to want to deenergize the plant, et cetera, et cetera.

DR. APOSTOLAKIS: So you have a number of error forcing contexts by selecting from the deviation scenario development.

MR. KOLACZKOWSKI: Yes, you could; yes, you could.

DR. APOSTOLAKIS: I think that's a critical --

MR. KOLACZKOWSKI: You could potentially have numerous contexts.

DR. APOSTOLAKIS: You need to emphasize it and say these are the contexts we're identifying.

MR. KOLACZKOWSKI: Okay; okay, good point.

Okay; given now we think we have a scenario that will, if it develops in the way that we described in the deviation scenario, we think along with the performance shaping factors provides us a more error-prone situation or error forcing context, as we call it. One of the things that we also do before we really enter the quantification stage is think about well, what if it really did get this bad? What are the potential recoveries?

I guess just quickly, for the case where he doesn't enter the EOP or enters it way too late, we've assumed that if things got that bad, right now for this illustrative analysis, we're not allowing any recovery in that situation, and by the way, that's very similar to what was done in the existing PRA. The existing PRA said if things get that bad that he never made the decision to even enter the EOP, he's not going to get out of this thing if the fire continues. So we're sort of in line with what the existing PRA was in that case.

If the fire grows, and it affects both the alternate and the dedicated equipment, which was one of the aspects of our deviation scenario possibilities, well, obviously, now, now, the question becomes what's he going to do, given he's got alternate equipment burning as well as dedicated equipment burning, and really, there is no procedural guidance for that. He's supposed to enter one or the other case, not both. So if the fire grows and affects both the equipment, or, if when he gets to the so-called good equipment, that is, the equipment not affected by the fire that randomly fails, that could occur because of -- this is getting to your point, George -- the operator could be making those problems occur, not just that the equipment fails.

This is sort of the operator inducing an initiator; in this case, this is the operator actually causing the reason why the equipment doesn't work. Maybe he doesn't try to start it up in the right sequence or something like that, and so, it doesn't work properly.

Now, we have allowed recovery for that in the analysis, and I think maybe the best thing I ought to do is go to the event tree, which is the next slide, that will show the interrelationship of the recovery with these unsafe acts. This is obviously very simplistic, but what it's meant to do is cover really the key points that we're worried about in how the scenario could progress. Notice we have the fire at the beginning. Suppose the operator does not timely enter into the correct EOP? That was the one that we said we're not going to allow a recovery for. That's unsafe act number one. If that occurs, we're going to assume for event tree purposes that that goes to core damage, like the existing PRA did.

But suppose it does enter the procedure, and suppose the fire does not jump to separation barriers; that is, it still remains in only the alternate area or only the dedicated area. And then, additionally, if the good equipment that he then tries to operate works, well, that's the way out. That's the okay scenario he's trying to get to. But if there is a problem either with the equipment working or if the fire, in fact, jumps over into -- let's say it starts in the alternate area and jumps to the dedicated area, maybe because of an Appendix R weakness, or maybe there's a fire door inadvertently left open, something like that, so the fire could get into the AFW pump A room, for instance, as well.

Then, the operator is going to have to try to deal with this situation that he's got fire affecting both alternate and dedicated equipment, or he has to deal with the fact that the good equipment has randomly failed and is not working, and when allowing a recovery there, he has to make a decision as to what sort of recovery action to take, and then, obviously, he has to carry out that recovery action.

That recovery action would probably be something like, well, let me go try to use the A equipment again, even though it's the equipment that's burning, because the B diesel isn't starting, so I've got to go try to use the A diesel. That's my only out at this point. So in event tree space, this is sort of the relationship between the UAs and the equipment and the recovery and how that's sort of all panning out.

DR. APOSTOLAKIS: Isn't this similar to an operator action?

MR. KOLACZKOWSKI: I guess certainly from the concept standpoint, yes; in terms of laying out the possible sequences, yes.

Next slide. George, I don't know if you want to get into the details --

DR. APOSTOLAKIS: No.

MR. KOLACZKOWSKI: -- of the codification other than to say that we used the existing PRA information to try to quantify, well, what's the chance this set of plant conditions would actually occur this way. And then, as we said, as far as actually coming up with the probabilities of the unsafe acts, at this point, they're still largely based on judgment and using other types of techniques like HEART to try to get some idea of what those numbers ought to be.

DR. APOSTOLAKIS: Why don't you go on to the difference between existing --

MR. KOLACZKOWSKI: Okay.

DR. APOSTOLAKIS: -- PRAs?

MR. KOLACZKOWSKI: So that takes me to the last slide in my presentation, which is really what we want to stress more than the quantitative numbers. As with PRA, the real value of doing PRA is what you get out of doing the process. The numbers are fine, and they sort of set some priorities, but we think the same is true of ATHEANA. And from a qualitative aspect, what we've done here is compare the existing PRA human performance observations and sort of what you learned out of the existing HRA and what you might learn out of doing an ATHEANA type of HRA on these same two fires, and these are meant just to compare the types of fixes or lessons learned, if you will, out of the HRA analysis that one might gain from the existing PRA versus the ATHEANA results, and let me just generally characterize them as I think the existing PRA gives you some sort of very high level ideas of some things that you might fix, and they generally fit the category of well, let's just train them more, or let's make this step bolder in the procedure so he won't skip it.

I think in going through the ATHEANA process and really understanding what the vulnerabilities are and how the scenario differences might trigger those vulnerabilities to be more prominent, I think you learn more specifics as to ways to improve the plant, either from a procedural standpoint, a labelling standpoint, et cetera, and what the specific needs are, such as like that first one up there on the extreme upper right. Clearly, there is a need for a minimum and definitive criteria for when to enter EOP-FP-Y or Z.

DR. BARTON: That may be almost impossible to come up with: how many meters; out of whack by how many degrees? Some of that is going to be real hard to put numbers on, numbers or definite criteria for getting in there.

MR. KOLACZKOWSKI: Granted; I'm not saying that all of them can be done or should be done, but these are the types of insights one can gain out of doing an ATHEANA type of analysis out of this. Unless you want to go through specific ones, that pretty much ends the presentation. It's trying to be a practical illustration of how the actual searches and everything work.

DR. POWERS: I guess I'm going back to the question of what has been accomplished? Why do we feel it's necessary to go to such a heroic effort on the human reliability analysis? And if we could understand why we want to do that, maybe we could decide whether we've accomplished what we set out to do.

MR. KOLACZKOWSKI: My short answer to that is go back to one of the first slides we had this morning. If you look at real serious accidents, they usually involve operators not quite understanding what the situation was; certain tendencies, et cetera, are built into their response mechanisms, and therefore, they made mistakes, and PRAs, quite frankly, as good as they do to try to determine where the risks of nuclear power plant accidents lie, et cetera, still do not deal very well with possible errors of commission, places where operators might take an action that, in fact, would be unsafe relative to the scenario. So maybe we're missing some of where the real risk lies.

DR. POWERS: I think we see this kind of a problem, especially when we look at severe accidents, pertaining to accidents where the operators disappear. Something happens to them, because they don't affect things very much.

And you get peculiar findings out of that, like we have people swearing that the surge line is going to fail; the four steam generators to fail or the vessel fails, because that's where -- the operator has apparently taken a powder and gone someplace and don't try to put any water into it, and despite what we saw at TMI, the surge line fails, and so, accidents become benign that otherwise would be -- and understanding the operator is going to take a powder, that will do something that seems like a very valuable thing.

The question you have to ask is is this enough, or should we do something much more?

[Laughter.]

MR. KOLACZKOWSKI: I don't know how to respond to that.

DR. POWERS: Well, putting it another way, I assume you can figure out the inverse to that statement, because that's already too much.

MR. CUNNINGHAM: Part of the reason we're coming out to talk to the committee and other people is just to sort out, okay, what are the next steps? We've taken a set of steps. We've made an investment and made a decision to go down a particular route.

DR. POWERS: Well, could you work and research just maybe operators might put water in and the surge line not fail first?

[Laughter.]

MR. KOLACZKOWSKI: We'll do that. We'll try to convince them.

DR. POWERS: Try to convince them that TMI actually did occur.

[Laughter.]

MR. CUNNINGHAM: People forget things.

DR. POWERS: But it is possible that it pours down under pressure and not had the surge line fail.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: Are you going to be here this afternoon?

MR. CUNNINGHAM: I don't know about most of us but --

DR. APOSTOLAKIS: Until about 3:00?

MR. FORESTER: I'd have to change my flight.

MR. CUNNINGHAM: Some of us will be here.

DR. APOSTOLAKIS: Okay; I propose that we recess at this time so that Tom and I can go to a meeting, and we will talk about the conclusion, followup activities at 12:45.

MR. CUNNINGHAM: 12:45 is fine by us.

DR. THOMPSON: I only have two more slides.

MR. CUNNINGHAM: We just have two slides, George, if you can just bear with us.

DR. APOSTOLAKIS: Yes, but I want to go around the table.

DR. POWERS: Unfortunately, he has an hour and a half of questions.

DR. APOSTOLAKIS: Yes.

[Laughter.]

DR. APOSTOLAKIS: Is the staff requesting a letter?

MR. CUNNINGHAM: We are not requesting a letter, no.

DR. APOSTOLAKIS: Okay.

MR. CUNNINGHAM: If you would like to write one, that's fine, but we are not requesting it.

DR. APOSTOLAKIS: Okay.

DR. POWERS: We could write one on surge line failures.

[Laughter.]

DR. APOSTOLAKIS: So let's reconvene at 12:45.

MR. CUNNINGHAM: 12:45.

[Whereupon, at 11:45 a.m., the meeting was recessed, to reconvene at 12:43 p.m., this same day.]

A F T E R N O O N   S E S S I O N

[12:43 p.m.]

DR. APOSTOLAKIS: Okay; we are back in session.

Mr. Cunningham is going to go over the conclusions, Catherine, so then, perhaps, we can go around the table here and get the members' views on two questions: the first one, do we need to write a letter, given the error forcing context that the staff is not requesting a letter.

[Laughter.]

DR. APOSTOLAKIS: And the second, what do you think, okay? So the staff will have a record of what you think. So, who is speaking? Catherine?

DR. THOMPSON: Okay; just real quickly, I want to go over two slides: the conclusion slide, we talked about all of this in the last couple of hours that we think ATHEANA provides a workable approach that achieves realistic assessments of risk. We can get a lot of insights into plant safety and performance and have fixes, if you will.

DR. POWERS: It boils down to a lot on what you call workable. It looks to me like it's not a workable approach. If I try to apply it unfettered, I have some limitation on where I'm going to focus it, but it completely gets out of hand very quickly.

MR. CUNNINGHAM: That's also true of event tree and fault tree analysis and lots of other parts of PRA. I think one of the issues that was discussed this morning of how do we fetter it, if you will, or keep it from becoming unfettered, and I think that's a legitimate issue that we perhaps can talk to you about more.

DR. POWERS: Yes; you need something that says, okay, you need something that's a nice progression, so that you can go from zeroeth order, first order, second order and have everybody agree, yes, this is a second order application.

MR. CUNNINGHAM: Yes, yes, and that, I think, again, probably within the team, we have those types of things in our heads.

DR. POWERS: Yes.

MR. CUNNINGHAM: But it's not very constructive from the outside world, yes.

DR. APOSTOLAKIS: The same goes to a straightforward.

MR. CUNNINGHAM: Of course; it's intuitively obvious, perhaps, that it's straightforward or some such things.

DR. POWERS: I got the impression that you had a variety of search processes that made it comprehensive; they may not have made it straightforward but a comprehensive search process.

MR. CUNNINGHAM: Okay.

DR. THOMPSON: Some of the followup activities.

DR. APOSTOLAKIS: Wait a minute, now, Catherine, you were too quick to change that.

DR. THOMPSON: Good try.

DR. APOSTOLAKIS: This comes back to the earlier comment regarding objectives. I don't think your first bullet should refer to risk. Your major contribution now is not risk assessment. You may have laid the foundation; that's different. But right now, it seems to me the insights that one gains by trying to identify the contexts and so on is your major contribution, you know, and that can have a variety of uses at the plant and so on.

So I wouldn't start out by saying that you have an approach to achieve a realistic assessment of risk.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: You don't yet.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: I, in fact, would make it very clear that there are two objectives here, if you agree, of course. One is this qualitative analysis, which I think I view as been knocked down a little bit and then the risk part, okay?

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: I think you should make it very clear, because if I judge this on the basis of risk assessment, then I form a certain opinion. If I judge it from the other perspective, the opinion is very different.

MR. CUNNINGHAM: Okay; I'll note that.

DR. APOSTOLAKIS: Develops insights: I have associated over the years the word insights with failed projects.

[Laughter.]

DR. APOSTOLAKIS: Whenever some project doesn't produce anything --

[Laughter.]

DR. APOSTOLAKIS: -- you have useful insights.

[Laughter.]

DR. APOSTOLAKIS: So in my view, you should not use that word, even though it may be true.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Supports resolution of regulatory and industry issues; you didn't give us any evidence of that, but I take your word for it.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Okay.

MR. CUNNINGHAM: So insights will be removed from the lexicon.

[Laughter.]

MR. CUNNINGHAM: Along with forcing, I guess, is another one we have to remove.

DR. APOSTOLAKIS: Yes; the thing about unsafe acts and human failure events, I really don't understand the difference.

MR. CUNNINGHAM: Yes; that's one of the things I was thinking about this morning in listening to this is again, within the team, I think it's well understood what those different terms means. But to the --

DR. APOSTOLAKIS: Yes.

MR. CUNNINGHAM: -- the general public, it's not going to be real clear.

DR. APOSTOLAKIS: But if it's an unsafe act, it should be a failure demand? That's why it's unsafe?

MR. CUNNINGHAM: I don't know.

DR. APOSTOLAKIS: From the words, from the words; it doesn't follow. And you are saying in the text that they are expected to act rationally. So why are you calling what they did -- anyway.

MR. CUNNINGHAM: Anyway, yes, we will try to do a better job of mapping those things out.

DR. THOMPSON: Okay.

MR. CUNNINGHAM: Followup issues?

DR. THOMPSON: These are some activities that we'd like to get in a little bit more. Some of them are already planned.

DR. POWERS: You don't have any my surge line up there.

DR. THOMPSON: Surge line?

[Laughter.]

MR. CUNNINGHAM: There was a typo. We meant to say surge line.

[Laughter.]

DR. POWERS: What you do is you didn't get the steam generator tube rupture problems.

DR. THOMPSON: Okay; we obviously are pretty much done with the fire issue. We're now working on PTS issue with Mr. Woods and some other members of the branch and helping him look at the human aspects of that. We'd like to get into some of the digital INC area, see what that could add to the human error when they start working along with digital INC.

DR. UHRIG: Are you looking at that strictly from the operations standpoint, or are you going to get back into the code development aspect?

DR. SEALE: The software side.

DR. THOMPSON: Software; we haven't -- these are things that possibly we could get into. This isn't really planned yet, digital INC part. So I don't know how far we would get into that.

DR. APOSTOLAKIS: So when you say digital, what exactly do you mean? I guess it's the same question. The development of the software or the man-machine interaction?

DR. THOMPSON: I think the man-machine.

MR. CUNNINGHAM: We were thinking not so much the development as it's being used in the facilities.

DR. THOMPSON: Right.

DR. UHRIG: The difference between an analog and a digital system is relatively minor when it comes to the interface. It's the guts that's different. Pushing the wrong button, it doesn't make any difference whether it's digital or analog.

MR. CUNNINGHAM: Yes; again, this has been suggested as a topic that what we're doing here might dovetail well with other things that are going on in the office. It hasn't gone much further than that at this point.

DR. POWERS: At what point do we get some sort of comparison of the leading alternatives to ATHEANA for analyzing human fault so that you get some sort of quantitative comparison of why ATHEANA is so much better than the leading competitors?

MR. CUNNINGHAM: A quantitative comparison or --

DR. POWERS: Well, a transparent comparison. You tried some things where you said here's what you get from ATHEANA, and here's what you get from something else. Any other different? But it's hard for me to go away from saying this saying ATHEANA is just infinitely better than the existing PRA results. Quite the contrary; I'm feeling that the things in the existing PRA must be pretty good.

DR. BARTON: A lot of them are very similar.

DR. POWERS: Yes, pretty similar.

MR. CUNNINGHAM: Okay; they are similar but --

DR. BARTON: The whole process may end up fixed it sooner to the fix out of play, the methods I'm using now.

MR. CUNNINGHAM: What happens in the context of like the fire example is you're identifying new scenarios as you go through the trees that seem to have some credible probability. How, you know, what the value or what the probabilities are that will be associated with them is still something we're still exploring. We expect that we will find scenarios that will have a substantial probability and will, you know, lead to unsafe acts or core damage accidents or whatever. Again, they go back to you look at the history of big accidents in industrial facilities, and you see these types of things occurring, so we're trying to match the event analysis with the real world, if you will. In a sense, that's one of the key tests, I think, of how well this performs is that do we seem to be capturing what shows up as important in serious accidents?

There are a couple of things that aren't on this slide that we've talked about this morning. We discussed for a good while the issue of quantification, that that may be -- is that on there? I can't read the thing; okay, improved quantification.

DR. APOSTOLAKIS: What is that?

MR. CUNNINGHAM: It's one of those bullets.

DR. APOSTOLAKIS: Full-scale HRA/PRA?

MR. CUNNINGHAM: No, the fourth one down, improved quantification tools.

DR. APOSTOLAKIS: I would say in degrading quantification.

MR. CUNNINGHAM: I'm sorry? Okay; quantification tools comes up as an issue.

DR. APOSTOLAKIS: Why does the NRC care about whether ATHEANA applies to other industries?

MR. CUNNINGHAM: Because it gives us some confidence that it's capturing the right types of human performance. As we've talked about many times or several times this morning, big accidents and complex technologies, we think, have a similar basis in human performance or are exacerbated or caused by similar types of events. Given that we don't have many big accidents in nuclear power plants, I think it's important that we go out and --

DR. APOSTOLAKIS: Did we ever apply this to other industries to gain the same kind of lessons? Let them use it.

MR. CUNNINGHAM: Again, it's not so much the --

DR. APOSTOLAKIS: In my years at the Nuclear Regulatory Commission, I don't know how much effort you plan to --

MR. CUNNINGHAM: Well, part of it, it's not a big effort, but it's also something where I think it's important to help establish the credibility of the modeling we have.

DR. APOSTOLAKIS: Like among pilots or airliners?

MR. CUNNINGHAM: Yes, the aircraft industry, over the years, we've had some conversations with NTSB and with NASA and places like that. Again, it's complex industries where you have accidents and --

DR. APOSTOLAKIS: I think developing quantification tools and the team aspects in NNR will keep you busy for another 7 years, so I don't know about the other industries. Again, that's my personal opinion.

MR. CUNNINGHAM: Well, you can take that in several ways. One of them is do you consider those the highest priority issues on the --

DR. APOSTOLAKIS: I find them the most difficult, the most difficult, applying it to other industries.

MR. CUNNINGHAM: I don't think we'd disagree with you.

DR. APOSTOLAKIS: I mean, it makes sense to -- adds credibility to say, yes, we did it in this context and it's --

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: But I wouldn't put too much effort into it.

DR. SEALE: But the preferable thing would be to have someone else use ATHEANA, and then --

DR. APOSTOLAKIS: Yes.

DR. SEALE: -- you could get them to act as an independent reviewer of your work and vice versa.

MR. CUNNINGHAM: Sure.

DR. SEALE: That strikes me as a much more --

MR. CUNNINGHAM: In that context, maybe apply is the wrong word but interact with other industries --

DR. SEALE: Yes.

MR. CUNNINGHAM: -- complex industries on the -- for the credibility and the application of ATHEANA.

DR. APOSTOLAKIS: Well, you also have, it seems to me, a nuclear HRA community. Why are the teams developing whatever processes or whatever? Is it because they're not aware of ATHEANA yet?

MR. CUNNINGHAM: You're taking some of the next presentation, which is on the international work that we're doing.

DR. APOSTOLAKIS: I'm not sure that we're going to have that presentation.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: I think we should conclude by discussing what we've heard, unless you really feel that -- I mean, I look at it. It's not just really useful.

MR. CUNNINGHAM: No, no, I'm sorry; there's a separate presentation.

DR. APOSTOLAKIS: There is?

MR. CUNNINGHAM: Yes; remember this morning that we discussed -- one of the first things on the agenda was the work we're doing internationally. We put that off until after that.

DR. APOSTOLAKIS: How many view graphs do you have on that?

MR. CUNNINGHAM: It's about eight or something like that. We can cover it in 5 or 10 minutes.

DR. APOSTOLAKIS: I think we should do that right now.

MR. CUNNINGHAM: Okay; it's up to you.

DR. POWERS: I would hope you would be able to tell me that little -- the Halden program plays or could play in the ATHEANA methodology.

MR. CUNNINGHAM: Do you want to go ahead and go to the international?

DR. POWERS: Whenever it's appropriate.

DR. APOSTOLAKIS: It's up to you, Mark. I think we're done with this.

MR. CUNNINGHAM: We're done with this; then, let's go ahead, and we'll cover the international thing.

DR. APOSTOLAKIS: I want to reserve at least 5 minutes for comments from the members.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Before we go on to the Sorenson presentation.

MR. CUNNINGHAM: Okay.

Basically, as we've been doing this ATHEANA work and our other HRA work, we've had two principal mechanisms for interacting internationally with other developers and appliers of HRA methods. One is through the CSNI principal working group five on PRA; in particular, there was something called the task group 97-2, which is working on the issue of errors of commission.

DR. APOSTOLAKIS: Who is our member?

MR. CUNNINGHAM: I'm sorry?

DR. APOSTOLAKIS: Who represents the NRC there, PWG-5?

MR. CUNNINGHAM: We have two or three different interactions. Joe Murphy is the chairman of PWG-5; I'm the U.S. representative on 5; the chair of the 97-2 task group was Ann Ramey-Smith. We also have our COOPRA programs. One of the working groups there was established to look at the impact of organizational influences on risk.

DR. APOSTOLAKIS: Is that what the Spaniards are doing?

MR. CUNNINGHAM: Yes, that's where the Spanish come in. It's the international cooperative PRA research program. It doesn't fit the --

DR. APOSTOLAKIS: That is one of the Former Chairman Jackson's initiative papers.

MR. CUNNINGHAM: Correct; she wanted to -- she wanted the regulators to work more closely together, and there were a couple of research groups established as part of that.

Anyway, okay, the PWG-5 task 97-2 had three general goals. You want to look at insights, although perhaps that's no longer the right word to use; develop perspectives on errors of commission to apply some of the available methods which supposedly handle errors of commission and for quantitative and non-quantitative, more qualitative analysis of errors of commission and to look at what data would be needed to support types of analysis.

DR. POWERS: Have any of the technical fields -- I can with modest amount of effort, have you seen the database that -- is there someplace that I would go to find data that are pertinent to human reliability analysis?

MR. CUNNINGHAM: Do you want to answer that? I'm going to have one of my colleagues come up and answer that a little more explicitly. One of the people over here was shaking her head; I don't know.

MS. RAMEY-SMITH: No, that's a short answer.

[Laughter.]

DR. APOSTOLAKIS: Would you identify yourself please?

DR. POWERS: Before she identifies herself as a major expert in the field that I noticed last year our first exposure to ATHEANA was on human reliability analysis, brand spanking new, put out by a book publisher, and so I immediately acquired a copy of this book; read it for an entire airplane flight from Albuquerque to Washington, D.C. and found not one data point in the entire book. But there were 30-some papers on various human reliability analyses but not one data point.

DR. SEALE: We still need to know who she is. For the record, please?

MS. RAMEY-SMITH: Ann Ramey-Smith, NRC.

If I can recall, the question was is there a database that you can turn to, and the short answer from our perspective of the kind of analysis that -- and from the perspective that we think you should do an analysis, which is within the context of what's going on in the plant and performance shaping factors and so on, there is not a database that exists that we can turn to and go -- and make inferences based on statistical data.

The fact is that we've developed our own small database that has operational data in it that we have analyzed. There are various and sundry databases of various sorts. The question comes down, and one of the questions that this PWG-5 is going to address is the fact that we have a lot of databases, none of which may serve the needs of the specific methods that people are trying to apply.

DR. UHRIG: Would there not be a lot of information available through the LERs?

MS. RAMEY-SMITH: Oh, if that were true. Actually, there is quite a lot of information available on the LERs. Unfortunately, it's difficult oftentimes in those writeups to understand fully what the context was, to understand why the operators did what they did and what were the consequences and what were the timing and so on and so forth. One concern that some of the HRA folks have is that possible changes to the LER rule will even strip from the reports the little information that it had before, so we're concerned about that.

The better source for information, actually, has been the AIT reports and some very excellent reports that were previously done by AEOD when they did studies of particular events that maybe didn't rise to the level of

AITs but were very in-depth analyses, and we were able to make use of those, particularly early on when we were doing this iterative evaluation of operating experience. It was quite helpful.

DR. POWERS: One of the issues that NRR is having to struggle with is these criteria in what actions should be automated as opposed to being manual. How long does it take somebody to diagnose a situation and respond to it? And there are several that they have, because they have some good guidelines; they just don't have any data.

MS. RAMEY-SMITH: I think this approach would be very helpful for understanding -- what is it? -- B-17, the safety-related operator actions. I think that the agency would be wise to evaluate that issue within the context of PRA.

DR. APOSTOLAKIS: This looks to me like a benchmark exercise. Is that what it is?

MR. CUNNINGHAM: No; the sense that I have is that someday, we might be able to get to a benchmark exercise, but the principal players weren't comfortable at this point in constraining the analysis to that degree.

DR. APOSTOLAKIS: So, oh, yes, because you're saying they apply to events of the --

MR. CUNNINGHAM: That's right; we have a variety of different methods, and what we were doing was trying to see what these methods were giving us, so we didn't try to constrain it to a particular method or a particular event.

DR. APOSTOLAKIS: Okay; thank you.

MR. CUNNINGHAM: As you can see on page 4, we have a number of different methods applied. ATHEANA was applied by the U.S. group, the Japanese in people in the Netherlands; also different methods applied such as MERMOS, SHARP. We have the Czech Republic spelled correctly today, so that was an advancement over yesterday.

[Laughter.]

MR. CUNNINGHAM: And some other models that, as you can see, we go back to the Borsele theory.

DR. APOSTOLAKIS: Is SHARP really a model?

Okay; let's go on.

MR. CUNNINGHAM: Okay; slides five and six are a number of the conclusions that are coming out of the task 97-2. I'm not sure I want to go into any of the details today, but you can see the types of the issues that they're dealing with and what the report will look like. The report has been by and large has been finished; the report of this group has been finished. It's going to go before the full CSNI next month, I believe, for approval for publication. So it's essentially -- this part is particularly -- is essentially done.

DR. APOSTOLAKIS: The words are a little bit important here. The rational identification of errors of commission is difficult. What do you mean by rational?

MS. RAMEY-SMITH: That was the word that was chosen in the international community that everyone was comfortable with. But the way you can think of it is it's as opposed to experientially, you know, so that it's more predicting to sit down and to be able to identify errors of commission a priori.

DR. APOSTOLAKIS: Do you mean perhaps systematic?

MS. RAMEY-SMITH: Yes, that could have -- I guess the point is to be able to I guess systematically analyze it, you know, a priori be able to identify an error of commission. Systematic is a perfectly good word. This was just the word -- we used on this slide the words that, in the international group that was working on this, they were comfortable with.

DR. APOSTOLAKIS: And what is cognitive dissonance?

MS. RAMEY-SMITH: Okay; perhaps Dr. Thompson would like to --

DR. APOSTOLAKIS: That was an international term?

MS. RAMEY-SMITH: No, cognitive dissonance is from the good old field of psychology.

DR. APOSTOLAKIS: Oh, okay.

DR. BARTON: It's Greek.

DR. APOSTOLAKIS: What?

DR. BARTON: It's Greek.

[Laughter.]

DR. SEALE: Could I ask if this group of international experts had all of these different approaches, presumably, they would have a great deal of common interest in making certain things like LERs helpful about what's there. Has anyone put together a sort of a standard format for what it would take to get an LER that had the information you needed in it be able to generate a database?

MR. CUNNINGHAM: Actually, one of the follow-on tasks of this work is for the HRA people here to go back and try to lay out what data do they need based on their experience with this type of thing. So today, I don't think we have it, but I think over the next year or so, CSNI PWG-5 is going to be undertaking an effort to put that in the lifestyle.

DR. SEALE: It seems to me that should be something you could go ahead on, and whatever happens, at least now, you'll be getting information that's complete --

MR. CUNNINGHAM: Yes.

DR. SEALE: -- in some sense.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: That would be a very useful result.

MR. CUNNINGHAM: And that's one of the things that PWG-5 is going to undertake.

MR. SIEBER: Does that mean that every LER a plant puts out here goes through the ATHEANA program?

DR. APOSTOLAKIS: No, no, no, no. The ATHEANA has developed guidance about the LERs. The guys who write the LERs don't need to know about ATHEANA.

MR. CUNNINGHAM: Okay.

DR. SEALE: Just what it takes to have all of that planning data and things like that in it so that you've got a picture.

MR. CUNNINGHAM: Just two clarifications. One was this isn't the ATHEANA guys; it's the -- this international group of HRA people, so it's the MERMOS guys and all those guys are going to be doing it. It's not an ATHEANA specific issue.

The second, I was talking about data needs in general. I wasn't trying to suggest that all of the data needs that we had would automatically translate into something at LER, a change in the LER reporting requirements. I wasn't suggesting that.

DR. APOSTOLAKIS: There has been a continuing set of discussions on human liability, and as I remember, former member Jay Carroll was raising that issue every chance he had. How can you restructure the LERs so that the information is useful to analysts? Because the LERs were not designed -- they were designed for the PRA phase, right? You don't need another review for that.

MR. CUNNINGHAM: The LERs have a particular role, and as that role is defined even today, it's not going to provide a lot of the detailed information. Now in parallel, though, with the development of all of the LER generation, you have the NPO and NRC and industry work in EPIX, which will be collecting information that is much more relevant to PRA types of analyses. So I wouldn't so much focus on LERs as EPIX.

DR. APOSTOLAKIS: It would be nice to influence what those guys are doing.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: Okay; next.

MR. CUNNINGHAM: Okay; going on to slide seven on the COOPRA working group on risk impact of organizational influences, basically, we're trying to -- the goal of the working group is to identify the relationships between measurable organizational variables and PRA parameters so that you can bring the influence in and explicitly model the influence in PRAs.

DR. APOSTOLAKIS: Next.

MR. CUNNINGHAM: Overall, I don't think I need to go into the outcomes as much as -- I think it's understood as to what that is. Right now, it's fairly early in the process. We're trying to get a better understanding of what people are doing in this area. You alluded to the Spanish work in this area. The Spanish are one of the key contributors in here. How many countries are involved in this?

MS. RAMEY-SMITH: It's about six or seven.

MR. CUNNINGHAM: Okay; about six or seven countries; the UK, France, Spain, Germany, did you say?

MS. RAMEY-SMITH: Yes, Germany.

MR. CUNNINGHAM: Argentina, Japan?

MS. RAMEY-SMITH: Japan.

MR. CUNNINGHAM: Japan. They're trying to work together on this issue. Basically, again, this is fairly early in the work here. There's going to be another meeting early next year to basically take the next step forward in the COOPRA work. That's --

DR. APOSTOLAKIS: That's it?

MR. CUNNINGHAM: That's the short summary of the international work.

DR. APOSTOLAKIS: Okay.

DR. POWERS: And so, the Halden program has no impact on your --

MR. CUNNINGHAM: I'm sorry?

DR. POWERS: The Halden program has no impact on your --

MR. CUNNINGHAM: The Halden program has traditionally -- Jay Persensky sitting back here knows far more about it than I -- but has traditionally been oriented towards not so much human reliability analysis for PRA but for other human factors issues. There has been some ideas that Halden will become more involved in human reliability analysis. That's at least, I guess, in the formative stages.

MR. PERSENSKY: Jay Persensky, Office of Research.

Halden has proposed for their next 3-year program, which starts in November, the development of an HRA-related activity based primarily on input from PWG-5, because a number of the people that have been involved with the Halden human error analysis project also serve on that or have served on that task force. The goal, as I understand it at this point, is aimed more towards trying to take the recommendations with regard to kinds of data and seeing whether or not they can play a role in that. At this point, it is in the formative stage, but it's looking more at that aspect of data since they do collect a lot of data, at least simulator data in-house.

Now, whether it can be used or not is another question. And that's what they're looking at at this point.

DR. POWERS: Is cross-cultural data any good? In other words, if I collect data on the Swedish or Norwegian operators on a Finnish plant, is that going to be any good for human error analysis, modeling or for American operators on American plants?

MS. RAMEY-SMITH: It has the same context.

MR. CUNNINGHAM: When you say data, it depends. If you're talking about probabilities, I don't know that any of the particular probabilities will apply, because again, there's a strong context influence. Can it provide some more qualitative insights? I suspect it could but again --

DR. POWERS: Cognitive things? What does it tell you about processing information, things like that? Are there big enough cultural differences that it's not applicable? I would assume that Japanese data would just be useless for us.

MR. CUNNINGHAM: I wasn't thinking of the Japanese, but there may be some cultures where it would be of real questionable use depending on the basic management and organization and how they do things and whatever, it could be and not be very applicable.

DR. APOSTOLAKIS: Okay; all right, why don't we go quickly around the table for the two questions: Should we write a letter, and what is your overall opinion?

Mr. Barton?

DR. BARTON: Yes; I think we need to write a letter. But let me tell you what my opinion is first --

DR. APOSTOLAKIS: Okay.

DR. BARTON: -- and maybe we can figure out if my opinion is similar to others; maybe not. I fail to see the usefulness of this tool for the work that's involved. Maybe I need to see some more examples. I mean, the fire example doesn't prove to me that ATHEANA is much better than existing processes I know when looking at EOPs and how I train people and how people use procedures or react to plant transients.

I think that as I look at this process, I also see where a lot of some of these actions depend on safety cultures, conservative decision making, et cetera, et cetera, and those two tie into this to understand more help and more safety culture and conservative decision making also.

I think the tool -- I don't want to poo poo the tool, but I think it's a lot of work, and I don't see that you get a lot of benefit out of going through this process to really make it something that people are going to have to use in their sites unless this is a voluntary thing. I don't know what the intent of ATHEANA is, but I don't see that benefit with the amount of effort I have to put into it.

DR. APOSTOLAKIS: And you would recommend the committee to write a letter stating this?

DR. BARTON: Well I think that if everybody else feels the same way, I think we need to tell somebody, you know, maybe that they ought to stop the process or change course or whatever.

DR. POWERS: I guess I share your concern that what we've seen may not reveal the definite capability of this, because there seem to be a lot of people here who are very enthusiastic about it. Based on what was presented on the fire, I come away with -- it just didn't help me very much.

DR. BARTON: It didn't help me either, frankly.

DR. POWERS: But putting a good face forward or seeing how it's applied I think is something we ought to do more of and more of a comparison to why is it so much better than the other, and I agree with you, the fire analysis just didn't help me very much at all.

DR. APOSTOLAKIS: Mr. Siebert?

MR. SIEBER: I will probably reveal how little I know about this whole process, but I did read the report, and I came away first of all with a nuclear power plant perspective -- it's pretty complex; for example and this reviews HRA, PSF, UA, HFE and HEM, all of those were used in this discussion. For a power plant person, I have difficulty with all of those acronyms. I had some difficulty in figuring out ordinary things like culture and background and training, and we struggled with that. So it could be -- the writeup could be a little simpler as it is. The only way I could read it was to write the definitions of all of these things down, and every time one would come up, I would look at what I wrote down.

The second thing was the actual application. In a formal sense, I think it's pretty good. And it would be useful to analyze some events to try to predict the outcomes of some events from a quantitative standpoint. That was left unreasoned. It was sort of like you arrive at a lot of things without -- and to me, that's not quantification. That's just a numerical opinion, and I'm not sure that that's -- the other thing that I was struck by was when I figured the cost to apply it would be with NUREG 2600 which was 10 to 15 people to do a level three PRA over a period of several months.

If I add ATHEANA onto that, I basically add 5 people. I add 5 people over a period of a year or so. That's a lot of people. Several of the people are key people, like the SRA. The training manager; the simulator operator; I mean, our simulators are running almost 24 hours a day at this point. So I think that the ability to make that investment, they would have to decide who am I going to lay off?

So there would have to be a clear description of why some of the somebody other than the NRC would be motivated to do this, and I can't find it in the fire scenario. There would be an awful lot of places where it would be very, very difficult to describe, you know, where all of this decision making or lack of decision making is. It is understandable and logical; it's complex to read. It's the state of the art. It would be expensive to apply. If you could show how this benefits safety --

DR. BARTON: And improve safety?

DR. THOMPSON: And improve safety.

DR. APOSTOLAKIS: That's it?

MR. SIEBER: That's it.

DR. APOSTOLAKIS: Bob?

DR. SEALE: Well, I have to apologize first for not being here for the presentation on fire. Mario and I were doing some other things on license renewal. I was impressed with the fact that the information that was presented on ATHEANA seemed to be a lot more detailed and a lot more thoughtful than what we had heard in the past. It's very clear that the staff has been busy trying to firm up a lot of the areas that we had raised questions about in the past. At the same time, I think of the 7 years. I seem to recall that it had something to do with the cycle on some things in the Bible.

[Laughter.]

DR. SEALE: But it seems to me for all of the reasons that you've heard from these people here and which I'm sure that you'd hear from other people, including plant people out there plant inspectors; that is, NRC people at the sites and so forth that you very badly need some application to show where this process worked, and I don't know enough about it to make a dogmatic judgment on my own as to whether or not those applications are there, but I would advise you to look very carefully to see if you can find someplace where you'd have a gotcha or two, because you clearly need a gotcha.

The other thing, though, is that in terms of the things that are in this international program, I do believe that whatever format the human performance problem takes in the future, you can make some recommendations as to what it takes to put our experience as we live it today in a form which would be more readily retrievable when we do have a human factors process that's a little more workable, and so, you know, I just think you need to look at examples and an application. That's where you're going to find your advocates if you're going to find any.

DR. BARTON: George, they did a fire scenario, and, you know, if you find this thing to the Indian Point II or the Wolf Creek draindown, what would you learn from that plant? Because I just left the plant yesterday, and one of the agenda items we had was human performance at the plant, and it's not improving. And I look at how could ATHEANA really help? And when you look at the day-to-day human performance events, this wouldn't do a thing for those kind of, you know, day-to-day errors.

You know, you're doing control rod manipulation. This is typical kind of stuff. You're doing control rod manipulation. You have the guy at the controls. He's briefed; he's trained; he's licensed. You have a peer checker. You go through the store; you go through all of the principles. You get feedback into your three-way communications; the whole nine yards. You're going to move this rod two notches out, and you do everything, and the guy goes two notches in.

Now, tell me how ATHEANA -- and this is the typical stuff that happens in a plant on a day-to-day basis. Now, tell me how I go through the ATHEANA process, and it's going to help me do something different other than whack this guy's head off, you know. And, see, Jay agrees with me.

MR. PERSENSKY: They didn't get to the part of cutting his head off.

[Laughter.]

DR. POWERS: Well, it strikes me that they will find an approach that they could tackle exactly that question. It strikes me that I came in here saying ah, they have a new way to do PRA, put human reliability analysis in total in this, and I see a nice package. I think they're not. I think they need to work on the way they tackle really tough reliability issues.

For instance, you pretty much set up one where you could apply all of these techniques that we talked about here to that particular issue, and I bet you they would come up with a response. In fact, that's the lesson I get. There is enough horsepower on it that you will get something useful on it. And what they don't have is something that allows me to go and do the entire human reliability portion of a safety analysis, you know, and just turn the crank. This is more for working on the really tough issues. It's perfect for my surge line issue. I mean, they could really straighten Tray Tinkler out.

[Laughter.]

DR. POWERS: Which would be a start.

MR. CUNNINGHAM: We don't want to promise too much.

MR. SIEBER: One of the things that's stated early on in the NUREG concept is that you don't blame people, and I'm sure you want to do that. On the other hand, when I read that, I thought secretly to myself some people just mess up. You pull records on operators, and you find some will make one mistake and some another, and when you move in instead of moving out, you know, there may be a lack of attention to detail or a lack of safety culture or a lack of attitude or what have you that is preventing that person from doing the right thing, and I think that you've missed --

DR. POWERS: The documentation used to be a lot worse. I mean, earlier documentation was really anathema to dare say that somebody screwed up.

[Laughter.]

DR. APOSTOLAKIS: Dr. Uhrig?

DR. POWERS: I'll take another shot at it.

DR. APOSTOLAKIS: Okay; Dr. Uhrig?

DR. UHRIG: A couple of things. One, anytime I've ever been involved with a plant with a serious problem, there has always been some unexpected turn of events that actually changed the nature of the problem, and I don't know how you would approach that. That's an observation.

The second one is it strikes me that if you need data, a modification of the LER procedures is a pretty straightforward process. It's not simple. I don't think you go to rulemaking to get the information that you need. I don't think so.

MR. CUNNINGHAM: It would require rulemaking, absolutely, and a major fight.

DR. UHRIG: Yes.

MR. CUNNINGHAM: And a major fight before that rulemaking every got very far.

DR. POWERS: I don't think that's the problem. I really don't.

DR. APOSTOLAKIS: But if you convince people you have the right approach --

DR. POWERS: I don't think it's a question of approach. You know, when I first came in, you need a bunch of data to prepare this, and I'm not sure. I think you need a bunch of problems to solve --

MR. CUNNINGHAM: Yes.

DR. POWERS: -- more than they need data to verify. I think if I were these guys, I'd be out looking for every one of these problems, and there's just one on the criteria for when they have to automate versus manual action that's been sitting over like a lump, and I think you guys could attack that problem and get something very useful out of it.

DR. APOSTOLAKIS: Anything else?

DR. UHRIG: That issue is another one that somehow needs to get addressed. We have literally done what we can do with training. I think we're asymptomatically approaching this problem, well, you can train people. Maybe automation is the next step. And I don't know quite how this would be done.

DR. POWERS: They have a very interesting kind of plan that would allow for people to accomplish -- you can't do it in that period of time, you have to automate. How long do you have to rely on somebody to recognize; they've got to do something to do it, and then, you would surely have to -- you need those kinds of numbers, and we've got some, you know. But there's no reason to think that it's real well-founded. The database that they're based on is proprietary. We can't even get it. And this looks like a methodology that I think attacks that problem very well.

DR. APOSTOLAKIS: Dr. Bonaca?

DR. BONACA: Well, you know, thinking about what's being done here, one of the problems I always see is about operators, people are always writing about what the operators will do at the most distant -- and it's very hard to bring most of this together. But, again, you know, I want to reemphasize the fact that where it is happening in that unique fashion was in the thinking-oriented procedure. Any experience that has been in the industry, it was a massive experience. Only when you put thousands of man hours when you have operators thinking together with engineers, with people who develop event trees, very specific trees with multiple options and so on and so forth;

I think there has to be some opportunity to benefit by grounding some of the work in ATHEANA on comparison to what was done there, maybe just the EPGs, for example, taking some example, getting some of the people involved in those.

I think the products will be people. You have some model of verification. You have some way to stand on some of the hypotheses of ATHEANA. Everything is speculative. It's probably correct, but we need to have some benchmark.

And second, that may offer you some simplification process and some issues that already have been dealt with in those efforts; take a look at procedures that may -- may help you in simplifying the process. But I can't go any further in speaking about it. But again, the point I'm making is that that's the only place that I know operators and analysts and development of processes came together for a long time. But I think that there will be a great benefit, actually, in trying to anchor ATHEANA on some benchmark, some comparison or some statement.

DR. APOSTOLAKIS: Well, I find it a bit disturbing that two of the members with hands-on plant experience are so negative. I would like to ask the subcommittee whether we should propose to write a letter, whose form will have to be discussed and content.

DR. POWERS: I don't think we have to write a letter that's critical. We need to have something that tells you to judge that data, and I don't think we need to write a letter on the external safety mechanisms. Cultural data, for example, on an organization.

DR. APOSTOLAKIS: The letter may say that.

DR. POWERS: If it says that, then fine.

DR. APOSTOLAKIS: Express reservations for the present state and may urge the further application with the explicit wish that the thing become more valuable.

DR. BARTON: I would agree with that.

DR. APOSTOLAKIS: The letter doesn't have to say stop it. In fact, I wouldn't propose such a letter.

DR. POWERS: Maybe we should say that these people should spend a year tackling three or four problems, visible, useful problems that -- and show the value of this technique, because I think it's not a technique that's going to get used. It would be wrong to hurt this, when I think they're just getting to the point where they can actually do something.

DR. APOSTOLAKIS: The letter, the contents of the letter are to be discussed; I think I got a pretty good idea of how you gentlemen feel, and certainly, I didn't hear anybody say stop this, although Mr. Barton came awfully close.

Yes, sir?

MR. SIEBER: I wouldn't want to be interpreted as negative, but I think things --

DR. APOSTOLAKIS: But you have been.

MR. SIEBER: No, I think things are needed.

DR. APOSTOLAKIS: Yes.

MR. SIEBER: I think simplification is needed; a good objective is needed; what we need to accomplish.

DR. APOSTOLAKIS: Does everyone around the table agree that a letter along those lines, which, of course will be discussed in December will be useful?

DR. POWERS: I have reservations about the simplification, because I know in the area -- we do have computer codes that are highly detailed, very complex things that we use for attacking the heart of very complex, tough problems; much more simplified techniques that we use for doing broad, scoping analyses, and I think there's room in this field, and I think maybe one of the flaws that's existed in the past in this human reliability area is that everybody was trying to make the one thing that would fit all hard problems, easy problems --

DR. APOSTOLAKIS: Right.

DR. POWERS: -- long problems, short problems, and maybe we do need to have a tiered type of approach in which you say, okay, I've got a kind of a scoping tool that --

DR. APOSTOLAKIS: No, I think --

DR. POWERS: I've got this one that's attacking the really tough, really juicy problems that have defied any useful resolution in the past.

DR. APOSTOLAKIS: I think the issue of screening, scoping the analysis, the raised approach that was mentioned earlier, all that part, I understand as part of this, and that was that you should have -- there also is -- but you have to convince me first that this event deserves that treatment.

DR. POWERS: Yes.

DR. APOSTOLAKIS: And that's what's missing right now. I would agree with Dana that you don't have to simplify everything, but I'm inclined to say that the majority of the events would deserve it.

Now, naturally, when you develop a methodology, of course, you attack the most difficult part, but I think a clear message here is develop maybe a screening approach, a phased approach that would say for these kinds of events, do this, which is fairly straightforward and simple; for other kinds of events, you do something else until you reach the kinds of events and severe accidents that really deserve this full-blown approach that may take time, take experts to apply.

You know, this criticism that plant people should be able to apply it, I don't know how far it can go, because if it's very difficult, they are known to hire consultants. So this is the kind of thing that they have to think about. We're not going to tell them how to do it, but that's what I understand by your call for simplification. You're not asking for something that says do A, B, C, and you're done.

Okay; so it seems to me that we have consensus, unless I hear otherwise, that a letter along these lines will be appropriate to issue, and I'm sure we'll negotiate the words and the sentences in December.

Dana? Your silence is approval?

DR. POWERS: No, my silence is that I'm encouraging at this point.

DR. APOSTOLAKIS: Yes; yes.

DR. POWERS: It's okay to have a methodology at this point that only Ph.D.s in human reliability analysis can understand very well.

DR. APOSTOLAKIS: I understand the concern about the tone, but I also want to make it very clear in the written record that these gentlemen have reservations and not random members. I don't think Mr. Bonaca is going to express as extreme views as you, but I'm not sure he's far away from your thinking. So if I have the three utility members thinking that way, I think the letter should say something to that effect without necessarily discouraging further development or refinement.

DR. POWERS: Yes.

DR. APOSTOLAKIS: But it's only fair; the letter will be constructive, but it will clearly state the concerns, and perhaps we should meet a year from now or something like that. We can say something like that in the letter. We look forward to have interactions with the staff.

DR. POWERS: I think I would really enjoy giving them some time to go off and think about some problems to attack and come back and say we think we're going to attack these two problems next time or something like that. I think that would be really interesting, because I think there are some problems out there that line organizations really need some help on solving, and I'm absolutely convinced that the human element is going to become of overwhelming importance if we're going to have a viable nuclear energy industry in this country.

The operators are asked to do so much, and it's going to be more and more with less and less over time, and we need to have something that constrains us saying, yes, the operators will do this, because right now, nothing constrains us from saying yes, the operators have to be trained on this; they have to know this; they have to worry about this and like that, and at some point, where that process has to be constrained a little bit.

But I think I really come in much more enthusiastic about this than you thought I would.

DR. APOSTOLAKIS: Okay; I think I've heard enough. I can draft a letter. I'm sure it will be unrecognizable after --

[Laughter.]

DR. APOSTOLAKIS: But at least I have a sense of the subcommittee.

DR. SEALE: Nobody overhead.

DR. APOSTOLAKIS: Yes.

MR. SIEBER: Can we see a copy of it before the meeting?

DR. APOSTOLAKIS: I'll do my best; I'll do my best, Jack, before the meeting. I urge you to send emails with your concerns; yes, and I will do my best to include your thoughts. I took notes here, but, you know, John, if you want to send me a fax or call me.

DR. BARTON: Okay.

DR. APOSTOLAKIS: Or Jack, because I'm particularly interested -- I mean, this is the way this committee has functioned in the past. I mean, if cognizant members express reservations, their views carry a lot of weight.

Is there anything else the members want to say before we move on to safety culture?

[No response.]

DR. APOSTOLAKIS: I must say I was pleasantly surprised to hear again the same members talk about how they wanted to see safety culture addressed. Miracles never cease, I must say.

MR. CUNNINGHAM: Could I ask a question? I believe we're on the agenda for the full committee in December.

DR. APOSTOLAKIS: Yes.

DR. BARTON: I think it has to be. I think after this, you're going to have to be.

MR. CUNNINGHAM: That's the question. What would you like for us --

DR. BARTON: To brief the other members.

DR. APOSTOLAKIS: How much time do you have?

MR. PERALTA: Probably just 45 minutes?

DR. BARTON: How much?

DR. APOSTOLAKIS: Forty-five minutes.

Would it be useful to talk about the fire scenario and in the context of the scenario explain ATHEANA? I don't think they can do both.

MR. CUNNINGHAM: I would agree. I don't think we can do both.

DR. POWERS: I think they ought to just explain ATHEANA. I don't think they should try the fire scenario.

DR. APOSTOLAKIS: I thought the scenario, the members found extremely useful.

DR. BARTON: Well, I think yes, it is, because it shows how they tried to apply --

DR. APOSTOLAKIS: Right.

DR. BARTON: -- the principles to an actual situation. I think that does help. Are you sure we can't squeeze some more time off?

DR. POWERS: No.

DR. BARTON: No, we can't.

DR. APOSTOLAKIS: Let us ask if Mr. Cunningham can structure it in such a way that he has the scenario, and on the way, you are explaining the method?

MR. CUNNINGHAM: Mr. Cunningham will try in 45 minutes.

DR. APOSTOLAKIS: We are reminded here -- is the document going to be available before the meeting on the fire scenario?

MR. CUNNINGHAM: I'm sorry; the --

DR. APOSTOLAKIS: We don't have anything in writing on the --

MR. CUNNINGHAM: On the fire scenario? Will we have that for the full committee?

MR. KOLACZKOWSKI: There is certainly a draft available.

MR. CUNNINGHAM: Okay.

MR. KOLACZKOWSKI: The NRC has not a chance to review it yet, so it certainly is subject to revisions.

DR. THOMPSON: It's still in development.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: So we're not going to have it?

MR. KOLACZKOWSKI: I don't think you're going to have it.

MR. CUNNINGHAM: No, okay.

DR. APOSTOLAKIS: Will that be a factor? We cannot comment on something that we don't have? But we have a presentation. We have view graphs with a comparison, so we can comment on those, right? We can say that we didn't have a written document, but they have some nice statements.

Mark, again, I don't want to tell you how to structure the presentation, but the figure you have -- well, the classic ATHEANA --

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: -- maybe you can use that one and explain the elements of the process and then jump into the scenario.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: I don't know.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Okay? And we will try to refrain from repeating the same questions that we have done here, right? And I see some smiles on the faces of some of my colleagues.

[Laughter.]

DR. APOSTOLAKIS: But we will try; we will try.

I think in fairness to Mr. Sorenson, we should move quickly on to his presentation, and I must tell you that I have to disappear at 3:30, so, Jack -- where is Jack?

MR. CUNNINGHAM: Jack is in the back.

DR. BARTON: He said 3:30.

DR. APOSTOLAKIS: But I want some discussion.

DR. BARTON: And you have to leave at when?

DR. SEALE: He has to leave at 3:30.

DR. APOSTOLAKIS: Who's leaving at 1:00?

DR. BARTON: No, I said you have to leave when?

DR. APOSTOLAKIS: 3:30. So we have about an hour and a half. I think it should be plenty, yes?

DR. SEALE: I have to leave at about 3:30, too.

DR. APOSTOLAKIS: Okay; no problem. 3:30, 3:32.

[Pause.]

DR. APOSTOLAKIS: Okay; this is an initiative of the ACRS. We don't know yet how far it will go; for example, our last initiative was on defense in depth, and it went all the way to presenting a paper at the conference PSA 1999, writing a letter to the commission and so on. That does not mean that every single initiative we start will have that evolution.

This is the first time that members of this committee besides myself are being presented with this, and we also plan to have a presentation to the full committee at the retreat; then, the decision will be up to the committee as to what the wisest course of action will be. We have asked members of the staff to be here, like Mr. Rosenthal, who left; he is coming back. Jay is here, and we asked the ATHEANA people to stay. They kindly agreed to do it. So we'll get some reaction from experts to our initial thoughts here, and again, where this is going to go is up to the committee, and we'll see.

Mr. Sorenson has been working very diligently on this, so I think he deserves now some time.

Jack?

MR. SORENSON: Thank you; I am Jack Sorenson. This discussion is based on a paper that George asked me to write earlier this year. There is a draft on his desk for comment. But getting to this stage took a bit longer, I think, than either one of us thought.

What I've attempted to do is put together a tutorial that will help non-practitioners of human factors-related things to understand what the state of the art is and what all the pieces are. This morning, you heard

-- and early this afternoon -- a great deal of discussion on one piece of a picture that I would like to draw in somewhat larger terms. There is no attempt here to advance the state of the art in safety culture; just to understand it. There is no attempt to review or critique the NRC human factors program.

What you will hear is undoubtedly a somewhat naive view, and I would encourage those of you who are expert in one or more aspects of the subject to offer, I hope, gentle corrections when you feel I have misrepresented something.

DR. APOSTOLAKIS: I wonder why anyone would ask this committee to be gentle?

[Laughter.]

DR. APOSTOLAKIS: Aren't we always?

MR. SORENSON: I was not, of course, not referring to the committee as being ungentle.

DR. APOSTOLAKIS: Oh, I see.

[Laughter.]

MR. SORENSON: The three questions that were posed, I think by the planning and procedures subcommittee relative to safety culture are what is it? Why is it important? And what should the ACRS and NRC do about it? We'll find out that the middle question, why it's important, is probably easier to deal with than either what it is or what people should do.

The term safety culture was actually introduced by the International Nuclear Safety Analysis Group in their report on the Chernobyl accident in 1986. A couple of years later, they actually devoted a publication to safety culture, and in that publication, they define it as shown here: safety culture is that assembly of characteristics and attitudes in organizations and individuals which establishes that as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance.

There are other definitions that may be useful, and we may get to them later if it turns out that they're important, but the main thing is that there are -- whatever definitions of safety culture you use, there are requirements established essentially at three levels. There are policy level requirements and management level requirements, and those two things together create an environment in which individuals operate, and it's the interaction between the individuals and the environment that is generally understood to be important here.

The framework is determined by organizational policy and by management action and the response of individuals working within that framework. Go on to four, please.

Just a quick preliminary look at why it's important. To understand its importance, I think you can simply look at what James Reason refers to as organizational accidents that have occurred over the 10 years following TMI. Of course, within the nuclear industry, it was the TMI accident that focused everybody on human factors issues. In the 10 years following TMI, there were a number of accidents where management and organization factors, safety culture, if you will, you know, played an important role.

The numbers in parentheses following each of these on the list are the number of fatalities that occurred. There was an American Airlines accident, plane taking off from Chicago where an engine separated from the wing. It was later traced to faulty maintenance procedures. The Bhopal accident in India, where methylisocyanate was released resulting in 2,500 fatalities; the Challenger accident; Chernobyl; Herald of Free Enterprise; some of you may be less familiar with that. This was the case of a ferry operating between the Netherlands and England that set sail from its Dutch port with the bow doors open; capsized with somewhere around 190 fatalities.

And the last one was Piper Alpha; it was an accident on an oil and gas drilling platform where one maintenance crew removed a pump from service, removed a relief valve from the system, replaced it with a blind flange which was leaking and leaking flammable condensate, and the second maintenance crew, the second shift crew, attempted to start the pump, and there was an explosion and resulting fire.

In the nuclear business, other than Chernobyl and TMI, we typically end up looking at what are called near misses or significant precursors. Two that come to mind are the Wolf Creek draindown event, where the plant was initially in mode four, I believe; 350 pounds per square inch; 350 degrees Fahrenheit. There were a number of activities going on; heat removal was by way of the RHR system. There was a valve opened, and 9,200 gallons of water were discharged from the primary system to the refueling water storage tank in about a minute. The cause was overlapping activities that allowed that path to be established.

There were numerous activities. The work control process placed heavy reliance on the control room crew. There was the simultaneous performance of incompatible activities, which were boration of one RHR train and strobe testing of an isolation valve in the other train. The potential for draindown was identified but was not acted upon. Probably the most significant item here was that the test was originally planned, the strobe testing was originally planned for a different time and was deferred, and there was no proper review done of the impact of that deferral.

More recent event, Indian Point II, trip and partial loss of AC power. The plant tripped on a spurious overtemperature delta-T signal; off-site power was lost to all the vital 480-volt buses. One of those buses remained deenergized for an extended period and caused eventual loss of 125-volt bus and 120-volt AC instrument bus. All diesels started, but the one powering the lost bus tripped.

This had a number of human factors related to it. The trip was due to noise in the overtemperature delta-T channel that was known to be noisy, and the maintenance to fix it had never been completed. The loss of off-site power was due to the fact that the load tap changer was in manual rather than automatic, and that resulted in the loss of power to the buses. The diesel trip occurred because there was an improper set point in the overcurrent protection and an improper loading sequence, and after that, post-trip activities were criticized by the NRC for being more focused on normal post-trip activities and not enough on the state of risk that the plant was in in attempting to recover from that risk.

One of the things that is worth spending just a minute on is the idea of culture as a concept in organizational behavior. The International Nuclear Safety Advisory Group introduces the term safety culture pretty much out of the blue. They make no attempt to tie it back to the rather substantial body of literature that exists in either anthropology, where culture is a common term, or in organizational development, where it has become somewhat more common in the last 20 years or so.

The term is not without controversy, if you will, particularly among the organizational development people. The term -- the idea of ascribing something called culture to an organization started to show up in the organizational development literature in the very early eighties. The two best-known books are probably Tom Peters' In Search of Excellence and a book by Deal and Kennedy entitled Corporate Cultures, and they essentially set out to determine why it was that organizations or at least some organizations didn't behave in ways that were clearly reflected in their structures; they were looking for some other attribute of the organization, and they settled on the term culture.

There are people in the literature who take exception to that. The expectation is if you use the term culture in an organizational sense or in the sense of a safety culture that it carries with it some of the properties of its original use. That may or may not be true in the case of organizational culture or safety culture, but the fact remains that it has found a place in the literature. It is quite widely used, particularly with respect to nuclear technology. You will also find it in other writings in other industries, such as the process industries and aviation.

Having said that, you find that virtually everyone then goes on to define it in a way that suits their immediate purpose. I would like to go back to an opening remark which I missed, and that's that I knew I was going to have some difficulty with this assignment when I ran across an INSAG statement that said safety culture was the human element of defense in depth, and having spent a couple of years in defense in depth, it just seemed unfair that --

[Laughter.]

DR. POWERS: One thing that you have to remember about the origins of the concept is that it came up after the Chernobyl accident. There was a strong effort among parts of some people in the IAEA to shelter the RBNK design criticism, and you had to criticize the operators, okay? But criticizing the operators individually was not going to fly any better, okay? Because if you had a bad operator individually, why did they allow it? Why did the system allow this bad operator to be this? You had to go to this safety culture, okay?

[Laughter.]

DR. POWERS: That preserved the RBNK from being attacked, and at the same time, it led to protecting the operators individually.

DR. BARTON: You have to admit they were a poor example of safety culture?

DR. POWERS: What did you say?

DR. BARTON: Nothing.

MR. SORENSON: Well, that makes a good bit of sense, obviously. Although the idea of employee attitude or management and worker attitude having a significant impact on safety of operations, you know, considerably predates Chernobyl. You can find references back to the early 20th Century when industrial accidents started to become significant in some way.

Okay; I think we can, yes, go on to -- the definition on organizational culture, which is a little easier to deal with than safety culture, that was offered by a critic of the Peters and Kennedy and Deal books is the definition here. Organizational culture: the shared values; what is important and beliefs, how things work that interact with an organization's structure and control systems to produce behavioral norms; the way we do things around here. This one appeared in an article by Brill, Utah and Fortune in the mideighties, and you'll see it repeated in very much the same form in current literature.

The last phrase, the way we do things around here, I actually tracked back to one of the managing directors of

MacKenzie and Company. It seems to be the most concise definition of culture that --

DR. APOSTOLAKIS: That's the best one I like.

MR. SORENSON: There are competing terms: safety culture, organizational culture, management and organizational factors, safety climate, safety attitudes, high reliability organizations, culture of reliability, and they all mean more or less the same or slightly different things, depending on how they're used and what the investigator decides to do with them.

So I think it's important to keep in mind that there are no -- there is no generally agreed upon definition. We are dealing with the way organizations work and the way people within those organizations react, and at some point, you choose a definition that fits your use and then hopefully apply it consistently thereafter.

Dr. Powers?

DR. POWERS: This one is the sixth sigma?

DR. APOSTOLAKIS: I've heard that, to.

DR. BARTON: Sick or sixth?

DR. POWERS: Sixth.

MR. SORENSON: That's one of the zero-defect --

DR. POWERS: Yes.

MR. SORENSON: -- cults, is it not?

DR. POWERS: Do everything right, yes.

MR. SORENSON: Yes; I've run across the term within the last few weeks and I --

DR. POWERS: There was a survey in the Wall Street Journal about a month ago.

DR. APOSTOLAKIS: Did this agency actually do a self-assessment of its safety climate a couple of years ago?

MR. SORENSON: There was a survey by the inspector general. I've actually been through the slides that are on the Web on that. I don't think I've ever seen the text of the report. And they were looking for something a little different than I would have called -- than what I would have termed safety culture. They were looking for, I think, more of the focus of the organization on its mission and assuming that if people were focused on the mission of the organization that that is factory safety culture. I may be misrepresenting that but --

DR. APOSTOLAKIS: They put climate.

MR. SORENSON: They used the word culture.

DR. APOSTOLAKIS: No, I remember the word climate, because I was impressed.

MR. SORENSON: Well, they may have used that also, but I think the survey was titled a safety culture survey.

DR. APOSTOLAKIS: The French are using climate as well. Climate is supposed to be really culture. Culture is more permanent, presumably.

MR. SORENSON: One of the better-known writers in this general field, James Reason, in his book on managing organizational accidents lists the characteristics of a safety culture as a culture that results in -- that encourages the reporting of problems and the communicating of those problems to everybody throughout the organization; a culture in which or an organizational climate in which the members, the workers, feel justice will be done; an organization that is flexible in the sense of being able to shift from a hierarchical mode of operation under normal circumstances to a different mode of operation during a crisis or an emergency and then shift back; and then, finally, a learning organization where the information that is made available is incorporated into the way things are done.

DR. SEALE: That clearly indicates, then, that a safety culture is not an evolving set of values but rather a break with the past; I mean, I can think of organizations you might characterize as a benevolent dictatorship, and that was the way in which safety was imposed. I guess under those circumstances, you would have to say the old DuPont organization really didn't have a safety culture, although it had a remarkable safety record.

MR. SORENSON: Yes; I think that's a fair characterization, as a matter of fact.

DR. APOSTOLAKIS: And I think a lot of the old-timers in the U.S. nuclear Navy also dismiss all of this and say Rickover never needed it.

Now, the question is was the culture of the Navy good because of one man? And do you want that? Or do you want something more than that? Rickover certainly didn't think much about human factors.

DR. POWERS: If you don't have enough people to go around --

DR. APOSTOLAKIS: I don't know, but Rickover did a good job.

DR. POWERS: There are people who would take a different view on that.

[Laughter.]

DR. POWERS: And I think you can fairly honestly show that there are good and bad aspects of his approach, of his tyranny.

MR. SORENSON: There were two boats lost.

DR. POWERS: The time it takes to put a boat to sea, the mission of those boats and things like that -- you can change your approach.

MR. SIEBER: We did a survey a number of years ago of the idea of safety culture. About 700 people out of 1,100 responded. They had the same list you have, except they added personal integrity to that and caring attitude to that.

DR. BARTON: There were other characteristics.

MR. SIEBER: And that seemed to really work. It changed the attitude in that facility; it really did, just finding out the practices.

DR. BONACA: Although the attribute of flexibility, I think, goes a long way in the direction. That's the key item that you described there of when you go to technical issues, the ability of flattening out organization and not having any more pecking order or a fear of bringing up issues. Flexibility is very important.

MR. SORENSON: One can deduce from the literature a few common attributes that virtually every -- all of the investigators share: good communications; senior management commitment to safety; good organizational learning and some kind of reward system for safety-conscious behavior, and the lists expand from that point, if you will.

DR. BARTON: Conservative decision making.

MR. SORENSON: I'd like to take a step back here just a little bit and try to put the safety culture issue into the context of the larger issue of human factors, and to do that, I think looking at the National Research Council report done in 1988 on the NRC human factors program is useful.

The National Research Council identified five areas that they thought the NRC, the nuclear regulators, should address in their human factors research. First was the human-system interface; second, the personnel subsystem; the third, human performance; the fourth, management and organization; and the fifth, the regulatory environment. The first two items, human-system interface and personnel subsystem, deal primarily with the man-machine interface, the way the machines are designed and the way the personnel are trained.

Human performance in the context of that report is intended to deal with what this morning was referred to as unsafe acts of one kind or another, the actions of the system and equipment operators, and the management and organization, what they call management and organization factors are part of what they called a culture of -- fostering a culture of reliability. That was their phrase rather than safety culture; and third, the regulatory environment which dealt with the issue of how regulatory actions impacted the way the licensees did business.

The safety culture, as I'm attempting to deal with it today, is focused on the fourth item, management and organization. It creates the environment that human actions are taken in, and it may contain the ingredients to create what James Reason calls latent errors, those things which change the outcome of an unsafe act, but the issue of safety culture deals with the management and organization factors and the climate it creates, the conditions it creates for the human to operate in.

One of the difficulties I had in going through the literature was trying to understand what all the pieces were, and so, one of the things that I ended up doing that helped me, and I think could be generally helpful in putting some of the pieces together is to look at all of the things that go into the process of establishing some interesting relationship between something called safety culture and operational safety or ultimately some measure of risk, and this figure shows the first half-dozen steps in that process.

But the idea here is if safety culture is interesting for me from an operational safety standpoint, you need to be able to establish something about those relationships. The process typically starts off with defining some kind of an organizational paradigm. Mintzberg's machine bureaucracy is very often used for nuclear power plants, and then, as soon as it's used, it's criticized for having several shortcomings. The investigators need to have some idea of how the organization works, and they generally should start with some definition of safety culture, what it is.

Having done that, then, they need to define some attributes of safety culture, and it might be the ones that I listed a few minutes ago: good organizational learning, good communications and so forth, but there are somewhere between a half a dozen and 20 of those attributes that can be identified, and having done that, then to evaluate organizations, you need to look -- you need to have a way to measure those things that you've just identified, and you might put together personnel surveys or, you know, technical audits or whatever, but you need some kind of evaluation technique that involves looking at how the organization, how an organization actually works.

Having designed the evaluation techniques, you need to collect data, and then, you need to have, once you have data, you need to have something to -- that tells you how to judge that data, and I've indicated that by choosing external safety metrics; if you collect cultural data, for example, on an organization, how do you decide that that organization is safe or not safe in judging the cultural data?

In their simplest form, those external metrics might be a SALP score. They might be the performance indicators that we're using now. They might be earlier performance indicators. But the investigator makes some choice of what he's going to compare his cultural parameters to.

And typically, that correlation is done with some sort of regression analysis, and as a result of doing the, you find out that some number of the safety culture elements you started with, you know, correlate with your safety parameters, and some don't. And the output from that first stage, then, is which of these safety culture elements turn out to be significant.

The remainder of the process, then, if you want to carry it, you know, all the way to its logical conclusion is you would like to be able to use these significant safety culture elements to modify in some way your measure of risk, and the next figure -- if you can move that one over a bit; pick up the balance of that. The bottom path there identifies, you know, relating the elements that you've decided are significant to the PRA parameters or models; box 11 finally modifying the PRA parameters and ultimately calculating a new risk metric.

DR. APOSTOLAKIS: So I guess ATHEANA, then, because you don't necessarily have to go to that, ATHEANA would be somewhere there in between 9 and 10, perhaps?

MR. SORENSON: I would put -- well, it doesn't work on performance indicators, as I understand it. I would say ATHEANA covers 8 and 11; is that a fair statement?

DR. APOSTOLAKIS: It definitely does, but perhaps to take advantage of the qualitative aspects, you need an extra box so you don't just make it PRA. So before eight, you might have the qualitative aspects of ATHEANA, and then, at the start of eight, of course, you have to do the quantification.

MR. SORENSON: I would be delighted to get critiques on this, too.

DR. APOSTOLAKIS: Don't worry; don't encourage people.

[Laughter.]

DR. APOSTOLAKIS: Susan, you wanted to say something? You have to come to the microphone, please; identify Your Honor.

MS. COOPER: Susan Cooper with SAIC.

I think with respect to interaction with ATHEANA, there are certainly two different ways. Already, we're trying to incorporate some symptoms, if you will, of culture and some of the preparation for doing ATHEANA. We'd like the utility people to try to examine what are their pre-operational problems as part of identifying what their informal rules or maybe some things that are, if you will, symptoms of a culture that, when they play it out through a scenario development and deviations, it would be organizationally-related, but we don't have what we see from some of the events, some of the other things that the organization can do that might set up a scenario, so we recognize that there may be some pieces missing, and we certainly need some kind of input to know not only what -- you know, what from the organization is going to cause things but then also, then, what is the impact on the plant? There are a couple of different pieces.

DR. APOSTOLAKIS: Now, if just for a couple of historical purposes, we go to the previous one, no, yes; box four, collect and analyze data, that was essentially the reason why one of the earlier projects on organizational factors funded by this agency was killed. The proposed way of collecting data was deemed to be extremely elaborate. They implemented it at Diablo Canyon, and the utility complained.

So, there is this additional practical issue here that you have to do these things without really --

DR. POWERS: I don't know why.

DR. APOSTOLAKIS: Dana's commentary here, I mean, certain things, by their very nature, require a detailed investigation. I mean, I don't know where this idea has come from that everything has to be very simple and done in half an hour, but I think it's important to bear in mind that the utility complained, and the management of the agency decided no more of this. I'm willing to be corrected if anybody knows any different, but that was my impression.

MR. SORENSON: Well, and we'll touch on that one --

DR. APOSTOLAKIS: Okay; sorry.

MR. SORENSON: -- a little in a couple of slides, as a matter of fact, but you're right: one of the results early on was that people did try to look for non-intrusive ways to collect data. One possibility is to look at the way the organization is structured, which you can deduce from, you know, organizational documents, if you will.

DR. APOSTOLAKIS: Yes, but the attitudes, you would never get that.

MR. SORENSON: You don't pick them up and --

DR. APOSTOLAKIS: These attitudes, you don't pick that up.

MR. SORENSON: And interestingly enough, the people that started down that path after a few years started to pull in something that they called culture, the way an organization worked.

Yes; I will, time-permitting, go through at least one example that sort of traces through those boxes, if you will. I would like to comment on the upward path on slide 16. The -- what you would really like to do is to be able to identify some number of performance indicators that were indicative of the safety culture elements and that you could translate, in turn, into modifications of the PRA parameters, and the idea there is if you can identify those performance indicators, then, you don't have to go back and do the intrusive measurements once you've validated the method.

And so, in the best of all possible worlds, you know, one would, you know, have processes that follow that upward path. Now, I would hasten to add in summarizing on this figure that there is a lot that goes on inside every one of those boxes, and, in fact, when I was discussing this with Joe Murphy -- I guess he's not here today -- and at one point, we pointed at one box in particular, and I asked him a question about it, and he said, well, of course, in that box, miracles occur, and that's still --

DR. APOSTOLAKIS: Did he also tell you that there's a NUREG from 1968 whose number he remembered that addresses it?

[Laughter.]

DR. APOSTOLAKIS: I mean, Joe usually does that.

[Laughter.]

DR. APOSTOLAKIS: PNL published a report in 1968 in March --

[Laughter.]

DR. APOSTOLAKIS: -- that is relevant.

MR. SORENSON: So the -- anyway, the summary here is that this path is neither short nor simple.

DR. APOSTOLAKIS: Yes.

MR. SORENSON: There are a lot of pieces that go into establishing a relationship between safety culture or other management and organizational factors and some risk metric.

Let me see what we might need to do here. How much time do you want to leave for discussion, George?

DR. APOSTOLAKIS: Well, you are doing fine.

MR. SORENSON: Okay.

DR. APOSTOLAKIS: I think people can interrupt as they see fit.

MR. SORENSON: Okay.

DR. APOSTOLAKIS: So, you're doing fine.

MR. SORENSON: What I'd like to do now is go through some of the boxes and some examples of some work that has been done referring back to figures 15 and 16. As the figure indicates, the process starts out somehow with a model of the organization you're interested in, and my conclusion as a layperson was that you can look at essentially the way an organization is structured; the way it behaves or its processes or some combination of those things.

If you look at slide 18, this was an attempt to look at structure only. The work actually started at, I believe, Pacific Northwest Laboratories and was continued by the same investigators, although at different places, over the next several years, and here, they attempted to look strictly at what they could deduce from the way the organization described itself, if you will. It does not involve culture. If you look at the literature referenced by these folks versus the literature referenced by organizational culture people, it's a different body of literature. There's very little cross-referencing.

This was designed to be non-intrusive. It has an obvious difficulty right up front, and that is that there are a lot of factors to try to correlate. They made an attempt to correlate with things like unplanned scrams, safety system unavailabilities, safety system failures, licensee event reports and so forth. There was other work sponsored by the NRC that began at, I believe, at Brookhaven; Sonia Haber and Jacobs and others, not all at Brookhaven, I would hasten to add, and this was a slightly different perspective on the same thing. They came up with 20 factors that included something they called organizational culture and safety culture, and this was the -- where the -- one where the data gathering, if you will, did become very intrusive. They made up surveys and went out and talked to a bunch of plant people and shadowed managers and so on and so forth, and they probably got pretty good data, but it was not an easy process.

Then, there is another process developed by -- I was going to say that eminent social psychologist.

DR. APOSTOLAKIS: I would like to add that Mr. et al. is here.

MR. SORENSON: Yes, good.

DR. APOSTOLAKIS: His first name is et; last name is al.

[Laughter.]

DR. APOSTOLAKIS: We call him Al.

MR. SORENSON: Anyway, one of the contributions here was to reduce the 20 factors to half a dozen, which makes the process more tractable, if you will, but it's a little different also in the sense that it focuses on the work processes of the organization and how those are implemented, and, in fact, the next figure, I believe, is an example of their model of a corrective maintenance work process, and the analysis includes looking at the steps in the process and identifying the -- what they call barriers or defenses that ensure that an activity is done correctly, and you can map these activities back onto the earlier list of six attributes, if you will, to determine the relationship between the organization and the work processes.

DR. APOSTOLAKIS: One important observation, though: these six are not equally important to every one of these. This is a key observation. For example, goal prioritization really is important to the first box, prioritization of the work process, whereas technical knowledge, for example, means different things for execution and different things for prioritization. So that was a key observation that Rick made on the factors that Haber and others proposed to deal with the work process. Then, it meant different things than he proposed.

And most of the latent errors of some significance were the result of wrongful prioritization. That is, we will fix it at some time, when it breaks; unfortunately, it breaks before you could --

MR. SORENSON: Okay; moving on to the next box in the activity diagram, coming up with some way to measure safety culture or whatever organizational factor you are concerned with, there is, you know, the obvious candidates: document reviews, interviews, questionnaires, audits, performance indicators. But I think the thing that struck me here is that regardless of what list of safety culture attributes you start with, in this process, you're going to end up with some questions that you hope represent those attributes in some way, so when you get done, you don't have just, you know, a direct measurement of organizational learning; you have answers to a set of questions that you hope are related in some way to organizational learning.

DR. POWERS: The difficulty in drafting the questionnaire that gives you the information that you're actually after must be overwhelming. I mean, the problems that they have on these political polls, they can get any answer they want depending on how they construct the question. I assume that the same problems affect the questionnaires.

MR. SORENSON: I would assume so, but this is also to assume what psychologists -- the organization --

DR. APOSTOLAKIS: Never rely on one measuring instrument.

MR. SORENSON: Would anybody like to comment on the difficulty that goes on within that box?

DR. APOSTOLAKIS: It's hard.

MR. SORENSON: It's hard.

DR. POWERS: That's a separate field of expertise, formulating questionnaires, is it not? I'm really concerned that you asked too much to be able to formulate a questionnaire that allows somebody to map an organization accurately when you have this difficulty that I can get any answer that I want depending on how I construct the questions.

MR. SORENSON: Of course, part of the way round that is -- well, there are ways of designing questionnaires so that the same question gets asked six different ways, and you can check for consistency and poor wording.

DR. POWERS: What do you do when they're inconsistent? Do you throw it out?

MR. SORENSON: That's what you pay psychologists for.

DR. POWERS: I mean, I don't see that you're out of the game here. I mean, I had enough to do with employee opinion poll taking and what not that it's been known that there is a culture or a discipline doing these things, and there are well-known principles, like the second year of the employee opinion poll, the results are always worse than the first year; the people filling out the questionnaires have gotten better at filling out questionnaires, so they can be more vicious in their evaluations. I mean, it just strikes me as a flawed process.

MR. SORENSON: Well, I think part of the answer to that is you try to measure enough things that if your measure is flawed on one or two or three of them, you can still get the -- an indication of the attribute that you're really trying to measure.

DR. SEALE: It's interesting, because so many organizations now have been convinced that their organization has to be a participatory autocracy, and so, they ask these questions in the questionnaires, and as you say, they deteriorate almost invariably, but they also systematically ignore the results, so that --

[Laughter.]

DR. SEALE: But, you know, in the name of, as I say, participatory autocracy, they do it.

DR. POWERS: I am intimately familiar with one organization who is absolutely convinced that the fact that they conducted a questionnaire on a particular aspect of behavior excuses them from ever again having to attend to that.

[Laughter.]

DR. APOSTOLAKIS: Why didn't you include the behaviorally anchored rating scales?

MR. SORENSON: I didn't intentionally exclude it. I didn't see it as different from -- in a process sense from what's here. I may have misread that.

DR. APOSTOLAKIS: Anyway, okay, that's another of the instruments that's available.

But let's go.

MR. SORENSON: Okay; selecting external safety metrics: I mentioned that briefly earlier, you know, one can rely on performance evaluations, performance indicators, do some sort of expert elicitation to evaluate the organization. In some industries, which we'll touch on in particular, process in aviation, actually, I have accident rates that you can use as a metric, where there is good statistical data on accident rates. But again, the point

I'm trying to make here is that the investigator chooses that as part of the evaluation process, and sometimes, that is lost sight of.

In the chemical industry, process industries in particular, they tend to use the audit techniques. They don't have the same reluctance to gather field data that seems to exist in the nuclear power business. They tend to use the terminology safety attitudes and safety climate versus safety culture, and the studies that I've looked at used either self-reported accident rates or what they call loss of containment accident rates, you know, covering relatively large numbers of facilities. One study covered, I think, 10 facilities managed by the same company, for example; 10 different locations.

And these studies in the process industries have resulted in very strong statistical correlations between the attributes of safety culture that we've been talking about here and accident rates, and you can show that the low accident rate plants, you know, show strong safety culture attributes. The typical correlation they might start out with, you know, 19 or 20 attributes as the Brookhaven people did and find out that 14 or 15 of those correlate and five don't for some reason.

DR. SEALE: Jack, how much of that, though, is due to the fact that the elements of positive numbers on the accident rate are the inverse or one minus the numbers on the safety culture? I mean, they're almost -- the way you characterize your safety culture almost certainly is painted by the idea that one of the worst things that can happen to you is an accident.

MR. SORENSON: Well, certainly, you've got to look at how the measurement is done. I don't have a quick answer.

DR. SEALE: No, I mean, what if you had just for instance or just for the fun of it, let's say we had two plants, and both of them didn't have any accidents; one of them had a good safety culture and one of them didn't. I don't know if your questionnaire would actually detect or make that distinction.

MR. SORENSON: In that case, I think you're absolutely right, but precisely the point I'm trying to make here is that in this case, we are not looking at plants with zero accident rates. We're looking at plants that have very low accident rates and very high ones.

DR. SEALE: Yes.

MR. SORENSON: So we've got statistics here that we don't have in the nuclear power business. The ratio of the best performing to the worst performing in terms of accident rates is typically about 40, the factor is. And, in fact, I'll come back to that later. The reason that one of these folks makes the point is in aviation --

DR. APOSTOLAKIS: PSA is one minus the -- you know, that's my problem.

MR. SORENSON: The aviation business, which presumably uses roughly the same equipment and roughly the same training methods worldwide for commercial passenger airlines, there's a difference of about a factor of 40 between the best and worst performing airlines.

DR. SEALE: Yes.

MR. SORENSON: So the point here is precisely that in those areas where you've got data, you can correlate these safety culture elements, if you will.

Which brings us to, you know, the areas of weakness or discomfort, most of which have been touched on here earlier. One of them is that at this point, nobody pretends to understand the mechanism by which the thing we call safety culture affects operational safety. Second area was what you just touched on, Bob. There is a lack of valid field data in the nuclear power business in particular. First, the actual accident rates are low, but there's even a lack of data on the safety culture side in general.

And the third area is there are no good performance indicators that have been identified at this point; clearly an area that needs additional attention, not only in the nuclear power business.

DR. BARTON: I think you're looking at too high a level for the field data to be looking at accidents. I think you don't have to look at accidents. Go look at lower levels of performance in the organization; go look at industrial safety events. Go look at human performance or look for operator errors. Go look at maintenance people not following procedures.

If you go look at a whole bunch of those things and relate that, you'll find out that the culture is different at that plant than it is at the other plant that hasn't had a major accident either but doesn't have the same numbers of those types of --

DR. SEALE: You could probably use LERs just as easy of that.

DR. APOSTOLAKIS: Or any number of attributes --

DR. BONACA: The trouble with LERs is there are not enough LERs written. These plants write three or four LERs a year. I don't know if there's enough data there.

DR. BARTON: Or whatever the correct level of --

DR. SEALE: Yes.

DR. BONACA: There are corrective action systems at the plants --

DR. SEALE: Yes, yes.

DR. BONACA: Because there are 20,000 inputs per plant.

DR. SEALE: Yes.

DR. BONACA: Probably, that's the biggest window that you have.

DR. APOSTOLAKIS: So you are saying that it would be perhaps worthwhile to see if some performance indicators can be formulated using this kind of evidence?

DR. BARTON: I think so.

DR. APOSTOLAKIS: Instead of going to models? That's a good idea.

DR. BARTON: Think about it.

DR. APOSTOLAKIS: It would be extremely tedious to go through those records.

DR. BARTON: Oh, yes.

DR. APOSTOLAKIS: But it would probably be worthwhile.

MR. SIEBER: A lot of plants.

DR. POWERS: You can find people within an organization oftentimes who know those records surprisingly well. If you have a lot more, then it's a lot easier.

DR. BONACA: I mean, an example of performance indicators at IAEA and all places, one could ask whether or not they should be nine or whatever. But have they had those elements that were --

DR. SEALE: They weren't accidents.

DR. BONACA: No, incidents.

DR. APOSTOLAKIS: But that is a necessary assumption that this really is a good indication of what will happen if there is a need for an ATHEANA kind of system, but it may be very good when it comes to a major -- when they pay attention. In fact, we had a guy call maintenance people; more than 50 percent, to my surprise, thought that the procedure was useless; they never followed them. They thought they were for idiots.

Now, those guys probably are very good, but if you are blind, you say oh, they don't use the procedures; my God, bad, bad boy. Yes; they're probably doing a better job than somebody else who goes with --

DR. BONACA: Even there, that's another issue.

DR. APOSTOLAKIS: So I think there is this presumption, although I like the idea, because at least you get something concrete, but maybe that's something else to think about: how much can you extrapolate from these fairly minor incidents, because there is this -- Jack didn't mention, but people also distinguish between the formal culture and the informal culture, the way things really get done. And do they take shortcuts? They do all sorts of things. And these are good people usually. I mean, they're not -- but I think that's a good idea. It's a good idea. It's just that, I mean, they have -- you know, whenever anybody proposes anything here, you have to say something negative about it. So, there it goes.

Alan, you have to come to the microphone.

MR. KOLACZKOWSKI: Alan Kolaczkowski, SAIC.

George, that's the very reason why, in the ATHEANA part, I think we're looking at both the EOPs and the formal rules, but then, you saw we also look at tendencies and informal rules.

DR. APOSTOLAKIS: Right.

MR. KOLACZKOWSKI: That's where we're trying to capture some of those -- part of the culture, if you will: how do they really do it? What are the ways they really react when this parameter does this? What are their tendencies? I think we're trying to capture some of that. We use the terminology informal versus formal rules, but I think we're talking about the same kind of thing.

DR. APOSTOLAKIS: Yes.

MR. SORENSON: By the way, though, not all investigators agree that let me call them near misses or incidents extrapolate properly to accidents.

DR. APOSTOLAKIS: Yes, you have to make some assumptions.

MR. SORENSON: And also, the people who question that also question whether the human performance information or models in the nuclear business translate to those in other hazardous industries. That's not a given.

DR. APOSTOLAKIS: Go ahead.

DR. SEALE: But the point may be, though, that the extent to which the organization has the capability of absorbing near misses in such a way that they do not propagate to major accidents may be the thing that's the measure of safety culture.

MR. SORENSON: Well, Reason would agree with that very precisely, because his definition of safety culture, you know, is, in effect, that culture which leads to a small incidence of latent errors that go undiscovered. And it's the latent errors that translate, you know, a single unsafe act into a disaster.

DR. SEALE: And then, but the ability to correct for the error in other parts of the organization so that it doesn't grow --

MR. SORENSON: Right.

DR. APOSTOLAKIS: But I think another measure of goodness which is really objective is to see whether they actually have work processes to do some of these things. Rick is working with -- Rick Weil is trying to develop organizational learning work. So what you find is that yes, everybody says, boy, organizational readiness, sure, yes, we do that. But how do you do it? And that's where he gets stuck. We do it. Somehow, we do it. There is no work process; they have no formal way of taking a piece of information, screening it, because that's the problem there: they get too many of those.

DR. BARTON: How many do they get a week or about a year?

DR. APOSTOLAKIS: About 6,000 items a year; I mean, here, you're not going to be producing power just to study 6,000 items.

[Laughter.]

DR. BARTON: I hope not.

DR. APOSTOLAKIS: So there is no formal mechanism for deciding what is important, which departments should look at it, and I think that's an objective measure.

DR. BARTON: Yes, it is, because you can prioritize those 6,000.

DR. APOSTOLAKIS: But they don't.

DR. BARTON: You can put them in buckets. Well, I know plants that do.

DR. APOSTOLAKIS: I'm sure; and those have a better culture.

DR. BARTON: I don't necessarily agree with that.

[Laughter.]

DR. APOSTOLAKIS: All right; no, but it is an objective measure of the existence of the processes themselves. It is a measure of some attempt to do something.

DR. BONACA: But it is also a measure of the way the work is getting accomplished or not accomplished that gives you some reflection on potential initiators. For example, a process that is overwhelmed that is unable to accomplish work on a daily basis, something is going to happen out there, because we're starting an item; you are closing it. You're delaying items, and something is going to start in a new activity before you close the other one at some point.

And so, if you look at that, you have a clear indication, and we're trying to begin to correlate that. So you have some indication of really what kind of a story. Now, the question is are they going to affect the unavailability of a system? See, we don't know that.

DR. APOSTOLAKIS: It may, but -- but there is something to the argument that -- not just nuclear. But it seems to be consensus of organizational learning is a key characteristic of good organizations. Now, if I see that, I really don't need to see real data to prove that. I mean, those guys are not stupid. They know what they're talking about. And, in fact, I remember there was a figure from a paper in the chemical, whatever; it was a British journal, comparisons of good organizations, excellent organizations. The key figure that distinguished excellent from everybody else was this feedback loop, organizational learning, from your own experience and that of others, and it's universal.

Anyway, let's have Jack continue. He's almost done, I understand.

MR. SORENSON: Yes; there are a couple more slides here, and I did want to touch on what we've just been discussing, you know, the evidence that a safety culture is important to operational safety. There is an overwhelming consensus among the investigators; if there is a subculture that thinks an attitude doesn't matter, I didn't find it in the literature in any event.

The accident rate data is pretty convincing. I confess obviously to not being an expert, but the writing, again, supports that. People outside of the field seem to think they have good statistical information there. And the little bit of nuclear power plant field data that there is, some of what the Brookhaven people did, Hauber and her colleagues and the little bit that was done in the Pacific Northwest Laboratory work confirmed a correlation between safety culture elements and operational safety as they defined it. There are not enough data, but what's there was positive.

I'm going to, on the last slide, relate my impressions again as a non-practitioner as to what is missing from the literature. Some of this, I've deduced from what other people have written and some just from my own feelings on the papers that I review. There is a lack of field data relative to nuclear power plant operations. There might be easy ways to get it, but right now, it's not there.

One needs to understand the mechanism by which safety culture or other management and organizational factors affect safety. We need performance indicators for safety culture or related things. We need to understand the role of the regulator in promoting safety culture, and we need to know something about the knowledge, skills and abilities of the front line inspectors in a regulatory environment where safety culture is important. One of the things that struck me in doing the research on this work is that we are -- we, the NRC -- are right in the middle of attempting to change the way we do regulation. We are embarking on and evaluating a new reactor oversight process. We are trying to convert our regulatory basis to something we're calling risk-informed and maybe performance-based, and other regulators elsewhere in the world, particularly in the UK, are observing that. If one is going to make this kind of a change, then you probably cannot do it within the kind of prescriptive regulatory framework that the U.S. is using at the moment.

That being the case, something called safety culture and how one fosters it becomes very important relative to the new regulatory process that we are expecting to implement. There is certainly a reluctance on the part of the NRC to, you know, venture into anything that would smack of regulating management and an even stronger reluctance on the part of the industry to, you know, allow any small motion in that direction, but it seems to me that in the context of this new regulatory regime, that management is terribly important, and at a minimum, the agency needs to understand in what ways is it important, and how does the agency best foster this ownership of safety amongst its licensees, and I don't think we know that right now.

That's all I have.

DR. APOSTOLAKIS: Yes; the big question is really what is it that a regulator can do without actually managing the facility. That's really the fear.

Dennis Bley, please?

MR. BLEY: My name is Dennis Bley. I'm with Buttonwood Consulting. I have to leave in just a minute --

DR. APOSTOLAKIS: Sure.

MR. BLEY: -- so I thought I would say a couple of words quickly. The last 5 years, I've been on the National Academy committee overseeing the Army's destruction of chemical weapons, and the program manager for chemical weapons destruction has sponsored a lot of digging into this area, and I think maybe they would be willing to share what they've found.

We've had people on our committee from DuPont, and, you know, the strong view from DuPont, coming back to what you were talking about earlier, is that if you get the little things under control, the industrial accident rates, those things, you won't have a bad accident. A lot of people don't believe that. They do very strongly. Jim Reason's book you were talking about, I think the last chapter, tenth chapter, he goes into that in some detail.

I kind of think from NRC's point of view, it gets difficult, because the expertise the Army has brought together to help them look at this in many places has all argued strongly that strong regulation and compliance don't get you where you want to be with respect to safety; it has to be the individual organization taking ownership, and all the way through, certain things are unacceptable, certain kinds of behavior are unacceptable by anybody, and that has to get buried into the whole organization.

Just an aside on ATHEANA, it would be -- where you pointed out where they would fit together, I think that's about right, and we've actually got, if you look at some of our examples, a little of that coming in but nothing like a real solid process for trying to find all of it. But I think you can -- there has been so much work in this area by so many different people, including studies in industrial facilities, that it probably doesn't make sense to do it all over again.

But I'll just leave it with that. That's the one source I've seen where people have -- they've really tried to draw a broad range of expertise together to help them with the problem, which they haven't solved.

DR. APOSTOLAKIS: I believe the fundamental problem that we have right now is that people understand different things when the issue of culture is raised and so on. There was a very interesting exchange between the commissioners and the Senators. Senator -- I don't remember; Inhofe?

DR. SEALE: Inouye?

DR. APOSTOLAKIS: No, no, no.

DR. SEALE: Inhofe, yes.

DR. APOSTOLAKIS: He was told by Former Chairman Jackson something about -- it was somebody else; not the chairman about culture and organizational factors and boy, he said I've never heard -- he said I'm chairing another subcommittee of the Senate where we deal with Boeing Corporation and all of those big -- and I've never heard the FAA trying to manage the culture at Boeing and this and that, and how dare you at the NRC think about that?

And then, of course, we have our own commission stopping all work, you know, overnight a year or so ago, and I think it's this misunderstanding; you know, I really don't think it's the role of the regulator to go and tell the plant manager or vice president how to run his plant. On the other hand, there are a few things that perhaps a regulator should care about. I don't know what they are, but for example, the existence of a minimum set of good work processes, in my opinion, is our business, and especially if we want to foster this new climate that I believe both Dennis and Jack referred to. In a risk-informed environment, some of the responsibility goes to the licensee. Now, we are deregulating electricity markets and so on, so that's going to be even more important.

But I guess we never really had the opportunity to identify the areas where it is legitimate for a regulatory agency to say something and the areas where really it is none of our business, and it's the business of the plant. And because of the fear that we are going to take over and start running the facility, we have chosen to do nothing as an agency.

DR. SEALE: Well, that goes to the question of where is it we ought to butt out? Where should we butt out? What are the things that we do that are counterproductive?

DR. APOSTOLAKIS: Absolutely right; absolutely right.

DR. BONACA: But again, I think if you want to talk about culture, management up there, it's very, very hard, and again, we're struggling with looking at an indication of an organization that works or doesn't work. At the industrial level, there are indications all over the place. But those indicators have to do with does the work process work, for example? Is the backlog that people perceive they have overwhelming them? What kind of -- absolutely. And again, there is work that is being done inside these utilities to look at those indicators there, and they don't even measure management per se; simply something is wrong with the organization. When you have something wrong with the organization, you go to the management, and you change it, because you expect that you will be able to manage that.

But I'm saying that it's probably feasible to come down to some of these indicators, and I think that the utilities are trying to do that.

MR. SIEBER: I would sort of like to add: I've been to some regional meetings for clients of mine where the plants have been having problems, where the regional administrator or his staff has asked questions about performance indicators on productivity, and for example, a lot of these processes are just a bunch of in-boxes, you know, like your work process. Which one is the in-box that has big holes in it? Why isn't work getting done? I've seen the NRC ask those questions. I think they're legitimate questions, and on an individual basis, I think that they're appropriate questions, but I have not seen an initiative to ask them across the board.

DR. BARTON: They all do relate to cultural issues.

MR. SIEBER: That's right.

DR. POWERS: Yes.

MR. SIEBER: Each one of them by itself is an indicator, and I think industrial safety is a prime indicator. You know, if you --

DR. BARTON: If it wasn't, they wouldn't spend so much time looking at it.

MR. SIEBER: Yes, and we actually hired DuPont, who is very good, to help us with ours, and our record, our accident rates, went down by over 90 percent. I mean, it actually worked, and that's part of the culture. If you can't make yourself safe, how can you make a power plant safe?

DR. BARTON: There are things you can look at without really getting into the management, so to speak, of the company. I think you have to draw that line, because the industry is going to get nervous as heck. They're just going to say -- they'll start looking at the safety culture and management's confidence and all that stuff. I think there is a set of things that you can look at objectively and determine what is the culture of this organization. You just have to figure out how to package it.

DR. APOSTOLAKIS: That's the problem.

DR. BARTON: How to package it.

DR. APOSTOLAKIS: That's the problem.

DR. BARTON: Expect that if you're looking at a bunch of indicators right now that I would tell you would fit into a box called culture. Look at it right now.

DR. BONACA: Well, I mean, again, there have been efforts; I've been participating in one, and I believe that if you look at other people who do it, they're finding out the same points. Now, again, you're going down to opinions for objective readings of certain boxes of work being accomplished or not accomplished.

DR. BARTON: And that's the problem. It's what you can do when you take this data, and you get it back to the region, and that's where people really get nervous now.

DR. BONACA: But I was talking about trying to correlate, for example, working efficiencies of backlogs, actual outcomes that you can measure somewhat for using PRA. That's -- I mean, that's probably something that you can do.

MR. SIEBER: One of the problems is that the boxes from plant to plant are not standardized. The thresholds that differ from plant to plant. So interplant comparisons are not very accurate. On the other hand, you know, something is better than nothing. And that's what plant managements use to determine the state of culture and how safe they are and how safe they aren't and how well their processes work. That's how you run the plant.

DR. POWERS: One of the things that I find most troublesome right now is taking the DuPont experience, and this attitude I hear all the time, the Mayer approach toward safety; you take care of all the little things, and the big things will take care of themselves versus we want to focus on the most important things in risk assessment. We seem to be dichotomizing opposite views. I'm wondering if we really want the outcome we're going to get going to risk-informed.

DR. SEALE: I'm not so sure.

DR. POWERS: It seems like it's worth thinking about, because these things have been very successful in another industry.

DR. SEALE: The thing, though, is that the things that are getting ruled out, if you will, on the basis of not contributing to risk are not the little things that show up in the plant performance things. They're truly the -- they're the not even on the radar screen things. At least that's my impression. It's a good point, but I don't think you're talking about the same population when you say risk versus low risk on the one hand and little things versus big things on the other hand.

DR. APOSTOLAKIS: Anyone from the staff or from the audience want to say anything?

[No response.]

DR. APOSTOLAKIS: Okay; any other comments?

[No response.]

DR. APOSTOLAKIS: Thank you very much. We will adjourn. So, this meeting of the subcommittee is adjourned.

[Whereupon, at 3:10 p.m., the meeting was concluded.]

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This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

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