Official Transcript of Proceedings ACRST-3254

NUCLEAR REGULATORY COMMISSION

ORIGINAL

Title: Advisory Committee on Reactor Safeguards Reliability and Probabilistic Risk Assessment and Human Factors Joint Subcommittees

Docket Number: (not applicable)

PROCESS USING ADAMS
TEMPLATE: ACRS/ACNW-005

Location: Rockville, Maryland

Date: Thursday, October 9, 2003

Work Order No.: NRC-1119

Pages 1-395

NEAL R. GROSS AND CO., INC.
Court Reporters and Transcribers
1323 Rhode Island Avenue, N.W.
Washington, D.C. 20005
(202) 234-4433

TR04

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

+ + + + +

JOINT MEETING OF THE

RELIABILITY AND PROBABILISTIC RISK ASSESSMENT

SUBCOMMITTEE

AND

HUMAN FACTORS SUBCOMMITTEE

+ + + + +

THURSDAY,

OCTOBER 9, 2003

+ + + + + +

ROCKVILLE, MARYLAND

+ + + + +

The Committee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dr. George A. Apostolakis, Chairman of the Reliability and PRA Subcommittee, and Stephen L. Rosen, Chairman of the Human Factors Subcommittee, presiding.

COMMITTEE MEMBERS PRESENT:

GEORGE E. APOSTOLAKIS, Subcommittee Co-Chair
STEPHEN L. ROSEN, Chairman, Subcommittee Co-Chair
MARIO V. BONACA, ACRS Chairman
WILLIAM J. SHACK, Member
JOHN D. SIEBER, Member

ACRS STAFF PRESENT:

MEDHAT EL-ZAFTAWY, ACRS Staff
MICHAEL R. SNODDERLY, ACRS Staff

ALSO PRESENT:

STEVEN A. ARNDT, DET/RES
SUSAN COOPER, PRAB/RES
MARK CUNNINGHAM, Acting Dep. Director, DRAA/RES
MICHELE G. EVANS, Branch Chief, ERAB/DET/RES
JOHN FLACK, Branch Chief, REHFB/RES
DAVID GERTMAN, INEEL
ERASMIA LOIS, PRAB/RES
ANDREW J. MURPHY, DET/RES
PATRICK D. O'REILLY, OERAB/RES
J. PERSENSKY, REHFB/RES

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

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

(8:30 a.m.)

CHAIRMAN APOSTOLAKIS: The meeting will now come to order.

This is the joint meeting of the Advisory Committee on Reactor Safeguard Subcommittee and Reliability and Probabilistic Risk Assessment and Human Factors.

I'm George Apostolakis, Chairman of the Subcommittee on Reliability and PRA.

Members in attendance are Steve Rosen, Chairman of the Subcommittee on Human Factors; Mario Bonaca, Chairman of the ACRS; William Shack and Jack Sieber.

The purpose of this meeting is to discuss seismic, digital I&C, and human factors research activities, with representatives of the Office of Nuclear Regulatory Research. The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for the deliberation by the full committee.

Michael Snodderly is the Designated Federal Official for this meeting.

The rules for participation in today's

meeting have been announced as part of the notice of this meeting previously published in the Federal Register on October 1st, 2003.

A transcript of the 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 regarding today's meeting.

Now, there are a couple of things I have to announce. An evacuation drill is to take place this morning. The drill is most likely to occur between 10:00 and 11:00 a.m. and is expected to last one hour. All occupants of this room are expected to evacuate, including members of the public.

Members and staff of the ACRS are to assemble in the area designated for the ACRS in the driveway between Eatzi's and Two White Flint North building.

To lessen the impact of the drill on today's presentations, I suggest that the seismic

presentation end at 9:30 a.m., and we will immediately begin the digital I&C presentation until 10:00 a.m.

After the drill we'll continue the digital I&C presentation until noon.

Thank you for your cooperation with this matter.

And now we will proceed with the meeting, and I call upon Dr. Murphy of the Office of Research to begin.

MS. EVANS: Good morning. My name is Michele Evans. I'm the new Branch Chief in the Engineering Research Applications Branch in the Division of Engineering Technology, and you know Dr. Andrew Murphy. He is here to give you an overview of the work that we're doing in the area of seismic research.

Thank you.

DR. MURPHY: Good morning. This morning's presentation will follow the outline that I have on the board. We'll first start with a discussion of the contribution --

CHAIRMAN APOSTOLAKIS: Excuse me. Can you move over there? Because you're really blocking this.

DR. MURPHY: Sure.

CHAIRMAN APOSTOLAKIS: With the computer and all of that. Sorry, Andy.

DR. MURPHY: No problem.

CHAIRMAN APOSTOLAKIS: This will be much better for everyone.

DR. MURPHY: Yes.

CHAIRMAN APOSTOLAKIS: You should become a quantum wave.

PARTICIPANT: We're good seeing through things.

CHAIRMAN APOSTOLAKIS: Okay.

DR. MURPHY: We'll keep that in mind. Now, let's see. Where was I?

This morning's presentation will start off with a discussion or mention of the contribution that the seismic program has been making to the performance goals of the NRC.

I will then touch on the activities in your science area; research and regulatory guide that we're producing; then the earthquake engineering program; and then talk about the continuing and emerging issues in this area.

The first slide mentions the contribution that the program is making to the

performance goals of the NRC. The basic products that we are looking at in the short term from this program include an update of the seismic hazard, calculations and estimates that are available and are used in Regulatory Guide 1.165 to go along with the update of the seismic siting criteria, the regulation that was formerly Appendix A and is now Part 100.23.

The importance of the new contributions from the seismic hazard and from the regulatory guides that are also part of the product goes to the regulatory realism of the program.

CHAIRMAN APOSTOLAKIS: But, Andy, when you say this, are you implying that the decisions that the NRC has been making have not been effective, efficient, and realistic?

DR. MURPHY: No, we go back over here to this word here.

CHAIRMAN APOSTOLAKIS: More.

DR. MURPHY: We're talking about more, more realistic than they have been in the past, more effective, and hopefully also more efficient.

We're looking for the same kind of contribution on the stakeholder side of the fence where we're talking about guidance to principally

the applicants that is more effective and more realistic and hopefully also more efficient in the process as well so that we will have better decisions and better licensing.

The next slide outlines the five major elements at this stage of the earth science program. We have an ongoing relationship with the U.S. Geological Survey, the University of California at Santa Barbara for some ground motion work. We're talking about updating the probabilistic seismic hazard estimates and the codes and data that are available for that.

We have two small issues associated with the hazard code validation benchmarking that has been carried out, and a cooperative program with the IAEA on earthquake ground motions.

Then I will also touch then on the regulatory guides that are currently in the pipeline and one that's somewhat downstream from completion at this stage.

What are we doing with the U.S. Geological Survey? We have a quarter to a third of a million dollar program on an annual basis with the Geologic --

CHAIRMAN APOSTOLAKIS: How much is this?

What are you saying?

DR. MURPHY: I said we had a 250 to $300,000 annual program with the U.S. Geological Survey here we go to them on an annual basis and indicate to them the issue areas where we have concern. They develop a proposal for us, and we come back and select between the items that they have suggested.

Generally we are paying probably ten cents on the dollar for the programs and for the information. What our intention is to do is to influence the way the Geological Survey thinks about earth hazard. Their principal concern is for the general public, if you want to say standard construction, standard hazards. We're interested in getting them to look at the differences between standard construction and nuclear construction and the difference between the hazards for standard construction and for nuclear construction.

At this stage I've got four of the current programs listed here. We've run between six and eight programs a year funded, again, probably about the 30 to $50,000 level for each of the individual projects.

The first one that we listed there is an

aerial screening of the liquefaction hazards. This is particularly in the New Madrid and the Southeast United States area where the survey is looking at special areas and trying to characterize them using standard engineering techniques, such as the cone penetrometer test.

One of the other issues that we're looking at with them is false segmentation. We need to estimate the magnitudes of the earthquakes in the seismic source zones in order to come up with the appropriate seismic hazard estimates, and it's a critical question to decide how a fault will break. We have the San Andreas fault as a classic example, running basically the entire length of California, both on shore and offshore. If that fault broke at a single time, it would be a truly monstrous earthquake.

But in fact, the San Andreas fault breaks in segments, which still create very large earthquakes. There are other faults that we are aware of that have a tendency to break in segments, but occasionally they break as a through-going fault rupture so that we're interested in being able to understand the fault mechanics so that we can understand and predict whether or not a large fault

will break as a unit or will break in different segmentations.

This is a program the GS has had for a number of years, and we're basically making a contribution sufficient to allow the principal investigator to get into the field a few more months out of the year.

We're also looking at the reevaluation of the ground motion models for the central eastern United States, plus in Canada, to see if we can better characterize the ground motion that would be generated from a moderate to large earthquake in these areas.

Also with the GS we're looking at the recurrence and uncertainty in the occurrence of earthquakes in the central United States. There has been in the last several years a major rethinking of the occurrence of the New Madrid faults, the New Madrid earthquakes. In the past, it had been assumed and thought that these earthquakes were occurring on a thousand to several thousand year interval.

It appears now that they are occurring more often than that, maybe on a 600 year interval, but as a mitigating factor, folks are beginning to

think about the ground motion, and it appears that the ground motion is generated by these earthquakes are not as large as originally thought.

The reinterpretation of that information is feeding into the ground motion models that will be used for the seismic hazard calculations.

DR. SHACK: Andy, just coming back to this again, without your support are you saying that they wouldn't be looking at these areas?

DR. MURPHY: They would be looking at them I would say with a different pair of glasses, that we're getting them to look at things with our perspective so that they're looking at high frequency ground motions as it might induce a response in the nuclear power plant structures and how that would feed into high frequency components, such as switchgear and relays.

So we're influencing them, like I said, to look at them a little bit differently, looking at them with a nuclear problem, a nuclear industry perspective rather than just looking at them from the standard civil construction.

MR. SIEBER: When you talk about high frequencies, could you give me a range of frequencies so I could sort of --

DR. MURPHY: Sure. We're interested at this moment if some frequencies probably between seven and ten or 11 hertz.

MR. SIEBER: Okay.

DR. MURPHY: As I'll talk about a little bit later, the East Tennessee seismic zone and the problems that occurred down there or the issues that developed down there.

MR. ROSEN: Andy, we have a report by our consultants, Link Technology, that talks about one project which I'll read you the title of. It's GV, and I Don't know what that stands for -- well, maybe Garner Valley.

DR. MURPHY: Garner Valley.

MR. ROSEN: "Downhole Seismic Array Operational Analysis of Data."

Let me read you this what I think is a curious description, and it may be wrong. If so, just say so or maybe I invite Spyros of Link, who's here, to talk about it, too.

It says, "The University of California at Santa Barbara is to operate a multi-element array of downhole, strong motion accelographs in the seismicly active Garner Valley of California and is to analyze and interpret any strong motion

seismograms recorded."

So far so good.

DR. MURPHY: Right.

MR. ROSEN: "The site is representative of sites in Eastern U.S." Hello? Is that right?

DR. MURPHY: Yes.

MR. ROSEN: Why would the Garner Valley site in California be representative of sites in Eastern U.S.?

DR. MURPHY: Because of the soil column that's at Garner Valley. We spent a considerable time interacting with the Geological Survey and the folks at the University of California at Santa Barbara to find a site that had a soft, shallow soil column. This is the kind of column that we find at many sites in the Eastern United States.

That's where the --

MR. ROSEN: So they go all around the United States to find something representative of the East and found it in California?

DR. MURPHY: No, not quite.

MR. ROSEN: I hope that's not true generally.

MR. SIEBER: It's close to Santa Barbara.

DR. SHACK: It's like the eastern soil with a California frequency.

DR. MURPHY: Yes. The initial program was, again, looking at a site that had a soil column similar to what was available in the Eastern United States.

We also looked at the Geological Survey's hazard and forecast map. The Garner Valley site is immediately adjacent to a thing called the Anza gap, which is, like I said, a gap in the seismicity along the San Andreas fault.

There is a prevalent theory that the next earthquakes that are likely to occur on a major fault are where there is a paucity or a gap in the seismicity. And a number of years ago the Anza gap was identified by the Geological Survey. The Geological Survey has placed an array of instrumentation in this area with the hope of capturing a moderate to large size earthquake from that area.

We were following up on that same thought and worked with University of California at Santa Barbara and established a downhole array to look at strong ground motion propagation through a shallow soil column, i.e., something like the

Eastern United States.

MR. ROSEN: One more question. Where is Garner Valley? I mean, what big town is near Garner Valley?

DR. MURPHY: Define "big town" and I'll tell you.

MR. ROSEN: Salinas, Monterey, San Juan Baptista, Carmel.

CHAIRMAN APOSTOLAKIS: Is it near Santa Barbara?

DR. MURPHY: Palm Springs. It's over the mountains from Palm Springs. Does that help?

MR. ROSEN: Over the mountains from Palm Springs. Palm Springs sits in a valley in which there are amounts around it, I know.

DR. MURPHY: That's correct. And it's over the ridge to the southwest, I believe.

MR. ROSEN: Southwest of Palm Springs.

DR. MURPHY: Right.

MR. ROSEN: That's what I wanted to know.

DR. MURPHY: More south than west.

MR. ROSEN: Okay. Thank you.

CHAIRMAN APOSTOLAKIS: Now, you know, all of this work, especially the Geological Survey,

I understand that you want them to look at things from your perspective, but are there any regulatory decisions that are before the Commission or before the staff that would be supported by this research or is it just research that helps us understand what is going on so we keep abreast of developments and, you know, we are not falling back?

DR. MURPHY: One of the thing is very definitely keeping us abreast of what's going on, keeping us ahead of the millstone a little bit, but it is also making specific contributions to things that we have ongoing. The work that the Geological Survey has been doing with the occurrence of earthquakes I'll say in the central United States will definitely feed into what we're doing with the potential revision of the seismic hazard methodology.

The work that they have done on ground motion in the central and Eastern United States, I think, has had implications in my mind for some of the work that EPRI is doing or has just recently completed to support the early site reviews.

CHAIRMAN APOSTOLAKIS: But you say potential revision of the seismic hazard methodology. Is that for future plans? I can't see

us doing anything to the existing plan.

DR. MURPHY: That is correct. It is basically for future licensing activities. Now, there is always the potential issue that if something major is discovered -- at this stage we don't anticipate it -- that it could feed back into the existing operating facilities.

CHAIRMAN APOSTOLAKIS: Well, that's a badly removed --

DR. MURPHY: Yeah, no question about it. It is a fairly remote possibility, and most of what is going on now at this stage is looking forward to both new plants and potential modifications to facilities.

CHAIRMAN APOSTOLAKIS: But as I remember, you know, and you were involved in that, the seismic hazard analysis methodology that that committee looked at and so on, the major conclusion there was that the whole thing really relies on expert judgment and interpretation of response evidence and so on.

Would this information help that process?

DR. MURPHY: Yes, I think so.

CHAIRMAN APOSTOLAKIS: Or even get out

of the process completely? I doubt that.

DR. MURPHY: When we -- well, let me jump ahead a couple.

One of the things that we do have ongoing at this stage, we've started up, is an update of what we call the Shack, the senior seismic hazard analysis --

MR. ROSEN: No, this is the Shack.

CHAIRMAN APOSTOLAKIS: This is the Shack.

DR. MURPHY: This is the other Shack. This is the one that has difficulty spelling its name.

CHAIRMAN APOSTOLAKIS: The twists.

DR. MURPHY: Yes.

CHAIRMAN APOSTOLAKIS: This "Shack" has one S. He's suffering silently there.

DR. MURPHY: But he is making faces.

DR. SHACK: I've heard every variation of "shack" there is. Trust me.

(Laughter.)

DR. MURPHY: Okay. When we did the revision to Appendix A, the seismic siting rules, one of the things that the Geological Survey pointed out to us was that at this stage the seismic

knowledge, the knowledge of seismicity and various parameters in the Eastern United States was particularly still fairly rapidly evolving, and we agreed to and put into our Statement of Considerations to do a ten-year evaluation of where we are with the ground motion and propagation and so forth and its implications for the hazard calculations.

We have recently started looking at that, and at this stage that's an evaluation to see whether or not we need to do anything. Probably next spring or next summer when we make a decision on whether to go forward with a full-scale revision or not.

One of the things that we are looking at right now is the U.S. Geological Survey's national seismic hazard assessment, which was basically published or is in the process of being published now this fall.

MR. ROSEN: You've already concluded, I think, you told us that the New Madrid frequencies are up substantially.

DR. MURPHY: Yes. Part of the question is how much will that influence the final results. In the past we have looked at some specific areas,

such as the Wabash Valley northeast from St. Louis in Ohio, to see whether or not new information about that had significant influence on the seismic hazard calculations.

We looked at that as we are developing the new Rule 100.23, and it turns out that most of the information that was confirmed by field work was already basically in the minds of the experts. So that there was not a significant change in their opinion about it.

Now, take this as anecdotal information. I understand that the Clinton early site permit had some concerns about a new earthquake that was discovered, I believe, west of the Clinton site, and that in looking at ground motion propagation from that site, there are issues for Clinton or for an early site permit for Clinton, the Clinton site, but they had to go back and very carefully analyze, look at the information that was available.

I think it's part of the work that the EPRI ground motion panel had --

MR. ROSEN: So that raises the general question of when you find new information at or near an existing site that is also one that may have new plants put on it, how does one decide to use it (a)

in the new plant and (b) not in the old plant or in both plants or not at all?

DR. MURPHY: I'll say to some extent that's an NRR call, but my understanding, my interpretation at this stage would be that last year we identified an issue with the East Tennessee seismic zone, and that looked like the calculations for Watts Bar were increased. It looks like the SSE ground motion in Watts Bar maybe should be raised.

Okay. Research took a careful look at that, providing some information to NRR, indicating that the new hazard information for the Watts Bar site from the program that we were conducting, research was conducting, raised the response spectra for the Watts Bar site.

In the high frequency end -- this is where the seven to 11 hertz comes in -- there appeared to be an increase. There was an increase. The question that the agency had was whether or not that increase was to be an issue, was an issue.

We actually generated -- and, again, we're jumping ahead in the slides here -- we generated a generic issue associated with a generic issue GSI-194 that was recently reviewed, and the recommendation was to drop it at this stage because

the influence would have been, again, in the high frequency area, the relays and switchgear kinds of things.

And seeing as how the plant had just recently gone through the IPEEE review and those items were looked at, it was decided it was not an issue that needed to be pursued at this stage. It was dropped.

If you want to say, we have it on part of the back burner with the Shack update as that comes along, to bear in mind as to whether or not the information that was developed for the East Tennessee seismic zone would have implications for the Watts Bar site and other sites in the southeastern United States.

MR. ROSEN: Was that an answer to my question?

DR. MURPHY: I'm not sure.

MR. ROSEN: It was interesting.

DR. MURPHY: I understand I started babbling. Would you hit me again with your specific question?

MR. ROSEN: Well, the specific question is when you find new information at a plant site, about a plant site that already had a unit on it,

which may also be considering a new unit, you have three choices: to ignore it, period, for both plants; to apply it to both plants, the old one and the new one; or to apply it only to the new one. There's a fourth choice: apply it to the old one, but not the new, but that's sort of ridiculous.

But what would you approach? Don't tell me the answer. Just tell me how you would approach the question.

DR. MURPHY: I think I gave you the answer, the process. Basically we would look at the data, look at the information, evaluate the validity of the information, apply that to start with to the operating facility, and look at the implications for the operating facility.

If there are no patients for the operating facility for reasons like we just said with Watts Bar, because it was in the high frequency end and they had already recently reviewed the high frequency equipment and it was not an issue. So basically we would say for the operating plant it's not a problem.

Depending upon the severity of the information, the degree of departure, it's likely that we would ask the applicant for an early site

permit on that site to consider that information, to do their homework and come back and tell us what their conclusions are and what is the basis for those conclusions.

CHAIRMAN APOSTOLAKIS: But it is conceivable that you would have to say a higher safe shutdown earthquake for the new plant --

DR. MURPHY: Yes.

CHAIRMAN APOSTOLAKIS: -- than the existing plant, and the rationale would be that this is a new plant.

DR. MURPHY: This is a new --

CHAIRMAN APOSTOLAKIS: But it wasn't worth backfitting the other one.

MR. ROSEN: Well, I don't know that that's too reasonable.

CHAIRMAN APOSTOLAKIS: Well, what else?

MR. ROSEN: What I'm saying is if you're unlucky enough to have a new phenomenon show up at your site, it's like the ultimate kind of operating experience, the earth operating experience.

CHAIRMAN APOSTOLAKIS: Right.

MR. ROSEN: And you can't turn you back on it just because there happens to be earth rather than some component in the plan.

CHAIRMAN APOSTOLAKIS: No, but the question is --

MR. ROSEN: I think you have to react to the operating experience that the earth sends you just as you do any kind of operating experience. You evaluate its importance to the plant.

CHAIRMAN APOSTOLAKIS: Okay.

MR. ROSEN: You decide whether your margins are still in place or not. Then you take appropriate corrective action.

DR. MURPHY: That's what we do.

CHAIRMAN APOSTOLAKIS: Yeah, but I think it's a similar situation to what the Commission could say about the new plants. They expect that new designs will be safer. Now, if you really want to scrutinize and say, "And why not existing designs?" well, the existing plants exist. It's not worth going back and backfitting, you know.

But for the new ones we'd expect them to be safer. So the same logic can apply here, unless you find that, you know, there is some serious implications with the existing plans, which would justify backfitting and all of that.

So, you know, I mean, it doesn't sound like it's a perfect, ideal situation, but it

wouldn't surprise me if it happened, you know, that you raise the SSE a little bit.

DR. MURPHY: Well, it has happened in a number of instances. I'm only to remember one of them at this stage, and that is a site that had two units on it, and I believe I'm correct that for North Anna the first unit has a lower SSE, lower response spectra than Anna 2, North Anna 2.

MR. ROSEN: See, to me -- pardon me, George and Andrew -- but to me that is something I just could not agree to.

CHAIRMAN APOSTOLAKIS: It is a little --

MR. ROSEN: Because it's just intellectually not stimulating enough for me.

CHAIRMAN APOSTOLAKIS: It is, absolutely.

MR. ROSEN: It seems to me the right answer is the earth is going to affect both units, whatever it does. So you decide what you think it's going to do, and then you apply it to both units. Now, in one unit, the new unit, it may be a front fit. When you back to the other unit, it may be a backfit. In the older unit you may choose to apply lower margins than your engineering analysis. Maybe that's the way you treat it.

But you can't have a different design basis. That's intellectually bereft of any ability to comprehend.

CHAIRMAN APOSTOLAKIS: You have to do a regulatory analysis to decide, you know, to backfit, and you may not pass. By the same logic, again, the Commission has very clearly stated that they expect new plants to be safer.

You can ask why.

MR. ROSEN: Well, safer, but the way you get safer on the site is by having the same design basis earthquake, but with more rigorous analysis or robust supports.

MS. EVANS: Well, I'm just going to make a comment. This Michele Evans.

Actually, I work in Region I, and up in New York recently there was an earthquake felt up there probably about two years ago, a year ago, and the three plants, you've got Nine Mile 1, Nine Mile 2, and Fitz. Nine Mile 2, which is your newest plant, was built differently than the other two, and they didn't even realize that there had been this earthquake that was felt at Nine Mile 1.

So you are going to have the situation that you're talking about. It's just as time goes

on we build to different standards. I mean Nine Mile 1, it's fine the way it is, but as we go forward, we build a little better every time and to different criteria.

MR. ROSEN: I think you're making my argument that the newer plants maybe had more robust support.

MS. EVANS: Right, exactly.

MR. ROSEN: Better analyzed or something like that, but they both suffered the same earthquake.

MS. EVANS: Exactly, and they all three -- you know, there was no impact or damage. It was just what was felt, and you had more robust --

MR. ROSEN: But they both suffered the same earthquake. That's my point.

MS. EVANS: True.

MR. SIEBER: Yeah, but that's not an uncommon practice. I know our plants, the seismic difference between them was like night and day, and that's a Region I plant. Unit 1 had a less seismic margin than Unit 2.

MR. ROSEN: Right, and as long as you evaluate it and say that's okay, that's fine, but the idea that you would have two different

earthquakes if one is older than the other one just doesn't do it for me.

MR. SIEBER: I don't think that that is the way it's applied.

CHAIRMAN APOSTOLAKIS: No, but it's the margins. The SSE defines the margins, does it not?

DR. SHACK: Yes, but the SSE isn't a real earthquake.

CHAIRMAN APOSTOLAKIS: It's not a real earthquake. It defines the margins. So what I'm saying is that for the new plant, it's conceivable you would have a higher SSE which translates into larger margins. But the earthquake itself, of course, is the same.

Now, ideally, I mean, you know, you would say why should this new plant have larger margins than the old plant, but that's what life is all about.

DR. SHACK: Well, that's a regulatory --

CHAIRMAN APOSTOLAKIS: They're both safe. They're both safe.

MS. EVANS: Right.

DR. SHACK: Before you leave this slide, can you tell me what the two estimates still at issue are?

CHAIRMAN APOSTOLAKIS: Yes. I don't understand that.

DR. SHACK: I missed that.

CHAIRMAN APOSTOLAKIS: Yeah, the two estimates on seven.

DR. MURPHY: Oh, I'm sorry.

CHAIRMAN APOSTOLAKIS: Slide 7.

DR. MURPHY: Right with you.

The two estimates are the same old two that we had before, Livermore and EPRI.

DR. SHACK: Oh.

CHAIRMAN APOSTOLAKIS: I thought they converged.

DR. MURPHY: Pardon?

CHAIRMAN APOSTOLAKIS: Didn't they converge?

DR. SHACK: That was the story we had, that they converged.

DR. MURPHY: They converged in a regulatory sense, if you want. The specific example that I had in mind where the two estimates are still an issue was associated with the decommissioning and the spent fuel pool issue; that if I understand things correctly, a particular frequency probability was chosen at which the applicant had to address

something, and if it was lower, they didn't have to address it.

And it turns out for the seismic fragility of the spent fuel pool, if you use the EPRI numbers, everything is okay. If you use the Livermore numbers, there was an issue that had to be addressed.

That's the specific example that I have in mind, and that was part of the trigger to begin to look at the Shack update again.

CHAIRMAN APOSTOLAKIS: Is this ever going to go away?

DR. MURPHY: Probably not, not in our lifetime, but I think it's going to be an issue like we've come and made progress on the seismic issue. We went from Appendix A, which made the adjudicatory process unbelievably hard. I think as we will get experience with a new Part 100.23, I think that we will have less problem, that there will be less contention, and then the performance goal back there at the start, we will become more realistic in our estimates, and we will be more effective and more efficient in their application.

CHAIRMAN APOSTOLAKIS: But, again, coming back to the earlier discussion, we have two

units on one site. They're thinking of building a third one. For the third one we're going to have this problem again, but if you do the Livermore thing, you're going to get one design standard; if you do EPRI, you get another.

DR. MURPHY: No.

CHAIRMAN APOSTOLAKIS: They're going to kill us if we say that. I mean, how long are we going to debate this issue?

DR. MURPHY: Good question. My thought at this stage is that what we have done with 100.23 and Reg. Guide 1.165, that for new sites that are looking at the seismic and geological siting criteria, making use of that information, there should be considerably less uncertainty and contention about that.

CHAIRMAN APOSTOLAKIS: So you say there should be, but are you implying that there isn't?

DR. MURPHY: No. I'm implying that we don't have a test case. My expectation is that not only should they, but they will be less contentious.

CHAIRMAN APOSTOLAKIS: Should that be something then that should be at the top of your list here to be ready? Because this is really an issue that can become real, and you can make a major

contribution here. If the seismic part of the licensing process is smooth, you know, that will be great.

Wouldn't that be more important to spend some time on and resources than, say, making sure that the geological survey has our point of view into their thinking?

This is real in my mind. I mean, I can see the industry complaining, I mean, if they say, "Well, gee, we're finally deciding to build something and you guys are creating again major obstacles."

DR. MURPHY: I don't think that we're creating the major obstacles, and I think what the Geological Survey is doing is feeding information into us that is valuable in updating the hazard curves, information that they will be able to provide us on the occurrence of earthquakes in that area.

It's better that we have that information and have folks gathering that information for us, and it's not a considerable effort, but I mean, there is an effort there to make certain that we are aware of what's going on.

CHAIRMAN APOSTOLAKIS: So what is

happening now, Andy? I mean, maybe you said it and I missed it. We have the two estimates still being an issue. Is there a research effort in your branch that tried to resolve this in a timely fashion, say, in a year or a year and a half so that if we have this happy occurrence, we will be ready?

DR. MURPHY: One of the things that we are doing is this program with the Geological Survey, different from what was back on viewgraph four or five. But we have -- well, let's back up.

The Geological Survey if you want to say was to some extent following what we in EPRI had done with the probabilistic hazard estimates, and they have gone out and over the last five or six years now have put their own efforts into developing a national hazard map and a national, if you want, hazard methodology and database.

Okay. With that information, which is coming out or has come out -- I've seen drafts and so forth. So I'm not certain exactly where they are in their publication of it -- but that information is a national effort rather than an NRC or an industry effort to look at this process.

We are actively looking at what the Geological Survey has done, and if we can -- and

that's a big "if" at this moment -- if we can, we may be incorporating that into Reg. Guide 1.165 as the process or part of the process to be used in geological hazard assessment.

DR. SHACK: We could have three estimates.

DR. MURPHY: We could potentially have three estimates, but that's speculation at this stage. The thought would be that if the Geological Survey methodology is acceptable, we can then lay the burden back at the Geological Survey as the national seismic expert and make use of their updates into the future so that with time, the EPRI and the Livermore process may fall by the wayside and we'll simply be using the Geological Survey's national maps.

DR. SHACK: But I guess from the way you're saying this, if you decided to go ahead with the ten-year update, you don't think the result of that would be a single estimate.

DR. MURPHY: No, I didn't say that. I didn't say anything about the single estimate. My personal view -- and that's all it is at the moment -- is that --

DR. SHACK: I mean, that could be one

outcome --

DR. MURPHY: That could be.

DR. SHACK: -- of the ten-year update.

DR. MURPHY: That could be one outcome of the ten-year update, yes.

DR. SHACK: Okay, but your bet is that it won't be.

DR. MURPHY: Watch my feet. I'm just not sure at the moment. I had some personal misgivings about the process the Geological Survey went through, and that's part of the reason for doing the evaluation, to look at the process, to look at their documentation, to look at how the results turn out, and to make an evaluation of it.

At this stage we don't, I haven't seen enough information to hazard a guess as to which way it will go.

Does that help, George?

CHAIRMAN APOSTOLAKIS: Not much.

(Laughter.)

DR. MURPHY: I'm sorry. But I'll say in nine months when we have some of the information with the Geological Survey and have had a chance to digest it, we may be able to come back with a better answer.

CHAIRMAN APOSTOLAKIS: That would be nice.

DR. MURPHY: But at this stage, my personal view is that we have a regulation on the books with guides on the books that for new facilities to provide us with an efficient and realistic way to look at seismic hazard.

Okay. Where were we?

CHAIRMAN APOSTOLAKIS: Is there at least a difference between the two decreasing?

DR. MURPHY: No. At this stage there is a status quo that's about ten years old for the EPRI and --

CHAIRMAN APOSTOLAKIS: So we were misinformed when we were told that the two methodologies were converging?

DR. MURPHY: No, you were not misinformed, and I'm not sure that you were told the specific verb "converging." We had gotten to the point with the new regulation and the new reg. guide where we had a reference probability that worked equally well for the EPRI estimates and worked equally well for the Livermore estimates, and with those, we were able to come up with a satisfactory new regulation and new regulatory guide.

CHAIRMAN APOSTOLAKIS: So when do you -- I don't know how the other members feel, but I think this is a very important issue because it's been there for a long time. It has been the source of irritation to a lot of people.

DR. MURPHY: Yes.

CHAIRMAN APOSTOLAKIS: And there are, I mean, real technical issues. It's not that it's --

DR. SHACK: Well, there are real practical issues, too.

CHAIRMAN APOSTOLAKIS: And there are practical, yeah. There are practical implications. I believe this committee has not really been kept informed, and it's not your fault, the last maybe few years about your activities. But when would be a good time for you to come back and focus on this and related issues and enlighten us a little bit more as to what's going on?

Because the purpose of this meeting is really different. It's to understand, you know, get the general picture of what you're doing so we will be able to say something in our research report.

But the other meeting will be more, you know, focused on understanding what is going on in

this area and when we might get some form of --

MR. ROSEN: And perhaps you shouldn't frame your answer in geologic time scales.

(Laughter.)

CHAIRMAN APOSTOLAKIS: So when in the next 10,000 years?

DR. SHACK: The repeat frequency?

PARTICIPANT: Six hundred.

CHAIRMAN APOSTOLAKIS: You said something like nine months earlier. Would that be --

DR. MURPHY: Where we stand with the program on the evaluation with the geological survey is we're expecting some answers from them in the springtime.

CHAIRMAN APOSTOLAKIS: Okay.

DR. MURPHY: And we're looking for us with the staff to do some evaluation so that maybe late summer, early fall, which is a short time period in geological terms.

CHAIRMAN APOSTOLAKIS: So roughly a year from now.

DR. MURPHY: We should be in a reasonable shape to come back --

CHAIRMAN APOSTOLAKIS: Okay.

DR. MURPHY: -- and tell you what's going on.

MR. ROSEN: And let's have a meeting just on this issue.

CHAIRMAN APOSTOLAKIS: Just on this issue, yeah. That's what I want, to understand better what the issues are, what the difficulties are, and I'm sure there are real difficulties. I'm not trying to downplay the issues.

MR. ROSEN: Yeah, I understand, and we could invite EPRI, too.

CHAIRMAN APOSTOLAKIS: Absolutely, yeah, yeah. We can have a real subcommittee meeting with maybe different points of view and discuss, but I think this is really -- I mean, if we're thinking in terms of regulatory action in the near future, this is certainly a major candidate.

MR. ROSEN: Sure. No, I think you have your hand on a good problem.

CHAIRMAN APOSTOLAKIS: And that doesn't mean that, you know, the understanding process is not important. I mean, I don't want to downplay the other stuff, but as we have been told many times with the Commission, this is a regulatory agency.

DR. MURPHY: Right.

MR. ROSEN: It's not a search for the ultimate truth.

DR. SHACK: No. It's a learning organization.

CHAIRMAN APOSTOLAKIS: So let's do that.

Sorry?

DR. SHACK: It's a learning organization.

CHAIRMAN APOSTOLAKIS: It's a learning organization. So let's do that.

MR. ROSEN: A learning organization that has to act in real time.Commission

DR. SHACK: Right.

CHAIRMAN APOSTOLAKIS: So in about a year then, next September-October time frame, we're going to be able to discuss this in more detail.

DR. MURPHY: We will be able at that time to come back and report to you what we have accomplished or not accomplished in that time period.

CHAIRMAN APOSTOLAKIS: Okay, okay.

MR. ROSEN: Now, we can go on to page 8.

CHAIRMAN APOSTOLAKIS: We're finally moving one slide? Progress.

DR. SHACK: Well, let's go back to Garner Valley.

MR. ROSEN: No, we're not going backwards.

DR. SHACK: I take it there's two components. One you sort of sit around waiting for something to happen and you have an active component where they're doing the shaker world.

DR. MURPHY: Right. The Garner Valley or the Anza gap is being studied by the Geological Survey, ourselves, and National Science Foundation has become involved. The Geological Survey is looking at the overall hazards of the area, i.e., they're operating a seismographic network there.

The NRC is operating the downhole array that was very nicely described in your paper there. And very recently, in the last year, National Science Foundation has responded to a proposal from the Santa Barbara folks and others and have put in an earthquake engineering program. They will build themselves a steel concrete structure at the Garner Valley site. They will actively shape it to get frequency response changes, and they will also be conducting shaker experiments using shakers large enough to they hope induce liquefaction in the area

to give some additional data that they don't have to wait for Mother Nature to deliver.

MR. ROSEN: So they're doing a lot of stuff at Garner Valley.

DR. MURPHY: Yes, sir.

MR. ROSEN: Not just looking at a stack of soil that represents something on the East Coast. They're looking at the Anza gap. They're looking at all of the other programs that you've mentioned. Probably the biggest thing that has happened in Garner Valley ever.

DR. MURPHY: Yeah, yes.

CHAIRMAN APOSTOLAKIS: We only have 11 minutes.

DR. MURPHY: Okay. We will speed on.

CHAIRMAN APOSTOLAKIS: We want to pick the slides that you feel are important. You certainly have to discuss the last one that says emerging issues.

DR. MURPHY: Okay.

CHAIRMAN APOSTOLAKIS: Is there anything in between? I mean, what do you want to say about the regulatory guides? You are working on them.

DR. MURPHY: We're working on them. These are near term. They should be out before

springtime.

CHAIRMAN APOSTOLAKIS: Now, what's going on with these regulatory -- we usually review regulatory guides. We don't review yours?

DR. MURPHY: I think the situation is what they were offered to -- no, they are always offered to the ACRS, and somebody made a decision as to whether or not they want to see them or not.

CHAIRMAN APOSTOLAKIS: Okay. From now on I want to be part of the loop that makes the decision.

MS. EVANS: They did come through here.

This is Michele Evans.

They did come through recently, and we received letters that they -- well, at least one of them. I think the first two did come through, and you guys passed on leaning on them.

CHAIRMAN APOSTOLAKIS: Okay.

MS. EVANS: Okay?

CHAIRMAN APOSTOLAKIS: That's fine. I don't dispute that. It's just that I want to be more involved.

Okay. So?

DR. MURPHY: Okay. Under the earthquake engineering, those are a number of issues that we

have been looking at for a while. I think probably --

MR. ROSEN: What's NUPEC?

DR. MURPHY: Nuclear Power Engineering Corporation. It's fairly close to being like a national laboratory for the Japanese, for the Ministry of Economy, Trade, and Commerce.

MR. ROSEN: So you're still collaborating with the Japanese on this?

DR. MURPHY: That's correct.

CHAIRMAN APOSTOLAKIS: No, it's not METI anymore. It's MITI.

DR. MURPHY: No, it went from I to E.

CHAIRMAN APOSTOLAKIS: Oh, it's METI.

DR. MURPHY: METI now.

CHAIRMAN APOSTOLAKIS: It's METI.

DR. MURPHY: They threw out industry and brought in economy.

CHAIRMAN APOSTOLAKIS: Which is broader.

DR. MURPHY: Right. Again, this is the program that we have with the Japanese, principally with the NUPEC group, which has now been split into two organizations.

CHAIRMAN APOSTOLAKIS: They are certainly at the forefront of earthquake engineering

research, right?

DR. MURPHY: Yes.

MR. ROSEN: Well, we shouldn't say that.

DR. MURPHY: Okay. There is the reg. guide that is in the pipeline at this stage for the earthquake engineering.

This is the continuing and emerging issues slide that I used last year with the one exception that the GSI on the East Tennessee seismic zone now has a number 194, and as I just indicated a little while ago, that has been evaluated and given a drop.

The other items on there, the what was then recent Turkish and Taiwanese earthquakes are still under evaluation. There are implications in the strong ground motion propagation that are coming out and have the potential of being influential in the United States' look at the propagation.

The coordination with the two --

MR. ROSEN: Not because of what's going on in Turkey or Taiwan. Those are a little distant from our sites, but because of the phenomena and the response of the soils and foundation materials.

DR. MURPHY: The soil response and foundation responses. Also, particularly, the

Turkish earthquake is on one of these long faults, the Anatolian fault, like the San Andreas. That has been breaking in segments, and we've been interested in how that process goes on.

The Taiwanese earthquake is particularly important in the strong ground motion that was produced. Some of that was very high, more than a G in some places.

The probabilistic seismic hazard, we're going forward with evaluating the Geological Survey. I think at this stage EPRI would be characterized as basically sitting back and at this stage watching to see what's going to happen before jumping in.

The new technology --

CHAIRMAN APOSTOLAKIS: Now why do you say new probabilistic seismic hazard? I mean that's a methodology. How can it -- what are you doing to the methodology that would be new?

Is it the inputs to the methodology that would be new?

DR. MURPHY: I think of the methodology as the database and --

CHAIRMAN APOSTOLAKIS: Well, that's part of it.

DR. MURPHY: -- the analysis code. So

in my mind that's what we're --

CHAIRMAN APOSTOLAKIS: Okay.

DR. MURPHY: -- we're looking at.

The new technologies down there buried partially imbedded structures. That has some potential implications for soil structure interaction. That was or is important, particularly because of the pebble-bed reactor and its prominence a year and almost 18 months ago. I'll say that's less of a prominent issue at this stage.

MR. ROSEN: One of our members who doesn't happen to be here right now believes that, has a theory about the pebble bed where these balls are all just sort of quasi stable; that if you change that arrangement, you change the neutronics of the core, and the one way to get those balls to shift is to shake them.

And it seems like we're going to need to know a lot more about that sort of phenomena when we get the PBMR.

Care to comment?

DR. MURPHY: Yes. We can provide information about the input to the structure. We can provide information on how that ground motion input works its way through the structure to the

core.

I don't know the technology that well, or hardly at all. And this program could provide that information. Somebody else will very definitely have to take that information and tell us whether or not it's an issue for the balls floating around in the core.

MR. ROSEN: Well, just think about a bunch of small balls in a glass jar, say, as a model, and you drop them in at random, and they sort of hang there. But if you were to take that and give it a good shake, they might consolidate.

DR. MURPHY: Yes, like a liquefaction event.

MR. ROSEN: Yes, just like that. So the neutronic implications of that could be significant.

DR. MURPHY: I'll say potentially if all of the frequencies and the inputs are correct. I have no clue as to what the sensitivities of the core -- I guess you call it a core -- for the pebble bed are.

MR. ROSEN: I just alert you to the fact that that could be -- I mean, it's not something that typically happens in a pressurized water reactor or boiling water reactor.

DR. MURPHY: No.

MR. ROSEN: The core is supposed to stay in its configuration. The fuel is.

DR. MURPHY: Right.

MR. ROSEN: Go on.

DR. MURPHY: I guess I'll say with that the presentation is finished with two minutes to spare.

CHAIRMAN APOSTOLAKIS: That's great. You should come here often.

(Laughter.)

DR. MURPHY: Is that a threat?

CHAIRMAN APOSTOLAKIS: It's a reward.

DR. MURPHY: Oh, thank you.

CHAIRMAN APOSTOLAKIS: Okay. So thank you very much.

I'm sorry. Are there any questions from members?

MR. SNODDERLY: George, I just wanted to confirm that I'll enter into our future activities list that we'd like to try to schedule a subcommittee meeting some time next fall, early fall, September, October, to discuss the different seismic hazards analyses and the work that was done at the U.S. Geological Survey. Is that correct?

CHAIRMAN APOSTOLAKIS: I think that's what we agreed.

MR. SNODDERLY: Okay.

CHAIRMAN APOSTOLAKIS: If you've got anything that you believe, you know, you should inform the committee about earlier than that, that's fine. Let us know.

DR. MURPHY: Okay. We will do that.

CHAIRMAN APOSTOLAKIS: I think we should get more involved with your activities --

DR. MURPHY: No problem.

CHAIRMAN APOSTOLAKIS: -- in the future than we have been in the past.

DR. MURPHY: We do honestly appreciate the attention.

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

So now -- yes, Michele, do you want to say something?

MS. EVANS: No. No, I don't.

CHAIRMAN APOSTOLAKIS: Okay. Well, thank you.

Steve, coming up?

MR. ROSEN: No break, right?

CHAIRMAN APOSTOLAKIS: Well, it's still

ten o'clock.

MR. ROSEN: At ten o'clock we're going to?

CHAIRMAN APOSTOLAKIS: Sure. Are you using transparencies or slides or what, Steve? Slides.

Is this computer ours, Tyrone?

MR. BROWN: No, it is not ours.

CHAIRMAN APOSTOLAKIS: Whose is it?

PARTICIPANT: I brought it down.

CHAIRMAN APOSTOLAKIS: So we don't have a computer?

MR. BROWN: Oh, yeah, we have one right there. They wanted to bring theirs.

CHAIRMAN APOSTOLAKIS: They wanted to bring theirs.

MR. BROWN: Brand new Dell.

DR. MURPHY: Yours?

MR. BROWN: Yeah.

DR. MURPHY: We'll trade.

MR. BROWN: No, we ain't trading.

(Laughter.)

CHAIRMAN APOSTOLAKIS: Okay. Now, what is your contact information? What is your extension?

DR. ARNDT: 415-6502.

CHAIRMAN APOSTOLAKIS: Six, five?

DR. ARNDT: Zero, two.

CHAIRMAN APOSTOLAKIS: And your E-mail?

DR. ARNDT: saa@nrc.gov.

CHAIRMAN APOSTOLAKIS: All right.

MS. EVANS: Hello again. I'm Michele Evans, the Branch Chief of the Engineering Research Applications Branch in the Division of Engineering Technology in the Office of Regulatory Research.

Dr. Steven Arndt, I think you probably have met and had presentations from Dr. Arndt previously. He's a senior staff member in my branch, and he's here today to give you an overview of the status of digital instrumentation and control research and digital systems risk.

CHAIRMAN APOSTOLAKIS: The seismic stuff and the digital I&C is under you?

MS. EVANS: Yes, I am very lucky.

DR. SHACK: I was going to ask. What's the scope of your entire day?

MS. EVANS: Well, we've got seismic, structural, and also an I&C group.

PARTICIPANT: Mechanical, as well

MS. EVANS: And mechanical is in there,

yeah.

DR. SHACK: Makes sense.

MS. EVANS: But they're not --

CHAIRMAN APOSTOLAKIS: So what do other branches have? You seem to have everything.

MS. EVANS: Well, there's a materials engineering --

CHAIRMAN APOSTOLAKIS: Ah, the materials.

MS. EVANS: Yeah, under Mike Mayfield there's a Materials Engineering Branch and then this Engineering Research Applications Branch, which is right now kind of a mixture of all areas.

We actually do have a few electrical engineers that are in the Materials Engineering Branch.

DR. SHACK: Makes sense.

MR. ROSEN: Don't try to get the Materials Branch.

MS. EVANS: No?

MR. ROSEN: You don't want that.

MS. EVANS: I don't want that either? Okay.

CHAIRMAN APOSTOLAKIS: Okay, Steve.

DR. ARNDT: As Michele mentioned, my

name is Steve Arndt.

MS. EVANS: You will have to stay close to the mic.

CHAIRMAN APOSTOLAKIS: Do you want the mobile microphone?

DR. ARNDT: I'll try and be good.

CHAIRMAN APOSTOLAKIS: Okay.

DR. ARNDT: The presentation this morning is going to be on the digital instrumentation and control research with emphasis on the digital system risk part of that. As I understand from the conference call we had, you particularly wanted to hear not only what we're doing and what we're up to date on, but also a couple of the projects that we have ongoing, the Brookhaven project and the University of Maryland project.

I will cover those as well as some of the other programs and try and give you an update of where we are.

The overview will basically be a quick review of the digital I&C research program, some of the external drivers, research areas, a little bit on our new reactor's work, future plans, basically FY '04 and beyond plans, a short summary.

I originally had planned this for the full length. Because of our interruption that we're going to have in a little while, it may be a little long. So I'm going to try and move through this reasonably quickly. If you have a question, obviously please stop me.

As you know, the NRC has a digital instrumentation and control research plan. It was published in August of 2001, including various areas. It was, in part, an answer to the recommendation of the National Academy of Science review recommending a more systematic approach developing new guidance and doing research in this area. It was endorsed by the ACRS, Commission, and had four major program areas.

The goals of the research program itself is basically to improve the decision making process, the things that we do at the agency more effective, efficient, and realistic. In support of that, we have various activities, develop more consistent guidelines, develop more effective analytical tools, develop new guidance and update existing guidance.

An example of that, of course, is the reg. guide that we came to you last week for to update based on additional guidance that is not

available in the industry.

So we're working in all of these areas, as well as the cross-cut of technology type issues that we're going to talk about in a minute.

The various inputs have come from a lot of different areas, both internally, NRR and NMSS user needs, as well as things that are going on in the industry. An example of this was the DOE I&C and Human-Machine Interface Working Group. That was a group specifically established by DOE to provide input on the next generation reactor program. What are the kinds of research that the industry, the DOE, other people should be doing?

And the output of that, which was published in a report to DOE in May, basically has three or four major areas. The two biggest ones is we should be doing more pilot applications to develop our tools and methods and regulatory structure, actually going out and doing pilots, developing facilities, that kind of thing.

And the second one, surprisingly, is that the regulatory structure needs to be more risk informed. That came out of all six sub-working groups, including the one on regulatory issues. So that was a very universally accepted opinion by the

working group.

The working group, by the way, consisted of six subject area leaders and about 40 other people, including 20 NAS fellows, three National Academy members, et cetera. So it was a very good organization.

Another example of this was the Halden workshop on digital system reliability. As you know, the Halden reactor project has gotten into digital systems quite a bit recently. Up until about two or three years ago, they were primarily focused on man-machine interface and operator aids and things like that.

In the last couple of years, mostly at our prodding, they have started getting more involved in this. And they had a workshop in December of last year, and they basically came up with the same answers that DOE did: that the primary issues to moving forward some of the more dicey digital system questions have to do with a better understanding of digital system reliability and a better way to quantify and assess those issues.

One of the biggest issues is not just quantifying it, but understanding how good those

quantifications are and how reliable they are and how effective you can use them, which are really our purview as opposed to the pure research kind of coming up with new models and things like that.

MR. ROSEN: But this focus on reliability, machine reliability itself, is understandable and probably appropriate, but my feeling is that there's a weakness you perhaps would address in understanding the human-machine interface for future plans that are highly digital with plants with a single control room, multiple units, run from a single control room.

And the analogue for the concern is the wrong unit, wrong train concern that we've seen over and over and over again in our existing plants, operators going in one unit to the wrong train and doing in Train B what they should be doing in Train A.

Well, going in the wrong unit, Unit 2 instead of Unit 1, and trying to do something that they were sent out to do in Unit 1 that they're trying to do in Unit 2 and maybe do and create all kinds of havoc, the analogue being that one control room now operating at three, four, eight, ten plants even, one of those plants is shutting down. One of

those plants is starting up. Two are running normally. Four are in refueling, and three are having transients.

Now, what do the operators do?

DR. ARNDT: There's actually two issues there, one of which is being addressed by the human factors and human performance people, another of which is being addressed by us and I'll speak to briefly.

But in brief, the issue is you have the human-machine and human performance issue associated with those kinds of things. How does the operator work? Can they distinguish? Is there enough information provided? Is there too much information provided? Is the information appropriate? How is it displayed? How can he move through the panels and do all of these things?

MR. ROSEN: The same panel. He doesn't move at all. He just presses a button and brings up a new screen typically.

DR. ARNDT: Well, depending upon the design you've looked at, and there's several floating out there, they usually have somewhere between five and eight screens to work with, and how you deal with them and what you prioritize and

whether or not alarms come up automatically or you have to work through them, there's a whole set of issues.

The other part of that issue is really a design issue for instrumentation control and man-machine interfaces, and as Professor Miller of Ohio State likes to say, the real trick to having a multi-modular plant is being able to function as if it is a single plant, one big plant, because if you really want this thing to be effective, you want it to be able to deliver power to the grid at whatever amount, and you bring on a plant or you take off a plant or you do maintenance on a plant to make that happen, to get the amount of megawatts and megabars out to the grid that you want.

So one of the design issues that most of the modular plant people are doing is cross-integration of all the systems. So you have shared systems at the control room, i.e., the operator interface. You have shared systems at the grid, you know, shared systems associated with the instrumentation as well as other things.

And dealing with both multi-modular issues, as well as the level of autonomy that the operator must have to be able to run five plants in

different areas, you have to have different levels of autonomy.

MR. ROSEN: Relative to my question, this all makes me feel terrible. In other words, Don Miller, a distinguished former member of this committee, ACRS --

DR. ARNDT: Yes.

MR. ROSEN: -- who is an expert on the issue, has just make the problem infinitely harder by suggesting the things he just suggested apparently.

And my idea was that there be ten equal and distinct and independent modules, which is tough enough to deal with because they're all in different phases of their operation. And that alone for one set of people, which is all there would be, operating off effectively one screen or maybe two or three, but certainly not ten, one for each so that they can go to the green one, the blue one, the slightly green one, the kind of green one. You know, they can go to all of these different screens.

That's not how they do it. They do it on one screen. The idea that they would now have integrated systems between these plants that are operating in different modes and under different

stressors makes the problem infinitely harder, and I'm even more concerned.

DR. ARNDT: And as I said, these are some of the very significant issues that are addressed or going to be addressed as part of the advanced reactor infrastructure research program. From the I&C area, you have the two issues, the multi-plant integration and also the single plant level of autonomy. Because if you want to do that, you have to be able to basically tell the computer or tell the plant that, yes, we're going to bring up the system as opposed to go through each and every little thing or you really can't effectively run it with one or two or three operators as opposed to 50 operators for ten plants.

So both of those things are things that are being addressed in the advanced reactor research plant in the I&C area. The screen displays and things like that, the actual human interfacing to the front of the panel, is in the human performance side of it.

And, yes, it is extremely complicated, which is one of the reasons DOE formed this group to give them recommendations.

MR. SIEBER: Okay. I have a different

line of questioning. You talk about risk informing the digital I&C area, and in my own mind I separate that into two aspects. One of them is the human-machine interface aspect, which I think is ripe for probabilistic analysis. The other one is the reliability of the system itself, which in my mind is a second order effect.

In other words, you have transducers, a controller that's got rate resept proportional band and that kind of stuff and an actuating device valve or damper or whatever, some motor someplace.

And I see jobs, for example, Y6332, which is a digital systems risk analysis by Battelle, where they plan to investigate digital I&C system analysis methods for incorporation into PRAs. Have we done the same kind of thing with analogue instruments? In other words, look at reliability and risk and uncertainty, incorporated that into PRAs, or is this unique to digital systems?

DR. ARNDT: The answer to your specific question, there has been some limited work in analogue systems, not a lot because they tend not to come up as risk dominant.

MR. SIEBER: Yeah, right. They're secondary effects. I would expect the same --

DR. ARNDT: Mostly because the ones that are doing things that are important have relatively high redundancy and unless you have a particular common mode failure issue, those tend not to come up, and most of the analogue system common mode type issues are fixed by some of the procedures that we have.

CHAIRMAN APOSTOLAKIS: Well, they're also continuous.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: Small changes in the inputs, small changes in the outputs. Digitally you don't know.

DR. ARNDT: You don't necessarily have --

CHAIRMAN APOSTOLAKIS: That's a major difference.

DR. ARNDT: Yeah, the potential for more dramatic failure modes both in how they fail, common motor, software, something like that, and the amount of change or amount of consequence when they do fail.

CHAIRMAN APOSTOLAKIS: But I would like to ask --

MR. SIEBER: Well, let's pursue that

just a second.

DR. ARNDT: Okay.

MR. SIEBER: In an analogue plant, analogue controlled plant, you have protection systems and you have control systems.

DR. ARNDT: Yeah.

MR. SIEBER: Okay. Protection and control are not supposed to be in the same equipment

DR. ARNDT: Right.

MR. SIEBER: In other words, they're supposed to be independent and diverse.

DR. ARNDT: Right.

MR. SIEBER: You would apply those same rules to digital systems. Okay? And so, you know, if you have one grand piece of software that's running the whole plant, it's not going to do the protection and control functions simultaneously. You would have separate systems for that just as we have seen in power plants from 1950 on.

DR. ARNDT: That's correct.

MR. SIEBER: And so the issue of reliability should not be and the consequence of a lack thereof should not be much different than you would have under the same analogue kind of system because the architecture is the same and the rules

are the same.

DR. ARNDT: Conceptually that is correct. However, some of the issues associated with how you build digital systems cause problems with the basic assumptions.

MR. SIEBER: So you think this would rise to a fundamental risk as opposed to a secondary risk in a PRA.

DR. ARNDT: It has the potential to.

MR. SIEBER: Then why would you ever allow them to install digital systems in the first place?

DR. ARNDT: The current rules have specific deterministic ways of trying to mitigate potential problems. For example, the current rule, which I'll touch on a little bit later, requires an additional diverse shutdown system if you have a digital system.

MR. SIEBER: That's right.

DR. ARNDT: Which is not required in the analogue. So there are specific areas that try to address that. What these groups, which are predominantly vendors and researcher, are saying is they want understanding of what's going on, and two, they want to be able to have more flexibility in

what they build based on a better understanding of what they have, and --

MR. SIEBER: In other words, they'd like to say your rules that are too stringent in --

DR. ARNDT: Your rules are too conservative and not realistic enough.

MR. SIEBER: I'm a sort of deterministic kind of guy, and so that sort of grates on me.

DR. ARNDT: And in point of fact --

CHAIRMAN APOSTOLAKIS: Let me as, Mr. Sieber. You said that the man-machine interaction is risk Category 1 and the reliability of the digital system itself is a second order effect because it's more reliable?

MR. SIEBER: Well, I can't state a source. That's my impression.

CHAIRMAN APOSTOLAKIS: Yeah, but that's what you meant, that it's more reliable.

MR. SIEBER: That's right.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. ARNDT: Well, and as I think many people have said before, the single most risk important piece of equipment in a power plant is the operator.

MR. SIEBER: That's right.

CHAIRMAN APOSTOLAKIS: Well, the problem the way I see it, having read part of the literature on digital I&C, it's really that we don't really understand the failure modes, and there is this possibility of discontinuities that are very disturbing, and as an industry, we're not used to that kind of discontinuity. Things are, you know, controlled by physical processes. When there is a delta X in the input, you get a delta Y in the output. You don't get Y to the X power.

And with digital systems, you may and this is really the concern. I mean, they are highly reliable, but we don't feel that we're on top of the issue of the failure modes. Is that a correct perception?

DR. ARNDT: That is the predominant issue. There are other issues as well.

CHAIRMAN APOSTOLAKIS: Yeah, yeah, sure.

MR. ROSEN: Is there experimental verification of that or is that just a fear?

DR. ARNDT: There is anecdotal evidence in several kinds of systems. Transportation industry is the biggest, where failure associated with digital systems, usually software errors, not always, have made dramatic changes. The Airbus

incident over I believe it was Berlin about six years ago is one where the system was designed to land the plane with no operator or pilot intervention, and it decided that it was going to land the plane about 100 feet below the runway.

MR. SIEBER: It didn't say anything about whether it could take off again, right?

MR. ROSEN: Well, pilots can do that, too.

DR. ARNDT: Yes.

MR. ROSEN: I mean that's not --

DR. ARNDT: But the issue was the system should have allowed the operator the second grab on the yoke to pull out of the control system, and it didn't. It blocked the system out, and they ended up having to actually pull a breaker to get control of the aircraft.

There are other dramatic instances. The THORAC-25 is another aerial system.

MR. ROSEN: Okay. Well, you don't have to tell the names of thee events, but there are enough real events that show you that the point that George is making is that there's a discontinuous function here. It's true.

DR. ARNDT: Yeah.

MR. SIEBER: Yes, but you get t he same kinds of failures in analogue equipment. For example, you know, you're controlling dampers, valves, motors on and off, and some modulating devices like control valves, for example, but the failure mode is either it goes shut or off or open and on. Now, that's it.

And the analogue systems do the same thing when they fail. You lose an airline someplace or some controller gets mess up and --

MR. ROSEN: Yeah, but in an analogue system you --

MR. SIEBER: It's not going to go to infinity.

MR. ROSEN: -- you turn Train A on or power up the Train A device, and it either goes on or it's off or something like that. In a digital system, you push a button on Train A to turn Train A off, and Train C turns on and all of the lights on Train B go on.

I mean, completely unexpected set of responses occur.

MR. SIEBER: It depends.

MR. ROSEN: Unpredictable, discontinuous.

MR. SIEBER: It depends on how you design the system. For example, if you run everything through one CPU with another CPU following along, you can get errors like that.

On the other hand, if you have a distributed system where you have control loops and what goes into those control loops is some master demand signal like what power level do you want, whatever you dial in there, and then it will send a bias function to every one of these loops, but the loops otherwise operate independently.

And so you could have a computer failure and not lose the plane.

DR. ARNDT: Right, and the primary issue associated with this particular kind of application is the kinds of things that would either fail a system, prevent it from being reset, lock the system out, fail a group of systems due to a common mode type issue, fail a system in an unpredictable fashion as opposed to fail open or fail close. It could oscillate or various other kinds of things.

So the primary issues are associated with that. One of the real issues that the industry and the academic world who design and conceptualize these system are having is that if you want to do

things as Mr. Sieber has pointed out, in a very, very conservative in that you only replace the analogue system with what --

MR. SIEBER: The digital equipment.

DR. ARNDT: -- the digital equipment that's exactly the same kind of thing, basically a very, very simple computer that only does a simple PID type thing or something like that, then you get very few of these problems.

As you make it more sophisticated to enhance the operability issues and in some cases the reliability issues, you introduce new failure modes that are more and more challenging, particularly as you try and do a tradeoff between on-line diagnostics and things like that.

So there's a whole set of tradeoffs in these systems that we didn't have in the previous systems.

MR. SIEBER: Let me ask just one more question and then I'll let you return to where you were originally headed. It seems to me that we don't have a -- we haven't yet built a complete digital control room --

DR. ARNDT: That's correct.

MR. SIEBER: -- in this country, and so

what you're really trying to do at this point in life is to specify the ground rules. Okay?

And if you don't have a physical entity to model, it's not clear to me how you determine the risk of something that doesn't exist and the design doesn't exist.

Do you know what I mean?

DR. ARNDT: Yeah.

MR. SIEBER: And so I look at a couple of million dollars, as I add up all of these projects, that are essentially getting ready for but not actually doing in the analysis, right?

DR. ARNDT: That's not quite correct.

MR. SIEBER: Okay. Well, that's why I asked the question.

DR. ARNDT: Okay. As you say, we don't have a completely digital control room in the United States, and we have quite a few abroad.

MR. SIEBER: Yes, we do.

DR. ARNDT: As you're aware.

MR. SIEBER: Yes.

DR. ARNDT: We have quite a few subsystems within the control room that are completely digital.

MR. SIEBER: That's correct.

DR. ARNDT: And we've got four plants on the books now with license applications for basically complete digital upgrades over the course of several refueling outages. We also have, as you know, four digital systems that have been approved by topical report for application to control as SFAS and RPS applications.

So we have the systems, and people are in the process now of licensing and putting these systems in, both in the safety grade, as well as the balance of plant type issues, which as you all know, can have a significant effect on reliability, safety type issues.

MR. SIEBER: And so this is why you're reevaluating all of the reg. guides.

DR. ARNDT: Right.

MR. SIEBER: Okay. Which I support.

DR. ARNDT: The reg. guides, we're looking at the tools. We're looking at the analysis methods both from a risk standpoint specifically, but also as an improved model of the system. Whether or not it gives us a reliability number or not, it gives us a better understanding of the failure mechanisms and things like that as well to improve the quality of the reviews and the realism

of the reviews.

CHAIRMAN APOSTOLAKIS: Are there any reports on the DOE and Holden workshops?

DR. ARNDT: There is summary document of the DOE workshop. Like I said, it was published, I believe, in May. It may have been July of 2002. I can provide that to the committee if you would like.

CHAIRMAN APOSTOLAKIS: Yes, I would. And Halden?

DR. ARNDT: The Halden workshop, there's basically a set of the presentations available and a short summary. I can also provide that.

CHAIRMAN APOSTOLAKIS: Yeah, when it's convenient.

What do we do here? We have a couple of minutes. I mean, there will be a siren.

DR. ARNDT: It will go through the PA system, I believe.

CHAIRMAN APOSTOLAKIS: Right, but I think people want to visit the facilities before we go out. So shall we stop now, two minutes before?

I mean, we've made progress. We're on the fifth slide.

(Laughter.)

MR. SNODDERLY: So you're suggesting we

take a quick break, come back in and wait for the announcement?

CHAIRMAN APOSTOLAKIS: Yeah. Just a few minutes.

(Whereupon, the foregoing matter went off the record at 9:58 a.m. and went back on the record at 10:54 a.m.)

CHAIRMAN APOSTOLAKIS: Okay. All right. We're back in session.

We have three members here. Okay.

DR. ARNDT: Okay. As we were saying, in addition to internal drivers, there's several external drivers. One thing I wanted to do before I left this slide, the EPRI D-3 working group was established in 2002. D-3 refers to diversity and defense in depth, and they specifically established a working group in EPRI consisting of licensees to look at the current diversity and defense in depth requirements within the regulatory structure.

There is a grants technical position that deals with exactly how to do that, and EPRI at the request of several licensees formed this working group to try and risk inform that process. So there is some movement specifically in these areas within the industry as well as the more general areas.

And I'm going to not go into that in any further detail unless anyone has any questions.

As I mentioned earlier, there are four primary program areas within the research program in I&C. I'll go through the first three quite quickly and then get to the fourth one which is the reliability area.

The first one is systems aspects, and those are external type issues to the actual system or things that are more generic to the system. So things like environmental stressors and things like that, environmental qualification, digital system requirement specifications and things like that fall into that work. And as you know, we have programs in those areas.

Software quality assurance issues are another major area. Those go to basically preventive actions to try and insure the quality of the digital system and the software that goes in it.

MR. SIEBER: Let's go back to system aspects.

DR. ARNDT: Yes, sir.

MR. SIEBER: One of the tasks you have is to evaluate the EQ qualification of fiber optics.

DR. ARNDT: Yes.

MR. SIEBER: What do you do that is different than what the industry would do in preparing their EQ reports for a specific product?

DR. ARNDT: What we do in the research side is investigate as the technology changes. Fiber optics, for example, are becoming more and more common both in benign environments and --

MR. SIEBER: Harsh.

DR. ARNDT: -- more challenging, harsh environments. They have certain capabilities and limitations. What we do in those kinds of areas is look at our requirements and look at the science and see whether or not they match. Has technological advance happened that makes some of our requirements either incomplete, less efficient, those kinds of issues.

MR. SIEBER: Yeah, but those requirements are pretty simple. You know, if you're testing for a harsh environment, which is basically inside containment or high rad area --

DR. ARNDT: Right.

MR. SIEBER: -- you have the qualification envelope, and that's the requirement. And so you age the and expose it in some kind of an autoclave or something or something like that to the

harsh environment and see if it still functions.

And it seems to me that really the job is to say, you know, here's the EQ envelope that applies. Here's the product they're going to use, and here's the test report for that product. And the test report really doesn't talk about, nor does the requirement talk about the physical characteristics other than it has got a function.

DR. ARNDT: That's correct. The issue there -- and granted it's not a big issue compared to some of these other issues -- is are the assumptions associated with the test matrix and things like that applicable. Do the kinds of advanced aging for cables, for example, which tend to go to the insulation and things like that, apply equally to fiber, for example, which has a different aging mechanism?

MR. SIEBER: Yeah, I would think the fiber itself might get cloudy.

DR. ARNDT: Well, also coupling and other issues like that tend to be a bit of an issue, and there has been some research in that area.

MR. SIEBER: I'm not aware of any fiber optics used or intended to be used inside containment.

DR. ARNDT: There is currently no fiber in containment. There have been several research and development projects, both in Asia and in the United States that investigated this possibility.

MR. SIEBER: Jumping to another area, you have a couple of projects in your overall plan that talks about external cyber threats. I know that any time you put a computer in a plant there's somebody trying to connect it to the Internet so they can play with it at home.

You could solve that problem by just saying if it's a control system with protected functions, don't connect it. And why don't they do that?

It frustrates the technician who is too lazy to come to work, but otherwise why have the connection if you're worried about a cyber attack?

DR. ARNDT: Can I put that question off for just two seconds?

MR. SIEBER: Okay.

DR. ARNDT: Are there any other questions on this slide?

(No response.)

DR. ARNDT: The other area is developing issues associated with emerging technologies. One

of those is computer security.

MR. SIEBER: Okay.

DR. ARNDT: I was close.

MR. SIEBER: We could work better together.

DR. ARNDT: Okay. One of the big issues, as you point out, is how does someone actually get into it to have a problem that deals with connectivity and issues like that.

As you know, we have the isolation requirements and other things. One of the biggest problems with that is dealing with the both advantages of using these systems to get diagnostic information and failure information and plant information and things like that, and you want to disseminate that, and also the issue associated with maintenance and things like that.

For example, even the most carefully isolated digital reactor protection system usually has built into it some way of updating the software, some way of doing on-line diagnostics and things like that that can be connected.

MR. SIEBER: Or they want to get flux maps out to run PDQ-7 conversations.

DR. ARNDT: Inputs to the plant computer

and things like that. These can be extremely well controlled, but in most cases you can't eliminate them because simply the idiosyncracies associated with running the system.

MR. SIEBER: Well, the other problem is that a lot of this stuff is COTS.

DR. ARNDT: Actually it is, and actually that varies.

MR. SIEBER: And because it's COTS, it comes with it.

DR. ARNDT: It comes with it. That's correct, and sometimes you want to use it; sometimes you don't want to use it, but you have issues not only with direct connectivity, but also indirect connectivity.

For example, you have a maintenance computer that you used up at the software that is attached once every six months. Well, if you --

MR. SIEBER: Infected that one.

DR. ARNDT: -- infected that --

MR. SIEBER: You infect them all.

DR. ARNDT: -- then you have the potential for a common mode failure of all the systems that it updates. And we've actually seen problems with that both in this industry and in

other industries.

So there are a lot of both functional issues like that, as well as actual conductivity issues and actual system issues. So we have --

MR. SIEBER: Well, there's two approaches to that. One of them is don't connect it. The other one is set up a firewall, plus a work-around program that says, "I'm infected in this area," and so all of that goes to manual.

DR. ARNDT: Right. And if you look at the programs we have in this area, several of them are specifically designed to look at vulnerabilities. What are the kinds of things that can be a problem?

And we've looked at one of the specific reactor protection system digital upgrades, and we're in the process of starting to look at a second one and look at the vulnerabilities specifically.

The other programs have to do with technology and how do you build things like effective firewalls and things like that. What are the things that as a regulator we want to look for when they say, "Well, we're going to put in a firewall"?

Well, does that help you? What needs to

be included? Those kinds of things, as well as some of these functional issues associated with "well, what do the procedures need to be? What are the things you have to look at?"

MR. SIEBER: Now, you have a couple of jobs. If I mention a name, maybe you can tell me if that fits this category. One of them is safety system isolation study, which Oak Ridge has done.

DR. ARNDT: Yes. That is specifically looking at issues associated with vulnerabilities and how effective the isolation is that we are currently doing.

Basically, are we doing all of the things you need to do to maintain separation in an additional environment from cyber.

MR. SIEBER: The other one is classification of digital system vulnerabilities by Pacific Northwest.

DR. ARNDT: That is a program that is looking at primarily the more generic aspects, a second thing I mentioned associated with what are the systems, what kind of failures do you have, what kind of vulnerabilities do you have, how do you classify them, how do you develop regulatory guidance to look at all the different important ones

associated with it.

MR. SIEBER: Okay. The third one is security tool vulnerability case study by Oak Ridge.

DR. ARNDT: That is basically an evaluation of some of the security tools that are out there.

MR. SIEBER: Okay. Why do you have different contractors doing different things?

DR. ARNDT: Primarily because the expertise in this area, although it is fairly broad for generic kinds of computers, it's fairly narrow for real time operating computers. There's a lot of work for cyber in things like PCs and accounting programs and things like that. For real time operational things, it's something that has not been widely looked at.

So there's a fairly limited experience base out there, and we are trying to get people who we thought would do the best job for that particular subset of things, and as it turned out, we chose two contractors, Oak Ridge, and Pacific Northwest.

MR. SIEBER: You also have another one here that looks at wireless.

DR. ARNDT: Yes. And we have a component of that project that looks at wireless

security issues, as well as the generic wireless.

MR. SIEBER: Okay. Now, what would happen to the staff's efforts if you didn't do any of this work? I mean, where would you get stopped first in the business of regulating digital instrumentation?

DR. ARNDT: I -- I --

MR. SIEBER: What would be the first hard spot you would come to?

DR. ARNDT: Okay.

MR. SIEBER: Other than approving Reg. Guide 1.168 and the stream of other ones that are marching down the path?

DR. ARNDT: We would run into two, maybe three generic issues. One, if we didn't have this program, the current regulatory review process as laid out in Chapter 7 would become more and more outdated.

MR. SIEBER: It's already 13 years old.

DR. ARNDT: It's already 13 years old, and --

MR. SIEBER: Fourteen years old.

DR. ARNDT: -- and things like that, and we wouldn't update things as technology changes, et cetera.

The second --

MR. SIEBER: Would that cause you not to be able to review some licensee's application?

DR. ARNDT: It would make the review process less effective, more difficult to do, and less realistic because we would not have a review process that was tailored to the current generation of technology.

The other thing is we would not be able to support new agency initiatives or industry initiatives to change the requirements or change the guidance or regulate in a different fashion, such as being able to embrace risk informed regulation.

So those are the two basic things we wouldn't be able to do, and then there's also the advanced reactor stuff that would be more difficult because we would not have a structure that would more appropriately fit --

MR. SIEBER: Yeah, but your research plan to me looked like it was equally tailored -- it was really tailored to the current generation of plants --

DR. ARNDT: That's correct.

MR. SIEBER: -- as replacements go forward, and just by the nature of it, it would be

applicable to advanced reactors. But even if there were no advanced reactors, they just said to heck with it and we'll stop at AP-1000 or the --

DR. ARNDT: That's correct. The vast --

MR. SIEBER: You would still need all of this.

DR. ARNDT: Right. The vast majority of our work is tailored for the replacement of current generation reactors. There's a few idiosyncracies of new reactors both in the risk area and in the actual system modeling area as we discussed earlier with Dr. Rosen that are specifically to that, but the vast majority of our work is specific to replacement issues in current generation plants.

MR. SIEBER: I apologize for interrupting your talk.

DR. ARNDT: That's what we're here for.

MR. SIEBER: But I need to fully understand that, and I think you're on the last bullet on this slide, technology review.

DR. ARNDT: Yes. These are various advanced or emerging things that people are starting to use and we're doing, and one of the things that fall under that category --

CHAIRMAN APOSTOLAKIS: Let me understand

something first though because I think I understand, but where exactly are we using digital technology in current nuclear reactors?

DR. ARNDT: Okay. Currently as we sit today we have digital technology in almost every balance of plant system.

CHAIRMAN APOSTOLAKIS: Balance of plant, okay.

MR. SIEBER: Feedwater is a good example.

DR. ARNDT: Feedwater is a perfect example. Turbine controllers, digital controllers.

CHAIRMAN APOSTOLAKIS: So this is both control, instrumentation and control.

DR. ARNDT: Instrumentation, control, protection.

CHAIRMAN APOSTOLAKIS: It's controlling the floor. Okay. Protection.

DR. ARNDT: Are all equally being used in safety important systems throughout the plant.

MR. ROSEN: In safety important systems?

MR. SIEBER: But not protection systems.

DR. ARNDT: Let me finish.

MR. ROSEN: Well --

DR. ARNDT: That's true. We are in the

process now of licensing safety systems, SFAS, RPS, with fully digital systems.

CHAIRMAN APOSTOLAKIS: What does it mean, "fully digital"?

DR. ARNDT: Computer based software, those issues as opposed to simple logic or something like that.

CHAIRMAN APOSTOLAKIS: So it would be also control functions?

DR. ARNDT: Control functions already exist in many plants, ATWS issues and things like that.

MR. SIEBER: Well, it's the perfect place to do logic.

DR. ARNDT: Right.

MR. SIEBER: It's the perfect place to do functional analysis, much easier than CAMS and followers.

DR. ARNDT: Absolutely.

MR. SIEBER: But the transmitter is analogue as its input, and the output device is also analogue. Everything else is digital.

DR. ARNDT: Yes, and even some of the instruments themselves are starting to become what is referred to as "smart instruments" that have --

MR. SIEBER: Well, the fluid properties that you're measuring are analogue, and so something is moving someplace.

DR. ARNDT: Right. Something is moving.

As I mentioned, the NRC has generically approved four different digital systems for RPS and FAS. There exists now I think it's five or six plants who have come in and said, "We're going to use those applications, those generic platforms to do a digital upgrade of the safety systems over the course of the next four or five years."

CHAIRMAN APOSTOLAKIS: So this is for RPS?

DR. ARNDT: Yes.

MR. SIEBER: One of the interesting things though is that, you know, I end up with a new computer mainly because I perhaps like to play with them about every 18 months, and it's always got a new processor and, you know, the operating system changes. In fact, the operating system these days is changing every other week, and so if you have a standard application, it's going to be obsolete within a year, and so Licensee A says, "I'm going to put in the standard application," but you don't know what's inside the box, right?

DR. ARNDT: We have a process --

MR. SIEBER: Nor does he.

DR. ARNDT: Well, that's an issue.

We have a process in which we review what's in the box.

MR. SIEBER: Okay.

DR. ARNDT: And there's a whole set of things that we ask, both the process type issues and product type issues associated with how did you develop and how did you QA it, things like that.

MR. SIEBER: Right.

DR. ARNDT: What is done almost exclusively in this area is the vendor will come in with a topical report on generic issues associated with it, and we will spend a significant amount of time reviewing that.

Then the plant will come in and reference the generic approval in their application and then provide additional plant specific implementation. There are some issues associated with that, too, because many of these systems the plant specific implementation includes some computer software changes to make it appropriately plant specific.

MR. SIEBER: True.

DR. ARNDT: And that's what we're reviewing right now for several plants.

MR. SIEBER: Yeah, basically what I'm saying is that, you know, there's going to be a day maybe not in the too distant future when you can't even buy a Pentium IV, and you know, so generally speaking when a topical comes in, it will say the mainframe is cot, you know, off the shelf.

DR. ARNDT: Yes.

MR. SIEBER: And that could mean anything. That means you can take that one out, throw it away, and put another one in of different manufacturers.

DR. ARNDT: We would have to approve that, but there is a process to approve COTS based on the available information associated with it.

DR. BONACA: I had a question regarding this move to I&C, to digital technology. Is it only because clearly the more advanced technology, more capable, first opportunity, or is it driven in part from, for example, recovery margin? What is it driving the most?

DR. ARNDT: There are several things driving it. One is the obvious issue that a lot of these older instruments simply are not made anymore

and there's some maintenance and replacement issues.

One is a purely personnel issue. There are less and less people who know how to maintain old mag amps and things like that, and so there are some operational issues associated with it.

MR. ROSEN: The what?

MR. SIEBER: They weren't any good anyway.

DR. ARNDT: There are other issues associated with the fact that the systems are more capable. If used properly, they can be more reliable. There's also issues that they allow thing like on-line tests and things like that that can improve operational issues.

We have had very few plants come in and ask us for relief because of that, but we anticipate that as these become more common in the industry and there's more operational experience that we're going to get those kind of relief requests.

DR. BONACA: The reason why I was asking is that some of the systems for entering the RPS are go/no go.

DR. ARNDT: Yes.

DR. BONACA: Very simple, find it systems, I mean, and so there, you know, unless --

of course it's hard to see any improvements. You get some functions like DMB protection. Then it becomes very important. Actually from some plants they need that capability to give you the power level that you want to run the plant at. Otherwise you couldn't support it.

But there are very few functions that really have that fundamental functional requirement.

DR. ARNDT: That's correct.

DR. BONACA: Okay.

DR. ARNDT: One of the things that it has been supposed, and I will say it in that way for a particular reason, is that a lot of the techniques that have been available for some time for diagnostics, for diagnostics of the instruments and controllers and production systems themselves and of the process could be exploited significantly with these capabilities.

The reason I say it's speculation is that even though the research and development to develop these methodologies have been ongoing for 30 years, there has been very little effort in this country to do that. There has been a lot of effort in places like Korea and France and Japan to use these systems so that the speculation is that once

the actual systems are in place, they have overcome the regulatory burdens, they have good operational history, that they will use these capabilities to improve the operational issues associated with diagnostics and things like that, longer times between surveillances and things like that.

DR. BONACA: And the last question I had is, therefore, I would expect that we may be seeing more and more attempts to reduce margin or reduce regulatory burden in some areas from the systems, and I think we have to be pretty alert to --

DR. ARNDT: Yeah, and the fundamental issue associated with that is if we can to do a good job and we want to do an efficient job, i.e., turn it around in a reasonable time, we need to have sufficient technical knowledge to be able to do that, and that's, in essence, what the National Academy study said in '97 and what we are trying to do on the part of the research program.

MR. SIEBER: Is that study a public document?

DR. ARNDT: Yes, it is.

MR. SIEBER: Is there a way I could get a copy?

DR. ARNDT: Yeah, I believe there --

MR. SIEBER: Is it a big, thick thing?

DR. ARNDT: It's 150 pages --

MR. SIEBER: That's not thick.

DR. ARNDT: -- something like that.

MR. SIEBER: It covers more than I&C?

DR. ARNDT: No, it's specifically I&C.

MR. SIEBER: Could I get a copy of it through Mike?

DR. ARNDT: It was actually funded at the request of the ACRS. So I'm sure you guys have a copy around here, but I can find my copy and have it copied and sent out if you want.

CHAIRMAN APOSTOLAKIS: You know, you're on Slide 7 and it's --

DR. ARNDT: I understand that, sir.

CHAIRMAN APOSTOLAKIS: Yeah. Can you speed it up a little bit?

DR. ARNDT: I will do my best.

MR. ROSEN: Try not to answer the members' questions.

DR. ARNDT: That's one option.

MR. SIEBER: I won't ask anymore.

DR. ARNDT: The last part was the technology review and infrastructure, and that basically is just kinds of things that we do to stay

ahead of things.

CHAIRMAN APOSTOLAKIS: Yeah, let's go on. Let's go to --

DR. ARNDT: The last major program element is the risk assessment, the issues associated with that. We have four major sub-sub elements in that area, one having to do with data, one having to do with the actual models of the system, one having to do with the reliability assessment and integration to PRAs, and the last one having to do with the risk guidance.

I'm going to try and step through this reasonably quickly. This is basically just a rationale for what I just said. To really be able to do this in a risk informed fashion and be able to review these kinds of applications, we have to understand the state of the data. We have to understand the capabilities of the system models. We have to understand whether or not when integrated into a reliability system, plant reliability model, whether or not they've been done properly and common model and system dependencies and things like that are appropriate, and we have to have some kind of guidance that's somewhat universally accepted.

In the digital I&C failure data issue,

there's a lot of stuff that's been done. Very little of it has been focused on nuclear power plant digital system reliability.

The MIL standards handbook is one area. We commissioned a study specifically to study, to look at what was out there. The aviation area, that's the NUREG that's listed there. There's other generic databases like the LER database.

The problems with these databases is that in most cases they're insufficient to support reliability calculations. There's not enough information. The kinds of failure modes are not specific enough. In many cases they're very sparse because the failure root cause analysis is basically "the card didn't work. We pulled it out and threw it over our shoulder and put a new card in."

That doesn't help an analysis database very much. So that's one of the big issues.

There's been some look at what is there, some trending data, some failure type issues, and what we've found is generically as a system is first introduced there's a lot of problems. As it becomes more common, it becomes more used and it has less problems, not a terribly earthshaking conclusion, but it makes us feel a little better.

We've looked at some of the kinds of basic issues. Is it primarily a requirements problem? Is it a random failure? Is it a software problem, these kinds of issues?

We've gained some information from that, but not sufficient to support data driven failure model type issues, and there's also not an agreement in the nuclear domain of how to integrate non-domain data into the system.

We have worked in house to try and develop a working database for our own analysis. We are also working with a group called the COMPSIS group, which is a OECD/NEA group that is developing an international database.

CHAIRMAN APOSTOLAKIS: Now, when we say "data," what do we mean? Do we mean a description of what happened?

DR. ARNDT: Primarily we're interested in what happened, what was the failure mode, what was the root cause of that failure, what was the consequence of the failure. Did the system shut down? Those kinds of things, as well as the issues surrounding it, the environment surrounding it. Was it during start-up? Was it during test? Was it during operation? Was it part of a transient?

CHAIRMAN APOSTOLAKIS: And this is only for nuclear plants?

DR. ARNDT: The research database is going to start with the nuclear environment, and then it's going to include the generic environment. The COMPSIS database is specifically for nuclear applications.

For example, in the pilot database we have, we have quite a few failures from the Pak's digital I&C upgrade. As you know, that plant went through a digital upgrade about two years ago, and they've just brought it on line, and they've found a lot of things that they weren't anticipating associated with that.

So we have data like that, which we hope will eventually give us enough to support a better understanding of digital system reliability in plants.

EPRI is also doing some work in this area, and it has expressed interest in working with us, and we've also had independent work at Brookhaven to look at specifically the strengths and weaknesses of existing databases in terms of reliability model.

We use the data for a lot of reasons.

One, we want to understand the failure modes. We want to understand the environment. We want to understand whether or not it's being caught in tests or in operations. So there's a lot of reasons for having the data.

One of the reasons is to support reliability modeling.

CHAIRMAN APOSTOLAKIS: But shouldn't BNL have some reliability model in their mind when they're doing this evaluation? I mean, do they know?

DR. ARNDT: What we've specifically tasked them with is go out, look at what's available, look at how it's being used from a PRA standpoint, from a "if this was any other system, what are the kinds of things that you want in a database to support a reliability model?"

So up until this point --

CHAIRMAN APOSTOLAKIS: Yeah, but to support data reliability model, that means they have some model in their mind or --

DR. ARNDT: They have a default model in their mind. The default model is a mark-up model, I believe is the default model that they're thinking about, but the idea is to -- up until about a year

ago, we were looking at this strictly from how do you model the digital system and understand how it works?

CHAIRMAN APOSTOLAKIS: Have you had the review of the strengths and weaknesses of the existing models?

DR. ARNDT: yes, that's also another part of the Brookhaven work, and I was --

CHAIRMAN APOSTOLAKIS: Is that being done now?

DR. ARNDT: Yes. The real issue is most of the work we've been doing is based on this is the difference from how you model it properly and get the failure modes and failures and things like that.

What we wanted to do was get another group of people working at it from the reliability side backwards, saying if this was another system that you would stick in a PRA, what are the characteristics, what are the integration issues, and things like that.

One of those issues is data, and that's this piece. The second part is basically the models themselves.

CHAIRMAN APOSTOLAKIS: That's my question really. I mean, before you launch into

this --

DR. ARNDT: Okay.

CHAIRMAN APOSTOLAKIS: -- shouldn't there be an evaluation of what various models do and cannot do?

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: And this is being concurrently?

DR. ARNDT: This is being done concurrently.

CHAIRMAN APOSTOLAKIS: But I understand you've been funding Virginia for a long time now.

DR. ARNDT: We've been funding Virginia for about six years now, five years now.

CHAIRMAN APOSTOLAKIS: Yeah. So you have some concrete results out of them?

DR. ARNDT: Yes, and we'll talk briefly about that.

As I said, up until about six months, a year ago, we've been pushing it from one direction. Understand the models get a good modeling capability of the system as opposed to specifically how do you model it in a PRA sense.

Recently we've started a second approach that basically goes from the other direction down,

starting with what do you really need from integrating this into PRA, and that is included in the review of the requirements, as well as review of the models.

CHAIRMAN APOSTOLAKIS: Would it be worthwhile to have a specific subcommittee meeting?

Which subcommittee? Is it your committee that handles this or the PRA?

MR. SIEBER: Well, it isn't any, but I'm the one that's the cognizant member.

PARTICIPANTS: PRA.

CHAIRMAN APOSTOLAKIS: They say PRA. So it's probably a joint.

MR. SNODDERLY: There's no I&C subcommittee.

MR. SIEBER: But there should be. By the way, you spent a million and a half at Virginia and 350,000 for this current fiscal year.

DR. ARNDT: that's right.

CHAIRMAN APOSTOLAKIS: Well, the pieces of this up until the risk part are really part of your subcommittee on what is it, Operating Environments? Yeah.

MR. SIEBER: I will do whatever.

CHAIRMAN APOSTOLAKIS: Yeah, and this

part is probably PRA, the way things are.

MR. SIEBER: It's sort of a mix the way I read it.

CHAIRMAN APOSTOLAKIS: It's a mix. It should be a joint subcommittee.

MR. SIEBER: That's the way it is. That's why I'm here.

CHAIRMAN APOSTOLAKIS: But I think we should have a meeting to discuss these things because you've been at it now for a long time and just having an hour and a half, I mean, doesn't do it justice.

DR. ARNDT: Right.

MR. SIEBER: Well, it's a topic in the research report, and I have my own opinions which may not agree with every other member, and so I think it's worth aerating all of this.

CHAIRMAN APOSTOLAKIS: I'm trying to form an opinion, and I don't know what kind of an opinion I'm going to have.

When is our input to Dana due?

MR. SIEBER: November.

CHAIRMAN APOSTOLAKIS: When? November?

MR. SIEBER: He's supposed to give us input in November. We're supposed to give him

feedback in December.

DR. BONACA: He's going to give us his views or a summary of the work that has been done already in November, and you'll have a month.

CHAIRMAN APOSTOLAKIS: How can I find out more about these things?

MR. SIEBER: About what, this?

CHAIRMAN APOSTOLAKIS: Well, I don't know what Virginia and --

MR. SIEBER: I think we need at least a half a day.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. SIEBER: Or more.

CHAIRMAN APOSTOLAKIS: I think each one of them probably is two or three hours, don't you think, Steve?

DR. ARNDT: Certainly the first two are that kind of time period. The others are less.

CHAIRMAN APOSTOLAKIS: Yeah. I mean, really if we are to make a recommendation, we owe it to them to understand what they're doing.

MR. SIEBER: You weren't at the last meeting, but this is a handout. You may want to look at this.

CHAIRMAN APOSTOLAKIS: The last meeting?

Which meeting was this?

DR. BONACA: The meeting.

CHAIRMAN APOSTOLAKIS: Which one was that?

DR. BONACA: Five hundred and sixth ACRS meeting.

DR. ARNDT: As part of updating the research plan, which we plan to do this spring and we're going to come to you and give you a much more detailed brief --

CHAIRMAN APOSTOLAKIS: So what you're saying, Jack, is that we should try to have a one-day subcommittee meeting before December so we can --

MR. SIEBER: I would think so, and I would like to have it -- you know, I was hoping that we would do more, but our agenda with two hours and a one hour break --

CHAIRMAN APOSTOLAKIS: Yeah.

MR. SIEBER: -- doesn't do it.

CHAIRMAN APOSTOLAKIS: So when do you think we should do this? I don't know that --

DR. BONACA: Good luck. November is a disaster.

CHAIRMAN APOSTOLAKIS: There is a one-

day meeting, a one day available.

DR. BONACA: I don't think so. I mean, the first week we have the 507th meeting. The second week we're going to Albuquerque. The third week we have --

MR. SIEBER: Well, I'm not going to Albuquerque.

CHAIRMAN APOSTOLAKIS: Are you going to Albuquerque?

MR. SIEBER: Yeah, well, I'm supposed.

CHAIRMAN APOSTOLAKIS: Is everybody going to Albuquerque?

MR. SIEBER: If you have something more important for me to do I can -- --

DR. SHACK: It depends on whether I have things at Argonne to keep me there that week.

CHAIRMAN APOSTOLAKIS: But I think, you know, this is a very important meeting.

MR. SIEBER: Why don't you form a special task force with George and me, and we'll sit down and meet, and we'll come here and sit down and meet with you?

CHAIRMAN APOSTOLAKIS: Will that help?

MR. SIEBER: At least we'll get the information. Maybe not everybody will, but I think

it's important for you and I to understand.

CHAIRMAN APOSTOLAKIS: Yeah, I don't know. I mean if Dana wants me to write something about this, I have no idea what I should write.

MR. SIEBER: Well, you also got and I think I've gotten four or five copies of it now, the Link report.

CHAIRMAN APOSTOLAKIS: Yeah, but these are, you know, high level summaries.

MR. SIEBER: Well, it's a start.

CHAIRMAN APOSTOLAKIS: It doesn't do justice to the investigators.

MR. SIEBER: No, it doesn't.

CHAIRMAN APOSTOLAKIS: You really can't understand what --

MR. SIEBER: But that's where you start from.

CHAIRMAN APOSTOLAKIS: Well, we have a problem, Houston.

MR. SIEBER: It's a new fiscal year. Our problem is still --

CHAIRMAN APOSTOLAKIS: We need a day. We need a day.

DR. ARNDT: To get a reasonable understanding of the various programs we're working

on, at least a day is necessary.

MR. SIEBER: I would think so.

CHAIRMAN APOSTOLAKIS: Because I see some failure rates here, some transition rates. Frankly, I'm against it. I really need to be convinced that this makes sense. Okay?

So I really don't want to be unfair, but if I were to write something now and look at these around this, it wouldn't be good.

MR. SIEBER: The other issue is a lot of these tasks seem to interlock.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: So shall we bring our calendars in? That seems to be more important than anything else.

MR. SIEBER: I have mine with me because I knew this was going to happen.

CHAIRMAN APOSTOLAKIS: You have what? Oh, you have your calendar?

MR. SIEBER: I knew this was going to happen. So I'm prepared.

CHAIRMAN APOSTOLAKIS: Can I be excused for a minute? Yes, Mr. Chairman.

DR. SHACK: Well, why don't we continue with this and settle this later? I mean, you k now,

this is burning up our hour and a half here.

CHAIRMAN APOSTOLAKIS: Steve is going to go --

DR. SHACK: At least we'll get a presentation of some sort here.

CHAIRMAN APOSTOLAKIS: We will do that, but I want to have some idea as to whether we can meet.

DR. SHACK: We're running out of time, George.

MR. SIEBER: Why don't we do that during lunch?

CHAIRMAN APOSTOLAKIS: Very good.

DR. SHACK: After the meeting.

CHAIRMAN APOSTOLAKIS: We'll do that. Okay. Go ahead.

DR. ARNDT: What I was going to do is briefly go through some of these methodologies just to give you a flavor of the kind of work we're doing.

We have the University of Virginia fault injection methodology, the University of Maryland software metrics methodology, which I'll go into in a little bit more detail.

We're also looking at several

methodologies --

CHAIRMAN APOSTOLAKIS: What's BBN?

DR. ARNDT: Bayesian Belief Network. The Bayesian Belief Network is a methodology to integrate disparate information. What we're asking them to do in the coming year as part of the cooperative agreement is to look at the Chapter 7 methodology of which we have a tool to walk you through and develop the Bayesian Belief Network that would look at all of the different methodologies, steps in that to assure the NRC that the systems are sufficiently reliable and safe, and then develop a methodology to integrate additional information into the decision making process, both analogue or descriptive kinds of things like software reliability and things like that, as well as the more deterministic software quality assurance and things like that.

They are also starting some model based reliability research. That's just in its infancy right now. The RETRANS tool is basically a very sophisticated decompiler. It's an assessment methodology as opposed to a risk methodology that was developed by the Germans in their development and review of the Teleperm product, which is one of

the platforms that have been proved generically for application in the United States.

And then we have Brookhaven looking at a more traditional reliability PRA type thing that looks at failure modes and effects analysis and builds up a reliability model from that.

CHAIRMAN APOSTOLAKIS: How about the Canadians? Haven't they done a lot of research in this area?

DR. ARNDT: The Canadians, surprisingly, have not done a lot of research. They have done some, as have the British. There is a significant effort in support of the Sizewell licensing, and we've talked to the British some, the Canadians not very much.

CHAIRMAN APOSTOLAKIS: I thought they did the formal methods. Didn't they take out the --

DR. ARNDT: They did a fairly sophisticated formal methods analysis, which goes to the requirements, completeness, and things like that, but it doesn't go to an actual reliability or failure rate type number. It just augments the QA type issues and increases the formalism of the QA.

CHAIRMAN APOSTOLAKIS: And we are satisfied we know how to handle that?

DR. ARNDT: We have investigated looking at that. NRR has been less than enthusiastic, shall we say, about that particular project, and given the other things we're doing, it just hasn't risen to the top of the ladder.

The Europeans, particularly the Germans and the Canadians, are very, very fond of formal methods requirements analysis. Other people have less enthusiasm.

CHAIRMAN APOSTOLAKIS: Well, it was not exactly formal methods.

DR. ARNDT: No.

CHAIRMAN APOSTOLAKIS: It was modeling from formal methods.

DR. ARNDT: It was a lot of different things.

CHAIRMAN APOSTOLAKIS: But it was not just formal methods.

DR. ARNDT: It was not just; that's correct.

The University of Virginia program is basically a method to look at whether or not a digital system meets a particular system reliability number based on a figure of merit, which is basically a system test coverage metric, which

basically is a measure of how much of the system has been tested and is known to function properly, which is basically what coverage is. It's a metric associated with that.

In the state machine, you obviously can't test all of the different states you can get to. So coverage is a metric associated with how much of the system you've tested, and it's fairly common usage in the business. You can improve effective coverage in a lot of different ways. Fault tolerances is a method to do that. Redundancy is a method of doing that as well. Systems and standby is a way of increasing that.

It basically uses a very detailed system model and a fault injection methodology to estimate coverage or mean time between failures.

CHAIRMAN APOSTOLAKIS: See, that's where now the disagreement, as you probably know, comes into the picture.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: What exactly does "failure" mean here? And is it reasonable to estimate things such as mean time between failures?

That implies this is a concept from reliability engineering for hardware where failures

are assumed to occur randomly.

DR. ARNDT: That's correct.

CHAIRMAN APOSTOLAKIS: And there is a whole group of people who believe that the failures in software do not occur randomly; that they're built into the system and they just appear at some point because the conditions, the context is correct.

DR. ARNDT: That's correct.

CHAIRMAN APOSTOLAKIS: And then other people say, "No, that's nonsense because, you know, the conditions that make them appear are random themselves."

DR. ARNDT: That's correct.

CHAIRMAN APOSTOLAKIS: So it makes sense to talk about these things. So does it make sense to estimate mean times between failures?

MR. SIEBER: I think so.

DR. ARNDT: Well, the --

CHAIRMAN APOSTOLAKIS: Why?

MR. SIEBER: Well, in my experience , I once did coding, but not perfect coding, but very complex logic networks, you know, a lot of "if" statements and things like that. It may take you months or years to get to a particular loop where

there's a fault, and you may not know where that is until it fails. Okay? You can test and test and test all you want. It's just the nature of things.

And so there is a probability that you'll never get to that, and there's a probability you'll get to it tomorrow. And I think that you can make a fair estimate of how long it will take, and I'm not completely sure in very complex programs that there are any programs that are bug free, especially if you change the platform.

CHAIRMAN APOSTOLAKIS: But don't you think whenever you find a fault, you fix it, don't you?

DR. ARNDT: That's correct.

MR. SIEBER: If you can find it.

CHAIRMAN APOSTOLAKIS: If you find it.

MR. SIEBER: Yeah. You need something like a decompiler and then a logic mapper in order to do it.

DR. ARNDT: As you pointed out, the people who are trying to make this work have basically stated that you can come up with numbers associated with it based on things like thinking of the known or unknown failure modes as a filter on some other random process like the environment and

things like that.

MR. SIEBER: Right.

DR. ARNDT: It's certainly not an ideal solution path for coming up with a number, and there may not be an ideal solution methodology, but the concept that's actually used by Virginia is that there are a set of conditions, be they random or not, that will lead to a failure that you don't want. Unsafe failures is their methodology.

Those can be estimated by both random failures of hardware and input and output issues and things like that, as well as the probability in essence of not discovering a fault and fixing it during the development and test process, which is basically why the coverage number is used frequently as a metric, because the coverage is basically a number that is related to the amount of code in an operational sense, not in the number of lines, that has been tested and fixed.

So the idea behind many of these models is that that number can be determined based on the likelihood of that known fault being encountered.

CHAIRMAN APOSTOLAKIS: I believe we should have a discussion with those guys and try to understand that.

DR. SHACK: Why don't you explain the next bullet? I mean, what does "successfully used" mean?

CHAIRMAN APOSTOLAKIS: Yeah. Well, that was another question.

DR. ARNDT: There are several other domains, transportation being the most common, that have decided that they're going to set a reliability standard, that they will not accept a system that doesn't meet a certain reliability standard or mean time between failure or something like that.

The train transportation business is the main one. For example, the Copenhagen subway system, which is a very sophisticated, automated system, putting two trains going together at the same time in the opposite direction on the same track and things like that is done almost exclusively in an automated fashion.

CHAIRMAN APOSTOLAKIS: We should check that out.

DR. ARNDT: And they would not permit the sale and licensing of this system unless they met a certain mean time between failure number.

DR. SHACK: So that means they implemented this, but we still don't know whether,

in fact, it really describes reality.

CHAIRMAN APOSTOLAKIS: That's right. That's accurate.

DR. ARNDT: They implemented it. They used it to determine if they found some faults that they would not have found otherwise, and they -- I use "successfully" because they licensed it and it's operating. From a licensing standpoint, they use the technology.

DR. SHACK: So it's an implementable technique at any rate.

DR. ARNDT: Yes, yes.

MR. SIEBER: So far no wrecks.

DR. ARNDT: And it has also been done in the Amtrak in the United States.

CHAIRMAN APOSTOLAKIS: But given the statement that you made, Steve, that they found faults they couldn't have found otherwise, I mean, I don't know. Anybody who could test anything finds faults.

DR. ARNDT: Yes.

MR. SIEBER: That's their job.

CHAIRMAN APOSTOLAKIS: This is the fundamental question, and I think it's a very important thing and we should really understand it

because, you know, there is a school of thought as you very well know --

DR. ARNDT: I'm very well aware.

CHAIRMAN APOSTOLAKIS: -- that says that you really have to go to the fault trees as you're doing it now, then be aware of the fact that some of these things are done even by digital machines, and build the failures into the fault trees.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: And you are always dealing with the hardware that takes commands from other things. This is very different from saying, "Okay. I have now the fault tree here, and I have the software here. There's another box that may have a mean time to failure."

And I tend to go with the first group because I think it makes more sense, but on the other hand -- and somebody pointed it out to me -- your PC, does it freeze every now and then? You know, that's not part of a fault tree. I mean there must be something.

And then you often start again and it works. So there may be something to this as well. So I think the challenge that we have in front of us is to really understand what these things mean.

It's amazing to me that these people, not just these -- I mean in general -- they don't read each other's work, and they just do things, and the other guy is stupid. You know, that's not -- we should try to build on what people are doing.

DR. ARNDT: It is a real challenge, which is one of the reasons we've started doing from the other direction work from a reliability PRA standpoint, working the opposite direction, which is exactly the point you are making.

CHAIRMAN APOSTOLAKIS: Yeah, the issue of fault injection, I mean, that's a very useful thing to do, you know, to make sure that you find mistakes and so on. Now, how useful it is in trying to estimate mean times to failure I don't know, but it is a useful thing to do.

MR. SIEBER: One of the interesting things is if you had a diagnostic code that you could apply to INC software that would find faults, you wouldn't find them all because you may end up with an iterative process that doesn't converge, and it would not be obvious that it wouldn't because part of the time constant is the external world, you know, valves, the fluid system, the temperatures that cause that to happen, and so you've got a

system that hunts or goes in the wrong direction.

DR. ARNDT: And there's actually a reliability estimation methodology that does exactly that. They're not really a growth model.

MR. SIEBER: But you cannot deterministically apply troubleshooting to find stuff like that.

DR. ARNDT: That's correct, but in any case, let me move forward on this because we're never going to get anywhere.

CHAIRMAN APOSTOLAKIS: I think it would be an interesting study -- sorry -- to go back to the databases that you are developing or others have developed and try very hard to understand by looking at things that have happened whether they justify the notion that things are random or not.

DR. ARNDT: Right.

CHAIRMAN APOSTOLAKIS: Were they really due to design or specification errors or were they really due to things that were random in nature? Nobody could have predicted that it happened.

DR. ARNDT: Right, and one of the things we're trying to do in taking the data and putting it all together is trying to be able to do those kinds of things.

CHAIRMAN APOSTOLAKIS: Okay. I think we need a day and a half, not just a day.

DR. ARNDT: We probably need a week, but that's a different issue.

One of the things we're trying to do is demonstrate these technologies in a nuclear application because there's a lot of domain issues associated with this. The current one we're working on which you just finished up is the Calvert Cliff main feedwater demonstration project.

Real quick, the idea is you develop a model, which is a very detailed, analytical model of the system. How does it work? Where are the bits and all of these kinds of things?

You develop a statistical model that basically tries to determine the kinds of tests you want to do, the number of tests, and things like that. It's actually a stratified statistical model.

You develop the generic fault model for the kind of system. You figure out the operational profile.

CHAIRMAN APOSTOLAKIS: So this is now using the Virginia approach?

DR. ARNDT: Yes, this is the Virginia approach.

You go through the kinds of fault evaluation and testing and things like that, and you inject the faults and basically do that. The outside loop on the right there is the operational profiles for the different operational profiles, and you eventually come up with a number that then you can use for parameter estimation for things like this coverage doppler.

CHAIRMAN APOSTOLAKIS: When you say "main feedwater," what do you mean? What does this system do?

DR. ARNDT: It does this.

MR. SIEBER: Controls the feedwater valve.

DR. ARNDT: It controls the feedwater valve.

CHAIRMAN APOSTOLAKIS: And the question is now, again coming back to the other thing, can you really look at the system separately from all of the hardware you're showing there.

DR. ARNDT: In point of fact, this methodology includes the hardware. What we have is a simulated system, and when I said "simulated," it can be completely in software, software simulation. Simics is a simulation model, or it could it be

partially hardware and software.

In this particular case, they had some of the hardware controllers as part of it and as well as the software of the controller and the different fault modes. You can do it entirely as a simulation of the software if you like. Most of the time Virginia tries to make the software simulating the software and the hardware simulating the hardware so that they actually have the physical system included because you want to simulate not only hardware failures and software failures, but the hardware on software or the software on hardware failures, the interfaces and things like that.

Because in some cases a software error will manifest itself differently depending on the hardware, and interrupts and things like that can have different effects on different softwares.

So the idea is you do that. You have an environmental simulation of some sort based on what is the plant demanding and things like that, and from that you will develop a model. In point of fact, it's a dynamic fault tree model, which is then converted into a Markov to solve it.

You can also generically make a very simplified Markov that basically looks like this,

which rolls up the coverage number, and this is a very simplified version of it. This is a comparator system. You have a primary, a back-up system. You can have both systems working. You have one system working. You can have failed in safe mode or you can have failed in an unsafe mode, and you have the various transitions associated with that.

CHAIRMAN APOSTOLAKIS: See, that's the question now. What is the basis of this lambda?

DR. ARNDT: Yeah.

CHAIRMAN APOSTOLAKIS: And how do we know there is a constant condition or probability of moving from one to the other?

DR. ARNDT: Right.

CHAIRMAN APOSTOLAKIS: And it's an easy way out of it, but gee.

DR. ARNDT: Well, it's an approach to modeling that has limitations, like any other model.

CHAIRMAN APOSTOLAKIS: Because it's not demonstrated.

DR. ARNDT: This is just a number associated with the importance of both the controller itself and the comparator and what kind of numbers you --

CHAIRMAN APOSTOLAKIS: See, this thing,

the first bullet killed it for me. "Assume lambda," 100 -- what do you mean? You know, I can assume I'm the king of Greece, you know.

MR. SIEBER: That would be --

CHAIRMAN APOSTOLAKIS: It's actually more likely. This is what these guys do critically. Can this show based on some sort of information that is believable that such a lambda exists, let alone it being 100 failures per million hours?

I mean you prove that to me I'd be more than happy to applaud.

DR. ARNDT: That particular bullet has to do with the assessment methodology. We assume you have to have a certain mean time between failure. Therefore, you need at least a lambda associated with a certain number. That's why that particular bullet is up there.

But the real issue you're getting to is how do you know that the methodology is at least reasonable.

CHAIRMAN APOSTOLAKIS: Right, right, and that there is a such a lambda that makes sense. That's the real question.

MR. ROSEN: Do we have any data on it?

CHAIRMAN APOSTOLAKIS: That's my

question:

DR. ARNDT: We have operational data in other domains, basically how long it took between failures of certain kinds of things. The primary problem with that is that most of these systems either failed right away because someone simply didn't think of something or take a long time to fail, tens of thousands, hundreds of thousands, millions of hours. So you have some very --

DR. SHACK: Very sparse data.

DR. ARNDT: Significant sparse data issues, and you can do a Bayesian analysis and figure out what level of confidence you can get from the data that's available.

CHAIRMAN APOSTOLAKIS: The question is: do you believe that these are random occurrences versus sophistication errors?

MR. ROSEN: Well, he just told us that by and large they are not random. It's by bimodal. Either they fail right away or they fail in very long times.

DR. ARNDT: The real issue is everyone knows that these kinds of things are basically imbedded failure type issues, and they're not random. The real issue is can they be effectively

modeled that way. Is there a modeling mechanism that's realistic that you can use to model them in a way that's analyzable really?

Because we know reality isn't that. It's a state machine that it either fails or it doesn't fail, but there are a lot of things in life that we can't model exactly. This is really an issue of --

MR. ROSEN: And that failure includes such things as a strange, off normal, circumstantial demand on the software that it never has seen before and didn't see during testing and just locks up.

I do that to my Microsoft stuff all the time. I ask it to do stated things, and it says fatal error and then gives me a number and it says do you want to know the details, and I press the button and it shows me the details. I don't understand them. So I just boot my machine up.

CHAIRMAN APOSTOLAKIS: This particular methodology physically goes through all of the operational profiles. The real issue is how -- one of the issues is how well do you know the operational profiles. That is better in our particular case because most of these are controlled very tightly on operational profiles. They're used

in very specific ways. There's procedures, et cetera.

There's always random type issues. So cosmic ray comes in and changes a bit, but by and large that's not a big problem, as much of a problem as a lot of these other issues.

MR. SIEBER: When you decide how you're going to lay out your budget, do you think about whether you ought to be putting money into developing programs and systems to make the software correct and end up putting in the projects that say, "How often do I think this is going to fail?"

In other words, you know, how do you balance that?

DR. ARNDT: Yeah, that's a very difficult problem because, as you know a lot of these things are unknown.

MR. SIEBER: Absolutely.

DR. ARNDT: And we're kind of shooting in the dark.

MR. SIEBER: Yeah.

DR. ARNDT: First of all, we don't do it to develop new methodologies. We do it to develop tools to help assess the methodology. So we look at both what is the consequence of us not catching

something, as well as what is the probability it's going to be an issue associated with what systems are being used, what systems are coming into plants and things like that.

It's usually a little bit easier to figure out what may come into plants ten years from now. Well, this is going to fail as bad as that scenario sounds because we at least have some anecdotal data associated with that.

MR. SIEBER: Yeah, and in a purely analogue system you wouldn't do any of this. You can put whatever research money you have into making the hardware better as opposed to trying to figure out when it's going to fail.

DR. ARNDT: Assessing the likelihood of hardware failure.

MR. SIEBER: Right.

DR. ARNDT: As a regulator we don't figure out how to make it safe. We figure out whether or not we believe them telling us they're safe is safe.

Real quickly, the University of Maryland system is looking specifically at software reliability prediction methods, and it's based on the premise that one of the things that really

affect software reliability is the software engineering itself, which is the same premise that Chapter 7 is based on.

It is also the same premise that a lot of the industry standards and industry evaluation methods, like the capability maturity model, is based on. So the idea is to look at what characteristics of the software engineering methodology really affects software reliability, the project characteristics, things like the size of the code, the complexity of the code and things like that, as well as developmental characteristics like was there a lot of effort spent on it; was there a lot of research dollars, et cetera.

So the idea is basically use these kinds of things to develop a reliability prediction system. The idea is you'd look at software measurements that are done.

The other nice thing about this is that many of these things are developed as part of the software process in the first place. So there is information out there on some of the software metrics, and then you develop a system of metrics that will cover the kinds of failure type issues you might have.

So what was done was they developed a methodology to do this, and we've done a trial sample of this or pilot, if you'd prefer, and the methodology is not that uncommon.

We looked at the different measures. There's over 100 widely used software quality measures or metrics. We narrowed that down to about 30. We had an expert elicitation to try to determine which ones are the most important and effective and which ones cover other ones, i.e., which ones are redundant to other one.

We then aggregated those in some sensitivity studies associated with the expert elicitation, and then --

CHAIRMAN APOSTOLAKIS: Yeah, I need to understand this much better. I mean, I don't know who the experts are, what they're doing, you know.

DR. ARNDT: Okay. We can provide that information.

CHAIRMAN APOSTOLAKIS: It's really as a follow-up behind this.

DR. ARNDT: There is a lot associated with this.

CHAIRMAN APOSTOLAKIS: So we are finishing in a couple of minutes. How do you want

to finish it? Do you want to go to the end?

DR. ARNDT: I'd prefer to step through it very quickly because there's a --

CHAIRMAN APOSTOLAKIS: All of them?

DR. ARNDT: I can do it in about --

CHAIRMAN APOSTOLAKIS: Steve.

DR. ARNDT: Because there's a couple of bits and pieces of information on various things.

CHAIRMAN APOSTOLAKIS: Can you give us those bits of information when you go to slide 30?

DR. ARNDT: Yes.

DR. SHACK: Well, let him step through and give the bits that he thinks are important.

CHAIRMAN APOSTOLAKIS: Yeah, on slide 30.

DR. ARNDT: These are the measures, some of which you know. This was the results of the pilot. The pilot was --

CHAIRMAN APOSTOLAKIS: You see, you're raising now a red flag in front of me. You think it's easy to go through this? Okay.

DR. ARNDT: The one thing you might care about is the actual middle column. That's the reliability prediction, the piece of S and the bottom number there was the anecdotal actual number

based on data.

MR. ROSEN: Ninety-one percent?

DR. ARNDT: yeah.

MR. ROSEN: My God, that's awful.

DR. ARNDT: It was not a particularly good system. The reason we used it was because we had the information available. The follow-up project is going to look at a real high reliability system, give us better implications.

The Brookhaven work is looking at, as I mentioned before, building up a PRA model in the traditional way, looking at the failures, looking at the data, going through the various descriptive analyses of the system, particularly looking at digital features and connections and things that are different in a digital system, as George pointed out, than most systems in a fault tree base kind of thing.

CHAIRMAN APOSTOLAKIS: So if we have this date in the future --

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: -- would you have someone come here and give us a critical review of the available models? This is what this model does and these are the pros and the cons. This is what

this model does.

I think this is an area where we really don't know very much, and it would be really useful to have this exhaustive, critical review.

Is anyone doing this now? Could the BNL guys do it, or you can do it?

DR. ARNDT: I can do most of it. I would like certainly to have some support from some of the people who have looked at it.

CHAIRMAN APOSTOLAKIS: Sure.

DR. ARNDT: And a longer, more concentrated time. Either the BNL guys or there are some people --

CHAIRMAN APOSTOLAKIS: Of you can be a group of people.

DR. ARNDT: That would be my choice.

CHAIRMAN APOSTOLAKIS: Yeah, yeah, sure.

DR. ARNDT: Getting that group together on short notice may be a challenge. So I can't --

CHAIRMAN APOSTOLAKIS: I understand that, but you know --

DR. ARNDT: -- guarantee, but I can do the best I can.

CHAIRMAN APOSTOLAKIS: I don't want you guys to repeat the mistake the human reliability

people did where they would just start, you know. Each group would start its own model ignoring everybody else.

DR. ARNDT: Yeah.

CHAIRMAN APOSTOLAKIS: You know, there has to be some interaction. At some point we have to agree that some things are not good.

DR. ARNDT: Right.

CHAIRMAN APOSTOLAKIS: And some things are good.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: Even if somebody else does not, right?

DR. ARNDT: That's correct.

CHAIRMAN APOSTOLAKIS: Usually what other people do is no god, but sometimes.

DR. ARNDT: Yeah, and one of the things that we are doing is sponsoring workshops and conferences associated with that. For example, there's a workshop, OECD workshop this summer on some of the software validation issues.

There's a large I&C ANS meeting int eh fall that's going to try and bring these things together.

What I have on the slide now is

basically some of the things that we're going to be doing in this area. We're going to be looking at some pilots to see whether or not the methods work in practice. We're going to be assessing the feasibility of basically what you said earlier, a plug-in model into a static PRA as opposed to the integration type issues.

CHAIRMAN APOSTOLAKIS: You know, I'm not really on top of the state of the art, but there are these, for example, conferences every year in Europe, SAFECOM (phonetic).

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: I think I sent you the last information.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: And I just glance at the papers, and what amazes me all the time is that the people are going 20 different directions.

DR. ARNDT: That's correct.

CHAIRMAN APOSTOLAKIS: If you read ten papers, you will be very hard pressed to say, "Oh, and this is the common thread." No. One guy says, "I'm going to use four more methods."

Another guy says, "Oh, I came up with this great approach."

Another guy says something else. That tells me that the state of the art is really very primitive. People are still looking. They're trying to understand what's going on.

MR. ROSEN: But isn't it true, George, that --

CHAIRMAN APOSTOLAKIS: So my point --

MR. ROSEN: -- in this area somebody stands up and says, "Ah, F equals MA," and everybody says, "God, that's terrific"?

CHAIRMAN APOSTOLAKIS: No, but my point is --

MR. ROSEN: I mean, until we get to that day no one is going to --

CHAIRMAN APOSTOLAKIS: And that's why I want this agency to sponsor a critical review of what people are using and say from now on if we see these works, that's garbage for such a reason, rather than jumping into methodologies that, you know, prestigious universities proposed without really having had the benefit of a critical review of all the ideas that are out there.

There was something like this years ago by a national laboratory, but it was really not very good.

MR. ROSEN: But my point, George, is it's a question really. Is it too early to do that? No one said F equals MA. They're all groping around trying to come up with something.

CHAIRMAN APOSTOLAKIS: But we're investing money into approaches. That's what I'm saying.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: We should be aware of what's out there, what are the pros and cons of each approach, without waiting for Newton's law, which will never come.

DR. ARNDT: Well, and the other real issue is that there are specific industry actions directed at using risk issues in I&C review. Whether we like it or not, whether we agree with the state of the art or not, there is current industry movement in the direction.

Finally, I have up there is basically to some extent what you are talking about. One of the things we're going to be doing in the next year or two is looking at guidance. What is the level, methods, data, and quality of analysis that we would require before we would even say let's look at it, as well as the issue of completeness and scope,

which is a real issue in this area.

How much of the system do you have to model, how much of the common mode things as well?

CHAIRMAN APOSTOLAKIS: That's fine.

DR. ARNDT: And as I mentioned, we did a study of that as part of several programs. The B&L program was one of those that will feed into that.

CHAIRMAN APOSTOLAKIS: Absolutely.

DR. ARNDT: We're not there yet.

CHAIRMAN APOSTOLAKIS: There are some very fundamental questions that we really have to debate among ourselves, and again, my comments are not made because I disagree with what Steve is doing. I mean, I fully appreciate the difficult position that you are in, but does it make sense to talk about failure rates or transition rates when you talk about software?

There's a whole school of thought that says no, that these things are specification errors, this and that, and they're not random in nature.

There's another school that says no, no, no. There is randomness to it. So it makes sense. So let's have a debate of that first and have a common approach, a common understanding. Maybe our conclusion will be, well, it's too soon to tell.

I don't know, but cán we do that and start moving as a group without, again, having these diverse, you know, you present something and I think something else? And that's what I would like to do, and I don't know if you are ready for that.

And another thing. I don't know if you're aware of it, but this committee now is very willing to participate in debates with the staff when the staff has a half baked idea and we're trying to help rather than criticize. Okay?

We have eliminated the pleasure of criticism because we want to be nice. At least some of us.

MR. ROSEN: Some of us. No, I take great pleasure in criticism.

CHAIRMAN APOSTOLAKIS: I think that that is great.

DR. ARNDT: The real issue now, there's two issues here, and I won't bother with the rest of the slides. I'll just go to the summary. AS I said before, we're doing some work in --

CHAIRMAN APOSTOLAKIS: Very good.

DR. ARNDT: -- advanced reactor area and this area as well.

The real issue is what is the believe as

to whether or not licensing actions based on these kinds of methodology are supportable by the state of the art in data as it was in the policy statement.

CHAIRMAN APOSTOLAKIS: Absolutely.

DR. ARNDT: And if we believe that it is sufficient, what are the uncertainties and what are the limitations associated with it that we're going to have to recommend or impose on those kinds of actions?

For example, one of the methodologies being proposed for the EPRI D3 project is basically just a bounding study. It basically says we're going to assume that certain things happen in the instrumentation and control systems, and they're no worse than such-and-so a number, and then based on that, we're going to do some other studies that show this is a small contributor to the risk.

I personally have a lot of issues with that idea because unless you model some of these issues, such as a system that may fail and prevent the operator from resetting it, that's not something you can model in a simple bounding analysis. Some of the common mode failure type issues.

So there are approaches being proposed in the industry now that if we don't have some

guidance could get us in serious trouble.

MR. ROSEN: Oh, big trouble. If you go back to George's comment, that this is not a continuous kind of failure, these are not random and, therefore, what we're talking about here do not lead to techniques that are used to bound randomness, and bounding analysis is a technique to handle randomness.

We say, "Well, yes, it's totally random, but it doesn't go above .8 of this value. Look at all of the data."

And so then you say, "Yeah, I guess that's true. There's a very low likelihood, practically infinitesimal, that if we take that value it will not be bounded."

Okay. In that case there's a lot of rationale for it, but when we're talking about what we're talking about here, that effort and that process falls apart fundamentally.

DR. ARNDT: That's correct, and even if you believe that there is a method that uses randomness to model this, the one they're currently proposing has real issues because my fundamental problem with it is not that it's bounding. It's that it's bounding without understanding what you're

trying to bound.

MR. ROSEN: That's not bounding.

DR. ARNDT: That's a real challenge.

CHAIRMAN APOSTOLAKIS: Okay. I think you did a good job raising the issues.

DR. ARNDT: Okay.

CHAIRMAN APOSTOLAKIS: No, really. I don't --

DR. ARNDT: We owe you a --

CHAIRMAN APOSTOLAKIS: It's really a difficult position to try to come up with something that's reasonable here when there are such strong disagreements among people. So I don't know.

MR. SIEBER: Let me ask one more question.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. SIEBER: On the previous slide you talk about a new plan. Is there going to be a new plan? When will it be and why will it be? What do you have to change that the old plan doesn't do?

DR. ARNDT: Okay.

MS. EVANS: Yes, Steve can talk about the plan. I'll talk about the schedule.

DR. ARNDT: The original plan was written. It was put out in August of '01. It

actually had a couple of years' worth of planing in it prior to that. So we were always planning on updating it as necessary either this year or next year, some time like that.

We believe that there are certain things that need to be changed primarily because we have finished some things; we have some new things, security and things like that in particular. We also want to change some of the direction, as I mentioned, in the reliability area and some other areas. So there's a need to do that.

Also, whether we like it or not, we at least from a policy standpoint are leading a lot of the other regulatory environments. When we put out the first plan about half the countries in the world promptly dumped theirs and had a new one based on ours.

So there's a certain amount of leadership both in the international cooperation and the international regulatory area associated with this, and we need a new plan to look at some of the new things that are going on.

MS. EVANS: And as far as time frame, we'd be looking to have something for ACRS actually next fall, in September.

CHAIRMAN APOSTOLAKIS: "Something" means?

MS. EVANS: A revised or new plan.

DR. ARNDT: A clean, revised plan.

CHAIRMAN APOSTOLAKIS: For?

DR. ARNDT: ACRS review.

MS. EVANS: For I&C, digital I&C.

CHAIRMAN APOSTOLAKIS: Research, after seven years of research we have a new plan?

MS. EVANS: An update. It's an update to the plan.

CHAIRMAN APOSTOLAKIS: It's like the five-year program of the former Soviet Union.

MR. SIEBER: Like the USSR.

CHAIRMAN APOSTOLAKIS: I would really like to have a subcommittee meeting way before then.

MS. EVANS: Right.

CHAIRMAN APOSTOLAKIS: I really want to avoid having a confrontation with the staff. Okay? And a year from now it seems to me we're working very hard to create a confrontation.

MR. SIEBER: I think we need one before we reply to --

CHAIRMAN APOSTOLAKIS: Dana.

MR. SIEBER: -- Dana.

CHAIRMAN APOSTOLAKIS: Okay. Now, the only day I see here --

MR. SIEBER: The last one on that last page.

CHAIRMAN APOSTOLAKIS: Is the 11th of December a good time?

DR. ARNDT: Of which year?

CHAIRMAN APOSTOLAKIS: Of this year, for us to have a debate. You know, you could bring in the Virginia guys, the Maryland guys.

MR. SIEBER: I could do that.

CHAIRMAN APOSTOLAKIS: BNL and you chair it. We have a meeting. This is what we're doing. this is what we think.

MR. SIEBER: Yeah, I could do it.

CHAIRMAN APOSTOLAKIS: I mean, you have more than two months to get preliminary feedback from the committee, not a letter. We're not going to write a letter.

DR. ARNDT: I know.

CHAIRMAN APOSTOLAKIS: You understand what I'm saying. This is a working --

DR. ARNDT: I understand that, and --

CHAIRMAN APOSTOLAKIS: Thursday, the 11th. We can start a little -- well, yeah. I don't

want to miss all of the -- how about if we start Thursday, the 11th, at noon and we continue Friday?

MR. ROSEN: Is that a regularly scheduled --

CHAIRMAN APOSTOLAKIS: No, this is a subcommittee.

MR. ROSEN: You're now scheduling it, right?

CHAIRMAN APOSTOLAKIS: Yes. You are now scheduling it, because I want to be able to write something useful for Dana, his research report.

MR. ROSEN: I have a Human Factors Subcommittee meeting the prior week, on the 3rd.

CHAIRMAN APOSTOLAKIS: Well, another thing is -- or we could have it on the 2nd, Tuesday, the 2nd.

MR. SIEBER: Well, that's fine with me. I would rather do that because that simplifies the number of trips I have --

CHAIRMAN APOSTOLAKIS: Is the 2nd of December okay for you guys? Tuesday?

DR. ARNDT: Without talking to people, it's a little hard to do that. I will physically be in Rockville those weeks.

CHAIRMAN APOSTOLAKIS: We know you have

influence, Steve. You can influence these.

DR. ARNDT: I can influence a lot of things, but there's a lot of things I can't influence.

CHAIRMAN APOSTOLAKIS: Well, look. I mean --

MS. EVANS: The scope of what you want, right, just so that we have --

CHAIRMAN APOSTOLAKIS: I want to understand what these contractors are doing.

MS. EVANS: Okay.

CHAIRMAN APOSTOLAKIS: And I want to have a free wheeling discussion among them and us as to whether these things make sense. Does it make sense to talk about the mean time between failures? Does it make sense to have a transition probability rate in these Markov models?

And let them defend it, and let them attack it, whatever, but we have to start building a common understanding before you guys go too far ahead and then come of us disagree with you.

MS. EVANS: Correct. Okay, and without talking to people outside of here, we know Steve will be here that day.

DR. ARNDT: Yeah.

MS. EVANS: But to do what you want, we're going to have to -- do we have a couple of days to pick from?

MR. ROSEN: Get the EPRI proponents of this bounding approach in here to take some heat.

CHAIRMAN APOSTOLAKIS: Well, he doesn't want to come here.

DR. ARNDT: I would be uncomfortable including the D3 group in this particular kind of --

MR. ROSEN: Well, if they're going to go around talking like that and making those kinds of -- they had better be -- I mean, I'm prepared to listen and to --

CHAIRMAN APOSTOLAKIS: Maybe at the second meeting.

MR. ROSEN: All right. Go ahead. Fair enough.

CHAIRMAN APOSTOLAKIS: And I'll go along. I think it should be among us.

MR. ROSEN: Sure, good, but let's not --

CHAIRMAN APOSTOLAKIS: An internal meeting, so to speak.

MR. ROSEN: I didn't detect a lot of agreement from you with the D3 approach.

DR. ARNDT: My personal opinion is there

are some significant issues that need to be dealt with.

CHAIRMAN APOSTOLAKIS: Okay. Let me put --

DR. ARNDT: I do not speak for the agency.

MR. ROSEN: No, we understand.

CHAIRMAN APOSTOLAKIS: We don't speak for the ACRS either.

MR. SIEBER: One of the --

CHAIRMAN APOSTOLAKIS: Okay, Jack.

MR. SIEBER: You know, you can also cover simple minded things like the project on lightning, and I wonder why you have a project on lightning when you already have standards for RFI and surge protection. What makes this different that isn't enveloped under that standard?

DR. ARNDT: We can propose an agenda or you guys can propose an agenda to us.

CHAIRMAN APOSTOLAKIS: Yeah, we can work on the agenda, but let me give you two dates because Michele wants two dates. We have the 2nd of December or we start at noon on the 11th and go on to Friday. I have to fly down on Thursday morning.

Because if we --

MR. ROSEN: I have a preference for the 2nd of December because Christmas is coming, and I begin celebrating early.

DR. SHACK: Skip the dinner.

CHAIRMAN APOSTOLAKIS: I'm skipping a lot of those dinners.

MR. ROSEN: This is going to be the PRA Subcommittee?

CHAIRMAN APOSTOLAKIS: PRA and Operations, Operating Plans, yeah, both, joint.

But you know, the reason for the 2nd is, you know, the members will be here anyway for the 3rd through the rest of the week.

MR. SIEBER: That saves me two days.

DR. SHACK: Yeah.

CHAIRMAN APOSTOLAKIS: Yeah. So we can --

MS. EVANS: Is the timing right for what you need to do and give Dana --

CHAIRMAN APOSTOLAKIS: I believe the 2nd is even better because the research report will be hot at that time. We will need to write something.

MR. SIEBER: We need to be hot, too.

CHAIRMAN APOSTOLAKIS: Yeah, we need to be hot, too. You know, before then it's kind of

unfair to you because you need some time to prepare, and this, of course, is uppermost in our thinking.

DR. ARNDT: Fair is generally not on the list.

CHAIRMAN APOSTOLAKIS: We don't want to create any discomfort, do we?

MR. SNODDERLY: So right now I'm going to go reserve December 2nd on our calendar, or schedule or calendar, unless I hear different from Michele and Steve.

MS. EVANS: Yeah, that's fine.

CHAIRMAN APOSTOLAKIS: And if you guys --

MR. SNODDERLY: And because you can't support it or the people aren't going to be able to, then we will set --

MR. ROSEN: Wanda Sikes told me earlier that the Fire Protection Subcommittee meeting currently scheduled for November is not going to come off.

CHAIRMAN APOSTOLAKIS: No, for the Human Factors Subcommittee meeting on Wednesday, do you need the whole day?

MR. EL-ZAFTAWY: Well, there is another subcommittee --

CHAIRMAN APOSTOLAKIS: Or you will find out this afternoon?

MR. EL-ZAFTAWY: Yeah, there is another subcommittee meeting.

CHAIRMAN APOSTOLAKIS: Because if you don't need the whole day, we would take some --

MR. ROSEN: Well, I don't know. We haven't gotten an agenda yet.

MR. EL-ZAFTAWY: There is another subcommittee in the afternoon at the Human Factors. On the 3rd, there was another subcommittee meeting also, on the afternoon of the 3rd.

CHAIRMAN APOSTOLAKIS: His Subcommittee on Human Factors is the whole day?

MR. EL-ZAFTAWY: No. Only have a day, and then there is another --

CHAIRMAN APOSTOLAKIS: The morning.

MR. EL-ZAFTAWY: Yes.

CHAIRMAN APOSTOLAKIS: He has the morning.

MR. EL-ZAFTAWY: He has the morning, and there's another subcommittee meeting in the afternoon.

CHAIRMAN APOSTOLAKIS: I really think one day with these guys is kind of short because,

you know, we're talking about ideas, Michele, and people need time to, you know, argue, and you cannot cut if off and say, "Keep going."

DR. ARNDT: It really depends a lot on the agenda, and obviously it's hard to do a lot in a short period of time, but it's also hard in some cases to do a little in a little time because we've got to figure out what the expectation is.

CHAIRMAN APOSTOLAKIS: The fundamental question is: does it make sense to use those rates of transition from --

DR. ARNDT: I understand your issue, George.

CHAIRMAN APOSTOLAKIS: Now, you ask those guys. If they want to come here and defend it, fine. Then the other thing I don't understand is this process thing that Maryland is doing. I mean --

DR. SHACK: We need somebody to attack the idea, George. Of course they're going to defend it.

CHAIRMAN APOSTOLAKIS: Do we have anybody?

(Laughter.)

MR. ROSEN: The other part of this that

hasn't been talked about, besides all of these cautionary things, is while we're walking around spending years, decades maybe, being cautious, we're losing the advantages that these systems bring, and they are substantial.

So the avoided costs of not having digital technology helping us with nuclear safety is also real.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: It's true. It's a cost benefit. It's benefit evaluation.

DR. ARNDT: Yes.

CHAIRMAN APOSTOLAKIS: Okay. Anything else?

MR. SNODDERLY: Well, I thought, George, just while we're on this, Steve said two and a half hours on the BNL methodologies, two and a half hours on the Maryland --

CHAIRMAN APOSTOLAKIS: No, no, no. We'll do that off line. We'll do that off line.

Steve, why don't you come up with a draft agenda, and then we'll comment and go back and forth.

MR. SIEBER: Very good.

CHAIRMAN APOSTOLAKIS: Okay? No

pressure.

MR. ROSEN: He said, holding the hammer in his hand.

CHAIRMAN APOSTOLAKIS: Any other comments from the members, from the staff?

MS. EVANS: No.

CHAIRMAN APOSTOLAKIS: Are you happy, Michele?

MS. EVANS: Oh, very.

CHAIRMAN APOSTOLAKIS: Okay. Thank you very much for coming. This was good. We should have done this five years ago, but it is never too late. Thank you.

We will recess and what? Reconvene at 1:20.

(Whereupon, at 12:21 p.m., the meeting was recessed for lunch, to reconvene at 1:20 p.m., the same day.)

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

(1:24 p.m.)

CHAIRMAN ROSEN: This meeting will now come to order.

DR. APOSTOLAKIS: It's in order.

CHAIRMAN ROSEN: This is a joint meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Reliability and Probabilistic Risk Assessment and Human Factors.

I am Steve Rosen, Chairman of the Subcommittee on Human Factors. Members in attendance are George Apostolakis, Chairman of the Subcommittee on Reliability and Probabilistic Risk Assessment; Mario Bonaca --

DR. APOSTOLAKIS: He is not present.

MR. SIEBER: He isn't here.

PARTICIPANT: He just stepped out.

CHAIRMAN ROSEN: He just stepped out.

-- Chairman of the ACRS; William Shack; and Jack Sieber.

The purpose of this meeting is to discuss human factors, organizational safety culture research, and the SPAR-H model activities with representatives of the Office of Nuclear Regulatory Research. The subcommittee will gather information,

analyze relevant issues and facts, and formulate proposed positions and actions as appropriate for deliberation by the full committee.

Med El-Zaftawy and Mike Snodderly are the Designated Federal Officials for this portion of the 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 1st, 2003.

A transcript of the 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.

DR. APOSTOLAKIS: Make sure they do that.

CHAIRMAN ROSEN: We have received no written comments or requests for time to make oral statements from members of the public regarding today's meeting.

We are here today to review existing and planned research in the human factors and human

reliability areas. This effort should be viewed as part of a larger effort, the effort to understand and monitor and influence development and maintenance of positive safety cultures at this agency's licensees and at the agency itself. This, of course, is a vital issue given the recent and past examples of the effects of degraded safety cultures at operating plants.

We will now proceed with this meeting, and I call upon Dr. John Flack of the Office of Research to begin.

John.

DR. FLACK: Thank you, Steve.

My name is John Flack. I'm the Branch Chief of the Regulatory Effectiveness and Human Factors Branch in the Office of Research.

Jay Persensky to my right heads up the human factors team in that branch. That branch consists of three teams and a group, an advanced reactor group, a team on human factors, a team on generic issues, and a team on regulatory effectiveness and operating experience.

And the committee has heard from, I guess, different members of my branch over the past few weeks.

So we're here to talk about human factors, and before we do that, I thought I would just kind of give a high overview of the three pieces that make up human factors research in the office.

There's really what comes down to the first piece, which is developing the technical basis for regulatory decisions, and from that we have developed reg. guides, support the development of standard review plan items, NUREGs, and so on. And you'll hear about that today at various points during the presentation.

The second piece is we looked at operating experience and effects of human factors on plant safety, and from that perspective, we look at ASP events, LERs, corrective action programs, and try to draw insights from that experience into understanding human performance.

And then the third piece is really anticipatory research, and that involves things like looking ahead, deregulation, effects of things like deregulation, as well as advanced reactor, new reactor research which you've heard before to some extent as we presented the advanced research research plan. You'll hear a little bit more about

that today.

So those are really the three basic pieces of research that we're doing.

CHAIRMAN ROSEN: Could I get you to repeat the first one?

DR. FLACK: The first one is really we develop tools and the technical basis for making regulatory decisions in various areas like fatigue and other types of rulemaking that might be going on, and we document that basis in things like reg. guides, NUREG reports, and SRPs basically in response to NRR user needs, is really the first piece.

CHAIRMAN ROSEN: Thank you. The user needs, operating experience, and anticipatory research.

DR. FLACK: Yeah, operating experience and anticipatory research.

CHAIRMAN ROSEN: So in that sense, operating experience is very important to you. It's one of your three things, and what we're looking at is recent operating experience that has shed some doubt on human performance and organizational reliability.

After all, human performance in

organizations, it depends to a very large degree on the organizational climate. The analogy that I like to use is that people and organizations are like fish that swim in a sea, and the sea is the culture, the organizational reliability that they operate in. If the sea gets poisoned, very soon the fish don't survive or aren't able to carry out their missions.

DR. FLACK: Which is very true. Even from what we have seen in the past and the studies that we have done, looking at LERs, for example, over 50 percent of the LERs do relate to some type of human error or human performance issue, as well as the ASP events we had, I guess, a year or so ago taken. We can talk more about that, a report that came out.

CHAIRMAN ROSEN: So what you're saying is reportable events show 50 percent of them having some human dimension.

DR. FLACK: That's right.

CHAIRMAN ROSEN: And my take is that of those 50 percent, many of them, especially the most significant ones, will have an organizational climate issue buried in them as well, and it won't be the single unconnected act of an individual. It will be somehow connected to some organization or

weakness in the organization.

MR. PERSENSKY: In one of the studies that John just mentioned, NUREG CR-6753, which was our look at the number of ASP events, particularly the most significant ASP events, in fact, supports your statement very clearly. So that is one of the projects we did, and we reported on that at one of our previous meetings.

CHAIRMAN ROSEN: So organizational reliability, I think you just concurred with me.

MR. PERSENSKY: Yes, I did.

CHAIRMAN ROSEN: That the data shows it's important, and yet we spend a lot of time working on equipment reliability. We send a lot of time on, you know, all of these programs for maintenance and whatnot.

We have programs that monitor active equipment reliability with the IST programs. We monitor passive equipment reliability with ISI programs. We monitor human performance individually of operators, for instance, and simulators. We monitor human performance of other people by having reportable events caused by human reported by LERs and so on.

But what can we do about organization

performance, organization reliability? We don't have a separate category for that. So it's little wonder that we have doubts as to the importance of safety culture or at least some people do. There's no reporting of instances of degraded safety because there's no system for such.

DR. APOSTOLAKIS: Can we translate that? At least the way I see it and what the Chairman said, for equipment now we have moved to a performance based system and we have the reactor oversight process that helps us monitor hardware reliability and the maintenance role, right?

PARTICIPANTS: Right.

DR. APOSTOLAKIS: I mean, if we want to be consistent and also, you know, recognizing the significance of organizational reliability and we want to be consistent with other regulations of the agency, we should have something in the ROP that deals with organizational reliability.

And what we're doing right now is we just acknowledge that, you know, safety conscious work environment and whatever, human corrective action programs are important, but we really don't have indicators that will alert us to the fact that something may be wrong.

So in that sense, it seems to me these comments fit very nicely within the existing structure without starting a new area of research, you know, culture, and all of that stuff. It's just that we are very inconsistent.

We are spending all our time through the ROP and doing, you know, the significance determination process, doing all sorts of things. We have performance indicators, but all of these things are focused on hardware oriented stuff, and there is nothing except lip-service on the organizational issues.

CHAIRMAN ROSEN: Well, yeah. We'll come back to these themes. George has very eloquently laid out aspects of it. ROP indicators are something we think are ultimately where this all goes. It all goes to the hard question of how do you find -- what are the leading indicators for a degraded organizational culture or organizational reliability is what I like. "Culture" is sort of a term that people have -- amorphous -- have trouble grasping, but reliability is really what I'm talking about.

The reliability of an organization, given a challenge, to do the right thing quickly

every time, that's perfect reliability, not that organizations won't have challenges, but when they do, they do the right thing. They do it promptly, and they do it every time. That's the ideal.

Now, we'll hear more about that. We'd like to have an indicator of when that capability in an organization is no longer there or is beginning to degrade. So, John, that's your task.

DR. FLACK: Yeah, and I think consistent with what we talked about earlier, I think we're looking at the framework being there to do this. It's just a matter of how we go about doing it.

CHAIRMAN ROSEN: I think the framework is there. You have got corrective action. You've got all of the kinds of things you need. It's just a question of getting our arms around it and getting --

DR. APOSTOLAKIS: And a lot of it is already done by the regions. In our letter of what, two months ago, we actually quoted from regional letters where people say, you know, when you fixed this, you apparently were not aware that something similar had happened before, and you didn't seem to learn from it.

I mean, that's part of culture,

organizational learning. So I guess what's missing is a formal approach to this, bearing in mind that the regions really don't want it to be too formal because they're afraid they're going to lose their flexibility and so on, but this is a challenging problem, but there is an inconsistency there.

CHAIRMAN ROSEN: So with all of these comments as kind of introductory, we'll listen to what you have to say about the research program, which there may very well be areas where you'll want to draw our attention back to these comments.

DR. FLACK: Okay. So why don't we get started?

Let me just go quickly through the agenda, what we have planned today, this afternoon. Basically we were planning on breaking it into really two parts. The first part we cover briefly the background of what transpired over the last few years, and then the status of what programs are going on today in the office, and that involves looking at the work that we're doing to develop standard review plans that support NRR, NUREGs, associated NUREGs and reg. guides.

The advanced reactors, we'll touch upon that. Of course the Halden reactor project, which

is you're aware that that's with the simulator that we're engaged in.

We have an activity going on that's going to result in a guidance document on risk communications coming forward, and also support to other groups, like on Davis-Besse and fatigue, rulemaking and that sort of thing.

So we'll briefly go through that. That's actually the activities that are going on, and then we'll move into the second piece which is talking about organizational reliability, safety culture, starting from the ACRS workshop, again going through background, what international activities are going on and other activities, such as what's going on at INPO and ASA.

And then talking about model theoretical underpinnings to this type of work, and ending with performance indicators, which I'm sure that's what Steve had in mind all along, and of course, the three pieces of that, the human performance, the corrective action program, the safety conscious work environments as looking at potential indicators for that.

So if there's no further questions on that part I'll turn it over to Jay and he can lead

us through the rest of the presentation.

Okay. Jay.

MR. PERSENSKY: Good afternoon. I'm Jay Persensky. I'm the senior technical advisor for human factors in Office of Research.

A little bit of background. I know some of you have been through various plans with me and the other human factors staff over the years.

DR. APOSTOLAKIS: An experience you remember fondly.

MR. PERSENSKY: An experience I love to think about every once in a while.

CHAIRMAN ROSEN: As being in the past.

MR. PERSENSKY: As being in the past and hopefully -- but anyway, the last formal program description we had as far as the human performance plan was, in fact, in SECY-0053, which was back in 2000, and that particular one did describe some of the interactions between the various organizations within the NRC and how we fit into the licensing and the monitoring and all those different issues, particularly with regard to user needs, but also with some anticipation of new technologies and new techniques coming up.

In nineteen, oh, or 2001 -- 1901? --

2001 --

CHAIRMAN ROSEN: Anybody can have a bad century.

MR. PERSENSKY: I just feel older and older every day.

We prepared a SECY that essentially sunset the human factors program as a separate document so that there is no longer a document called "Human Performance Program Plan" or "Human Factors Program Plan" or anything like that.

The intent at that time was to take any of the activities that were within that plan and incorporate it either into a digital I&C plan, which had already been published, or in the human reliability plan that at that time was still under development, but was pretty much final.

So since that time we have not had a plan against which to work, except our standard operating plan within the Office of Research and going through the budget process with the prioritization as we normally do.

Last year about this time we gave a briefing to pretty much the same committee, some parts of it where we talked about the relationship between human reliability and human factors. It was

a big part of that presentation.

Another part of that presentation was, in fact, an example of some work that had been done at the Halden research reactor simulator and how we could, in fact, take the data from that simulator and use it to enhance the quantification, the understanding of some human reliability information.

This was one of the things that we showed in terms of how the two programs do relate. You have the deterministic kinds of things in human factors, which provides information for PRA and also gives ideas of where we might have some problems, where we need some help, and on the other hand, if you go down to the HRA, there it would help us to look at what areas we should be working in, what types of scenarios we might use in simulator experiments, and to prioritize some human factors activities.

So that's the model we've been working on as far as our relationship is concerned.

Over the last year to 18 months we have, in fact, as John indicated, developed a number of products and done a lot of research to bring to conclusion some areas. The biggest thing right now, and you will be, in fact, seeing this in you

December meeting; both the subcommittee will be meeting on it, December 3rd, and then the full committee the 4th.

We have done a major revision to Chapter 18 of the standard review plan, which is human factors engineering. That revision is based on NUREG-0711, Revision 1, which we developed in Research, and it provides a human factors engineering review model that lays out the entire review process that NRR would go through in terms of everything that you might look at in a licensing review.

CHAIRMAN ROSEN: Now, is that for new plant or is that an event review?

MR. PERSENSKY: Well, it can be used for either, but its first intent was for new plants, but then as we're looking at the number of modifications and the number of control room modifications that we're expecting to come in, it can be used in both ways for both new plants and existing plants.

As part of that --

CHAIRMAN ROSEN: And new plants or existing plants, but really what I was asking, Jay, is it used for operational events analysis or is it mainly for design and construction of new plants or

existing plants?

MR. PERSENSKY: Oh, seven, eleven not so much for operational events. It might be used in the sense of, say, okay, have I gotten all of the pieces because it lays out a process. I meant to stick that in here, where it talks about the need to look at procedures in HSI, human reliability, operational experience, all of the different aspects of what goes into that design process.

But you'd also want to make sure that there's a change, for instance, in your human system interface. Has there also been corresponding changes in the training and the procedures and all of that?

So it's the one place where you can lay out the entire human factors --

CHAIRMAN ROSEN: So if you have an operational event that's based on change, failures of changed management due to a modification that was put in that wasn't properly implemented or not understood by the operators, here's a place you could go to help you.

MR. PERSENSKY: Yeah.

CHAIRMAN ROSEN: Okay.

MR. PERSENSKY: Another major document

that we have been working on, and this is the second and last revision for it, is NUREG-0700, which is the human system interface guidelines, review guidelines, and originally it was developed for the detailed DCRDR, detailed control room design reviews, back after TMI.

We did revise it back in the early '90s to look at what were at that point considered advanced plants, and we most recently revised it to make sure that we covered all of the digital systems and the digital areas that we could, made some other modifications to take some of the process stuff out and put it into 0711.

That document is pretty much final. It's going out for public comment, and again, we're going to be discussing this in December.

The third document here is 1764, which is a guideline for the review of changes to operator action, which has been developed to be risk informed in the sense that we're going to have two elements to it. One is a risk screening process so that when a change is submitted to us it can first be looked at from the standpoint of risk to see what level of review should be applied to it, and then based on that categorization.

It, of course, is based on Reg. Guide 1.174 in the back, and that's why I said we also modified a slight modification, Chapter 19, since Chapter 19 is where the PRA information is. So there's really just sort of a cross-reference back to it in this.

The schedule is there for early December. Based on recommendations from the ACRS that this activity be sunset, we are sunsetting the activity in the area of NUREG-0700.

DR. APOSTOLAKIS: But do you agree with it? Do you think that there's work that needs to be done?

MR. PERSENSKY: I believe that there is work that probably could be done, especially in the advanced reactor area, that we have not completely covered on the interface issues. We will be looking at other ways of accomplishing that.

DR. APOSTOLAKIS: And we can always come back to it when we really have an advanced reactor in front of us.

MR. PERSENSKY: Well, I think that's really a big part of it. I will say that it's in a very well used document, both here in the NRC as well as in the industry, but we've also gotten a lot

of requests and a lot of reports on use in some of the new Navy ships, that people are working on the design of those control rooms.

We've seen a lot of other use outside, as well as international use.

DR. APOSTOLAKIS: The military?

MR. PERSENSKY: Military.

DR. APOSTOLAKIS: Military ships?

MR. PERSENSKY: Yeah.

DR. APOSTOLAKIS: That's great.

MR. PERSENSKY: And it has been a well received document in the area.

DR. APOSTOLAKIS: This is where we had a disagreement about the seven feet cord.

MR. PERSENSKY: It was a six foot cord that never existed.

DR. APOSTOLAKIS: Never existed, yeah. Well, you know.

MR. PERSENSKY: But it got recorded.

DR. APOSTOLAKIS: He never said it either. Okay.

MR. PERSENSKY: Well, we have it in the transcript.

Another set of research we've started, and this is really relatively new, and I know John

has presented in the past a lot of the work in the advanced reactor area, but especially when the PBMR was being considered, one of the first things that came in and said was, "Hey, we're not going to meet the staffing requirements that we currently have," which is in 50.54(m), "for licensed operators. We just don't need that many people."

So they essentially said they were going to look for a waiver. We had already been anticipating this work. We had started this work some time ago with some work at Halden to look at, you know, what are some good ways of -- what would affect in terms of advanced control room, the same standard type of reactor, what effects might that have on staffing?

But we have come up with, and this will be published fairly shortly, a method that is function based. Again, this is used primarily in the military now in the design of their ships and tanks and other equipment, where they try to determine what is the appropriate staffing level based on the functions that have to be carried out as opposed to the very deterministic approach that we have taken in the past based on the experience we had back in the early 1980s, which is when we wrote

50.54(m).

So as we see changes in the operations, the concept of operations, the use of modular reactors, all those different aspects, we're expecting that there would be an approach that we would use as a more function based.

We also as part of this are looking at the use of a behavioral modeling tool, computerized behavioral modeling tool that can expedite the use of the functional analysis function, task analysis.

CHAIRMAN ROSEN: That's a task analysis.

MR. PERSENSKY: Yeah.

CHAIRMAN ROSEN: It seems to me it's a more fundamental way to go about it than just using your gut instinct and experience, is to look at what they have to do.

MR. PERSENSKY: And with using the modeling tool like this, you can make a lot of modifications very quickly without having to deal with real time experiments. Again, this is going to be a SRP revision that will endorse this NUREG that we're coming out with. We expect it will get into more detail on this project probably some time shortly after the first of the year when we talk about this SRP.

CHAIRMAN ROSEN: So for my purposes here, can I use the word "function based" as equivalent to job and task analysis?

MR. PERSENSKY: Actually function is a little bit higher than job and task analysis. Typically, the hierarchy is a functional allocation where you look across what things should go to the person and what things should go to the machine.

So you start at the function level. What function has to be accomplished? How do you then distribute those? And then you get down to the task analysis. So it's a higher -- it starts at a higher level. It does work eventually.

The model is, in fact, a task analysis tool.

CHAIRMAN ROSEN: So for our purposes here, the function analysis says these are the functions that will have to be done in this time window, critical time window. This will clearly -- these functions can be done by the machine, but clearly these can't, and therefore, we need three people because you can't do all of these things in this time window without at least three sets of hands.

MR. PERSENSKY: It gets into issues of

not only the functions, but the work load, the situation awareness, all of those kinds of issues that are human issues.

CHAIRMAN ROSEN: Well, I'm glad to hear.

MR. PERSENSKY: So that's the approach we're trying to take rather than using the more deterministic --

CHAIRMAN ROSEN: Well, I think that's a more fundamental approach, and I commend you for moving in that direction.

The other work that we did over this last year in the area of new reactors is we had one of our contractors take a look at all of the various reactor concepts that are out there, talk to the vendors, you know, look at whatever documentation we can given, look at whatever research has been done; also, look at aspects that we anticipate.

For instance, the modular reactor, multi-modular reactor. We don't have much operating experience for that in the nuclear industry, but there is similar types of situations in other industries, particularly the petrochemical industry where they're looking at monitoring several oil wells or gas lines from a central point.

So that we're trying to take experience

from these other industries that we can relate to the types of experience that we would expect in a new type of reactor.

So we from that try to identify what types of issues are important to the operation and the maintenance. We're not talking just about operators at this point.

We also looked at the review guidance that's out there that we currently have. Is it going to be adequate, which might bring in the question of something like the 0700 again?

Another part of this study, and this again is based on a recommendation from the ACRS, was that we look at is there a need for new research facilities, particularly human factors research facilities, having our own simulator as an NRC operated rather than depending on Halden or depending on other types of simulators.

CHAIRMAN ROSEN: You were talking about a concept simulator there rather than a wall full of gauges and dials, more of a --

MR. PERSENSKY: We're talking primarily about the same thing that would be a couple of CRTs and some --

CHAIRMAN ROSEN: You wouldn't want to

try to mimic any site specific.

MR. PERSENSKY: We're focusing this a lot on advanced reactors, more on how we might deal with an advanced reactor concept.

There's also an ANS/DOE -- Steve, what's the name of that group?

DR. ARNDT: DOE Work Group on -- I don't remember.

MR. PERSENSKY: A DOE work group on advanced reactors and I&C and human factors or something.

DR. ARNDT: Yeah, it's the same report that we mentioned this morning.

CHAIRMAN ROSEN: Identify yourself.

DR. ARNDT: I'm sorry. It's Steve Arndt.

The report that Jay is mentioning is a report out of a work group that was formed by DOE to support advanced reactor I&C and human factors research, and it's the same report that was identified this morning.

MR. PERSENSKY: And so we try and take advantage of that kind of thing, and one of the recommendations from that report was that DOE, in fact, look into development of an advanced reactor

simulator.

CHAIRMAN ROSEN: Really?

MR. PERSENSKY: If I remember correctly, and so we're going to see to the extent that we can hang onto something like that.

CHAIRMAN ROSEN: Well, really do we need two of them, one --

MR. PERSENSKY: Oh, no.

CHAIRMAN ROSEN: -- and one at NRC?

MR. PERSENSKY: We would support DOE funding such an effort rather than our doing it ourselves, but since they don't do much human factors research internally --

DR. APOSTOLAKIS: So why would DOE be interested in this? Am I missing something? You just said they're not doing much.

MR. PERSENSKY: Well, they don't have a large human factors staff in house as we have a human factors staff.

DR. APOSTOLAKIS: Sure.

MR. PERSENSKY: And they rely on their contractors to do most of that type of work, but that would mean that we couldn't work with them on those, in that area.

DR. APOSTOLAKIS: What do they do with

that kind of work? Why would DOE do that?

MR. PERSENSKY: I think this is part of their -- let's see.

DR. FLACK: Well, we shared with them our advanced reactor research plans, and they know that there's a lot of issues that are talked about in those plans, and they're always trying to find ways of, in a sense, expediting our licensing process, and if this is one way --

DR. APOSTOLAKIS: Oh, I see.

MR. PERSENSKY: Again, the big issue here was trying to identify gaps and what's needed, what we believe is needed and what's out there now, and this is some of the lessons learned. This is the interim basis right now. The report will be out in the next couple of months, but if you look at the whole concept of interaction with advanced systems, not necessarily nuclear, but advanced systems in general, you find that the first issue is human performance is impacted by these advanced systems.

A lot of people say, "Gee, this is going to be an advanced reactor. It's going to be passive, slow acting. We don't need to worry about human factors issues."

A lot of people have said that in some

of the other fields and found out that it turned out that there were problems with that kind of thing.

They are often designed for the use of the designer as opposed to the user. There is unanticipated consequences from some of the information and the way things are designed.

They have an impact on things like staffing, as we said. As we got into the staffing project, of course, we looked at it from the standpoint of current licensing requirements. There could very well be an opportunity to change the requirements for licensing. We may have much different KSAs, the knowledge, skills and abilities, that we now use for the licensing exams that would be changed. It would be a different way of looking at the people that actually control the reactors.

So that gets again into the training as well, and there will be a big change on how these operators, the current operator moving into a completely digitized control room, especially with an advanced plant behind that digitized control room, is going to have a different way of operating, different way of functioning, which is, again, one of the reasons we wanted to go to the function based approach, so that we could identify the functions

from the early design and then continue to iterate on that to come up with the best staffing level and the best design concept.

CHAIRMAN ROSEN: Well, what is this HSI?

MR. PERSENSKY: Human-system interface.

CHAIRMAN ROSEN: You owe me a nickel for using an acronym I didn't know.

MR. PERSENSKY: Okay. Does that go both ways?

(Laughter.)

CHAIRMAN ROSEN: No.

MR. PERSENSKY: Okay. Human-system interface. It used to be man-machine interface, man-computer interface, human-computer interface. We've used here human-system since we're not talking about just machines anymore.

Some of the other aspects, again, we've pretty much always functioned or focused on operations, and I think we may have a whole different look in some of these areas to determine the maintenance, the need for maintenance and even of the digital systems.

Some of these designs, the operator may be also responsible for fuel handling, on-line fuel handling. So there would be completely different

kinds of roles that would have to be considered.

The next general area in which we've been using our resources in the Halden reactor project which we've discussed in the past and would be glad to discuss in more detail in the future, but basically from a human performance standpoint, human factors standpoint, the main aspect of Halden that we use is the fact that they have the simulators. They have the simulator capability. They have what would be considered an advanced digitized control room, and that digitized control room can operate either a BWR, a PWR, or a BBBR reactor model, and we can look at various influences as we change the design of control room, change the procedures, change alarm systems, look at, again, the interface.

One of the big changes or improvements in the program starting this past year has been the inclusion of a much stronger human reliability contribution or concept in their overall planning so that we, in fact, are interfacing with the HRA group and working so that when the studies are designed, HRA is taken into account in terms of what kinds of data they can collect, the form they can collect it in, the types of scenarios that they're running so that they're high risk scenarios.

So we've been working very closely, and we're trying to build up their capability. We currently have -- and Erasmia may talk about this later -- a PRA expert from INEEL that's on detail there for six months to help them build --

DR. APOSTOLAKIS: Is that Curtis Smith?

MR. PERSENSKY: Curtis Smith, yes. That's a knowing smile.

DR. APOSTOLAKIS: Halden doesn't have an HRA group.

MR. PERSENSKY: They're developing an HRA group.

DR. APOSTOLAKIS: They are?

MR. PERSENSKY: Yeah, they're beginning to develop one.

DR. APOSTOLAKIS: Good. How many human factors people do they have there? I mean, you know, what you would consider professional people.

MR. PERSENSKY: I think they've got about 12 now.

DR. APOSTOLAKIS: Really? They certainly make a lot of waves for 12 people. That's good.

Are they the international group.

MR. PERSENSKY: It's the international

group. They also make a lot of use of people who are detailed, visiting scientists that are there. So they generally have three to four visiting scientists at any one time. Almost every other country in the Halden group sends people there routinely.

Japan has one to three people there almost continuously.

DR. APOSTOLAKIS: But the only agency or country that is sending PRA experts is us?

MR. PERSENSKY: At this point, but we're trying to --

DR. APOSTOLAKIS: That's good.

MR. PERSENSKY: We're working with -- in fact, I don't know if you're going to get into this, Erasmia. I haven't seen your presentation.

MS. LOIS: I will.

DR. APOSTOLAKIS: Yeah, that's fine. This is good.

MR. PERSENSKY: But we're working with CSNI. They're part of it. We've got Halden staff involved with the CSNI working group on risk. So we're trying to bring that all together and build that capability at home.

DR. APOSTOLAKIS: That would be nice.

Have you ever been there, Steve? Halden?

MR. PERSENSKY: Again, their function in the past has been mostly on building or designing new types of equipment for improving the performance and the efficiency of the plant through better interfaces with the operator, better knowledge based systems and computerized procedures, these various systems that they test, and then we use the data from those tests.

We have used it in the past, for instance, as part of the technical basis for the 0700 type of guidelines, and now we're moving more towards this HRA, inclusion of HRA quantification as a part of their efforts.

They also have a VR simulator, a very detailed virtual reality simulator to do things.

They do, in addition to this general research that the various countries contributed, they also do one on one research for various countries in terms of helping them design their systems. They've been looking at designing some of the replacement control rooms for Sweden, for instance, for the Swedish utilities.

DR. APOSTOLAKIS: It's costing us not very much, anyway.

MR. PERSENSKY: Well, depending on how you look at it. I mean, the total cost is about a million dollars a year, but that includes fuels research, materials research --

DR. APOSTOLAKIS: No, no, the human, the human.

MR. PERSENSKY: The human factors stuff and the human reliability is just around 300,000, and then the digital I&C is another 150, 200. So about half of it is the digital I&A and human factors and the rest is the materials and fuels work.

In addition, we do have opportunities. They've been bringing together in the last couple of years for a one week training course in some area every other year. One year they do an MMI or man-machine interface area like they did human-systems this year. Last year they did a fuels course. So it's --

DR. APOSTOLAKIS: And they have an annual meeting, don't they?

MR. PERSENSKY: It's about every 18 months. The next major meeting, t he enlarged hull and program (phonetic) group meetings is in May of '04. I believe it's the week of the 9th of May. I

know Bill has been to that.

DR. APOSTOLAKIS: Maybe one of us should go. Oh, you're going, Bill?

DR. SHACK: I've been there.

MR. PERSENSKY: He's been there for some of the --

DR. APOSTOLAKIS: So you've listened to the human factors --

DR. SHACK: No, no.

MR. PERSENSKY: No, he was on the other side. They break it up into two --

DR. SHACK: It's concurrent sessions. So --

DR. APOSTOLAKIS: Oh, concurrent?

DR. SHACK: Yeah.

CHAIRMAN ROSEN: They have sessions on cracking and materials. They do materials research.

MR. PERSENSKY: I'll be glad to send you the information on the program.

CHAIRMAN ROSEN: Jack claims to know something about that.

MR. SIEBER: Every day even more.

MR. PERSENSKY: The other thing is they do workshops where they bring together experts, particularly from the sponsor countries, and part of

that is to help them define their user needs in the sense of what kinds of things should they be doing. Where are the gaps?

So they just had one in August on --

DR. APOSTOLAKIS: But is Halden -- which organization is sponsoring or not sponsoring, but --

MR. PERSENSKY: It's an OECD.

DR. APOSTOLAKIS: OECD.

MR. PERSENSKY: It's an OECD activity, and it's operated by the Institutt for Energi Teknikk, which is the Norwegian element of it, and they pay about somewhere between a half and two-thirds of the operation, and then the generic general program pays part of it, and then they do these bilateral agreements also.

DR. APOSTOLAKIS: Is Halden very far from Trondheim?

MR. PERSENSKY: From Trondheim, yes. It's about two hours southeast of Oslo. It's right down along Oslo fiord. It's almost at the border of Sweden.

MR. SIEBER: We go there in summery.

MR. PERSENSKY: Yes, you should go in the summer. May is a good time actually. It is an excellent time to go.

I probably won't be able to go this year. So we'll have somebody else.

At the end of the month they're doing a workshop on knowledge management, which is a new area for us.

DR. APOSTOLAKIS: Knowledge management, what does that mean?

MR. PERSENSKY: We're going to get into that in a minute.

DR. APOSTOLAKIS: Okay.

MR. PERSENSKY: One of the other efforts that we've been spending a good deal of time on this year and resources is actually an internal effort. We're developing risk communication guidelines for our staff.

There has been some concern that we don't always communicate well with the public particularly.

DR. APOSTOLAKIS: So stakeholders does not include us.

MR. PERSENSKY: Well, it does to the extent that you're not part of the internal staff, but we are looking at stakeholders. We are also going to be, based on what we've done this year, probably move into internal communications as well.

DR. APOSTOLAKIS: So how do you do this? Do you have external consultants that are helping you?

MR. PERSENSKY: We have had external consultants that have helped us put together these guidelines. They're looking at more of the concepts how you better communicate particularly when you're talking about quantitative and risk-based things like don't say ten to the minus six because the public doesn't understand what that means, and how to phrase some of those things. So the concepts behind that.

We've also looked at the best practices from -- the practices and picked out what we feel were the beset practices from other agencies. EPA has had guidelines in this area. The military has guidelines and this type of communications as well.

We've taken that information and modified it. That will be published by the end of the year. We've been doing some testing, internal testing. In fact, there's a test going on right today with some issues which is almost more internal in terms of talking, trying to communicate some new findings to the NRC, NRR leadership team.

We've been working with --

DR. APOSTOLAKIS: Do they understand ten to the minus six?

MR. PERSENSKY: I'm not sure. There are some other elements, but it's not just that, but to deal with some of these types of communications.

DR. APOSTOLAKIS: There are two messages here. There was years of research or miscommunication.

MR. PERSENSKY: And we've used --

DR. APOSTOLAKIS: The most fundamental result they came up with was never lie to the public.

DR. FLACK: That's in there.

MR. PERSENSKY: That's in there.

DR. APOSTOLAKIS: It takes about a million dollars to get it.

MR. PERSENSKY: It hasn't cost us a million dollars on this.

DR. FLACK: No, trust is important though.

DR. APOSTOLAKIS: Yeah.

DR. FLACK: It's a very important piece.

MR. PERSENSKY: But, again, this is more for an internal --

DR. APOSTOLAKIS: Which one is the most

credible governmental agency, city-state? Do you know? The latest result, if you want to communicate to the public?

MR. PERSENSKY: The most credible?

DR. APOSTOLAKIS: The most credible. Fire fighters.

MR. PERSENSKY: Fire fighters?

DR. APOSTOLAKIS: Fire departments. They tend to be trusted by the American public much more than anybody else, and there is good reason. There is good reason.

MR. PERSENSKY: Generally it's the small local governments that have the most immediate and the fire fighters often fall within that.

DR. APOSTOLAKIS: Yeah, absolutely.

MR. PERSENSKY: The closer you are to the source, but when you're trying to explain the situation at a place like Port Clinton, Ohio, with the risk associated with vessel head corrosion, it can be confusing.

As John mentioned, part of our work is not only just complete user need. It's not complete doing research, but to support other people, both the other human factors group and NRR, but also some of the other people have indicated some needs in the

area of human factors.

There is a rulemaking that's underway in the area of fatigue and working hours that I've been supporting NRR or a human factors group in that area based on my long history in sleeping, and based on the fact that -- I actually prepared 82.12, which is the policy statement that's still out there.

DR. APOSTOLAKIS: Regarding?

MR. PERSENSKY: Regarding working hours.

DR. APOSTOLAKIS: Regarding sleep.

MR. PERSENSKY: Sleep. It says they've got to have sleep.

And based on that, both Dave Desaulniers (phonetic) who was working on that project from NRR and I were asked to help answer, to develop some orders in the area of fatigue for the guards because of problems they've been having and the fact that they were not covered by the policy statement in the first place and the tech. specs that resulted from the policy statement.

We're also supporting the Davis-Besse safety culture inspection. Actually Claire Goodman from NRR and I are members of the inspection team that's focusing on safety.

DR. APOSTOLAKIS: How do you do that

though? I mean, Jay, they can appear like they're doing everything by the book, right? The culture is great, but the next week it can be bad. So I wonder how -- in fact, this particular plant has gone through ups and downs.

MR. PERSENSKY: It has had its cycles.

DR. APOSTOLAKIS: Yeah. It's such an elusive concept. I mean the best you can do is say, "What I see now makes sense," and let us all pray to God that things will come --

CHAIRMAN ROSEN: Do you remember what I said, George about safety culture? It's easier to talk about organizational reliability.DR. APOSTOLAKIS: Okay.

CHAIRMAN ROSEN: And the definition of that is that they do the right thing promptly every time. So you can't assess it with just a snapshot.

DR. APOSTOLAKIS: Exactly.

CHAIRMAN ROSEN: It has a dimension --

DR. APOSTOLAKIS: On the other hand, what can he do. I mean, Jay is asked to do it, and he can only do it, you know, so much, I mean, like everybody else. So we need something else. That's what you're saying, right? We need something else, some other methods.

MR. PERSENSKY: To get a good handle on safety, organizational reliability, you need history. You need a three year rolling window of some kind. That's not a snapshot.

DR. APOSTOLAKIS: It's the performance indicator idea from our OP, which on what, a three year rolling basis, whatever it is.

CHAIRMAN ROSEN: You need to integrate some data before you can make that determination.

DR. APOSTOLAKIS: Yeah, that's right.

MR. PERSENSKY: Well, from the standpoint of what we are actually doing, I mean, the basis for our doing this, the regulatory basis for our doing this inspection is Appendix B, Criterion 16, which says that if they identify in their root cause analysis that they've got a condition adverse to quality, that we can, in fact, follow up on what they have said they're going to do.

We can check to see what they're going to do is adequate, and maintain --

CHAIRMAN ROSEN: Finally.

MR. PERSENSKY: -- their long term. So from the standpoint of your most immediate, you know, what can we do after them, we can look right

now.

In fact, we are not doing a safety culture assessment. What we are doing is looking at whether or not we feel that the safety culture assessment that was done both by their external consultant and what they are doing internally is generally consistent with what we're considering internationally approved guidance, which is the INSAG-15, where with INSAG they have a certain set of criteria or not criteria -- I'm sorry -- characteristics for safety culture, and are they addressing those? Are they asking those kinds of questions?

CHAIRMAN ROSEN: Doesn't that put you in kind of a curious position? Here you are an NRC employee having to look at international standards to judge --

DR. APOSTOLAKIS: I think there's nothing else to turn to.

CHAIRMAN ROSEN: -- one of the most important things.

MR. PERSENSKY: It's the only thing I have to turn to at this point, as George says. I mean we don't have anything internally. The only thing we have, I mean, even within the NRC, we do

have the policy statement on the concept of operations, which, in fact, suggested to the utilities that they do have a safety culture program that includes an assessment, but there was no guidance that went along with that in terms of how to do that.

CHAIRMAN ROSEN: Well, I'm obviously suggesting that that's a situation that needs to be corrected.

MR. PERSENSKY: Right.

DR. APOSTOLAKIS: Hint.

CHAIRMAN ROSEN: That was a hint.

DR. APOSTOLAKIS: The Chairman of INSAG now is a familiar figure. I don't know whether he has taken over yet. Do you know who he is?

MR. PERSENSKY: Ashok? Or no. I don't know who the new Chairman --

DR. APOSTOLAKIS: Richard Meserve.

MR. PERSENSKY: Oh, Meserve.

CHAIRMAN ROSEN: Ah, that's a name I know.

MR. PERSENSKY: I did hear that.

DR. APOSTOLAKIS: I don't know whether he has actually taken over or it's imminent.

DR. ARNDT: I think it's December.

DR. APOSTOLAKIS: December? Yeah.

CHAIRMAN ROSEN: Is that a corollary position or has he quite the Carnegie Foundation?

DR. APOSTOLAKIS: No, no, no. This is just on the side.

MR. PERSENSKY: But, I mean, inside, and it has pulled together now. You know, it started with INSAG-3 back in the mid-'80s so that that process has matured over time, and we've been following what's going on. It's not that we've been completely out of the picture. We've been involved.

We've also been involved with some of the stuff that the IAEA staff does. INSAG is sort of like the ACRS in a sense. They are an independent group that advises the IAEA. The IAEA staff also develops and they have their safety culture services that they do, including doing assessments and going out and teaching utilities how to do their own assessment. That's their preferable approach, is to teach the utility to do self-assessments.

MR. SIEBER: Where you are right now is just in the area of best practices and encouraging because you have no regulatory foundation to do anything except what exists in Appendix B, right?

MR. PERSENSKY: That's right.

CHAIRMAN ROSEN: Which is corrective action.

MR. SIEBER: Well, there's several places, and also in Appendix B you could somehow or other construe it to apply to --

CHAIRMAN ROSEN: The clearest thing in Appendix B that applies to safety culture is Criterion 16, which is corrective action, because that's the linchpin of safety culture or organizational reliability.

Remember what I said. Organizational reliability is doing the right thing when issues turn up promptly every time. So that's almost a definition of corrective action program. So corrective action is at the heart of organizational --

DR. APOSTOLAKIS: Well, another thing, speaking of hearts, one of the things on the heart -- it must be a big heart -- is organizational learning. In fact, in your review of the Davis-Besse safety cultural inspection, maybe one of the things you ought to focus on is whether the company has formal mechanisms so that the organization will learn from experience.

According to the experts, this is one of the most difficult things to implement in a major organization because individuals, you know, you can teach them. You can learn, but companies, what does it mean for a company to learn? Like what does it mean for the NRC to learn to put things in the regulatory guides, to put things in the rules, to educate their staff? It's the same thing for companies.

You know, they have a department. Is that enough? Do they have it in their papers there? And that's not an easy thing.

MR. PERSENSKY: It is not, and it is, in fact, a very important element. Now, I think Criterion 16 is actually -- that's the focus of what we're doing in the inspection. We do have other elements within our inspection programs and within the ROP that allow us to look at various elements.

For instance, we do have a training rule. Training rule is part of organizational learning, but it's not all of it.

DR. APOSTOLAKIS: It's not all of it, exactly.

MR. PERSENSKY: Actually the corrective action program is part of organizational learning

because once you have the corrective action plan in place and if you look at how you -- what actions you've taken, what kinds of problems, are you learning from that? Are you moving that forward and trending and keeping that information?

CHAIRMAN ROSEN: And the generic implications requirements.

MR. PERSENSKY: Right.

CHAIRMAN ROSEN: It's a learning process.

MR. PERSENSKY: You know, are you getting common cause kind of thing? If you go back and look at your program, are you beginning to see common cause? So a lot of it gets into that.

So we do have elements, and at the workshop -- and I was going to get at this later, but I'll throw in -- when Claire made her presentation, Claire Goodman made her presentation to the workshop, if you take the elements of INSAG-15 and you go across the various documents that we use within the NRC that we can get to in terms of inspections and rules and reg. guides and such, we have parts of almost all of those elements.

DR. APOSTOLAKIS: Yes, yes.

MR. PERSENSKY: But we don't have a way

of pulling it all together, and it may not be that there's a one way of pulling that one number or anything, but that's the kind of concept, and again, sine organizational learning is, in fact, one of the INSAG-15 characteristics, that is one of the things that we're looking about at Davis-Besse.

But as far as the long term, we're making sure that they have in place periodic checks on their safety culture both in the short term and longer term, they might do another bit, external assessment, but also these internal assessments along the way.

DR. APOSTOLAKIS: By the way, that presentation by Claire probably was in my memory the single presentation where this stuff has had the most influence on the ACRS thinking on that topic. I'm telling you, the letter would not have come out the way it did if it was not for her.

MR. PERSENSKY: Because we said we had everything there.

DR. APOSTOLAKIS: That was a major input, yes, and she also gave numbers and said, you know, this regulation, that regulation, but just saying that you have it is not -- she gave facts.

PARTICIPANT: Is she here?

MR. PERSENSKY: She's here.

MR. SIEBER: Yeah, that was a good talk.

DR. APOSTOLAKIS: That was really a great, great talk.

Shall we move on?

MR. PERSENSKY: We can get into safety culture. We actually have time to talk more about that.

CHAIRMAN ROSEN: Please, go on, go on.

DR. APOSTOLAKIS: Safety culture is work environment. That means something specific to the agency.

MR. PERSENSKY: Safety conscious work environment means something specific to the community.

DR. APOSTOLAKIS: So let's separate it from safety culture from now on.

MR. PERSENSKY: It's an element.

CHAIRMAN ROSEN: Think of it as an element of safety culture.

DR. APOSTOLAKIS: They don't coincide though.

CHAIRMAN ROSEN: It's a subelement.

DR. APOSTOLAKIS: Safety culture is bigger.

CHAIRMAN ROSEN: Safety culture is the big thing, and then there are three factors: safety conscious work environment; corrective action programs; and human performance. Those three things seem to me -- and there are others, learning the organization -- but the three principal ones are safety conscious work environment, corrective action, and individual human performance.

DR. APOSTOLAKIS: Very good.

MR. PERSENSKY: Safety conscious work environment really focuses mostly on allegations. It focuses on the retribution. The terminology is HIRD, harassment, intimidation, retribution and discrimination, which are the four elements, and right now we have a rule, 50.9 or 50.7 -- sorry -- that gets into the issues of safety conscious work environment.

MR. SIEBER: But that is a small part of safety culture.

MR. PERSENSKY: It's one element of safety culture. I carry around a badge that they hand out at Davis Besse, as a matter of fact. One side of it has a definition of safety culture and the other side has --

DR. APOSTOLAKIS: Is that the INSAG

definition?

MR. PERSENSKY: Pretty close, pretty close. They --

CHAIRMAN ROSEN: What does the other side have?

MR. PERSENSKY: The other side has safety conscious work environment.

CHAIRMAN ROSEN: Okay.

DR. APOSTOLAKIS: So why do you have it with you now? I mean --

MR. PERSENSKY: So I can remember it. I use it a lot, believe it or not. When we start talking about this, I can pull it out and say, "See, this is the difference."

Now, the last thing I have on this report to others is that we're, in fact, serving as a licensing element of NMSS when it comes to the MOX and the gas centrifuge facilities. We've developed an SRP for them in the human factors area, and we're actually implementing it and supporting them from a --

DR. APOSTOLAKIS: I understand the agency is still working on human reliability issues.

MR. PERSENSKY: We are still working on human reliability issues and Erasmia is going to

address those later.

DR. APOSTOLAKIS: Are you supporting those as well?

MR. PERSENSKY: We are supporting them primarily through the involvement with Halden, but also in another project that Erasmia has on quantification with INEEL. We're working with them on that, and actually we worked together quite a bit in terms of what can be done and what --

CHAIRMAN ROSEN: We're keeping on schedule here. So move fast.

MR. PERSENSKY: Yeah, I'm moving fast.

CHAIRMAN ROSEN: What you haven't talked about, I think, are the last two bullets on this slide.

MR. PERSENSKY: This slide here, right. These are all things that we're continuing to do. Management of undocumented expert knowledge, this is really as a response to the fact that we're losing a lot of people to retirement, both here at the NRC as well as in our laboratories or moving on to other things, and there are now technologies available to gather and store this knowledge in a way that it makes it easier to get to.

DR. APOSTOLAKIS: Very good.

MR. PERSENSKY: I've been working with EPRI. EPRI has, in fact, selected a system on concept mapping that they're using or that they're testing in a sense at this point, and I hope to make this a cooperative project with EPRI because part of it is the two big human factors elements of it is how do you elicit the knowledge. You know, who do you pick to do that? How do you go through the process with the most efficient ways of getting the knowledge out of those experts?

And then other is how do you design the interface such that it's easy to get out when you're for the people.

CHAIRMAN ROSEN: EPRI started that when one very important contractor of theirs, a fellow who was a world's foremost authority in pump design was dying over illness, and he over a period of, you know, a year or so, he was getting more and more unable, and he had all of the industry and knowledge up in his head. No question.

DR. APOSTOLAKIS: In one guy?

CHAIRMAN ROSEN: No, the question was how do you get it out.

MR. PERSENSKY: And that's what this is really looking at. I mean there are software

systems that you can buy, and they're anything from huge mainframes that run them to basically particularly one that's really on a laptop right now.

DR. APOSTOLAKIS: Well, what do they do? I mean, do they just have questionnaires or --

MR. SIEBER: They install a USB port in the guy.

(Laughter.)

CHAIRMAN ROSEN: In the guy's head, right.

MR. PERSENSKY: Most of it is questionnaires, but it's storytelling. You can use the system to do videotaping and with links. It's a very interesting system. I hope to be able to demonstrate to you or have EPRI come in and demonstrate it some time or other.

DR. APOSTOLAKIS: I think it should be like any other expert system that is used to release information from experts.

MR. PERSENSKY: Right.

DR. APOSTOLAKIS: And there's no difference here.

MR. PERSENSKY: In the sense that, you know, instead of doing -- sometimes the expert

solicitation, you know, you're doing it in groups and things like this where this might be a single person, and you may be looking for very specific knowledge; you may be looking for a very broad knowledge.

CHAIRMAN ROSEN: But you don't know the questions to ask.

MR. PERSENSKY: And that's part of this issue, is how do you best get into that issue. That's where the research part of it comes in. How do you best get that in?

DR. APOSTOLAKIS: You gets the world's foremost expert who knows the questions to ask the world's foremost expert who knows the answers.

MR. PERSENSKY: We now have three entry level people that are working with me in research, and I've been thinking a lot about this every time they come to ask me a question. I say, "Why don't you know that already?"

It's usually something that --

DR. APOSTOLAKIS: So you are one of the experts who is about to disappear? Are you one of the experts who are trying to --

MR. PERSENSKY: I have the opportunity, as a matter of fact.

CHAIRMAN ROSEN: But you don't have the USB port.

MR. PERSENSKY: And then the final project here for '04, we actually do have some resources to start a very modest level working on the human performance safety indicator.

DR. APOSTOLAKIS: All right.

CHAIRMAN ROSEN: Now, why are you working on a human performance safety indicator? You know, the industry has, every plant has human performance indicators. Why don't you just collect them from all of the plants and then pick the good ones?

MR. PERSENSKY: That may be exactly how we do it.

MR. SIEBER: Are you talking about the HPES?

CHAIRMAN ROSEN: No, I'm talking about human performance indicators, you know, the number of errors that have occurred, the mean time between a significant error, what kind of errors. I mean, plants plot all kinds of things like this that some of them are meaningful and some are not, but I think there's enough examples of it that one ought to just go out and look.

MR. PERSENSKY: Well, the way we typically do our research, we don't do basic research. We don't have the resources to do that -- is we go out and we try to find out what the best practices are, who's doing what, and how can we use that information; how can we report that information into the format that's needed to do it here at the NRC.

And again, we write guidelines that are used for review. We don't actually do the designs. We review how the design is done. So you have to sort of step back in how we do that.

So we're looking at what would be the most important, the most useful indicators to get to the issues that we need to from the standpoint of --

CHAIRMAN ROSEN: So you are going to collect them. That's a good thing.

MR. PERSENSKY: Yeah, yeah, yeah. We're not ignoring it.

CHAIRMAN ROSEN: It doesn't mean you have to use them exactly as is, but you should know what's going on.

DR. FLACK: Yeah, I think the application of the indicator is really what we would -- how would we use this information to do what

with, and that's where we would be more --

CHAIRMAN ROSEN: I think you have to decide that in the context of the kind of information that's available and what other people are using it for, plants are using it for. You need to collect that, too.

DR. APOSTOLAKIS: Very good.

MR. PERSENSKY: And we've probably talked a lot about this stuff already, but you know, based on a request from the ACRS to put together some thoughts on safety culture, very quickly I go through some of these early slides here on the background.

As some of you know, back in '98 we were essentially told by the Commission that we should no longer do work -- it has been interpreted that we should no longer do work in the organizational factors area. Before that we had been, in fact funding work in organizational factors for some years.

One of those organizational factors being safety culture, but we were looking at it a little bit broader at the time.

DR. APOSTOLAKIS: So there was actually at one time a SECY with a title "Competence of

Management"?

MR. PERSENSKY: Yes. It was a response to --

DR. APOSTOLAKIS: And nobody was shocked?

MR. PERSENSKY: Oh, yes, they were shocked.

(Laughter.)

MR. SIEBER: That's why you never heard of it.

CHAIRMAN ROSEN: You know, I didn't say anything about competence of management. It talked about organizational reliability.

MR. PERSENSKY: Yeah. May I explain what that says? This is exactly the kind of reaction, but --

CHAIRMAN ROSEN: Managers get to have some element of the organization to be reliable in the job.

MR. PERSENSKY: There was a GAO report, a GAO report that said, "Why are you not looking at competence of management?" It was a report that came to the NRC essentially indicating that we should be looking at competence.

The staff prepared a SECY. In that SECY

we talked about if we were to do that, these are various options as to how we might do that. There was no indication or no options that we should do it. In fact, the preferred option was not to do it. But the reaction from the Commission to that SECY is exactly what you see here in the Commission paper or the SECY SRM that says, you know, "Don't do this anymore. We're taking the money out of your budget."

CHAIRMAN ROSEN: We're not suggesting that be done. Let's be clear.

MR. PERSENSKY: And we are not suggesting it be done whether and never have suggested it be done. I'm just telling you the difference. This is history.

DR. APOSTOLAKIS: It's another example of a six foot cord.

MR. PERSENSKY: The GAO recommended it, not the staff. The staff in response to it, and that's part of our job; we have to do that.

CHAIRMAN ROSEN: But our job is to look at outcomes. What happens in the plants?

MR. PERSENSKY: And we don't disagree with that.

MR. SIEBER: And that's the issue, you

know. Incompetence is self-revealing sooner or later. It will show up as a --

DR. APOSTOLAKIS: Well, there are certain ways it can be revealed that we don't like.

CHAIRMAN ROSEN: We've seen one of them lately, right?

MR. PERSENSKY: In any event, this, in fact, because I know some of you weren't here when we were doing the organizational factors, but this is what brought the demise of the organizational factors research and anything that smells of it, like saying safety culture or safety management or anything like that. So that's why we don't have at this point anything that talks about those areas. In the last --

CHAIRMAN ROSEN: Nor are you advocating it.

MR. PERSENSKY: Nor are we advocating it and didn't advocate it in the SECY either.

MR. SIEBER: Is that institutional learning?

(Laughter.)

MR. PERSENSKY: That is, in fact, institutional learning. It shows how -- I was sort of related to the game of telephone where you stand

around -- you know, you whisper in a person's year and it goes around and by the time it gets back to you it's completely different from what you said. I mean if you look at this SRM, it's very specific to competence, but it has been interpreted over the years to be anything.

So that also --

MR. SIEBER: We also had an opportunity to step in that cowpie.

MR. PERSENSKY: There was another one at right about the same time on safety conscious work environment that said, you know, just do whatever you're doing now. Don't do anything new.

We indicate that in the last program on human performance that we would monitor and participate in any activities that's going on outside, but not actually initiate any new work.

DR. APOSTOLAKIS: So when you say human performance here, what do you mean?

MR. PERSENSKY: This was the program. This was the broad human performance program.

DR. APOSTOLAKIS: You have been asked to monitor international activities, activities in the area of safety culture. Is this the SECY that did that?

MR. PERSENSKY: This is the one that did that, and then most recently the SRM --

DR. APOSTOLAKIS: Well, the SRM actually.

MR. PERSENSKY: Well, the SRM, which is at the bottom here is the one that indicated that we should continue to monitor what's going on internationally, particularly in the area of measurement.

DR. APOSTOLAKIS: So continue to monitor efforts, but don't do anything yourselves? How do you interpret --

MR. PERSENSKY: That's the way that has been interpreted, that we would monitor what's going on at IAEA, what's going on at CSNI, what's going on at INPO.

DR. APOSTOLAKIS: And as a result of this monitoring, what do you do? You write a nice letter to somebody or --

MR. PERSENSKY: Eventually if there is enough evidence that we should go forward and do something more aggressive, more assertive in the area, then we would prepare a Commission paper indicating that it's time to -- we believe that there's now enough evidence out there that there are

good objective measures or acceptable objective measures that we can use that we might be able to pull --

DR. APOSTOLAKIS: This is very interesting though. In other words, what you're saying is that we're waiting for others to develop those good measures,b ut we're not going to try to contribute to that development. Why are we reserving this treatment to this particular area?

I mean, in another area we --

CHAIRMAN ROSEN: But they aren't. They're only saying they are. Where they're not, where they are just two slides ago told us you're going to go out and look at this human performance data --

MR. PERSENSKY: Human performance indicator.

CHAIRMAN ROSEN: -- human performance indicator, that's an element of safety culture. If you collect those indicators and pick a good set, it doesn't have to be perfect. Just pick a good set of them and you will have gone 80 percent of the way to getting one of the big elements on the table.

DR. APOSTOLAKIS: I suspect when people say safety culture in this context they mean the

psychological stuff and they don't want you to get involved, but if you come up with indicators, that will be great. I mean, that's what the Commission probably means.

Don't go and ask people, you know, "How do you feel today?" We don't care. We care about performance.

CHAIRMAN ROSEN: Right, and the human performance indicators are about operational errors.

MR. SIEBER: So you have to call it something else and then you're home free.

CHAIRMAN ROSEN: No, I think what we need to do is realize that the data you'll collect represent real people's performance in nuclear plants in this country that in some way didn't meet the standards that those people had set up, the people themselves, and those reports are very valuable, and their trend is very valuable, and I would suspect if you could go back retrospectively and look at Davis-Besse over the years you'd see a period -- and had all of those reports -- you'd see a period of better human performance and then a decline.

MR. SIEBER: Yeah. Yeah, you would.

CHAIRMAN ROSEN: It would be detectable.

MR. SIEBER: It would.

DR. APOSTOLAKIS: I really suspect that's what the Commission had in mind, the psychological stuff. Don't go ask people, you know, "Do you put safety first?"

MR. SIEBER: No.

CHAIRMAN ROSEN: Right. I think I agree with that.

DR. APOSTOLAKIS: Nobody is going to say, "No, I don't."

MR. PERSENSKY: Yeah, I think the fact that we're going forward with some work in the area of performance indicators that relate to human elements that --

DR. APOSTOLAKIS: Performance is very different.

MR. PERSENSKY: -- we're taking another look at it.

I won't waste any time on this slide. This is essentially the workshop and our exchange so far back and forth on your letter to use, our letter back to you.

DR. APOSTOLAKIS: Well, is it fair to ask you whether you think that the existing regulations are adequate?

MR. PERSENSKY: I think that they're probably for most instances we can live within the framework, but as Claire said at that meeting and I've said several times, what we don't have is currently a process for pulling that all together.

The other part is we don't have the indicators yet. We haven't done that piece of work that could help us identify.

CHAIRMAN ROSEN: This is hard.

MR. PERSENSKY: Again, I don't think the staff has ever indicated that we wanted a rule on safety culture.

CHAIRMAN ROSEN: No, you don't need a rule. You just need indicators, hard stuff, the number of human performance errors of some kind, the number of safety conscious work environment indicators. You know, maybe that's allegations; maybe it's something else, and the performance of the corrective action system.

There's lots of indicators for all three of those subjects. So it's a question of putting them down, selecting the minimal set, and getting on with it. And I think it would be very powerful.

MR. PERSENSKY: Actually that's what I hope to get to here at the end of this presentation,

as we come closer to the end of this presentation. What I was going to say is I'd really like to get some input from you guys and have an interactive session. I think it's too late to ask for that, isn't it?

(Laughter.)

MR. PERSENSKY: Just to update you on some relatively recent IAEA activities, there was a workshop on lessons learned from recent events held by IAEA and Bill Travers was the chairman of that report. I think there's a draft report on it.

Basically, you know, these were five major events, including Davis-Besse, all of which had a large contribution from safety culture, and what they did was they looked at what are the common characteristics.

CHAIRMAN ROSEN: You mean a large contribution from organizational reliability?

MR. PERSENSKY: Organizational reliability.

CHAIRMAN ROSEN: And those three things we just talked about.

MR. PERSENSKY: Right. Well, they talked about the various elements. What are the common elements amongst these things because --

CHAIRMAN ROSEN: I grant there may be more than three. They may include organizational learning.

MR. PERSENSKY: In fact, a couple of weeks ago there was a technical meeting on the role of the regulator in safety culture.

DR. APOSTOLAKIS: Did you go?

MR. PERSENSKY: I did attend that.

DR. APOSTOLAKIS: How was it?

MR. PERSENSKY: It was an interesting meeting. The report on that is in a draft stage at this point. The first initial draft, we're working on the comments on it.

There are about 25 countries that were represented. Only one of the countries has, in fact, a regulation dealing with safety culture, and that is Finland, but they don't have a good way to get --

DR. APOSTOLAKIS: Well, incidentally, they aren't the only ones who are building a reactor.

CHAIRMAN ROSEN: The only ones what?

DR. APOSTOLAKIS: Who are about to build a reactor.

MR. PERSENSKY: They're building a

reactor. That's right.

CHAIRMAN ROSEN: Was there some acknowledgement that the role of the regulator could have an impact on the licensee's organization or reliability and vice versa?

MR. PERSENSKY: There was a long discussion on that. In fact, we developed a little -- I kind of developed this little Venn diagram on the interactive roles there, and --

DR. APOSTOLAKIS: It's safer, isn't it?

MR. PERSENSKY: -- so that's something.

Again, this is an area that is of interest internationally, and it was not only the major company. We had Malaysia there and --

DR. APOSTOLAKIS: Malaysia?

MR. PERSENSKY: Malaysia was there because they're interested in safety culture not necessarily at the power plant level, but at the materials level.

CHAIRMAN ROSEN: They don't have nuclear plants in Malaysia?

DR. APOSTOLAKIS: No, they don't.

MR. PERSENSKY: No. Cuba was represented and actually has a very strong program in safety culture for their materials licensees. So

there was a --

DR. APOSTOLAKIS: You mean nuclear material.

MR. PERSENSKY: Nuclear material, yeah.

MR. SIEBER: Source.

MR. PERSENSKY: Source.

MR. SIEBER: By products.

MR. PERSENSKY: And medical use, things like that. So they -- it was well attended. There was a very wide range --

DR. APOSTOLAKIS: All but the regulator.

MR. PERSENSKY: And again, we did address this issue of how the regulator can effect, and I'm going to get into a couple of slides on --

DR. APOSTOLAKIS: I would like to see those reports when they come out. This was a one week meeting where starting Wednesday you write?

MR. PERSENSKY: Yeah. Actually we started -- yeah, we started Tuesday with presentations, and we started working on -- we had workshops, individual breakout sessions and worked on it.

The following week, which I did not attend, was a consultant's meeting, which is the first one because they usually go through a series

of consultants meetings before they go to this next level, which is the technical meeting which I was at on performance indicators.

And I've been sending E-mails over there saying, "What happened? What happened?" and I haven't gotten anything back yet. So I was hoping to have something to report in this area, but they, again, IAEA -- this is the staff, not INSAG -- but IAEA is working in this area of performance indicators for safety or safety management.

At this very moment -- well, actually it's probably late in the day for them -- but at CSNI the SEGHOF is meeting, the Special Experts Group on Human and Organizational Factors.

CHAIRMAN ROSEN: Organizational Factors.

MR. PERSENSKY: That's right.

Is meeting and they're talking about scientific approaches to safety management, and they have a technical opinion paper on management of change, and they are also working on their strategic plan in which one of the major elements is organizational issues and safety management.

CHAIRMAN ROSEN: Well, I'm very glad to see this paper on management of change because even in an organization that has a good organizational

reliability history, change management is crucial because it can derail; a big change can derail that organization's reliability.

For example, a change in the boss or a change in the way staffing is done --

MR. PERSENSKY: Or constant changes in bosses.

CHAIRMAN ROSEN: Or constant changes in bosses or not knowing who the boss is.

DR. APOSTOLAKIS: Safety management is kind of big in Europe.

MR. PERSENSKY: The term is much more used in Europe.

DR. APOSTOLAKIS: You know that the Propan (phonetic) where the major, if not the only one, technical university of Norway is, I was amazed to find out that one of the required course of all engineering disciplines was a personal safety management. Unthinkable in this country, unthinkable that you would go to a mechanical engineering department and say that there should be a core requirement on safety management. They would laugh at you.

We have too much to teach them in heat transfer, fuel mechanics, you know, structural

mechanics, and not just mechanical; any department.

CHAIRMAN ROSEN: And the rest of that sentence, we have too much to teach them and they'll learn by sad experience.

DR. APOSTOLAKIS: I made it a point to find out, and they told me that, no, it's a required course of all the engineering students, and I know at Delft, I don't know if it's required of all of them there, but they also have a whole chair of safety management.

So they take it -- I mean they look at it very differently from the way we do.

MR. PERSENSKY: The Swiss were represented. In fact, the chairman of the workshop on the role of regulator was Swiss, and they are not using the term "safety culture" at all. They are looking at it from the standpoint of safety management.

So real quickly because I know I'm going over time here, but INPO, you did hear from them at the workshop. They do have an SOER out on --

DR. APOSTOLAKIS: Tell me again what SOER is.

CHAIRMAN ROSEN: Significant operating experience report.

MR. PERSENSKY: And it said that all plants have to do a self-assessment and turn that into INPO. They're looking at those.

The other thing they're doing is they're enhancing the focus on safety culture in their plant evaluations. One part of what we are doing in terms of this monitoring concept is in fact Claire is going to go on plant evaluation to observe at one of the safety --

DR. APOSTOLAKIS: Does the NRC ever do a self-assessment? See, that is what we tried to raise with our letter. Does the agency have an organizational learning program?

I mean, again, I'm sure there are pieces of it here and there, but, for example, did anyone go back and say why did certain things happen at Davis-Besse?

MR. PERSENSKY: Well, we have a lessons learned report that come out of various --

DR. APOSTOLAKIS: Yeah, but that's a report, which is a very important first step.

MR. SIEBER: It has an action plan. Don't worry.

MR. PERSENSKY: But there's an action plan. Again, there's an action plan that comes out.

There are things going on right now. I mean, as part of that, this whole concept of operational experience, in fact, was determined to be a major element of it. So we now have another task force as a result of the lessons learned to look at the use of operational experience in the NRC.

DR. APOSTOLAKIS: So do we know for sure now what happened with our inspectors there, how much they know and when did they know it?

MR. PERSENSKY: I'm not at liberty to or knowledgeable enough about that topic to talk about it. That's something that you --

DR. APOSTOLAKIS: It's classified?

MR. PERSENSKY: No, I don't know. I literally do not know. I'm not part of that loop.

DR. APOSTOLAKIS: Okay.

MR. PERSENSKY: But we are going to get involved more with plant evaluations from INPO. I just wanted to bring up that since we last talked the NASA report of the Columbia accident came out, and they very clearly state in there that organizational culture and structure had as much to do with the accident as foam, and they had a couple of chapters in the report talking about it.

And they're going to be moving into that

area, and it looks that there's a place that we may actually look to.

CHAIRMAN ROSEN: Let me make a point about NASA for the moment, and the point about safety culture and organizational culture. If you don't correct it, you're going to have it happen again because it's an underlying phenomenon, and after the Challenger accident they had a board that got together and an eminent physicist named Richard Feynman -- Feynman?

DR. APOSTOLAKIS: We are not on the same level. I know Feynman.

CHAIRMAN ROSEN: He went to -- taught a school in California, I think.

He said NASA's engineering judgment was not the judgment of its engineers.

DR. APOSTOLAKIS: That's the greatest line ever uttered, and I think that was, you know, related in some way to what you see here. NASA's organizational culture had as much to do with this accident as the external tank foam.

DR. APOSTOLAKIS: I think it's an exaggeration, by the way, but I know what they're trying to say.

MR. PERSENSKY: Did you read the report?

DR. APOSTOLAKIS: I read pieces of it, yeah.

MR. PERSENSKY: It's got a lot of details. They have an interesting concept in there about sharing by viewgraph, that so much of the information was passed on. It was only passed on at the level of viewgraph so that a lot of the engineering behind the information was lost and nobody thought to ask the questions.

DR. APOSTOLAKIS: But also the main complaint, I think, was that after the piece of foam came off, some engineers demanded that they investigate further, but it's not clear what they could have done, right? Okay. Let's look at it more carefully. It may could cause damage, but what they could have done is not clear.

But anyway, that was a major reason why management was not responsive to what the engineers got.

MR. PERSENSKY: What I want to do here very quickly --

DR. APOSTOLAKIS: This fellow is at MIT, you know.

MR. PERSENSKY: W@ho?

DR. APOSTOLAKIS: Schein.

MR. PERSENSKY: Schein? Yeah. Edgar Schein is one of the fathers, in a sense, of the concepts behind. He's a social anthropologist, and he talks about in his model -- and we're actually getting to the performance indicators issue here -- is that there are certain artifacts that he said you can see, and there are things that people talk about and say, and then there's these basic underlying assumptions. These are the things that are harder to get at.

DR. APOSTOLAKIS: But he did this for culture, not safety culture.

MR. PERSENSKY: He did it for culture in general, but it has been applied, and it is, in fact, the primary basis for most of the IAEA work. At the conference in Rio de Janeiro last winter --

DR. APOSTOLAKIS: Yeah, I saw that.

MR. PERSENSKY: -- he was the keynote speaker there and got into it. What IAEA has done is if you take these things like the artifacts patterns of behavior, these are the things that you can see, the safety outcomes being on top.

DR. APOSTOLAKIS: Yes.

MR. PERSENSKY: So these are the things that you can see and measure. So these might be the

performance indicators, where as these ideas, knowledge, underlying assumptions are things you can't see, and though they do interplay and do impact on culture, they're not measurable amounts.

DR. APOSTOLAKIS: So this committee is on record saying that you should be dealing with visible stuff that you regulate.

MR. SIEBER: It is those items below the line that drive the ones above the line.

MR. PERSENSKY: They're the ones that drive it.

DR. APOSTOLAKIS: But we have no business getting there.

MR. PERSENSKY: And it's also the harder part to get to.

MR. SIEBER: That's true.

DR. APOSTOLAKIS: The trigger -- go back to the previous one. The trigger for us is a violation of the top blue boxes, right?

MR. PERSENSKY: Right.

DR. APOSTOLAKIS: If something happens there, then we say, "Well, gee, we'll have to find out what happened and why." But we will never go to patterns of ideas and knowledge and underlying assumptions.

CHAIRMAN ROSEN: We don't want to have too many of those on the top. It's too late.

DR. APOSTOLAKIS: We don't need it.

CHAIRMAN ROSEN: We need some leading indicators.

MR. PERSENSKY: And how do we get to it through these things?

CHAIRMAN ROSEN: That's right.

DR. APOSTOLAKIS: And I suspect when the Commission says safety culture they mean really the orange stuff.

CHAIRMAN ROSEN: I mean to measure. I want indicators of those two blue boxes, patterns of behavior and artifacts. By "artifacts" I mean human --

DR. APOSTOLAKIS: Well, what we said in our letter is that it's the industry's job to worry about the green and the --

CHAIRMAN ROSEN: Yes, of course.

DR. APOSTOLAKIS: They can do whatever they like, right?

CHAIRMAN ROSEN: That's the manager's job.

MR. PERSENSKY: But some of the things in the green are things you can see and you can give

a --

CHAIRMAN ROSEN: You can see them, but really what the CEO says at his meetings, his body language when you bring him bad information, we can't regulate that. Those are important aspects of this.

DR. APOSTOLAKIS: And we shouldn't.

CHAIRMAN ROSEN: But that is the job that -- the orange box is below the line and the green box above the line are the management's job at the plant.

MR. PERSENSKY: So you believe that we draw the line here.

CHAIRMAN ROSEN: Right.

DR. APOSTOLAKIS: Now, if you --

CHAIRMAN ROSEN: The thing we care about is the two blue boxes because they're leading indicators. The top is too late. Of course we're going to know about them, but it's too late.

DR. APOSTOLAKIS: But we do regulate some organizational structures and strategies, don't we? We have programs.

MR. PERSENSKY: What we look at in the early licensing phase, we look at things to make sure that the nuclear is separate from other parts

of it. We don't really regulate the structure in terms of how they --

DR. APOSTOLAKIS: But when you tell them that they should have so many people in the control room, aren't you regulating the organizational structure? Yes, you are.

MR. PERSENSKY: It's more of a -- from their standpoint, but that's one of the limits. They are elements, but not necessarily how they are structured, but at least some elements with --

DR. APOSTOLAKIS: Some elements, yeah.

CHAIRMAN ROSEN: Probably one of the few examples you can name. Maybe when we talk about the size of the fire brigade, we tell them they need a certain kind of person, a medical review officer. You know, there are some things we tell them.

DR. APOSTOLAKIS: Some things, and they are not unique to us. I mean, the airlines, they cannot fly 747s with one pilot, right?

MR. PERSENSKY: That's right.

DR. APOSTOLAKIS: They cannot.

MR. PERSENSKY: They're not allowed to. They could.

DR. APOSTOLAKIS: They're not allowed to.

MR. SIEBER: He'd be a busy boy.

CHAIRMAN ROSEN: Okay. Go on, Jay. I'm going to start beating on you now because this is the good stuff and we're running out of time.

MR. PERSENSKY: Okay. I'm trying to get there.

Again, this is part of --

CHAIRMAN ROSEN: Your fault.

MR. PERSENSKY: -- and what I've done is that I've taken Schein's model and I try to come up with some more nuclear related stuff and how they relate. If you don't have a good working relationship, you don't have a good outcome, whereas if --

CHAIRMAN ROSEN: Wait, wait. Too fast. Go back, go back, go back.

MR. PERSENSKY: All right.

CHAIRMAN ROSEN: So these are all of the pieces. National culture. Now, you see, national culture does influence this. It's different from country to country. I think that's one of the things that Helmreich and Merritt were talking about.

MR. PERSENSKY: Right.

DR. APOSTOLAKIS: That's why we don't

want Swedish operators in Norwegian plants, right?

CHAIRMAN ROSEN: No. That's why the things you teach a Japanese pilot in a cockpit of a 747 are different than the things you teach an American pilot, because he had to be taught how to operate in this environment differently because his national culture is different than an America.

DR. APOSTOLAKIS: I hope they're not that different. It's the same thing.

CHAIRMAN ROSEN: Well, what you really want to do is you want them both to succeed in flying the same plane, but the way they do it may be different.

DR. APOSTOLAKIS: The way, right.

MR. PERSENSKY: Well, I think some of the examples that Helmreich and Merritt give is where you had a -- they were talking, in fact, about a Malaysian airline and a co-pilot, a Canadian or Australian pilot, and the Malaysian because of their culture would not question the pilot, and that's where they started getting into problems.

We had the same problems here in the U.S. where the staff doesn't question the pilot, and the pilot makes a mistake, and they just let it go.

DR. APOSTOLAKIS: They don't question

professors either. That's great.

MR. PERSENSKY: Yeah.

DR. APOSTOLAKIS: American kids do that all the time.

CHAIRMAN ROSEN: Well, I think you're referring to the same work I'm thinking of, "Culture at Work in Aviation and Medicine."

MR. PERSENSKY: Yeah. A lot of what's here comes from that, and in fact, this is their model. This is the Helmreich and Merritt model that I tried to put in where you have professional culture. That's one of the things that, in fact, in some cases may drive the fact that even though you have a poor organizational culture or safety culture, the professional culture of the individuals actually working may carry the day in many cases. So --

DR. APOSTOLAKIS: So let me understand what's going on here. You guys are working on these things?

MR. PERSENSKY: No, this is the theoretical underpinning that drives us to safety behavior here. We're not working on any of these issues. This is something --

CHAIRMAN ROSEN: This is understanding

some of the literature.

MR. PERSENSKY: I'm trying to bring some --

CHAIRMAN ROSEN: To listen to the literature.

MR. PERSENSKY: -- to see what the model is to what we're doing.

DR. APOSTOLAKIS: Actually you're working on what that is related to these things?

MR. PERSENSKY: This I put together for this presentation.

DR. APOSTOLAKIS: This?

MR. PERSENSKY: This. It's the beginning of where I think we should be going in some of these --

DR. APOSTOLAKIS: So this is consistent with our earlier recommendations of a few years ago that when you guys start working on something, you have some mental model.

MR. PERSENSKY: A mental model.

DR. APOSTOLAKIS: Well, wonderful, wonderful.

MR. PERSENSKY: I did this for you, George.

DR. APOSTOLAKIS: I appreciate, Jay.

I'll buy you a glass of water.

MR. PERSENSKY: But I think this probably driving to the final picture here is that we have a lot of different inputs in terms of you have team performance, and these are all of the inputs.

Part of this might be, for instance, you were talking about ATHEANA. The -- I forgot the word.

DR. APOSTOLAKIS: Error forcing.

MR. PERSENSKY: Error forcing context. This is part of the context. This is part of what makes up the people. It's their attitudes, their training and everything.

DR. APOSTOLAKIS: It's interesting that in the human reliability models I don't think we're taking the fact that we have teams very explicitly in the model, do we? I think that we're talking about this amorphous "the operators."

MR. PERSENSKY: That's one of the directions we're moving with some of the new models. In fact, one of the projects that we're doing at Halden brings more of the team element into it.

DR. APOSTOLAKIS: Okay. That's important. That's very important.

MR. PERSENSKY: One of the elements --

CHAIRMAN ROSEN: And remember the caution in the ACRS letter that said the teams you test in the simulators that are cohesive teams are not the teams that will operate the plant at least a third of the time.

DR. APOSTOLAKIS: Yeah, I remember that. That was a very good observation, yes.

MR. PERSENSKY: But if we had a place to do it like Halden, we could actually make them perhaps not so cohesive.

CHAIRMAN ROSEN: If you had an experimental simulator, yes, you could do that.

MR. PERSENSKY: But if you come down here to the end of this model, the right end of the model, you have the performance outcomes and the organizational outcomes. This is where I think we need to work, these outcomes areas, which is the performance indicators. So I'm just trying to bring to this a little bit of theoretical background and some modeling.

Now, the next three slides -- and if you want to look at them in your handout because it can be hard -- as Steve said, there are a lot of indicators already out there.

CHAIRMAN ROSEN: You know about them. I didn't have to lecture you.

MR. PERSENSKY: That the industry is using and other people are using, and what I've done is I've taken the three primary crosscutting issues from the ROP, which is the corrective action program or problem identification and resolution is really the way I think it's coined there. The other is safety conscious work environment, and the latter is human performance.

CHAIRMAN ROSEN: You made my day, Jay.

MR. PERSENSKY: And this is just a list that we've pulled together over the last few days.

CHAIRMAN ROSEN: Sure. It's not complete, but you know.

DR. APOSTOLAKIS: All right. Let's move on.

MR. PERSENSKY: And I don't know that it is complete or --

DR. APOSTOLAKIS: Why does it have to be? It doesn't.

MR. PERSENSKY: And it may be that we only want some subset of those, but part of what I would like to get from you is, in fact, some idea of which ones you think are reasonable, and the other

part of it is --

DR. APOSTOLAKIS: Human performance indicators? Oh. From this list?

MR. SIEBER: Those three.

MR. PERSENSKY: I mean these are things that some utilities and some other people are using right now. They're concepts, and you can look at any one of these. Some of them are --

DR. APOSTOLAKIS: I think they're very useful, but I'm not sure that anyone really --

MR. PERSENSKY: Or some combination, some algorithm. Do we need an algorithm to put them together or do we need multiple --

DR. APOSTOLAKIS: Individual error rate is obviously an important thing.

CHAIRMAN ROSEN: These are all useful, and they have to be viewed in context.

DR. APOSTOLAKIS: They all contribute to the picture that one forms.

CHAIRMAN ROSEN: Right. This is the first time I've ever seen it on an NRC slide, the things that I typically see when I go to plants in my other dealings, and the question you just raised is the key question. How do you put it together? What kind of algorithm should you use?

I would suggest an industry workshop for this sort of thing. What does the industry think the NRC should use? Does the industry want an input?

I mean, maybe they'll say, "Don't use any of these things. These are for us."

DR. APOSTOLAKIS: There is a fundamental problem with all of this. All of this is --

CHAIRMAN ROSEN: Those are cards. You can't look at our cards.

DR. APOSTOLAKIS: These are normal operation observations, and we just don't know what happens if there is an accident.

CHAIRMAN ROSEN: We just don't know what happens --

DR. APOSTOLAKIS: We are extrapolating. The assumption is that if these are mediocre, then the culture is mediocre, right?

But if these are very good, do you really know whether there will be that single omission or whatever they do? And that's an impossible thing to do. I mean we should be aware of what we're trying to --

CHAIRMAN ROSEN: Absence of evidence.

DR. APOSTOLAKIS: -- what is the basis

of the -- because we have two basic --

CHAIRMAN ROSEN: But, George.

DR. APOSTOLAKIS: -- modes of operation, normal and accident.

CHAIRMAN ROSEN: Right, and we don't get much data on accidents, thankfully.

DR. APOSTOLAKIS: Which is something that we --

CHAIRMAN ROSEN: Which is what we've been trying to do.

MR. PERSENSKY: But the place that we do get some data on accidents is through simulator work, and that may not be --

CHAIRMAN ROSEN: Yeah, imperfectly, but --

MR. PERSENSKY: -- completely perfect, but it's an element that we can't forget there is a way of getting, and a lot of other people rely on it.

CHAIRMAN ROSEN: None of this is perfect.

DR. APOSTOLAKIS: No, you're right, as long as it's in context. You see, the problem with the EPRI OREs -- what was it? Operator reliability experiments of 15, 20 years ago -- was that they

went to the extreme. They were arguing that these were data, period.

No. If you say this is the only thing I can have from accidents, you know, I can take it with a grain of salt or think about it or some limitations, that's great because that's the only thing you can have.

But this is not real data.

MR. PERSENSKY: It's data. It's not from a real environment.

DR. APOSTOLAKIS: Under controlled.

MR. PERSENSKY: Under a controlled situation.

MR. SIEBER: You're talking about simulator performance?

PARTICIPANTS: Yes.

MR. SIEBER: Simulators are a whole different world than controllers.

CHAIRMAN ROSEN: Well, you said you wanted our feedback on these indicators. Let me give you one piece of feedback on the indicator on corrective action. To me one of the core corrective action indicators is recurrence rate. How many times did something happen again that happened once before that you thought you fixed?

Because that's what the program is supposed to be doing, is fixing once and for all a problem.

MR. PERSENSKY: And that is a learning organization. That's where you get --

DR. APOSTOLAKIS: And that is, I notice, again -- from the limited sample of letters I read from the regions, this is a recurrent theme there. You didn't learn from this incident that happened six months ago. You didn't learn from this incident that happened a year ago.

The regions do pay attention to that.

CHAIRMAN ROSEN: So anyway, I'll try to give you off line some comments on these.

MR. PERSENSKY: Right.

CHAIRMAN ROSEN: But I think that's the direction. Let's have some serious study of these things and put together an algorithm. Which is the minimal cut set? What is the minimal set of things that should be looked at. Let's get some proposals.

DR. APOSTOLAKIS: Very good.

CHAIRMAN ROSEN: I think a workshop with the industry or a consultation with the industry would be useful, and then let's get on to monitoring them, at least in a tentative, pilot way, perhaps to

be ultimately put in the ROP.

MR. PERSENSKY: Actually, you talked about a workshop with industry. I don't know if you're familiar with the human performance root causae and trending workshop. It's an annual conference of the human performance people from all of the --

CHAIRMAN ROSEN: That's great, and you should do that, but I'm thinking now in this context do we --

MR. PERSENSKY: Yeah, but it's --

CHAIRMAN ROSEN: -- with the ROP. So maybe you'll get a different set of reactions if you suggest that.

MR. PERSENSKY: But that is a good forum to work with in terms of --

CHAIRMAN ROSEN: All the way from "these are our causes. You can't look at them" to "here's the best set. Here's a limited set."

MR. PERSENSKY: Yeah.

CHAIRMAN ROSEN: "Here's some more."

MR. PERSENSKY: The last line here I had was, you know, some other thing. How do you actually measure some of these things? What are the threshold criteria forms? Getting into is this

something that we look at from a risk implication?

DR. APOSTOLAKIS: The risk implications. You need the significance determination process for your kinds of --

MR. PERSENSKY: We need an STP just for human performance.

CHAIRMAN ROSEN: Oh, sure.

DR. APOSTOLAKIS: Not just.

MR. PERSENSKY: For human performance.

DR. APOSTOLAKIS: Human organization, not just, because we don't have that now. Do you see that? If you guys convince the agency to actually take this seriously, I think we would be well on our way of doing something significant in this area because in developing it you will realize you have many other needs that you will have to investigate.

But why should I, you know, spend a lot of time developing tools that allow me to determine the risk significance of having two sirens instead of three, right? And I don't do the same thing when I see something that is a bad human performance. I should, right? We are putting them on the same level.

In fact, we have agreed that human

performance is more important than a lot of the organization reliability; is of equal importance as hardware in that, and yet we're treating them very different.

DR. SHACK: But, I mean, human performance is an event. You have a significance determination process for the event.

DR. APOSTOLAKIS: That's true, but I think, again, the event proceeds an uncovers its impact on the plant and maybe here we were talking about a little broader than that. There is something that will include maybe organizational relevance.

CHAIRMAN ROSEN: I'm talking about taking these things and stacking them up in some sort of algorithm that then which is your measurement and criteria and threshold, looking at the risk and then saying this is a pattern that we think is not great. At least it requires additional attention.

DR. APOSTOLAKIS: But it is in place.

CHAIRMAN ROSEN: Let's go back to what we're doing here.

DR. APOSTOLAKIS: A lot of it is in place.

CHAIRMAN ROSEN: We're going through the action matrix. That's what we're doing with this. The question is: what gets you to the action matrix?

DR. APOSTOLAKIS: That's a graded response.

DR. FLACK: But I think the difficult is that, you know, with the ROP we can go to a PRA, and we can see what's modeled in there, and then we can adjust those things based on the condition of the plant.

We're talking about things that we don't have explicitly in the PRA. This is the difficult.

MR. PERSENSKY: That's right.

DR. APOSTOLAKIS: Well, because as you attempt to do it, you will appreciate some other needs you may have.

CHAIRMAN ROSEN: It has been talked about, in fact, by members of ACRS at this table, that PRAs don't model organizational performance.

DR. APOSTOLAKIS: Well, it's true because it's true.

CHAIRMAN ROSEN: And should they?

DR. APOSTOLAKIS: We never say --

DR. SHACK: We have also said we can set

thresholds on a performance basis even if they're not explicitly in the PRA.

DR. APOSTOLAKIS: What?

DR. SHACK: Our last letter said you should not set the thresholds.

CHAIRMAN ROSEN: On risks.

DR. APOSTOLAKIS: Oh.

CHAIRMAN ROSEN: Thresholds are not on the risks, no. Performance.

DR. APOSTOLAKIS: No, performance.

CHAIRMAN ROSEN: Thresholds.

DR. APOSTOLAKIS: I think if they ever stop thinking about it, we're going to have a discussion that would be very interesting.

MR. SIEBER: I'd like to ask --

DR. APOSTOLAKIS: Think about it though. An SDP that will be initiated by observations in the organizational aspects.

CHAIRMAN ROSEN: Which are builds-up. They really --

DR. APOSTOLAKIS: How are we going to do it?

CHAIRMAN ROSEN: They're conclusions that come from looking at these individual things you have on your Slides 25, 26, and 27, not looking

at the individual ones, but looking at trends and patterns in the ones on 25, 26, 27, and a conclusion that's drawn from a pattern, a pattern of declining corrective action system performance, a pattern of increasing safety conscious work environment problems, a pattern of declining human performance.

A conclusion from those patterns can be a white or not green conclusion, and to me if you were able to do that and engage a licensee or the agency on that, you'd probably head off these safety culture issues. You'd probably find the plants that are heading for real trouble.

DR. FLACK: But even before you do that, you'd have to validate it somehow, right?

CHAIRMAN ROSEN: Sure, through a pilot program of some kind, I think, is the only way you could do that.

DR. APOSTOLAKIS: Ten years ago we didn't know how to do SDPs. Now we know. So now we don't know how to do this.

CHAIRMAN ROSEN: Are you predicting we'll have to wait ten years?

DR. APOSTOLAKIS: I'm just giving you encouragement.

MR. SIEBER: Before we get too far

toward the end, maybe we could go back to slide 27. There you go, and here's a list of things. It seems to me that after having walked through maybe four dozen plants over the last 20 years, what I notice when I walk through is the difference in apparent standards, and I don't see that reflected here, and that has an impact, first, on the material condition of the plant; secondly, on what people report as being deficient.

You know, if you have low standards, then nothing is deficient, and so you don't have too many things to correct.

CHAIRMAN ROSEN: And it also has an impact, big impacts, on human performance.

MR. SIEBER: Yes, it does.

CHAIRMAN ROSEN: On how the people perform.

MR. SIEBER: Yeah, and do they report when they make mistakes?

CHAIRMAN ROSEN: And they do a report, but also how they perform in individual accuracy.

MR. SIEBER: And it seems to me that if you don't get to the matter of standards which really reflects the management's attitude toward that operation, how much they're wiling to spend in

time, effort, and money, and other resources to establish high standards, until you get to that, I don't think you're going to get too far in safety culture. You've got to be able to measure that somehow.

DR. FLACK: Yeah, that's the key input. How would you go about measuring something like that?

MR. SIEBER: Well, that's -- you know. I only work part time.

CHAIRMAN ROSEN: What, housekeeping?

Jack, what was the question? How do you go about measuring housekeeping?

DR. FLACK: The standards.

MR. PERSENSKY: The standards.

CHAIRMAN ROSEN: Oh, no, no, no. You don't measure standards. That's below the line. You measure housekeeping.

MR. SIEBER: Well, you can measure conditions somehow.

CHAIRMAN ROSEN: Measure condition, material condition of the plant for a back-up, which includes housekeeping.

MR. PERSENSKY: That's right up in here.

MR. SIEBER: And that's a surrogate for

the standard.

DR. FLACK: Yes, sure.

MR. PERSENSKY: That's up here.

DR. FLACK: That's an observable.

MR. PERSENSKY: Because you can observe it.

MR. SIEBER: You've got to get that in here somehow.

CHAIRMAN ROSEN: And you can go to a place that's perfect, know what perfect is, and then you can go to a place that's less than perfect and see the differences.

MR. SIEBER: And you can also see a difference in performance and a difference in safety.

MR. PERSENSKY: Actually that is my last slide, gentlemen.

CHAIRMAN ROSEN: It has been a real pleasure.

MR. SIEBER: That was a great last slide.

(Laughter.)

CHAIRMAN ROSEN: I'm looking around the room for someone who can schedule the next Human Factors Subcommittee meeting to hear more, and I

realize that that's me.

DR. APOSTOLAKIS: We have a list of the projects that you're funding right now? Do we have it somewhere?

MR. SIEBER: Yes, we do.

DR. APOSTOLAKIS: What is it? Is it Link Technologies?

CHAIRMAN ROSEN: No, we're going to hear that starting at 3:30, right?

DR. APOSTOLAKIS: No, that's human reliability at 3:30.

CHAIRMAN ROSEN: That's right.

DR. APOSTOLAKIS: Human factors and organizational safety. You mentioned things as you went along, but --

MR. PERSENSKY: Okay, but if you look back at the one slide -- now, how do I get to it?

DR. APOSTOLAKIS: Well, escape. Escape and you will be able to go. Escape, no? Yeah, now you can find on the left.

MR. PERSENSKY: This is basically what we have money in to work in each of these areas.

DR. APOSTOLAKIS: Okay, yeah. All right. That's good. Now, I know.

DR. FLACK: We're looking at this as a

long-term project as well. It's not just for FY '04. We're looking for the out-years to continue. This is just the initiating stage basically is what we're talking about.

CHAIRMAN ROSEN: Fascinating stuff, gents. We'll be back at 3:30 and we're --

DR. APOSTOLAKIS: Wonderful, Mr. Chairman.

(Whereupon, the foregoing matter went off the record at 3:14 p.m. and went back on the record at 3:34 p.m.)

DR. APOSTOLAKIS: Okay. We are on the record.

Okay. The next item on the agenda is human reliability research. I don't see Mr. Hamzehee, but I see other distinguished people here. So, Mr. Cunningham, please introduce the ladies and tell us what it's all about.

MR. CUNNINGHAM: Thank you, sir.

My name is Mark Cunningham. I'm the Acting Deputy Director of the Division of Risk Analysis in the Office of Research. With me today are Erasmia Lois with the PRA Branch in the Office of Research and Susan Cooper, PRA Branch in the Office of Research.

And we're here to talk about and give you a summary of our human reliability analysis program, give you some sense of what's been accomplished over the last few years, as well as what we're doing now and what we expect to be doing in '04 and '05.

The first part of it, my part of it, is fairly generic and historical in nature, and if you like we can move quickly through that into the substance of it.

DR. APOSTOLAKIS: Yes, yes, we should.

MR. CUNNINGHAM: Okay. So I'll talk very briefly about why HRA research is important, some of the things we've done, and the current summary of the current program.

And then Erasmia and Susan will talk about some of the issues we're currently addressing and some of the future work.

Do I need to discuss human reliability is an important issue?

PARTICIPANT: Yes.

DR. APOSTOLAKIS: No.

(Laughter.)

DR. APOSTOLAKIS: We had a long discussion, and some members are unconvinced.

MR. SIEBER: We've been here before.

CHAIRMAN ROSEN: Human reliability analysis and risk analysis is one of the two areas in PRAB that probably get the most funding on a long-term basis at least over the last few years, human reliability and fire analysis, because we're concerned that these can be very important contributors to risk, and that our state of knowledge is not as good in these areas as they are in many other areas of PRA.

So we made a lot of progress in both areas over the last few years, and we'll talk briefly about the fire analysis work tomorrow, but we still believe that it's important to improve the modeling of human performance and to collect data to help validate, if you will, the human performance models.

We are also getting into the position of extending traditional HRA methods into other types of applications beyond just reactors, and Susan will talk about some of that a little bit later.

Over the last few years what you could see is a diminishing in significance, if you will, or funding is another way to think about it, basic methods development. The committee and ourselves

had a number of discussions over the years about during the development of ATHEANA and me to move beyond that.

Basically we're in a mode now where ATHEANA development is completed. We are in what we call a maintenance mode. We use ATHEANA as a tool for use in PRA. We try to maintain that tool to reflect current technology and to reflect lessons that we learned as we apply it. Certainly over the last year or so a big aspect of our HRA work has been applications. You've heard a great deal about the pressurized thermal shock work that we've done. We're also applying it to an evaluation of steam generator tube ruptures. These are tube ruptures in the sense that these are accident induced steam generator tube ruptures as opposed to your traditional initiating event tube ruptures.

CHAIRMAN ROSEN: In other words, these are the high pressure primary side, dry-out secondary side?

DR. FLACK: Correct, correct. And there's an evaluation that's going on across the three divisions that's concerned about it started a couple of years ago, concerned about how quickly the tubes would fail, degraded tubes might fail under

those types of conditions, and so there's interplay between the engineering of the tube performance, human actions that could make it better or worse, and the mechanics of other aspects of the reactor coolant system that might be in some respects weaker in these conditions or stronger, and so there's risk tradeoffs, if you will between something that could have a high consequence if a tube fails or lower consequences if you have failures in these conditions in another part of the reactor coolant system.

We have work going on in requantifying our estimates of fire risk. Human reliability issues are coming into that as well.

MR. SIEBER: Going back to ATHEANA, you spent 2.7 million up to last year, 350,000 this year. What do you project in the future for expenditures for ATHEANA?

MR. CUNNINGHAM: It would be no more than the 250. It will probably be down from that a little bit.

MR. SIEBER: Three hundred and fifty.

MR. CUNNINGHAM: Three hundred and fifty? So it will be --

MR. SIEBER: Yeah, that's a lot of

money.

MS. LOIS: Actually we haven't done any developmental work for ATHEANA last year, 2002. The funds, although the title of the project is, I think, development and maintenance, most of the funds are used for performing actual analysis and also for looking at what I'm talking about, the HRA guidance and insides from ATHEANA to incorporate them.

MR. SIEBER: Yeah, some of it is applications. Some of it is to apply V&V techniques to it. Some of it is to revise NUREG-1624.

MR. CUNNINGHAM: Yes.

MR. SIEBER: I think there are two tasks like that.

MR. CUNNINGHAM: Yes.

MR. SIEBER: And the support of international activities.

MR. CUNNINGHAM: Yes.

MR. SIEBER: So those are the non-application kinds of things. So I take it you would say that development is now completed.

MR. CUNNINGHAM: Yes, basically that's correct.

MS. LOIS: And some of these tasks were

not active at the time.

MR. SIEBER: Okay. Thank you.

MR. CUNNINGHAM: As we were kind of getting to, one of the things we're getting more and more into now is the development of guidance for use of HRA or the review of HRAs. Erasmia and Susan will talk some more about that as well.

To give you a sense of the program on a very, very broad level, we're working on HRA tasks in all of the basic arenas in the agency. The biggest one is reactors. Even there we're getting some conventional reactor, some advanced reactor work. We have made a lot of efforts in the last year or so with respective to waste and materials applications, and we have some specific applications in the security area. We've heard some of those as well.

It covers the gamut from rulemaking support to NRR, development of guidance for licensing actions and licensing reviews, and building the basic infrastructure, maintaining the infrastructure through guidance, through applications, and that sort of thing.

CHAIRMAN ROSEN: What does "ex-control actions" mean?

MR. CUNNINGHAM: I'm sorry. It's what is?

CHAIRMAN ROSEN: What does that mean? "Ex," hyphen, "control actions" on your slide.

MR. SIEBER: In the second column.

MR. CUNNINGHAM: Ex-control room, outside of the control room.

CHAIRMAN ROSEN: Oh, outside of the control room.

MR. CUNNINGHAM: Outside of the control room. There's one word missing there.

We're working now in the area of guidance development and collection of data to get at three basic things: to improve the consistency of PRA modeling or HRA modeling. We're trying to better define the applicability of different HRA models and different situations and that sort of thing, and get at some of the basic issues of collecting data that support and would validate the models.

Again, as I've mentioned a couple of times already, we're extending our traditional HRA work out into other areas, materials applications, waste applications, that sort of thing.

CHAIRMAN ROSEN: Your first bullet, "HRA

practices," it says "consistency." "HRA methods are implemented differently." That's true within a method, but it's also that there are lots of different methods.

MR. CUNNINGHAM: Yes, yes, that's correct.

CHAIRMAN ROSEN: What would be the primary thing, I would say, is you use a method and I use a method, and we come up with the same event and we come up with wildly different answers.

MR. CUNNINGHAM: Yeah, that's fair.

CHAIRMAN ROSEN: So that issue is the principal issue, I think, that we need to grapple with. Let me just ask you to get a little philosophic with me for a minute here. Just take two minutes out of the agenda and ask: why do we have so many different models? And is there any likelihood that we can converge on one model? Could we somehow as an industry pick a model and just say it's good enough and to use this for event analysis or for SDP or something like that?

MR. CUNNINGHAM: Susan is the newest employee in the branch. So she'll get to handle that one.

MS. COOPER: First of all, I'm going to

respond to what you said first. Part of the HRA guidelines or guidance is going to address when different types of HRA models or methods are appropriate to use. That's part of what the guidance document --

DR. APOSTOLAKIS: When we say "different" do you refer to other people's models?

MS. COOPER: Yes, yes. One is THERP, ASEP, you know, whatever.

DR. APOSTOLAKIS: It could be MERMOS, the French MERMOS?

MS. COOPER: I don't know that we're addressing MERMOS.

MS. LOIS: In the future.

MS. COOPER: Now, getting to your broader question, I don't know if we will ever converge onto one model, and part of that has to do with differences between applications, and let's just take MERMOS and ATHEANA.

MERMOS was developed specifically for EDF's new plant design, a computerized control room, and much of their basic psychological research was put into a model of how a crew operates in that control room using a computerized interface, using computerized procedures the way they want them to

use them, not maybe -- you know, I know that we may be moving in that direction, too, but the way they want to use them and also how their crew structure is set up.

So their basic psychological model underlying the rest of it, including the quantification is different than I envisioned likely being something that we need to address in the near term.

DR. APOSTOLAKIS: But how about CREAM? You know, I was at a review meeting earlier this week of the NASA Space Shuttle PRA, and they are using CREAM, and I asked them why, and I didn't really get a satisfactory answer.

MS. COOPER: I don't -- well, they may be using CREAM. I worked with --

DR. APOSTOLAKIS: They are.

MS. COOPER: -- NASA just before I left my previous job, and they said they were using CREAM. I'm not sure they are.

DR. APOSTOLAKIS: But we need -- we need a critical review, and I was saying the same thing this morning.

MS. COOPER: Well, one other thing about the second generation methods, and I think this was

recognized by the international community, which was, you know, the HRA community, which they were all working together on these different methods, CREAM, MERMOS, ATHEANA, and they all had one thing in common, and that is that they thought they each had -- well, two things in common.

One, they all had very much the same sort of perspective on why accidents occur. That is a common factor, and it is a new perspective. It's a different perspective.

CHAIRMAN ROSEN: In other words, error-forcing context.

MS. COOPER: Well, but the point is context, context.

CHAIRMAN ROSEN: Context.

MS. COOPER: Context is the driving factor in all of them, and it --

CHAIRMAN ROSEN: And that's like a common language, like the Rosetta Stone with these different --

MS. COOPER: Right. It is, and it recognizes that humans are not machines that fail randomly. There's a reason why they fail, and it's usually the situation that they're put into. So that's common to all of the second generation

methods.

DR. APOSTOLAKIS: So you will point that out?

MS. COOPER: I would point that out as a commonality among all of them.

DR. APOSTOLAKIS: That's wonderful. That's great progress.

MS. COOPER: Now, each of them then address different aspects of it, more or less another. MERMOS makes much of the fact that they have focused on a crew model. ATHEANA doesn't really have a crew model. We treat it a little bit more simplistically. CREAM has some more organizational factors in it.

I think it's just simply a recognition of the fact that these second generation methods, while they're an improvement over the first generation, we still don't have all of the pieces in one method, and people still are struggling with trying to understand how best to represent the --

CHAIRMAN ROSEN: But in your first revelation, which I'll write as Revelation Susan Cooper No. 1 --

MS. COOPER: Oh, boy.

CHAIRMAN ROSEN: -- context matters.

MS. COOPER: Yes.

CHAIRMAN ROSEN: Isn't it also true that the context is different from a French N-4 plant to these other plants?

MS. COOPER: That's true.

CHAIRMAN ROSEN: So one might have a different model and still be on the same philosophical wavelength with Susan's first principle.

MS. COOPER: I think that's true, and that's being recognized not just in the nuclear power industry but, you know, medical, aviation, you know, across the board.

CHAIRMAN ROSEN: Context matters, yes.

MS. COOPER: Context matters, and that's when --

CHAIRMAN ROSEN: I mean, if your life depends on getting down the next 10,000 feet --

MR. CUNNINGHAM: Yeah, that's exactly --

DR. APOSTOLAKIS: Because of the CREAM reasons, I look at the book on CREAM. Amazing. For 240 pages the book criticizes other people's methods, and starting on 240 he does the same thing. He calls it different.

Now, somebody with authority, like these

here people, very nice people, ought to say somewhere that we are really doing the same thing, and you call it performance or somebody calls it performance shaping factor. Another one, common performance --

MS. COOPER: I think that was recognized in the Mosaic.

DR. APOSTOLAKIS: -- conditions.

MS. COOPER: The Mosaic Group. I don't know if it's still active. They're a --

CHAIRMAN ROSEN: The importance at this point is not saying that, you know, this research or that research is better than that. It's that we now have a principle. Context matters, and one can now say what was the context and what are the key contextual parameters.

DR. APOSTOLAKIS: Right, and the differences between models is that they are emphasizing different aspects of the context.

CHAIRMAN ROSEN: Right.

MS. COOPER: Yes.

DR. APOSTOLAKIS: But that is tremendous progress.

CHAIRMAN ROSEN: Absolutely. I agree 100 percent because we can use that. We can use the

turnaround right away and say if we want to assess an event, we have to look at the context, and it doesn't matter what method you use as long as it's contextually driven.

MS. COOPER: I don't know if I would go quite so far as anything you use because the premise also is that some of the things that we thought were important are not necessarily always important. I mean procedures are important. Yes, they are, but in some cases they --

CHAIRMAN ROSEN: In certain context they're not.

MS. COOPER: That's right.

CHAIRMAN ROSEN: Like in knowledge base space.

MS. COOPER: Right.

CHAIRMAN ROSEN: I mean, there isn't a procedure anyway. So how can it be important?

MS. COOPER: So there needs to be some flexibility in looking at the --

DR. APOSTOLAKIS: Another major insight, I believe, which we can now state with assurance that it's true, not assurance --

MS. COOPER: Confidence.

DR. APOSTOLAKIS: -- confidence, is that

one way or another no matter who you are eventually you will have to rely on some expert opinion to produce numbers.

MS. COOPER: Yes, I think that's true.

DR. APOSTOLAKIS: And let's acknowledge this. Put it out there and say, "This is the way it is."

No model produces numbers from a statistical basis or --

CHAIRMAN ROSEN: No.

DR. APOSTOLAKIS: At some point they will say table such-and-such will give you.

CHAIRMAN ROSEN: And we'll say experts have to apply numbers, and the way they apply numbers is they take a couple of standard numbers, one for one's ten to minus three and one's ten to minus two. I forget which those two are, for two different kinds of human actions.

DR. APOSTOLAKIS: Oh, the omission and commission.

CHAIRMAN ROSEN: Whatever. We'll take some base numbers and multiply them by factors, and the expert's job is to decide what those factors are, and those factors are driven by --

DR. APOSTOLAKIS: The adjustment

factors.

CHAIRMAN ROSEN: The adjustment factors are driven by the context.

MS. COOPER: Well, I wouldn't go that far. I mean that's a specific method that I would not --

CHAIRMAN ROSEN: I'm trying to get -- Susan, I'm trying to get a specific. The bottom line here is I want a specific method that we can all agree to, one that is simple principally, but then we get to argue. What we argue about is not the simple structure of the method because it will be contextually driven and all of that. What we argue about is the expert's opinion. That's where the argument comes up.

Whether we believe it, and the range of uncertainty is the range of experts' opinion. It seems so simple to me. I just don't know why.

MR. CUNNINGHAM: If we could proceed back into the discussion and come back to these later because we'll give you some idea of where we're trying to get data to get past, if you will, we'll start with ten to the minus two and multiply it by this to get on to something that's a little more at least defensible, if not more defensible

than that.

CHAIRMAN ROSEN: Okay. I'd like to be more defensible than that, but I'd like something more than we have now, which is every --

DR. APOSTOLAKIS: But it's also pretty much --

PARTICIPANTS: Yes.

DR. APOSTOLAKIS: It's not just range.

PARTICIPANTS: Yes.

CHAIRMAN ROSEN: Where we find ourselves right now is that you can get any number at all using different methods, and that's not a satisfactory situation.

MS. LOIS: Last year, I guess, Dr. Powers kind of challenged us what is our vision, and we did put up a consensus high level model, and that's what we're talking about, and high level at least agree. And I think with the various activities that we have, we tend towards reaching that level so that we can start discussing the details on where we differ and why, and I'll talk a little bit about that.

DR. APOSTOLAKIS: By the way, speaking of different models, I was so frustrated years ago that I went to a colleague of mine who is a reactor

physicist, a well known reactor physicist, and I said, "This PRA is nonsense. I ought to quit. You know, everybody does his own thing."

And he said that in the early days of reactor physics it was very similar. Each group would have its own code to do the reactor kinetics calculations. They would consider different things and so on, and then slowly the industry settled on a code or maybe a couple of codes for doing this thing when details.

So it's not unusual when something new is created for people to take different paths. The problem with HRA is that it has been going on too long, you know, too long. For too long people have been developing their own stuff, ignoring other people.

MR. CUNNINGHAM: We might say that more broadly in PRA, but in other aspects of PRA as well.

DR. APOSTOLAKIS: Well, yeah, PRA, but I think in a lot of respects we have settled on certain things.

MS. LOIS: On HRA guidance, the objective of this work is to provide the technical basis for developing an SRP or reg. guide for reviewing and performing human reliabilities. The

work is going on at Sandia.

The need comes from the fact that HRA analysis plays more and more important role at the NRC's decision making. Staff is making decisions for a licensee request for changes.

DR. APOSTOLAKIS: Is it because we have complained about it?

MS. LOIS: I'm sorry?

DR. APOSTOLAKIS: We have complained about it.

MS. LOIS: You have.

DR. APOSTOLAKIS: The power up rates.

MS. LOIS: That's right. Power up rates.

DR. APOSTOLAKIS: Give credit where credit is due.

MS. LOIS: Changes in the pulse design and operations, reliance on human performance becomes increasing, and as we mentioned, the NRA state of the art is evolving and we don't have convergence yet.

So this came up, was recommended by NRR to help address those issues. We think that the benefits will be to improve the staff's capability to perform a more consistent and technically correct

evaluation of our licensee requests and standardize the HRA practices.

I'll talk a little bit more about what we're doing in the HRA guidance, but I would like to mention that EPRI is also having activities for developing HRA guidance, is looking more into how do you perform specific methods. How would you do HERP (phonetic) or HCR or --

DR. APOSTOLAKIS: When you say "HRA guidance," you include quantification?

MS. LOIS: It's quantification, yes.

DR. APOSTOLAKIS: Okay.

MS. LOIS: It's all aspects, identification of human activities needed to be performed. It's the whole --

DR. APOSTOLAKIS: You have already done this. Sandia has already issued the guide?

MS. LOIS: We are working on that, and I'll get into that in a minute.

DR. APOSTOLAKIS: Okay.

MS. LOIS: So this is why we do the work. How we're doing it, we're building on the insides from reviewing and performing HRAs. We're particularly taking into consideration the lessons learned from ATHEANA, both development and

applications.

There is a particular concern that we would like to address, is whether or not the non-explicit treatment of error, of commission in licensee's PRAs at the moment may contribute to overlooking potentially significant human failure events, and that's very important for decision making aspects for off-licensee (phonetic) requests.

And also the other concern is whether or not requests for applying design and operation changes may introduce, has the potential to introduce new failures that we haven't seen, we haven't analyzed, and of course, the impact of --

CHAIRMAN ROSEN: The difficulty with error of commission, as opposed to error of omission, in error of omission, you know the error that is omitted because you defined it and you say it didn't happen. So there it is.

Error of commission is infinite. I mean, really you know, what they say in the Navy is you really have to -- they've got a very inventive bunch of sailors. You've got to invent errors that they can make that you've never, never dreamed of.

DR. APOSTOLAKIS: In all fairness though, we also don't include in our PRAs not errors

but acts of commission that are beneficial, and we've seen that it applies.

CHAIRMAN ROSEN: Acts of commission that are beneficial?

DR. APOSTOLAKIS: Well, not commission.

MS. LOIS: Recovery, capability to recover.

CHAIRMAN ROSEN: Oh, yes, sure.

DR. APOSTOLAKIS: Improvisation.

CHAIRMAN ROSEN: Oh, yeah, sure. No, okay. Sure, sure.

MS. LOIS: However --

CHAIRMAN ROSEN: But I'm worried about commission errors, non-treatment of errors of commission. To treat them you've got to say, "Okay. This is the error that the person commits, and it's not an error that's" -- you know, maybe you have a list, but it never can be a complete list because, as I say, they're going to think of an error you didn't think of.

MS. LOIS: I think though through the -- I mean, Susan can respond to that better than me -- but I think through the search mechanism that ATHEANA has developed and by going systematically looking at the specific environment, the specific

conditions that human actions have to take place, then you can have very good leads as to what could happen.

So you don't have an infinite set as much as you thought.

CHAIRMAN ROSEN: Better than controlling a PWR, you could pick a transient, any transient. I challenge you to pick a transient, any transient you like, and then I'll go in there and routinely push a button, fly into it, and say that was my error of commission.

Think about how many buttons there are to push.

MS. COOPER: Well, there are two premises that I think are pretty reasonable ones. One, people are going to do things for a reason, and they're --

CHAIRMAN ROSEN: That's what you think.

(Laughter.)

MS. COOPER: As a regulator, maybe it would be a good place to start. If they do it for a reason --

CHAIRMAN ROSEN: Well, my point is exactly that that is wrong. They will do something --

MS. COOPER: I don't know how to defend anything else.

CHAIRMAN ROSEN: Well, okay. They will do something for a reason, but it's not the reason you think.

MS. COOPER: Okay. No, it may not be, and it may be for a reason.

CHAIRMAN ROSEN: It may be because they just may.

MS. COOPER: It's intentional, but -- well, --

CHAIRMAN ROSEN: It may be because they're tired.

MS. COOPER: That I also have a little trouble defending.

CHAIRMAN ROSEN: It may be completely your left-right brain crossed or something.

MS. COOPER: Okay. That's good. Okay. Now, defensible reasons, things that I can defend, things that they intend to do but for the wrong reasons. That I can defend, and that I can find and search for, and I can find things that have serious consequences.

I am not going to go after things that - -

CHAIRMAN ROSEN: You're almost there. You're almost at my worst nightmare, which is -- let me put the last two things you said together -- they do something for the right reasons, right?

MS. COOPER: No, for the wrong reasons.

CHAIRMAN ROSEN: Okay.

MS. COOPER: They do it for the wrong reasons.

CHAIRMAN ROSEN: Oh, they do it for the wrong reasons. I was going to say here is the operator who does the right thing for the wrong accident.

MS. COOPER: How could that be? How could that be?

CHAIRMAN ROSEN: The right thing for the wrong accident? HE doesn't understand what's happening.

MS. COOPER: Well, I don't know.

CHAIRMAN ROSEN: He has completely lost his mental model of --

MS. COOPER: Okay. I would turn that around.

CHAIRMAN ROSEN: -- in a situation of awareness. He thinks --

MS. COOPER: The accident can't be

wrong.

CHAIRMAN ROSEN: He thinks, for example, the pressurizer -- he has indication the pressurizer is full, and that means that the system is full.

MS. COOPER: Well, I agree with you. The terminology is different.

CHAIRMAN ROSEN: And so he stops the ECCS. Do you recognize that scenario?

MR. CUNNINGHAM: Yes, yes.

MS. COOPER: Yes.

DR. APOSTOLAKIS: I think that's a higher order.

CHAIRMAN ROSEN: So that's a mental model error.

MS. COOPER: Yes, yes, and that's an important one, and I agree with you. It's just that I would use different terminology. I wouldn't say it's the wrong accident. I would say it is the accident, and he has got the wrong one in mind, and yet absolutely I would --

CHAIRMAN ROSEN: He does the right thing for the wrong accident. I'm think of the TMI case. If he had done that and the pressurizer was solid and the system was solid, he would have been doing the right thing.

MS. COOPER: Right. Yep, I agree with you completely. And I would say caveat, for things with serious consequences also.

CHAIRMAN ROSEN: Yes, of course.

MS. COOPER: Not just "no, never mind."

CHAIRMAN ROSEN: Sure. Of course, you're going to have to search through a lot of "no, never minds" to get to leave the ones that have serious consequences.

MS. COOPER: Depending on how you search. I think the ATHEANA search process focuses you on the things that have high consequence.

CHAIRMAN ROSEN: Okay. Very interesting.

MS. LOIS: We plan to have three documents. The document one would provide the -- describe the driving influences of human failure, and it would be like the scientific journal kind of a document that would set up the stage for why we have to have this guidance.

Document two, we characterize it as good practices, and these will provide the technical basis for the SOP or the reg. guide.

And in actuality what it does is it starts out with the ASME standards and goes to lower

level.

DR. SHACK: What does that mean?

MS. LOIS: It means that each one of the elements on human reliability, that ASME stating, for example, a human action dependence; some human action shall be taken into consideration and probably has a couple of other elements.

So then it goes in and says why and how exactly it should be done, providing very low level of guidance or more detail on how to do that.

DR. APOSTOLAKIS: Now, document one, didn't the staff do 67 percent of that years ago in a NUREG? It was in ATHEANA, I believe, and the first couple of chapters were a review of what people believe was driving influence.

So is this a repetition of that or is it a more mature version?

MS. LOIS: This is going to be a condensed version.

DR. APOSTOLAKIS: A more mature version of that?

MS. LOIS: Yeah, or taken into consideration with Davis-Besse conditions or the newest information we have, and the evolution of the thinking since NUREG.

DR. APOSTOLAKIS: So are we going to have chances to look at those things before they are final?

MS. LOIS: As a matter of fact, I didn't put it --

MR. CUNNINGHAM: Yes.

MS. LOIS: I didn't put it in that bullet, but we plan to come and brief you.

DR. APOSTOLAKIS: Before they are final?

MR. CUNNINGHAM: Yes.

MS. LOIS: It's going to go out for public comment, and before that.

DR. APOSTOLAKIS: Now, don't tell me that.

MS. LOIS: No?

DR. APOSTOLAKIS: No, here, internal.

MS. LOIS: Oh, yes.

DR. APOSTOLAKIS: Public comment, that's too late.

MR. CUNNINGHAM: Yes, you will get an opportunity to --

DR. APOSTOLAKIS: We cannot --

MS. LOIS: I'm going to talk to Mike and just set it up.

MR. CUNNINGHAM: Yes.

MS. LOIS: We're almost there. We're almost ready. For document two we're in good position to come here and brief you.

DR. APOSTOLAKIS: Mark was up there many times. He knows the answer.

MR. CUNNINGHAM: That's correct.

DR. APOSTOLAKIS: Let's move on.

Now, what's the time schedule? You're going to show us the time schedule for these things?

MS. LOIS: It's right there.

DR. APOSTOLAKIS: Yeah, it's right there. Great.

MS. LOIS: So I don't know. Before Christmas you want us to --

DR. APOSTOLAKIS: Now, why do you put document two ahead of document one?

MS. LOIS: Because that's the one that is more mature in terms of development. We have a good draft that we are ready to circulate for internal review, including the ACRS and our own staff that are going to be users, and I think we're going to get there real soon.

Now, document --

DR. APOSTOLAKIS: Now, one of the things that I would like to bring to your attention, and I

don't know if you ever read the ACRS -- this infamous benchmark exercise from ISPA, there you're going to go and address some of the issues that it faces.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: You don't read the ACRS letters.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: And there is a short paper in the PSA '89 conference where the name of the author is there, and I'm sure if you use your influence you can get actual reports from ISPA if they exist, but it's a diagram there that bothers me a lot, you know. Eleven teams, all teams using the same method. The results are up and down. The same team using different methods, the results are up and down, and I don't know what to do about it.

So please address that in one of your documents.

MR. CUNNINGHAM: I'm just trying to remember. Was that an HRA or is that --

DR. APOSTOLAKIS: HRA benchmark exercise.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Either they picked a

German plant and they had 11 teams, Americans as well, and they said, "Look. This is the accident sequence, and here is a recovery action. Go back to your country and quantify it. Pick any method you want."

And it was incredible the results they got. All of this up and down, I mean, that is really bothersome. So somehow we have to close up chapter, PSA '89.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: Okay? Andre Posei is the author. He didn't do the whole thing, but he is --

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: And it is also cited in one of the letters we wrote recently.

MR. CUNNINGHAM: Yes.

DR. APOSTOLAKIS: Oh, you knew that?

MR. CUNNINGHAM: Yes, I remember that. I seem to have heard that once or twice before.

DR. APOSTOLAKIS: And you will hear many more times.

MS. LOIS: This is the unfortunate benchmarking HRA.

CHAIRMAN ROSEN: Unfortunate?

MS. LOIS: Yeah.

CHAIRMAN ROSEN: Why do you say unfortunate?

MS. LOIS: Because I don't know if it was well designed.

DR. APOSTOLAKIS: Well, your answer may be just that, but I think there is more to it than that.

MS. LOIS: Yeah, yeah, it may be more than that.

CHAIRMAN ROSEN: Well, we're drawing a different conclusion. We're drawing a conclusion that the methods are intolerably different.

DR. APOSTOLAKIS: Yes, and you will have to do something to eliminate that.

CHAIRMAN ROSEN: Well, she says we may be wrong to draw that conclusion, that the study was bad, which we are prepared to listen to that argument just as we are prepared to listen to EPRI is not --

DR. APOSTOLAKIS: I'm willing to listen. I'm really dying to.

CHAIRMAN ROSEN: -- notwithstanding all of the macroscopic evidence that it does.

DR. APOSTOLAKIS: I get it from Mark; I

get it from you; I get it from Susan. I can't defend myself.

Can we move on?

CHAIRMAN ROSEN: Yes.

MS. LOIS: Okay. So we have another activity that is a --

CHAIRMAN ROSEN: Because Newton wasn't Green?

CHAIRMAN ROSEN: -- by Idaho. This is developing data. This is the work that we're doing in the collaboration with Jay Persensky and the human factors people. What we try to do is to make a more effective use of existing information, to be able to use information and evidence instead of just data in terms of failures and opportunities, and we hope that we'll be able to develop Bayesian type methods to use the evidence in estimation.

We call it INFORM, human performance information repository. We're currently focusing on nuclear power plant experience and probably will get to address other types of sources as well.

We think that we're going to get an improved understanding of human performance and the influences on human performance including accidents; have more realistic estimation of probabilities and

also support a variety of NRC activities which is the SDP processes, et cetera.

There are related activities going on at Halden and CSNI, and I'm going to cover them quickly as well.

I guess the question was how different the HRA methods are. This activity starts out with characterizing the information needed to perform an HRA, and it attempts to identify the concepts and terms, terms that are used in the various HRA methods, and develop a glossary that will translate the concepts and at least identify the shared concept commonalities.

DR. APOSTOLAKIS: How is this different from the three documents? The three documents are different than this?

MR. CUNNINGHAM: Yes.

MS. LOIS: The documents are talking about how you should do a good HRA, but they're not dealing with what is the definition of and context of ATHEANA versus the definition of what is, you know, CREAM or, you know.

MS. COOPER: Or CICAS.

MS. LOIS: Yes, CICAS.

DR. APOSTOLAKIS: But if you have HRA

good practices, won't you have to address that? I thought that -- I mean, the three documents appear to me that they were really addressing all of these questions. Now it seems you're opening up a new project.

MS. LOIS: The three documents are document two, good practices, for example, will tell you from a practitioner point of view how we should do, that you have to take into consideration the time available, the PSA, the PSF.

DR. APOSTOLAKIS: Because these are important things.

MS. LOIS: Yes.

DR. APOSTOLAKIS: So this guy comes back and says, "The information you need is the time available." I mean, how is he different from that?

MS. COOPER: This is getting at the issue that you were just talking about, variability and quantification. The information that this database is to collect is to better educate and inform the applier of a method, as well as, you know, whoever is in charge of developing the numbers, the quantification.

So you need to have that information base, and we recognize we need to have a better one,

especially since we have a new perspective on what is the driver of serious accidents, and so this is an attempt to try to develop that information base that can inform the overall HR process all the way through quantification.

DR. APOSTOLAKIS: But the first document says that it will describe what the driving forces for human performance are.

MS. COOPER: Okay. The guidelines document, the three volumes, the first one is a perspective document. This is how you should look at HRA and what you should be worried about in HRA, and that is as you said before. It's going to have some similarity to what's in ATHEANA.

The rest of the three documents then are to assist either a practitioner or a reviewer of HRA to evaluate whether or not the HRA is of appropriate quality and the appropriate techniques have been used.

The database is to do a very different thing, and that is to actually assist the user in trying to do the best job that they can in applying that HRA.

DR. APOSTOLAKIS: But the first document must have a glossary. It must identify a concept

and commonalities.

MS. LOIS: What we envision for the first document is to be a very broad journal type of description of here is the database, the structure of the database. So then in order to perform -- I mean, if you think -- you may think in a PRA space, you can think that you come in and you create a model of your design and the equipment, and then the data is the additional thing that comes. Now, what do I need to do my quantification of failure modes?

DR. APOSTOLAKIS: But if you are to describe the driving inferences and you're going to say ATHEANA says context is important, now if you go to CREAM, they mean the same thing, but they call it common inference factors, whatever.

So you are doing the second sub-bullet, aren't you? Identifying commonalities, and you're developing a glossary.

MS. LOIS: Document one is not going to talk of any HRA methods. Document one is going to talk as to if we sit back and look at the accidents and the important events, what have we seen, and therefore --

DR. APOSTOLAKIS: So it's not going to address the different models?

MS. LOIS: No.

DR. APOSTOLAKIS: I thought we were.

MS. LOIS: No, no, no. Document three --

DR. APOSTOLAKIS: Didn't we say that somebody is going to review the models?

DR. SHACK: That's document three.

MS. LOIS: Document three we're going to come in now and say given that this is how HRA should be done, if you look at ATHEANA and THERP and ASEP and HCR, what is the capability of the method to meet --

DR. APOSTOLAKIS: And document three is based on this, on this work?

MS. LOIS: A lot of that could be used. This is a database.

DR. APOSTOLAKIS: Should be used, not could be used.

MR. CUNNINGHAM: Will be.

MS. LOIS: Will be used.

MR. CUNNINGHAM: Will be used.

DR. APOSTOLAKIS: So document three will come out after this is done?

MS. LOIS: It's -- it can be. It can be because we haven't started doing document three yet.

DR. SHACK: I mean, there may be some overlap, George, but certainly to put information in a database, you have to do this first so that you know where to bin the data.

MS. LOIS: Yeah, yeah.

DR. APOSTOLAKIS: In which document you will review critically the existing models and identify the commonalities and differences? Where is that going?

MS. LOIS: Document three.

DR. APOSTOLAKIS: Document three, and that, and that would be based on INFORM?

MS. LOIS: It will use INFORM information.

DR. APOSTOLAKIS: And what other information?

Who's developing three? Idaho?

MS. LOIS: No, Sandia.

DR. APOSTOLAKIS: Oh, so Idaho developed this and Sandia will do document three. All right.

And which document was ready last August? Document two was ready last August.

MS. LOIS: Yes. We have a good draft and --

DR. APOSTOLAKIS: Okay. So document

three is next year. Okay.

MS. LOIS: Document three should, once we have decided what a good HRA is, then we come in and we critique the methods.

DR. APOSTOLAKIS: Well, the reason I'm asking all of these questions is because I look at this and I get scared. Are we starting ATHEANA all over? Characterize information, identify sources, you know, decide what HRA is. Geez, in the year of our Lord 2004?

MR. CUNNINGHAM: No, sir. We're not doing that.

MS. LOIS: I think it's -- I think probably it's misrepresented. We're using what we have found through ATHEANA, the database, et cetera, and we came together. We developed a or, you know, decided this is a good database structure. That's all we did.

DR. APOSTOLAKIS: So when will be the first time we see this?

MS. LOIS: Any time you want I can schedule it.

DR. APOSTOLAKIS: I'd like to see it before June of '04.

MS. LOIS: Okay.

DR. APOSTOLAKIS: Because this is really an important document.

MR. CUNNINGHAM: I was going to come back to this later, but we'd be interested in getting a sense of what the next step would be. Do you want a subcommittee just on going into the next level of detail?

DR. APOSTOLAKIS: I don't know. We probably do, right?

CHAIRMAN ROSEN: I'm still struggling trying to understand where this fits in the whole process.

MS. LOIS: We have David. David, do you want to help out here?

MR. GERTMAN: Dave Gertman from --

DR. APOSTOLAKIS: No, not from where you are.

MR. GERTMAN: I'll stand under the TV here and hope it doesn't fall on me.

DR. APOSTOLAKIS: Who are you?

MR. GERTMAN: Dave Gertman from the Idaho National Engineering Laboratory.

What we have here is not beginning to recreate HRA all over again. In deriving a structure for the informed database, we went ahead

and said what we want to do is give the analyst flexibility. Therefore we'll look at the input requirements for different HRA methods including ATHEANA and see what sort of information an analyst would need to perform an HRA, and through our characterization of information and event, we would build a repository that could support different methods, the other document being derived -- one of the first ones said there are situations where you'd prefer to use ASEP, other ones in which you'd need to know a lot about errors of commission perhaps and you would use ATHEANA.

The idea is that if we do it properly, we create an information base that for those situations where you would use one technique, you could go to that database, and in another situation where you would use another method, such as ATHEANA, you could also come in and go to that same repository.

It wasn't to redefine what was needed or critical to HRA. In going through the second sub-bullet there about how do you build a structure, this concept and commonalities, we grappled with the same issue you brought up, which is in one method you look at these things that are influences on

human behavior and they are called PSFs. You go to something like CREAM, and they're called common performance conditions. You go to something like HEART, and they're called error producing conditions.

And what we try to do is say, "Well, what are those things?" and just take one label and see if we can envelope all of those things, make sure the database can house those different influences. That's all I believe that first bullet tries to say.

DR. APOSTOLAKIS: This is extremely important work, and I think this subcommittee and the full committee should be informed as you progress and maybe get our perspective so that we all agree that next summer we have a good piece of work.

MR. CUNNINGHAM: Okay.

DR. APOSTOLAKIS: I would hate to disagree with you guys at the end.

MR. CUNNINGHAM: As would we.

DR. APOSTOLAKIS: I'm telling you that guy has been there many times.

No, this is really great. I hear the promises. It sounds great. The fact that I'm going

to see a report, say, from -- the first thing I'm going to do is I'm going to look at the list of references. Okay, David?

CHAIRMAN ROSEN: And this is going to --

DR. APOSTOLAKIS: And if I see again all Sandia, Sandia, or INEEL, INEEL, INEEL, I will know how good the work is.

CHAIRMAN ROSEN: This will produce a number or given human action in a PRA and an error bound on that number in terms of its likelihood.

DR. APOSTOLAKIS: Well, actually it will produce a method for getting that stuff, right? Not the number itself.

CHAIRMAN ROSEN: Oh, I know, but the method that would allow me to produce this one.

DR. APOSTOLAKIS: And understand the context and understand what kind of errors can occur, right? All that stuff.

MS. LOIS: yes.

CHAIRMAN ROSEN: So I end up with a number and a range around the number.

MS. LOIS: If you're going to, yes. You will have the data to create a number.

CHAIRMAN ROSEN: And I say, "George, it's either the minus 1.1 E to the minus three, plus

or minus a factor of two" -- times two on the high side and times one on the low side, times 1.5 on the low side.

DR. APOSTOLAKIS: I guess you would be able to say that.

MS. LOIS: I guess it would give you the capability if somebody comes in and says ten to the minus three, for example, or ten to the minus five. Then you can look at this for a specific type of human error. You can look at that database and see how many events have happened, what will the circumstances be, is this number reasonable.

So use it more for a Bayesian type of analysis as opposed to I don't know if you could --

CHAIRMAN ROSEN: Well, somebody is arguing here that their PRA says that this event is one E to the minus seven and, therefore, not important. And I say, "Well, what are the elements of that?"

And then I look at his analysis and I see it is largely driven by human area or human recovery actions, and how I can get into using this, but the ranges on this are on the number, and the pieces. What were the error context, the context, and was the heat considered, the analyst considered?

And what would I consider?

And I can look at the factors and decide whether I believe them or not and then come out with my own analysis using my own factors and say, well, it turns out that I have different numbers, but I come up with roughly the same answer because I credit other things, and so and so, or I can say the number is completely hosed up and I don't agree.

DR. APOSTOLAKIS: And it would help you do it.

MS. LOIS: Many of these types of applications --

CHAIRMAN ROSEN: And this is something I will be able to do within form and

DR. APOSTOLAKIS: Right. Well, we'll put the issue of the ISPRE benchmark exercise to rest. All right? We will do that.

Second is a regulatory decision that has triggered a lot of reaction, is the power up rates where the staff did a very good job identifying the various human actions that are affected by the power up rate, an excellent event, and the licensee, both. You know, the licensee and the staff, you know, they looked very carefully. They did that.

And then they said, you know, based on

thermal hydraulic calculations and so on, the time available before they operate was 42 minutes. Now it comes down to 39 minutes.

Now you guys come in. What happens now with the human error? Okay? The guys used one method because he was --

CHAIRMAN ROSEN: Well, let me answer the question. I think one answer is that time is not the only variable.

DR. APOSTOLAKIS: Well, let them decide that, but all I'm saying is that's what they came up with, and then they applied one method and they got, of course, a different and so that's very small, and you know, I disagree with that.

But these are the kinds of things, and then you have to help the regulatory staff say, well, time may be the driver, but there may be other elements of the context that are important, too, and we look at those, and we concluded that they are not affected significantly or they are affected, and so on.

But then what do you do with the numbers? My argument was that I don't even have to go to the numbers. I can argue based on judgment that from 42 to 39 minutes the numbers are not

affected that much, but what do you do if it goes from six to four minutes? Can you really say that again?

I don't know, and that's where the regulatory staffing needs help. It's not just doing a PRA, but this is a real regulatory decision.

CHAIRMAN ROSEN: But what if I say it's for six to four minutes or 39 to 42 minutes in one case and in the other case it's 42 to 39 minutes, but in one case it's completely black and very smokey and in the other case it's not?

DR. APOSTOLAKIS: Ah, well, then that's the context, yes, absolutely, absolutely, but it's not so black and white.

CHAIRMAN ROSEN: Basically the argument there was nothing else changes.

DR. APOSTOLAKIS: Nothing else changes, right.

CHAIRMAN ROSEN: The only thing that changes is the time. If they say that, then you get to examine that.

DR. APOSTOLAKIS: I don't even need to model it.

MR. CUNNINGHAM: So this is the type of discussion that would end up in the SRP that we're

helping right.

DR. APOSTOLAKIS: And these are the kinds of issues that it would be nice to have you guys settle. This is what you're doing in that situation.

MR. CUNNINGHAM: And that's what our colleagues in Aurora are basically saying, too.

DR. APOSTOLAKIS: Gee, I wonder why.

MR. CUNNINGHAM: At least one.

DR. APOSTOLAKIS: After two letters to this committee.

MR. CUNNINGHAM: We need to settle some of these things.

DR. APOSTOLAKIS: Yes.

MS. LOIS: And I should mention that INEEL and Sandia are working closely, and the two activities are really fielding each other. It's not like there are two parallel activities.

DR. APOSTOLAKIS: Is that an achievement by itself?

MR. CUNNINGHAM: Somewhat.

CHAIRMAN ROSEN: Erasmia, if I don't do something about you getting done, Mike is going to hit me with a hammer.

DR. APOSTOLAKIS: You put Erasmia up

there and you'll never finish. She's still on Slide 11.

MR. CUNNINGHAM: How much time do we have?

CHAIRMAN ROSEN: You're out.

MR. CUNNINGHAM: We're out?

CHAIRMAN ROSEN: But go ahead for another minute or two.

DR. APOSTOLAKIS: Oh, we have a SPAR on this.

MR. CUNNINGHAM: Okay.

MS. LOIS: I guess status, we have a prototype ready. We can come and brief you as soon as --

DR. APOSTOLAKIS: I think we should discuss schedule at the end perhaps and have some idea when.

MS. LOIS: I just want to make you aware that CSNI has an activity for sharing data, both simulator type and operating experience. It's very important. People feel that we should do it, and we are going to have a report by September that will preach. It will be kind of --

DR. APOSTOLAKIS: Are you guys ever learning anything from these activities, CSNI and

all of that?

PARTICIPANTS: Yes.

CHAIRMAN ROSEN: That's the right answer.

MR. SIEBER: There you go. Moving on.

DR. APOSTOLAKIS: I've seen some of the products from these organizations. I'm not sure it's worth it.

MS. LOIS: Halden, Jay talked about it. It's exciting what's happening. I guess I would strongly recommend if I can that ACRS members go to Halden. It will --

DR. APOSTOLAKIS: In January.

MS. LOIS: I think it will be important from the perspective to both understand their capabilities and also --

DR. APOSTOLAKIS: I understand there is this big meeting in May.

MS. LOIS: But that big meeting is really very, very broad brush of everything they do. We went as a team to Halden in June and we sat down and they walked us through, and we understood the technology they are using, how they do data analysis, how they design experiments and these are very important aspects for designing human

reliability.

And they are willing to learn and develop expertise in HRA. Curtis is there doing the tech. transfer kind of activity. They are coming here. So --

DR. APOSTOLAKIS: They are coming here?

MS. LOIS: They will come here. As a matter of fact, they would be happy to come and brief the ACRS on their activities.

CHAIRMAN ROSEN: We'll keep it in mind.

MS. LOIS: They put it in their minutes that they would like to do that.

Susan.

MS. COOPER: Just a few minutes.

CHAIRMAN ROSEN: Better than going to Prime Time in January.

MS. COOPER: I'll just touch on this and then you can ask questions, I guess, in the time that might be remaining.

I just wanted to mention to you that we have a new area that's opening for us. NMSS has asked Research to help them develop an HRA capability. In this sense HRA is defined quite broadly. It's not to be interpreted as an HRA quantification tool to support PRA. They have a

quite broad set of activities and different types of needs than we do.

At present we are working on Phase 1 of this project, a feasibility study where we are trying to identify important actions and user needs for NMSS staff. That includes medical applications, industrial applications, also everything on the waste side.

And so we're in the midst of doing that work right now. When it gets to Phase 2, we are going to get into a development phase of developing some products for them and probably an HRA method will not be the first thing that we develop. There will be some different kinds of things that they will need.

So fine.

CHAIRMAN ROSEN: This is interesting, but they have shied away from using PRA for so long now. I'm puzzled to see why they'd want to do HRA, an element of PRA.

MS. COOPER: Well, as I said, HRA here is to be interpreted broadly. Well, there are two different motivations. One, they have an interest in, I guess, a requirement to risk inform themselves.

The other thing is that they do have problems. They have high error rates if you will in a number of their activities, medical and misadministrations and so on, and they have an interest in trying to better understand human performance and human reliability is one way of going at that and helping them in that way.

So that's where they're looking to us. Now, they do have some interest in PRA. I mean there are safety studies for Yucca Mountain. There are things related to spent fuel storage where HRA as a support to PRA is a useful tool, and they do have some interest in that area as well.

CHAIRMAN ROSEN: You'll no doubt tell them that organizational reliability is important to HRA.

MS. COOPER: I'm sorry?

CHAIRMAN ROSEN: You'll no doubt tell them that organizational reliability is important to human reliability.

MS. COOPER: yes, I think they know that, and we recognize that as well.

MR. SIEBER: -- on the wrong mountain.

CHAIRMAN ROSEN: Yeah, you wouldn't want to dig a hole in the wrong mountain.

(Laughter.)

MR. CUNNINGHAM: With that I think we'll just stop the presentation.

CHAIRMAN ROSEN: Fine.

DR. APOSTOLAKIS: You're skipping the last slide?

MR. CUNNINGHAM: Yes, we'll just skip that.

CHAIRMAN ROSEN: Now, when I come back, we're going to go down and talk about SPAR-H here for a minute, but one of the things I want to come back to is with Jack and Jay. Did they take off?

MR. CUNNINGHAM: Yes. They had a commitment downtown this afternoon.

CHAIRMAN ROSEN: They got away without me asking them where's all of the research. I haven't seen the research on what they talked about, the Halden reactor, standard review plan and all of that, risk communications.

All right. We'll come back to that. Now we'll go on and turn the floor over to Mr. O'Reilly who's going to talk about, with Hussein -- no, Hussein is not going to be here. However, I thought you'd have the SPAR-H.

PARTICIPANT: We're not going to break?

DR. APOSTOLAKIS: Yeah, we can take five minutes.

MR. SIEBER: Five minutes, yeah, ten minutes.

CHAIRMAN ROSEN: Well, if you need a break, you can have a break. It's 3:33. Let's come back at 3:43, 3:45.

(Whereupon, the foregoing matter went off the record at 4:32 p.m. and went back on the record at 4:46 p.m.)

CHAIRMAN ROSEN: I guess I'll turn this over to Pat.

MR. O'REILLY: Thank you.

I'm Pat O'Reilly. I'm with the Operating Experience Risk Analysis Branch in the Office of Research. I'm the project manager for the SPAR model development program, and we have a two-part presentation here.

First of all, I will give you a brief history, and it will be very brief, of the SPAR HRA methodology -- we call it the SPAR-H method -- as you had requested, and then --

CHAIRMAN ROSEN: We requested that it be called SPAR-H?

DR. APOSTOLAKIS: We requested it?

MR. O'REILLY: No. You requested a presentation on the SPAR-H method.

CHAIRMAN ROSEN: Okay.

DR. APOSTOLAKIS: Okay.

CHAIRMAN ROSEN: You need to be very careful. We're still listening even at this late hour.

MR. O'REILLY: Yes, and then I'll turn the rest of the presentation over to David Gertman from INEEL, who will go into the technical details of the methodology.

Okay. To start with, in 1994 the development of the SPAR HRA methodology began. Its purpose in the beginning was to improve HRA practices for use in the accident sequence precursor program.

What we were looking for is a general, easy to use method which could handle actuation, recovery, and dependency by using a consistent model of human behavior, and in the development of the methodology we developed some worksheets which simplified the application on the part of the analyst.

In 1999, some modifications were made to the initial method that were based on the results of

a benchmarking process where we benchmarked the SPAR HRA method results against results from other recognized HRA methods. And then this resulted in some changes in performance shaping factors, the treatment of dependency, and the human error probability calculations.

And finally, in 2002, we funded some additional modifications which were based -- and Dave will go into this in more detail -- we refined the definition of the performance shaping factors. We provided a better uncertainty analysis capability, and we evaluated the performance shaping factors and extended them to low power shutdown conditions.

We also increased the detail in the assignment of dependencies and we documented it in a draft NUREG.

CHAIRMAN ROSEN: And that is this one?

MR. O'REILLY: That is correct. That's the draft NUREG, which is down for review.

Some specific applications of the SPAR HRA methodology, they've been incorporated. We've incorporated the method into the Level 1, Revision 3 SPAR models and also into the Level 1 low power shutdown SPAR models. The worksheets that are in

the method that Dave will describe to you are also used in some instances in the regional offices by the senior reactor analysts, the SRAs, when they perform Phase 3 analyses in the significance determination process.

And one other example where we use the method. It's being used in the ASP program now to do uncertainty analysis of events which involve issues surrounding operator performance. Two such examples of that are the recent analysis of the August 1999 loss of safety bus 6A at Indian Point II and the February 2000 steam generator 2 rupture again at Indian Point II. Both of those involve some operator performance issues.

Recent accomplishments. The last several months we have, number one, we conducted a one day public workshop in conjunction with the PRA Branch and Research on the SPAR-H method. This was held in June of this year, and the reason for the workshop was to explain the basis for the methodology so that the reviewers could perform a peer review of the report that Mr. Rosen just identified and focus their attention on the report and wouldn't have as many questions about the origin of the methodology and that sort of thing.

Also, we put the draft report out for peer review by both our internal and our external stakeholders. Internal stakeholers, NRR research, regional offices, and by omission, the ACRS is supposed to be on there, and external stakeholders include NEI, EPRI, INPO, the various NSSS owners groups, and the Union of Concerned Scientists.

And in parting, I would like to point out that that peer review process is part of a two step program by which we do our model development. The first consists of developing a methodology that will provide a sound technical basis over the area of applicability that we're trying to analyze.

And second, we have a peer review process which will guarantee, we believe, that the particular model methodology that we had developed is sufficient for the job at hand, given the scope of applicability.

I will now turn the presentation over to Dave.

CHAIRMAN ROSEN: Not so fast. Just let me ask you about --

MR. O'REILLY: Sure.

CHAIRMAN ROSEN: This peer review that's going on, is that done or when is it?

MR. O'REILLY: We have the comments. Several of the organizations asked for a little bit of extension on their comments, and so we have all of the comments now, I believe, and we're in the process of analyzing and evaluating the comments. So --

CHAIRMAN ROSEN: Get any show stoppers or anything that we should know about at this time?

MR. O'REILLY: There really wasn't much in the way of --

MR. GERTMAN: Actually at the very end of the second presentation that I have, talk about the status and we have categories for the kinds of comments that we received, and we can go through those.

MR. O'REILLY: To give you a flavor for what we've received, and if you have any comments, they're more than welcome.

DR. APOSTOLAKIS: So are we going to review this ever?

MR. O'REILLY: SPAR-H?

CHAIRMAN ROSEN: Yeah, we've got it.

MR. SIEBER: We've got it.

DR. APOSTOLAKIS: And if I read it at home, what happens?

CHAIRMAN ROSEN: Well, if you read it at home, you fall asleep. I don't know. You get mad. You write comments. What?

DR. APOSTOLAKIS: Are we reviewing this?

CHAIRMAN ROSEN: It's in the package.

DR. APOSTOLAKIS: But today's meeting?

MR. SNODDERLY: Of course, you can write a letter or something.

DR. APOSTOLAKIS: Yeah. It's not intended to review the thing. Today's meeting is, you know, what are --

CHAIRMAN ROSEN: No, no, no. We didn't intend to write a letter on it.

DR. APOSTOLAKIS: That's what I'm saying. So we are not reviewing it.

MR. SNODDERLY: Unless you report as needed. In other words, if you hear something that you'd like to comment on; otherwise, no. Pat is not looking for a letter here.

MR. O'REILLY: No, I don't believe we've asked you for a letter, George.

DR. APOSTOLAKIS: I know you haven't.

MR. O'REILLY: If you have any comments that would be useful in making it a better method or a better document, then we're more than happy to

consider them.

DR. APOSTOLAKIS: Well, I mean, the basic question is why this SPAR-H when we have all of this effort in HRA.

MR. O'REILLY: We're getting to that.

DR. APOSTOLAKIS: Okay.

MR. GERTMAN: These are some questions that we had, and the first one very --

CHAIRMAN ROSEN: These are Dana's questions?

MR. GERTMAN: Yes.

MR. O'REILLY: Yes.

MR. GERTMAN: And what we thought we'd do, they broke into four questions, and then we add another two areas. One was 2003 accomplishments, what we have done over the past year, and for the question that George just raised, which was the nature of comments to date on the draft NUREG, you know, where it's going, where it's heading, your question also, whether or not there are certain show stoppers, and we'll cover that.

I don't believe we have show stoppers, but I'm happy to discuss the nature of the comments we received, and where we are in the process of addressing them. A lot of them I look at as some

good suggestions to make it a better document. So we're happy to incorporate it.

So the four areas are why SPAR-H; justification for the various PSFs that we use in the method; a comparison with other methods including the quantification approach that we decided to employ, and the comparisons that we've made with either experimentally based or experiential type data.

So the first question: why SPAR-H? SPAR started, the program, back in 1994. It was a relatively low level of effort, about two staff months' worth, and back in 1984 the NRC for the accident sequence precursor program, for the HRA portion of that, was using just formal rules and one heuristic for HRA, and I think that work, that formulation might have been some of the work of Bill Vesely back then.

But in any case, NRC came back to Idaho and said, "We think we believe to have a more realistic representation of human performance in NRA. Can you go ahead and either go out and look at methods for us and bring one back that you believe we should use or develop whatever is necessary to get us there? But it should be simple and easy to

use." And that was the driver at the time.

So we looked at HRA methods. For example, some of those such as THERP were just too detailed and too resource intensive to apply easily, and we had the problem with some of the findings in the ISPRE benchmark that George had raised in the session before, that is, people went off with different methods and people that were expert in their own method were able to use it, and once they handed it to other people, the results were fairly dismal. There wasn't much divergence or concurrence among the analysts.

So we also at that point in time in the mid-'90s were informed by second generation methods that were evolving, and we mentioned ATHEANA and CREAM and MERMOS and others and the importance of context, and also international activities through the NRC.

INEEL was directly involved in some of the work that was going on through the OECD, CSNI, NEA work on the human reliability analysis task force, and we were involved in a review of that for HRA methods, was one task. Actually a report was out in '98, and at that point in time Ann Ramey-Smith from Research was one of the active

participants in that work.

So we had the knowledge of these things, and we had also gotten involved a bit in organizational management factors research, until that program was stopped because it was misconstrued to be assessing leadership style utilities, and that work came to an abrupt halt, but we also were informed a little bit about that, and work we had done through University Research Consortium on work practices through MIT, with work process analysis, analysis method, and we had for some time an exchange with some students who were doing work there, working out at the lab. Tica Valdez and Karen Marcinkowski and Rick Weil participated in looking at work process analysis.

So we had these things going on concurrent with the request to go ahead and improve the approach to SPAR.

So in order to meet the ASP, the programmatic requirements, what we did is we were asked not to go out and do as much research as to come back with an amalgam of existing methods, take the best that was out there, make it simple and easy to use, come back with a simplified approach that would diminish inter-analyst variability. Make it

so that somebody that didn't have a lot of training with the method would be able to apply the HRA technique.

So that was sort of one of our objectives, and the analysis should be able to be compiled in a brief period of time was also very important because the SPAR HRA and SPAR event analysis, an analyst may only have two or three days to go ahead and make an assessment using the SPAR models either at the region or back at headquarters. So you couldn't have an HRA method that did some of the --

DR. APOSTOLAKIS: Okay. So I appreciate those needs. So what you're developing here then can be viewed as a conservative, simplified version of the more refined methods that you are developing under INFORM. True?

MR. GERTMAN: Yes, I would agree with that.

DR. APOSTOLAKIS: In other words, it should be consistent with INFORM.

MR. GERTMAN: Yes.

DR. APOSTOLAKIS: Should it not?

MR. GERTMAN: Yes, consistent with INFORM.

DR. APOSTOLAKIS: Because here you're using, for example, terminology of PSFs, right, performance shaping factors, and some of the other models don't use that. They use something. They use context. They use common performance conditions, but essentially it's the same thing.

MR. GERTMAN: That's true, yes.

DR. APOSTOLAKIS: I think that's how it should be viewed, that it is a simplified version of this more refined model, because the last thing we want is to have something that is based on different assumptions than the refined one.

MR. GERTMAN: Yeah, I --

DR. APOSTOLAKIS: So make sure that that happens. Make sure you work with a guy at Idaho who develops INFORM.

MR. GERTMAN: Okay. I had a meeting with him on the airplane out.

DR. APOSTOLAKIS: Okay. Good. Next to each other, right?

MR. GERTMAN: Yes.

MR. SIEBER: One in the front, one in the back.

MR. GERTMAN: Also, we tried to come up with a method that would be appropriate for most

human behavior as you would model it, characterize it, quantify it in PRA.

I would say one of the aspects of it also about why SPAR and how it is different, SPAR does not have an exhaustive search for errors of commission as ATHEANA does. Being a simplified approach, again, with a short time period, maybe it's an 80 percent solution, which is good enough in most cases.

If I had a huge issue and I had months to go ahead and evaluate it, I would use a more detailed approach, but for most applications, particularly in development application of these models, the goal was to get something that was good enough for most situations.

Okay. So, again, part of this belief is that we believe a simple model of human behavior is adequate for HRA. There's an awful lot of research in behavioral sciences down to the levels what's the neural activity underlying certain types of decision making. Again, that drill-down is way too deep for what we need for most applications.

And we have a more rolled up method where we believe we can incorporate the import aspects of performance into the HRA.

We based it on human performance and cognition, now on a plant condition. We don't have a different model of the human for low power and shutdown or if we were to do severe events versus normal operations versus emergency conditions. The idea is a simple representation of human cognition and performance is adequate to cover the situations, and what varies is the context, the plan conditions, and the shaping factors.

And what you do when you describe these different situations, you talk about changes in the performance shaping factors that can be used to multiply against a nominal failure rate.

Okay, and so the PSFs can be identified, and we identified them -- here's the next slide -- through a couple of different sources. One is if I switch the words a little bit in this slide, we have a model that's theory based, based on rational decision maker and information processing and behavioral sciences, and from that theory, upon which there's a lot of experimentation on things that influence performance, whether it's the effect of noise on performance or the effect of work load, which can be having to do tasks more quickly or having to do a lot of tasks concurrently, that sort

of thing.

There are different types of performance curves. There's failure analysis and success performance data that have been out there, that have been collected for 30 or 40 years. What we try to do is use that information to help us select PSFs and help define the range of influence for the shaping factors.

We also went out and what we call is not really in a true sense of the word a validation and verification. I'd say what we did -- again, this is a much lower scope of course -- is we went out and we calibrated against other methods and against the information from the literature.

So when we went out and we looked at training, for example, we went out and we said, "Well, we look at these different HRA methods. We look at ATHEANA and we look at THERP and we look at ASEP and we look at CREAM and we look at HEART and say this training exists as a shaping factor."

And the answer is yes, and so we did it that way. We also went across the methods for two other reasons. We went ahead and looked at the range of influence afforded for these shaping factors and made sure that the range that we had

selected was someplace within that distribution, and we did the same when we went ahead to determine nominal failure rates.

The existing literature that supports, you know, the SPAR-H right now are in part of the document, part of the document that you have. We talk about the existence of different types of performance distributions. We'll talk a little bit about that later, but the point was often in HRA we talk about there's not enough data or there aren't any data.

Well, it depends. If you're talking about crew performance at a power plant that is with great denominators, it is not just simulator based. A lot of that work has not yet been done.

If you're talking about variables one at a time, what happens in low lighting, what happens with the poor interface, there are good data out there. So we tried to avail ourselves of what we could find, what was out in the literature.

Okay, and part of our model for response is in information processing space what we have is we have people -- there's an inflow of information for modalities and perception. There's working memory or short-term store, and there's processing

or long-term memory, and then you have response.

In this block traveling inside for information and perception, you have visual, auditory, and kinesthetic. You receive auditory alarms. You can see changes in displays. You can get kinesthetic information, a rumbling of the plant. You could put your hand alongside of a piece of equipment and, you know, tell the bearings going out aside from just the sound of it.

In short-term memory or store and working memory, we have things such as attention, a situation awareness, and information processing capacity.

In long-term memory is where people have strategies and you have an influence of training. People have heuristics that they bring to bear on issues, and then finally we have action and a response which the end state can either be -- for us it's just two states: either diagnosis or action.

In diagnosis, we also include planning activity. The reason for this, again, is it's a simplified HRA and most actions that you need to model in PRA and HRA can be broken down into either diagnosis or action.

Here are the summary level influencing

factors, as Harold Blackman called them in the 1999 version of this report. They are in the report now as performance shaping factors.

CHAIRMAN ROSEN: Why isn't time there?

MR. GERTMAN: Time available certainly should be there. So which one is -- it's not there.

MR. SIEBER: It's not there, but it's in the chart in your book.

MR. GERTMAN: It's in the chart before, isn't it? I apologize for that because the time available is the first one on our worksheets. That is an error of omission.

CHAIRMAN ROSEN: And its probability in the context?

MR. GERTMAN: One over 16 slides. If that's the only one we find, I guess we can either --

CHAIRMAN ROSEN: The context is the ACRS subcommittee.

MR. GERTMAN: Right.

CHAIRMAN ROSEN: It doesn't matter. No impact, no consequence, low stress.

DR. APOSTOLAKIS: Which page?

MR. SIEBER: Figure 2.1 on --

CHAIRMAN ROSEN: Yeah, Appendix A. So I

could put a bullet on that slide "time available." That's what you're saying.

MR. GERTMAN: Yes. If this was a grease pencil, I would do it. It starts with time available. That's the first one on all the worksheets.

DR. APOSTOLAKIS: Complexity and stress, work load, all of these things because you do depend on time.

CHAIRMAN ROSEN: You can get an infinitely impossible task, right?

MR. GERTMAN: No, the point is --

CHAIRMAN ROSEN: A zero likelihood that it will be successful.

DR. APOSTOLAKIS: Are these influencing factors presumed to be independent?

MR. GERTMAN: No, they are not.

DR. APOSTOLAKIS: And are we double counting there somewhere? Has this issue been addressed? Because the stress on the operators clearly depends on the time available.

MR. SIEBER: That's one factor.

DR. APOSTOLAKIS: Because you know, you have now eight level influencing factors. If we start talking about it, I'm sure we can increase the

list.

The only thing that would limit the size of the list is the requirement of reasonable independence. So is that taken into account somewhere?

MR. GERTMAN: As in with a lot of HR -- I'll just address this straight on. The approach that we have doesn't deal directly with the fact that these factors, these influencing factors are not orthogonal. Okay? They are not truly independent of one another. In fact, there's a certain amount of overlap between them.

This is a problem for the field. When we go to Swain's work, when we go to anybody's work, including work that uses expert judgment methods, the degree of overlap between these is not very well known, whether it's 20 percent or 30 percent.

I believe there's a technical approach to solving this issue that could be done in less than a year that would give us a much better technical basis for this.

So right now it's treated as if it were independent. You take a nominal failure rate and it's multiplied by these shaping factors, and there is some degree of overlap. The best that you can do

as an analyst is try to be consistent, is try not to double count things as best you can.

Again, it's a simplified method. So it's not going to solve something that has been an issue for the last 15 years without the research behind it.

That being said --

DR. APOSTOLAKIS: But INFORM will do that.

MR. GERTMAN: Well, INFORM could do that when the database is large enough, and I'll tell you how. INFORM is not meant to solve this issue, but the way that you could do it is that if I could take 10,000 LERs and take a subset of the 20 or 30,000 that are out there now, what I would do is I would use the equivalent of a Web crawler, and I would run on a high speed computer, which could be done at the lab. I would look for the coincidence of pairs of shaping factors over this huge database of information, and I would get the relative frequency with when complexity shows up with work practice problems or fitness for duties implicated along with poor ergonomics.

And from that I could infer the degree of overlap, and if I could do that, I could come up

with the equation that would take care of the double counting problem.

Then I would go ahead and after I did that, I determined those relationships by looking at them two and three at a time, and I think it could be just done in months. Then I would look to see the nature of the relationship, whether it was a covariate in a positive or a negative fashion.

With that you could create the calculation. That work has just never been done, by the way.

DR. APOSTOLAKIS: Yeah, but you're describing the Cadillac approach, and what I'm saying is that before we go there maybe we can look at the Saturn or maybe what's next? I don't know. The Honda.

MR. GERTMAN: The Yugo.

DR. APOSTOLAKIS: No, I don't want the Yugo.

MR. GERTMAN: Okay.

DR. APOSTOLAKIS: The Yugo is what we do now.

PARTICIPANT: He wants a Honda Accord.

DR. APOSTOLAKIS: So, in fact, I would endorse undertaking such an investigation, but even

before then you can give some guidance because that's the only thing that limits the list. So at least in INFORM you may want to say, "Well, look. I mean, okay, we don't know to what extent time affects stress, affects complexity, you know, but we know it's an influence."

MR. GERTMAN: Yes.

DR. APOSTOLAKIS: So we have to make a decision now. You know, do we add time to this or by having complexity or stress already, we have taken care of it. So I don't have to put it in there, you know, that kind of thing, and then maybe try to justify it and eventually I'm sure you will be allowed to do what you just described, which will be a more detailed investigation.

But that was the problem with SLIM as well, as you know.

MR. GERTMAN: Yeah.

DR. APOSTOLAKIS: They had the summation there of various factors, and they said, "My God, I can sit down and use you sit down. You have your own; I have my own. We put them together, and then Bill give us his own. We put it together, too, and there is no end."

And then all of a sudden SLIM jumps from

500 to 800 to 3,000. So the only thing that -- and this is a fundamental thing. I mean, all of these methods are really based on some theory of decision analysis, and that's a fundamental requirement there, that your objectives have to be fundamental. They have to -- otherwise they aren't even there. You will just double count, triple count, put -- you know.

So it is really a fundamental issue here, and I appreciate that you cannot spend the time to really do a good job, but maybe there is some guidance you can give to these guys because it will never occur to them. The users, it will never occur to them that they're double counting. At least give them some warning and that maybe this factor depends too much on that factor.

I don't know by how much, but it does.

DR. SHACK: Well, isn't that taken sort of implicitly into account in the multipliers that you assign? You know, how did you come up with those?

MR. GERTMAN: Again, we looked at the multipliers. The levels came from the relative ranges afforded by other methods in our interpretation of the literature.

The idea of having a caveat in the document that doesn't exist currently that says if you already because of time available have increased the failure rate or increased the failure likelihood for that human error probability, then you probably don't need to go ahead and add a multiplier for stress as well.

That kind of guidance isn't in there. It could be thought about. What you have to do is, I guess, do the expert meeting where you think about what the degree of overlap probably is, and maybe that's a stop in between.

CHAIRMAN ROSEN: If you told me to go over there and diffuse that nuclear weapon and the time available is, you know, infinite essentially, but you have to do it, I'd still be stressed out.

MR. GERTMAN: Well, yeah, and the way I would do it is I would start with your human error probability. I'd have to say is there some troubleshooting. If you don't have a procedure and you don't have the training, I really don't care about the time available unless some other people can come in to help you.

CHAIRMAN ROSEN: My point is only on stresses. Just because you have a long time doesn't

mean it's not stressed.

DR. APOSTOLAKIS: No.

CHAIRMAN ROSEN: Just because you have a short time doesn't mean it's high stress.

MR. GERTMAN: Okay.

MR. SIEBER: Well, it's treat individually.

CHAIRMAN ROSEN: I mean, it's dependent on the past.

MR. GERTMAN: Right.

DR. SHACK: Like you said, there's overlap.

DR. APOSTOLAKIS: I didn't say it was deterministic.

MR. GERTMAN: But that's true. There's not overlap in all cases, which goes to the context that you're talking about. You can say what do we use for nominal. We say with the multipliers. Nominal for the shaping factor means you accept the nominal failure rate overall for the action, let's say.

And what you'd say for time in that case is you'd say, well, time may not be an issue. Therefore, I wouldn't change my nominal failure rate, but when I go to stress, I'm going to come to

a high stress or threat stress.

So you would make your assignment on the basis of stress, but not necessarily time.

CHAIRMAN ROSEN: You've got to have some accompanying discussion.

MR. GERTMAN: Absolutely.

DR. APOSTOLAKIS: But, yeah, that's what I'm saying.

DR. SHACK: But that's not the way your worksheet works.

DR. APOSTOLAKIS: You need some guidance at the moment.

MR. GERTMAN: Well, the worksheet says is time a factor when you come down there, and if it's not a factor, then you assign an 01.

DR. SHACK: But, I mean, if I just go through here and I check each of these boxes and then I multiply, I mean, I get an answer.

MR. GERTMAN: Right, and what you would say is, again, you could go to the thing and you could say I have expanse of time. Therefore, I should decrease my nominal rate either depending on whether we're low power or full power, either by a factor of ten or a factor of 100, or in this situation what you would do instead of assigning

that, you would say if time is not a factor, which is the situation we have here, then the directions are to use one.

So I still would not have to multiply it by the value if I didn't think it influenced the failure rate itself.

DR. SHACK: Okay, but I mean, I assumed when you did this expansive time you had already made some judgment as to whether having all the time in the world really made a difference. I mean, otherwise you'd just set it at one.

MR. GERTMAN: Well, yeah, if the time does not make a difference, you would set it at one. If it does, yeah, then you would decrease it, and that was to take into account situations where in the control room you can call the tech. support center or bring in the licensing engineer or a second shift comes and people are available.

Again, for a simplified HRA approach, I think it probably envelopes a lot of the situations.

DR. APOSTOLAKIS: Are experience/training and procedures truly independent? At nuclear plants I don't think they are.

MR. GERTMAN: I would agree that there

is some overlap there.

DR. APOSTOLAKIS: There is a whole lot of overlap between those two. Forget about time. We overkill time.

MR. GERTMAN: But if you want to talk about what's the degree of overlap, it depends what scenario we conjure up.

DR. APOSTOLAKIS: Absolutely, but I think those two tend to overlap a lot because experience usually involves procedures.

MR. GERTMAN: You know, I wouldn't disagree in the laboratory. Of course, what you do is you get people with equivalent experience and training, like we can do in Idaho when we run through a lab, and then all we do is vary the procedures, and you can look at the influence with the other variables being held constant.

But there is an overlap there.

DR. APOSTOLAKIS: I'm not asking you to solve the problem now, but I do think that it would be wise of you when you respond to all of these comments to take this as a comment and do something about it.

I think you agree with the principle.

MR. GERTMAN: Yes.

DR. APOSTOLAKIS: Now, what we put there, I mean, I'll leave it up to you. Some sort of warning, I think, is needed because the user is not sophisticated enough to do that.

CHAIRMAN ROSEN: There's a Section 2.7.5 on this in SPAR-H, right? On the categorization and orthogonality of PSF?

MR. GERTMAN: Yes.

CHAIRMAN ROSEN: So there is a discussion in here.

MR. GERTMAN: And Appendix G actually gives a table where we sat down and tried to do a degree of influence mapping among the eight factors.

MR. SIEBER: In the definition --

CHAIRMAN ROSEN: Not silent, the method isn't silent.

MR. SIEBER: The definitions are in Table 2.2, which is page 10 and 11, which tells you what to put in the box.

MR. GERTMAN: Yes.

MR. SIEBER: It has got available time, stress, complexity, experience, training, procedures, ergonomics, fitness for duty, and work processes.

CHAIRMAN ROSEN: Well, you need to read

2.7.5, yeah.

MR. GERTMAN: Well, it does not say that if you've already talked about barely adequate time being available and you've raised the HEP, now stress is high. What proportion of the fact that stress is high is due to the time factor you've already accounted for?

We bring up the issue, but we don't solve it. One of the comments we had from it was either NRR or EPRI was you brought up the issue, but you didn't solve it. Maybe you just shouldn't even have it in the document as an issue then.

And I think that's probably not quite the right way to go.

DR. APOSTOLAKIS: Well, some guidance, I think.

MR. GERTMAN: But maybe --

DR. APOSTOLAKIS: At least sensitizing the user factor and let the user do it.

MR. SIEBER: I think it depends on the individual, too, because, you know, one of your categories is the time available equals the time required. Okay? And you have stress.

Now, if a person is confident and he thinks he knows what he's doing and he's confident

that he can do it, then he will be less stressful than somebody who said, "Boy, I'm afraid of this. I'm not sure I remember, and boy," you know.

DR. APOSTOLAKIS: But sometimes incompetent people are less stressful because they think they can do it.

MR. SIEBER: I have known some of those.

DR. APOSTOLAKIS: I appreciate the difficulty of the task.

CHAIRMAN ROSEN: This document would be much less useful if it did not have a discussion of the orthogonality. It's much more useful as is. We will think about how it will be used. People will argue about these answers, one side or the other, and at least if the argument focuses at some point on the independence of these parameters, it will be useful to have that discussion.

MR. GERTMAN: I think that's a good comment, and --

DR. APOSTOLAKIS: I don't understand. What did you just recommend?

CHAIRMAN ROSEN: I said have it in here.

DR. APOSTOLAKIS: Oh, okay.

CHAIRMAN ROSEN: So that we can --

DR. APOSTOLAKIS: You put in three

negatives there.

CHAIRMAN ROSEN: And a method to try to adjust, and then let people work the analysts on both sides if there are more than one viewpoint on the answer, to argue their case as cogently as they can.

DR. APOSTOLAKIS: I think Jack and David already mentioned some solution. Sensitize the user to the fact that --

MR. GERTMAN: Sensitize the user, and then the other thing is --

DR. APOSTOLAKIS: There's no unique answer, but don't overdo it. You said that. If you feel that you have already put in the stress because of time, and so you know.

CHAIRMAN ROSEN: Let's go on. We're in violent agreement.

MR. GERTMAN: Okay, and this is what we've said about we had a basis for --

DR. APOSTOLAKIS: There is such a thing as Fitt's law?

MR. GERTMAN: Fitt's law.

DR. APOSTOLAKIS: How about Fick's law. Fick's law is what we all know. Fitt law?

MR. GERTMAN: Fick's? I don't know

Fick's,

DR. APOSTOLAKIS: You don't know Fick's.

MR. GERTMAN: Unless it's a cousin go Fitt's.

DR. APOSTOLAKIS: Reactor theory.

MR. GERTMAN: Ah. Well, Fitt's was a --

DR. APOSTOLAKIS: Fitt's was a cousin of Hick.

MR. GERTMAN: Well, this Fitt's was an engineering project at Purdue University.

MR. SIEBER: You missed the possible oculus postulate.

DR. APOSTOLAKIS: You never heard of Fick's law? Come on.

MR. GERTMAN: No, no.

MR. SIEBER: I'm lucky I've heard of Ohm's law.

MR. GERTMAN: I've heard of an Occan's Razor.

CHAIRMAN ROSEN: I've heard about the Miller's magic number seven. Let's hear about that.

MR. GERTMAN: That has to deal with memory, capacity, and seven plus or minus two items is best recalled from short-term memory. The other part of that is that you have two effects, primacy

and recency, which means in a long list of items you tend to remember the first things you heard and the last things that you heard, and you lose the stuff in the middle.

DR. APOSTOLAKIS: Seven also is the optimal number of groups, working groups. You shouldn't have more than seven.

CHAIRMAN ROSEN: Because if you have eight you don't remember the eighth person.

DR. APOSTOLAKIS: That's right.

MR. GERTMAN: You never want a tie either in a vote.

And Fitt's law goes to reaction times as a function of distance. Hick's is distributions of human performance for tasks involving choice among alternatives.

The arousal and stress work is interesting. It's an inverted U-shaped function where under a low stress you tend to have higher failure rates. Under very high stress to have high failure rates. Your best performance is under a modern amount of stress.

DR. APOSTOLAKIS: Yeah, we've known that for a long time.

MR. GERTMAN: Again, part of the point

that that was going to go to, these performance distributions, and as a convenience in HRA, we've used error factors and assumed log normal distributions for failures and things like that, and we go to the human performance literature and not everything follows a log. Some of these are cubic; some of these are quartic, and there's that aspect of it.

And then there's documentation and there's research on things like complexity. One of the HRA methods, which I guess is second generation, would be the CAR method from Oliver Strader out of Germany, Connectionist, the Connection Associationist method for HRA, and that bases a formulation of error probabilities on the complexity of the situation.

It goes back to the rash curves, which are formulated in very late '40s and '50s and used in a lot of different applications for complexity work. So he uses that model to talk about whether or not people will fail. There's some research on that. As you increase the complexity of a situation, the failure rate increases.

The interpreting factor for that is the next bullet down, which goes to the expert versus

novices, as you're beginning to talk about how experts do.

Under high stress, experts do much better than novices in terms of not being interrupted, but at a certain level, their decrement in performance, it's a very accelerated kind of a curve.

So they seem to resist at the last moment, and when they fall apart, it's not a general degradation. They fall apart like everybody else. It just takes them further out before they get into that realm So that's why that would be an influencing factor on how well somebody is going to do in a stressful situation.

Comparison with other methods. As with THERP, we use nominal failure rates. We use shaping factors. We calculate dependency, and we break actions into -- we break the behavior into actions and diagnostic tasks.

So we've got that in common with THERP.

DR. APOSTOLAKIS: Why use the beta distribution?

MR. GERTMAN: Why use beta?

DR. APOSTOLAKIS: Un-huh.

MR. GERTMAN: Well, we used a

constrained noninformative prior, some of the work by Atwood.

DR. APOSTOLAKIS: I forgot that item.

MR. GERTMAN: Yeah, so we have to do that even if he has left the lab and now he lives someplace near Bethesda.

CHAIRMAN ROSEN: But he promises to come back if you don't use his method and haunt you forever?

MR. GERTMAN: We'd be happy to have him come back.

And what had been done before with THERP and with other methods is you use this error factor, and one of the things that was kind of sloppy about the way things were performed in the past, it was very easy to get a human error probability of if you start with diagnosis and put people in a bad space where there's sketchy procedures and high stress and not a lot of time. You quickly come up with a failure rate of four E minus one, five E minus one.

And then you go to the error factors of ten and five and eight, and you do the multiplication and come up with the upper bound. You would come up with an upper bound failure probability of eight or five or seven, and it was

this kind of an oddity.

And people would say, "Well, of course, of course. It's an artifact of doing it this way, and we know it's one. Just ignore it and go on."

Well, it seemed to us a better approach, and we were asked to see if we couldn't refine uncertainty the way it was approached in at least this simplified HRA, was to go to a beta distribution which very easily can mimic standard distributions, normal distribution, which you have a lot from human psychology literature and how people act and decide and behave, along with logarithmic assumptions for error probabilities, and the value of the beta would give us a probability between zero and one, which is a reasonable range.

DR. APOSTOLAKIS: I thought it doesn't use the two of these. I mean, the beta is not particularly easy for somebody to use.

MR. GERTMAN: Actually it's quite easy for the user to do this. What happens is you require a best estimate, and we use the mean for the best estimate, and that is the mean that you get by taking the nominal rate and multiplying it by the shaping factor, and then you can either go to Excel for beta or we tend to -- in working with the PRA

analysts, SAPHIRE has that capability. So you go ahead and elect that --

DR. APOSTOLAKIS: But you need some sort of computer --

MR. GERTMAN: Computer code.

DR. APOSTOLAKIS: -- and so on. Okay.

MR. GERTMAN: Well, I think we're also able to mock it up in Excel, but we once upon a time talked about actually having tables in here. We could go in for the values produced for a simple look-up table in the back as an appendix.

DR. APOSTOLAKIS: A look-up table. That's kind of --

MR. SIEBER: The scientific calculator.

MR. GERTMAN: Yeah.

DR. APOSTOLAKIS: It's kind of unusual to hear that a simplified method uses a beta.

MR. GERTMAN: We worked with --

MR. SIEBER: You've got to use something.

MR. GERTMAN: We worked with fancy PRA guys back in Idaho, and it --

DR. APOSTOLAKIS: Now they're fancy.

MR. GERTMAN: -- seems simple to them, right, Curtis?

Okay. We talked about --

DR. APOSTOLAKIS: -- basis for the users, right? For the inspectors, is it?

MR. GERTMAN: Yes.

DR. APOSTOLAKIS: Yeah. The SPAR-H is to be used by the regions.

MR. SIEBER: Senior analysts.

DR. APOSTOLAKIS: Those are the guys I have in mind, not the Idaho guys.

DR. SHACK: Whether he calls beta inverse in Excel or he calls log normal, does it make a difference to him?

DR. APOSTOLAKIS: Log normal is always easier to use, probably.

MR. O'REILLY: Well, at the present time, George, they're not really interested on certainly yet. We're pioneering that.

DR. APOSTOLAKIS: You will suffer the fate of pioneers.

MR. O'REILLY: That's correct.

CHAIRMAN ROSEN: No good deed goes unpunished.

MR. O'REILLY: Never.

DR. APOSTOLAKIS: Never does.

MR. GERTMAN: Just to make sure I'm

clear on this, are you suggesting that we --

DR. APOSTOLAKIS: I'm not suggesting it.

MR. GERTMAN: Okay, okay. The last bullet talks about the PSFs are fixed. They're calibrated against other methods, and based on the psychological theory.

One of the comments we did have in the review of the documents said that how come we used a fixed set of PSFs. Suppose through learning I come up with three more. How will you handle that and what will you do? Why shouldn't you have an infinite set of PSFs?

The simple method was the easiest answer, I think, but George had raised the problem earlier when he said, "Well, I give this situation to somebody else, and with SLIM they come up with eight PSFs and somebody else has ten and somebody else has 14.

First of all, we wanted it fixed to make it reproducible so that when people sat down to apply the method they consider just these eight factors, and we know they will always have to address these same eight factors.

The other challenge I put out is when I think of the other PSFs that people come up with I

can pretty well map them someplace to the eight that we have. I haven't come across a shaping factor where I couldn't map it to one of the PSFs that we do have.

CHAIRMAN ROSEN: What do you mean by "map"?

MR. GERTMAN: What I mean "map," if we talk about -- I'll give you --

DR. APOSTOLAKIS: Like we did with time.

MR. GERTMAN: Well, the time is its own PSF on the worksheet. So that one is pretty easily done. But if somebody says, "Well, okay. I've got the influence of a second checker and a third checker the way we do business at our plant," where do you have second checker down there or third checker for an error recovery?

Well, first of all, we talk about recovery much the way you would see an ASME of a functional recovery or restoration. For an HEP what we would do is say, "Okay. I've got a second checker. That's my shaping factor. I want to call it personnel redundancy. What do you do?"

And my answer is I go to work practices, and if I see there's a practice the way they organized for work, the way they conduct business,

the way they do their rounds that is superior or I think has a positive influence, that's the PSF I would manipulate.

If somebody says, you know, we don't have procedures or procedures are incomplete, I would go to our procedures PSI.

If somebody says, "We expect in this situation that people will be working a double shift. It's during an outage. They worked a lot of hours in this week. I don't see your outage shaping factor," or, "I don't see your sleepiness factor."

And I would map right to fitness for duty. So as we go through situations, again, for this method to fit with most of the situations you see when you do HRA, it's been pretty successful and to be able to take aspects of that context and just map them for the PSFs that we have.

DR. APOSTOLAKIS: Okay. Let me ask you something.

MR. SIEBER: It's sort of subjective though, it seems to me.

MR. GERTMAN: That's a good comment. There is some subjectivity. For me it's more apparent, but it's unfair because I work with the method development.

One of the comments we had was couldn't you develop a few more examples in the report, kind of come up with a scenario just as we're talking about here and say this is the situation. This is the context. Here is how I would manipulate or not manipulate these eight PSFs. Do it for a small library, and I could use that as a guide as I got my situation and see if I could match it.

DR. APOSTOLAKIS: Good idea.

MR. GERTMAN: Yeah, I thought it was a good comment.

DR. APOSTOLAKIS: Let me ask another question.

MR. GERTMAN: Sure.

DR. APOSTOLAKIS: This will be used by the senior reactor analysts in the regions.

MR. SIEBER: Yes.

CHAIRMAN ROSEN: And the utilities.

DR. APOSTOLAKIS: Who are doing STP?

MR. O'REILLY: Phase 3.

DR. APOSTOLAKIS: Significance, right?

MR. O'REILLY: Phase 3.

DR. APOSTOLAKIS: That was my question. It's Phase 3.

MR. O'REILLY: Phase 3, correct.

MR. GERTMAN: Those analysts --

DR. APOSTOLAKIS: But then wait, wait. Isn't there another stage where the utility can come back or you guys can go ahead and say this deserves a more detailed evaluation?

MR. O'REILLY: Use Phase 3.

DR. APOSTOLAKIS: Well, no. You can go beyond that.

MR. SIEBER: The licensee gets an opportunity to comment on what the staff has said.

DR. APOSTOLAKIS: So it's not Phase 2. You're sure it's not Phase 2.

MR. O'REILLY: Phase 2, George, is they just go in there right now with the worksheet.

CHAIRMAN ROSEN: The licensees are going to do their own SPAR-H to check the staff because --

MR. O'REILLY: And they come up with a color.

CHAIRMAN ROSEN: Well, they'll do SPAR-H though because they know the staff is doing SPAR-H, and then they'll do their own method, which will be complex.

MR. SIEBER: And argue about the PSF.

DR. APOSTOLAKIS: If the issue is --

CHAIRMAN ROSEN: They'll argue about

everything.

MR. O'REILLY: Yeah, they'll just take it to Phase 3. That's correct.

DR. APOSTOLAKIS: They will start breaking -- I mean tearing it apart and saying, you know, this standardized approach is not really appropriate. Let's go more deeply.

MR. O'REILLY: Yes.

DR. APOSTOLAKIS: But this is Phase 3. That was my question.

MR. O'REILLY: That is Phase 3.

MR. GERTMAN: Okay. The calibration, again, we've kind of covered this. We talked about behavioral sciences literature and just mentioned a couple of the more classic studies in the field from '50s and '60s.

The other ones were simulator trials. In the early '80s we went to Oconee and some other utilities from Idaho on the NRC task, and we looked with simulator trials, and we found a high correlation among the quality of response from the simulator crew in terms of accuracy of response and time to response as evaluated by the training group in shaping factors of stress and procedures and the training, whether or not they've had it before,

either experienced it on shift or had been trained to the particular scenario we presented them with.

So again, that's some -- I wouldn't call it a strong validation, but it is a convergence. It's a calibration of the method against experimental data.

Experiential data comes from NRC users and the people working in application of the risk based plant inspection notebooks, and the NRC users at headquarters and regions came back in '99 and in 2002, as Pat presented, and said, "Hey, this is a difficulty. We need this definition sharpened up. We don't know what this means. We feel like we need a larger dynamic range."

It was difficult to assign a PSF level for this situation, and we've been in the process of updating based on user feedback really over the years.

Additionally we've gone out and we went to NASA. Some applications I guess have actually used CREAM and some others. We went and we looked at some ground based maintenance for NASA down at Johnson, looked at jet engine refurbishment, and we also looked at tank filling operations to support the neutral buoyancy laboratory they have down

there, and we had good convergence with using SPAR-H.

The other two methods that were used were a failure modes and effective analysis and a detailed task analysis with looking at error. They did an error analysis within the task analysis and looked at different failure modes, and we had pretty good convergence with SPAR.

When we went ahead and did our quantification with SPAR for some of these tasks, we came up and highlighted the exact same task they did using other methods. So this, again, is another degree of support or validation for it.

In terms of experiential data, the operating experience data, Jay Persensky earlier today talked about NUREG 6753, which was the risk impact of human performance on operating events, and we went through all of the summation of the 255 failures that were documented in that review of LERs and AITs and looked for the 23 categories they fell into.

Again, I knew the guys in Idaho who had worked on the document, and looked at the descriptions in the appendices of that, and again, we were pretty comfortable mapping that information

back to the shaping factors that we have in A.

Now, what's interesting is in those events that we went through, there was an awful lot of information having to do with corrective action program, corrective action backlog, failure to trend, failure to notify internally, failure to respond to NRC notices.

And for us the way we adjusted in that method is we go ahead and we assign a value within the work practices PSF where that bin is used to modify the nominal rate.

So we have that and from INFORM what we've done in building up some INFORM data set, it uses a lot of the shaping factors with additional information from other methods, and there is enough information in INFORM also the way it has been put together that you could go out and use it. You'd meet the input requirements of the SPAR-H method, for example.

And, again, we didn't find the kind of situations occurring in INFORM yet in the LERs that we reviewed and the AITs that are also being input into that database. We didn't find evidence of things that would not fit into SPAR-H.

Now, the INFORM goes beyond that because

it goes into a lot more depth about maintenance and complexity factors on maintenance, and again, it's a product working with NRC staff and part of the ATHEANA team to grow the classification system for INFORM.

But you go ahead and with that information you can meet the input requirements of this and you could perform a calculated HEP, for example. It's not part of that task, but I had a few minutes, and I did do it once. So --

DR. SHACK: That was one thing that struck me as strange. I mean, we're looking at this word processes which vary from .8 to two. I would think in the range of probabilities we're talking about here, that's all equal to one.

CHAIRMAN ROSEN: Yeah, but that's what you do at the end, not at the beginning.

DR. APOSTOLAKIS: This is not an exact science.

MR. GERTMAN: Again, I think the point that Steve made about what you do by picking a non-nominal value is you force the conversation about that as an issue and decide whether or not you need to do more analysis. With a simplified approach to the HRA, that's probably getting far enough down the

road to do what it should be doing.

Again, the work sheets, again, they're uniform, unique to SPAR. Most methods, or none that we could find, come with a worksheet. Okay. The idea, that you would have break-away sheets. It would force you to consider the same things in the same order with the same kind of weights depending on the level within the PSF that you inform so that you would have a chance at having a pretty high degree of convergence or inter-rater reliability.

The idea is to get away from some of the problems that we had, and it's for benchmark, particularly for quick turnaround studies. You have the analysts out in the field, the SRAs in the headquarters. You might only have two or three days to do an event analysis and come up with and indicate what you see on the gross level your change is to conditional core damage probability.

HRA can only be a small portion of that three days total that you have or some portion of that.

CHAIRMAN ROSEN: Have you piloted this at all, SPAR-H? Have you tried it with SRAs?

MR. GERTMAN: When we had our public meeting, we had SRAs present. We had NRR present.

We've gone ahead within our own work group because there is some 70 to maybe 75 now SPAR models.

MR. O'REILLY: Seventy-two.

MR. GERTMAN: Seventy-two SPAR models out. So we have practice in applying the method and being used in events analysis.

We haven't gone out for --

CHAIRMAN ROSEN: And gotten some users separately from you to try it.

MR. GERTMAN: Well, we have some SRAs. We have some of the NASA staff. We have ourselves to model.

CHAIRMAN ROSEN: Have you gotten some SRAs to do the same event and seen how different their answers are?

MR. GERTMAN: No, we haven't. No, we haven't.

The only time that has been done, it was part of some, again, a small level of tasking we had in '99, is we went out, but it was among lab members, and we went out and gave them the same event to look at.

CHAIRMAN ROSEN: Well, you might consider that. Obviously the repeatability of this is clearly something you're aiming for. I would

hope that it would turn out to be relatively repeatable for the same or similarly qualified people on the same event.

MR. GERTMAN: I would agree wholeheartedly. I'm not sure whether it's -- it's for somebody else to decide whether something like that is part of this NUREG effort we have now or if it's something that afterwards if we come out with reliability coefficients or whatever is appropriate.

I think the tradeoff here for a lot of us involved with SPAR-H right now is the method has gone along because of the level of funding since '94 with upgrades; that there is no externally published document that's available for utilities and people who want to find out about it.

MR. O'REILLY: That's the biggest impetus behind the current effort.

MR. GERTMAN: You know, that's the tradeoff.

MR. O'REILLY: Is because we had no real referenceable document. It was incorporated as a section in the user's manual for each of the SPAR models. We needed a stand-alone document.

CHAIRMAN ROSEN: But I think you're agreeing that --

MR. GERTMAN: Yes, I am.

CHAIRMAN ROSEN: -- one of the measures of success of this --

MR. O'REILLY: Yes.

CHAIRMAN ROSEN: -- would be repeatability.

MR. GERTMAN: Absolutely.

MR. O'REILLY: Yes.

MR. GERTMAN: Complete and violent agreement once again.

DR. SHACK: Is the dependency condition table Appendix G?

MR. GERTMAN: Is it now G?

DR. SHACK: It's this relationship among SPAR PSFs. Is that --

MR. GERTMAN: Ah, that was a --

DR. SHACK: Or what is a dependency condition?

MR. GERTMAN: Okay. The dependency condition table is on, I believe, page 3 of the worksheets. The table you're referring to is one where we try to look at the degree of relation or correlation among the PSFs, and that was Julia Marvel and I sat down and had a -- argued about that briefly.

Again, that was not part of the scope of documenting where we were in time and the amalgam of methods that we were. The dependency table goes a step beyond THERP. What it does is it leads you into five conditions.

One is there's no dependence. Maybe it's the first action of the sequence.

The second one is there could be complete dependence, the failure in a previous -- almost insures that the subsequent task has failed.

Then there's calculations for low, medium, and high.

The equations are at the bottom, which are basically six times the probability divided by seven for the one that's moderate.

Those equations, that set came from THERP, from that NUREG.

The assignment of how you get to different dependency conditions, whether it's the same crew close in time using the same equipment with no new cues coming in or new cues coming in, that we just expanded a little bit about what Alan had to give you a few different factors that seemed to us were contributing to where you were in space with dependency.

Again, we view that as a simplified approach, as some of the reviewers have noted. Where do we address positive or success, positive dependencies, success to previous put you down the right path? You tend to be not really random on your next test. You're more inclined to be successful.

Again, a simplified method. It's a challenge for the field. We don't deal, we don't account for or, you know, quantify positive dependency as part of the method.

Part of the answer is that we expect in the situations where you apply the method it's off-normal or emergency conditions. You don't expect to find a lot of positive dependency. You expect the preponderance to be negative.

So, again, that's an assumption, but that would take work to talk about the positive dependency.

Again, in how we allow for a task to have aspects of diagnosis and action, and you simply add those two failure rates. If you went back to THERP and you go to the HR event tree, if you have a failure rate of three E minus three, you don't consider all the way down the tree the success is

one. It's really .997.

Again, this is a simplified approach so that we don't deal with success dependency or any kind of a calculational correction factor for that. Again, we'd be so far out of the simplified NRA it would be kind of angels on the head of a pin for this method.

Okay. Last slide. Well, next to the last slide.

Peer review comments. We talked about them. Most of them was why we used a fix set orthogonality.

Practitioner questions, a number of the questions we had from the public review and from those at EPRI and elsewhere and the agency and other labs that went ahead and reviewed the document were how would I really go about modeling this, and we put them in a practitioner level question.

How far should I decompose? Should I use things on a task level or sub-task level, or can I have it mixed within the same HRA and PRA?

Again, these are issues which are not a function of the simplified approach. These are issues that have been argued about for the last decade or two, and we have general guidance.

You know, if you decompose to sub-tasks, you should be consistent within your HRA. If you're worried about it making a difference, do it both ways and see what the delta is. We feel that with this method that since you're highlighting what could go wrong and looking at its contribution or importance to risk at the end, the difference that you get in most cases between decomposing to one level versus another is not so great that it's going to really shift the importance of human performance within the PRA.

But, again, decompose to the same level. Be consistent, and if you think it's going to make a difference, you should do both, and then do your own sensitivity and see what the difference is.

Again, these are practitioner questions.

Extend the checkout was another issue, the one you raised for the inter-rater reliability. We had a comment. We think the national lab knows how to do this, and we think headquarters knows how to do this. A few other people might have to know how to do this. We think you need to go out and get the word spread to other people and have more practical applications by a wider audience of NRC staff.

Fair enough. Probably not to be dealt with in this version of the NUREG that we're winding up, but I think in tech. transfer or in training within maybe ASP event analysis that you're going to launch here or --

CHAIRMAN ROSEN: Well, here's the main genesis of the question or the prodding to do that.

MR. GERTMAN: Yeah.

CHAIRMAN ROSEN: Is that because this will be important to the answer in many cases, and the answer is important to the action matrix and the ROP, you need to have preestablished, I think, that you've done some repeatability work, I think. Because otherwise one of the criticisms will be, hey, even NRC can't get the same answer twice using this method.

And so, you know, if you did the work, you'd be able to acknowledge, yeah, we don't get exactly the same answer, but in our trials we got within a factor of three consistently or something like that with trained analysts.

So we're confident that the answer we have here is probably if we did the trial this time it would come out within a factor of three for just repeatability.

Otherwise there will be that stress on the system of not having it validated for repeatability. Anyway, that's the last I have to say on that.

MR. CHEOK: I think that's a fair comment, but I think we do this in the field under Phase 3 of SDP. In Phase 2, it's the worksheets, and they don't account for recovery. So they don't do SPAR-H for Phase 2.

But in Phase 3 when they do do it, they do submit their results to the licensees during a sub-panel. At that point if the licensees feel that the HEP that they see is not reasonable, they can comment on it and why they think it's not reasonable.

So in that sense we do get this feedback, but you are right. We should do a cross-SRA comparison to make sure that it is consistent.

CHAIRMAN ROSEN: You're going to have to do whatever you can do to deal with this.

MR. GERTMAN: Okay.

DR. APOSTOLAKIS: State who you are.

MR. CHEOK: I'm Mike Cheok.

CHAIRMAN ROSEN: Oh, we know who Mike is.

DR. APOSTOLAKIS: No, but she doesn't.

CHAIRMAN ROSEN: What's this? Go jump in the lake if you don't agree?

CHAIRMAN ROSEN: That's Montana.

MR. GERTMAN: Just to make everybody wish that they lived in Idaho or Montana.

MR. SIEBER: Yeah, that's Montana.

DR. APOSTOLAKIS: Which river is this? It's a creek?

MR. GERTMAN: River of no return.

CHAIRMAN ROSEN: If you go up there, you don't want to come back.

DR. APOSTOLAKIS: It doesn't look like Niagara Falls.

MR. GERTMAN: No, it isn't the Falls. It's actually a small river outside of Boise.

DR. APOSTOLAKIS: It looks like this what, three hours a year?

MR. GERTMAN: Well, when you break away the ice it always looks like this.

(Laughter.)

CHAIRMAN ROSEN: Well, okay.

MR. GERTMAN: Thank you for your attention.

CHAIRMAN ROSEN: Thanks very much. That

was very useful.

It has been an extraordinarily useful day. I'll ask for my colleagues if they have any further comments.

MR. SIEBER: I thought the last presentation was pretty good.

DR. APOSTOLAKIS: Except for the last presentation, you said?

(Laughter.)

MR. SIEBER: I thought it was very good, easy for me to understand. I'm all in for simplified things.

DR. APOSTOLAKIS: How about Susan and Jack?

MS. LOIS: We need another presentation.

CHAIRMAN ROSEN: Okay. Are there other comments from my colleagues?

DR. APOSTOLAKIS: Yeah, just one comment. I don't know what to write about digital I&C. I think we really need to be educated. I mean, everything else I think I'm comfortable with, but the digital I&C I really have --

MR. SIEBER: I agree.

DR. APOSTOLAKIS: We have to learn a little more. So Mike I think has already blocked

the section for December.

CHAIRMAN ROSEN: Exactly.

DR. APOSTOLAKIS: Let's see. Let's hope that something will come out of it. Other than that, Mr. Chairman, I'm happy.

MR. SIEBER: Well, if that date in December doesn't work, we need another date.

DR. APOSTOLAKIS: We need another date.

MR. SIEBER: Right around that time.

DR. APOSTOLAKIS: Yeah, exactly.

MR. SIEBER: Because this is a factor in the research report.

DR. APOSTOLAKIS: Especially you, Jack, because you --

MR. SNODDERLY: December 11th is our fall-back.

DR. APOSTOLAKIS: You're going to write -- what did you say, Mike?

MR. SNODDERLY: December 11th is the fall-back or the alternative date.

DR. APOSTOLAKIS: Yeah.

MR. SNODDERLY: But the first choice is the 2nd.

DR. APOSTOLAKIS: Okay.

CHAIRMAN ROSEN: Do any members of the

staff wish to rebut anything they've heard here? Comment on it? No.

Members of the public who are here?

None. If none, then thank you all very much for a very useful day. We will adjourn sine die.

(Whereupon, at 5:50 p.m., the meeting was concluded.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Reliability and Probabilistic Risk Assessment and Human Factors Joint Subcommittees

Docket Number: n/a

Location: Rockville, MD

were held as herein appears, and that this is the original transcript thereof for the file of the United States Nuclear Regulatory Commission taken by me and, thereafter reduced to typewriting by me or under the direction of the court reporting company, and that the transcript is a true and accurate record of the foregoing proceedings.

Rebecca Davis

Rebecca Davis
Official Reporter
Neal R. Gross & Co., Inc.

United States
Nuclear Regulatory Commission

Human Reliability Analysis Program
Overview

Mark Cunningham, Erasmia Lois, and Susan Cooper
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

Presented to
Joint Subcommittee on Reliability Risk Assessment and Human Factors
Advisory Committee on Reactor Safeguards
USNRC Headquarters • Rockville, MD • 9th October 2003

Presentation Overview

- Why HRA research is important
- Accomplishments
- Summary of HRA Program Plan
- Issues currently addressed
  - HRA guidance
  - HRA data
    - NRC
    - Halden
    - CSNI
  - NMSS
- Future activities

HRA research is important because...

- Human performance is more complicated & less understood than most other risk contributors
  - Human error is frequently the cause of serious accidents
  - Human failures are usually significant contributors to risk
- Although on-going research has accomplished a great deal, HRA remains an important contributor to overall uncertainty in risk studies
  - Modeling and data of human performance has not reached the maturity level of some other PRA areas
- "New" issues for PRA (e.g., advanced reactors, HRA for Materials and Waste) require expanded knowledge base for HRA

HRA Research Program--Accomplishments

- Developed improved HRA Technology, e.g., ATHEANA
- Performing HRA applications that lead to more realistic results
  - PTS PRA (completed)
  - SGTR PRA (in progress)
  - Fire re-quantification (in progress)
- Developing lessons learned supporting regulatory activities
  - HRA Good Practices Document
  - Post-fire manual actions rulemaking (Revision To Appendix R)
  - Incorporated in SPAR HRA methodology (SPAR-H)

Summary of HRA Research Program Plan

	Conventional Reactors	Advanced Reactors	Waste & Materials	Security & Safeguards
Rules	✓ Fire Manual Actions			
Licensing	✓ Fire ✓ SGTR	• HRA for Upgraded & Advanced Reactors	✓ Specific applications	Specific applications
Monitoring				
Infra-Structure	*Methods and Tools* ✓ Human performance information repository ✓ Human Actions Under Severe Accidents (SGTR) ✓ Individual and Crew Performance (Halden) • Latent Conditions, Safety Culture • Extended Applications: LPSD, Slowly Evolving Events, Ex-control Actions • Screening Human Actions *Implementation* ✓ Guidance ✓ Standards *Coordination with other programs* ✓ CSNI ✓ Halden ✓ IEEE ✓ ASME ✓ EPRI		*Methods and Tools* ✓ Feasibility study • Methods • Data *Implementation* • Guidance	

✓ ongoing
• planned

Issues Currently Being Addressed

- HRA Practices
  - Consistency: HRA methods are implemented differently
  - Applicability: Some methods may not be suitable to address the issue at hand
  - Data: Lack of data quality is recognized by experts as contributing significantly in the uncertainties of HRA
  - HRA guidance development
  - HRA data development
- New HRA knowledge for emerging needs
  - Materials and Waste

HRA Guidance

- Provide the technical basis for developing an SRP (and a Reg Guide) for reviewing/performing HRA
  - Developed by Sandia
- Recommended by NRR to help address decision-making
  - Licensee requests on plant modifications
  - Options 2 & 3
- Benefits
  - Improve staff's capability to perform more consistent and technically correct evaluation of licensee requests
  - Standardize HRA practices
- Related activities
  - EPRI HRA guidance--method specific
  - IEEE HRA standards
  - ASME PRA standard

Approach for HRA Guidance

- Build in insights from performing/reviewing PRAs/HRAs
- Lessons learned from ATHEANA development and applications will be used to address issues such as
  - Whether and to what degree the non-explicit treatment of error of commission in licensees PRAs may contribute to overlooking potentially significant human failure events?
  - Whether changes in plant design and plant operations create the potential of inducing new human-induced failures?
- 3-step Approach
  - Document 1: describes what are the driving influences on human performance in nuclear safety--set the stage for Document 2
  - Document 2, "HRA Good Practices," Provides technical guidance for performing/reviewing HRA--start with the ASME standard and go to lower level
  - Document 3: Evaluates methods (1st and 2nd generation) for their capability to meet the attributes identified in Document 2

HRA Guidance--Status

- Document 2: HRA Good Practices
  - Draft submitted August 03
  - Public Review and Comment: January 04
  - Final Version: June 04
- Document 1: Drivers of Human Performance
  - Draft to be submitted, Nov 03
  - Public Review and Comment --under consideration
  - Final: June 04
- Document 3: Evaluation of HRA methods
  - Draft June 04
  - Final Sept 04
  - Public Review and Comment: Jan 05
  - Final: June 05

Data Development

- Make an effective use of existing information
  - Hard data (failures/opportunities) are sparse
  - Information/evidence is available
  - Bayesian type methods allow the use of evidence in estimations
- A Human Performance Information Repository (INFORM) is being developed for HRA and HF
  - Developed by INEEL
  - Currently focusing on NPP operational experience
  - Future plans include other sources
- Benefits
  - Improved understanding of human performance
  - More realistic probability estimation
  - Support a variety of NRC activities
- Related activities
  - Halden , CSNI HRA data sharing activity
  - RES/OERB equipment failure database

Approach for INFORM Development

- Characterize the information needed for HRA
  - Identify concepts and terms used in the various HRA methods
  - Identify concept-commonalties
  - Develop glossary
- Identify and evaluate data sources for usefulness
  - Determine what information should be extracted
  - Propose a structure to incorporate the information
- Create-test a repository
- Develop methods to estimate human failure event probabilities

INFORM Development--Status

- CY 03
  - Prototype of repository and limited number of operational events
  - Interaction with users/internal review
  - Letter Report describing INFORM (to become NUREG/CR)
- CY 04 and Beyond
  - Finalize software, add events
  - Develop Bayesian type methods to use information
  - Continue collaborate with Halden, CSNI and other related activities

Halden Simulator Experiments

- Design simulator experiments specifically for HRA
  - Experimental data is the best thing next to "real"
  - Improve understanding of both successes and failures
  - Examine operator and team performance
- NRC support to Halden
  - NRC HRA team meeting at Halden, June 2003
  - INEEL staff at Halden, Sept 03 - March 04
  - Plans for Halden staff visiting to NRC/National Labs, 04
- Benefits
  - Capability to test hypotheses employed in HRA methods
  - Achieve rigorous (systems-type) modeling methods
- Related activities
  - CSNI HRA data sharing
  - INFORM development

CSNI Activities on HRA

- CSNI is "outlining a framework for HRA information exchange"
- HRA WGRisk meeting was held, 9/24-26/03
- Countries expressed strong interest to achieve this goal
- A detailed outline of a report was created
  - Simulator and operational events were considered as useful
  - Need for including data related to design and construction of new reactors was recognized
  - Lead authors of the report are representatives from Germany, Switzerland, USA
- A version of the report for CSNI approval will be ready for next CSNI/WGRisk meeting, Fall 2004.

HRA FOR MATERIALS AND WASTE

- Develop HRA capability specific to Materials and Waste applications
- User Need (NMSS/RTG) asks for
  - Phase 1: Feasibility study to identify important human actions, user needs, & development requirements
  - Phase 2: Development of HRA methods, tools, etc. based on feasibility study
- Benefits
  - Allow NMSS to better risk-inform their activities
  - Support important NRC activities (e.g., Yucca Mountain)
- Related activity
  - Pilot PRA for dry cask storage
- Status
  - Phase 1: To be completed by Dec 03
  - Phase 2: CY 04 and beyond

Future HRA Research Program Activities

- New knowledge for emerging needs
  - Latent conditions (FY 04)
  - Advanced reactors (FY 04)
  - Level 2 (FY 05)
  - External events (FY05)
- Continue activities on data, guidance, and standards as needed
- Continue work on NMSS HRA
- Analyze information collected or generated to test/improve HRA models (FY 05)
- Continue international interactions
  - Leveraging the general knowledge and resources

SPAR HUMAN RELIABILITY ANALYSIS (HRA) METHODOLOGY (SPAR-H METHOD)

Patrick D. O'Reilly
Operating Experience Risk Analysis Branch
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research
October 9, 2003

SPAR-H METHOD
History

- 1994 – Initial Development of Methodology.
  - Purpose: Improve HRA practices for use in ASP Program.
  - A general, easy-to-use method which handled actuation, recovery, and dependency through a consistent model of human behavior.
  - Use of worksheets simplified application of the methodology.

SPAR-H METHOD
History (Continued)

- 1999 – Modifications Made to Initial Method Based upon a Benchmarking Process.
  - Performance shaping factors (PSFs).
  - Dependency.
  - Human error probabilities (HEPs).

SPAR-H METHOD
History (Continued)

- 2002 – Further Modifications:
  - Refined PSF definitions.
  - Provided uncertainty analysis capability.
  - Evaluated PSFs for low power/shutdown conditions.
  - Increased detail in dependency assignment.
  - Documented in draft NUREG report.

SPAR-H METHOD
Specific Applications

- Incorporated in Level 1, Revision 3 (Full Power) and in Level 1, Low Power/Shutdown SPAR Models.

- Worksheets for Performance Shaping Factor Estimation Used by Regional Office SRAs in Phase 3 Analyses in Significance Determination Process (SDP).

- Used by ASP Program in Uncertainty Analysis of Events in which Operator Performance is an Issue (e.g., August 1999 Loss of Electric Power to a Safety Bus at IP-2; February 2000 SGTR at IP-2).

SPAR-H METHOD
Recent Accomplishments

- One-Day Public Workshop on SPAR-H Method in June.

- Peer Review of Draft NUREG by Internal/External Stakeholders.
  - Internal (NRR, RES, Regional Offices)
  - External (NEI, EPRI, INPO, Owners Groups, Union of Concerned Scientists)

Idaho National Engineering and Environmental Laboratory

SPAR-HRA Methodology

US NRC ACRS Meetings

David I. Gertman and Harold S. Blackman

October 9, 2003

Highlights for Discussion

- *Why SPAR-HRA?*
- *Justify various PSFs used in SPAR-HRA*
- *Comparisons with other HRA methods, including quantification approach*
- *Comparison with experimental or experiential data*
- *2003 accomplishments*
- *Nature of comments to date on draft NUREG/CR*

Why SPAR HRA?

- *In 1994, the NRC ASP Program was using 4 formal rules and 1 heuristic for HRA (range from 1.0E-3 to 1.0)*

- *NRC requested that INEEL recommend or develop a method to allow for more realistic analysis of human error*
  - *Reviewed HRA methods, - - too detailed, too resource intensive to apply easily*
  - *Informed by 2nd generation and international developmental activities*

Meet ASP Programmatic Requirements

- *Based on an Amalgamation of Other Methods*
- *Easy to use*
- *Simplified approach*
- *Analysis can be completed in short time (If a full scope, detailed HRA is needed, other existing methods should be used)*
- *Ensure relevant factors are addressed/accounted for*
- *Appropriate for most human behavior*

Assumptions

- ***A simple model of human behavior is adequate***
- ***Model is based on human performance and cognition; <u>not</u> on a specific plant condition***
- ***PSFs can be identified that influence decision making and actions and cover each stage of the human behavior***
- ***Plant conditions, tasks, people, and situations combine to create a context described by PSFs that influence performance***

PSF Approach

- *Theory and model based*
- *Reflects PSFs used in many current HRA approaches*
  - *Influence ranges are calibrated*
- *Existing literature supporting SPAR-HRA PSFs*

Human Behavior Model

Inflow and Perception	*WM/STS*	*Processing/ LTM*	*Response*

Summary Level Influencing Factors

- Complexity
- Stress
- Experience/Training
- Fitness for duty

Procedures (job aids)
Ergonomics
Workload
Work Practices

Technical Basis for the PSFs Comes From the Psychological Literature

- *Miller's magic number 7*
- *Fitt's law (reaction time)*
- *Hick's law*
- *Performance under arousal and stress (Yerkes-Dodson's Law)*
- *Work shift effects*
- *Complexity*
- *Experts versus novices*

Comparison with Other HRA Methods

- *Comparison with THERP*
- *Worksheets – unique*
- *Two levels of tasks (diagnosis, action)*
- *Use of nominal rates and PSFs*
- *Multiplicative approach to HEP calculation*
- *Use of Beta distribution in place of error factors*
- *PSFs are fixed, calibrated against methods, and based on theory*

SPAR HRA Results Calibration

- *Experimental data*
  - *Behavioral sciences*
  - *PSF Simulator trials – Oconee work in 1980's*
- *Experiential data*
  - *NRC Users*
  - *Operating experience data*
    - *NUREG/CR-6753 and INFORM HRA data effort*
- *1994 results showed good inter-rater reliability*

Worksheets Ensure Uniform, Consistent Application of Method

- *Unique to SPAR HRA*
- *Major functional areas included:*
  - *Plant information*
  - *Error description*
  - *Task type*
  - *Performance shaping factors*
  - *Dependency condition table*
- *Tractable, HEP calculation on the worksheets*

Draft NUREG Report Contents

- ***Update and refine definitions***
- ***Provide more examples***
- ***Offer better uncertainty approach***
- ***Provide more technical basis information on PSFs***
- ***Extend applicability to LP/SD***
- ***Provide calibration findings***

Peer Review Comments

- *PSF issues*
  - *Fixed versus flexible PSFs*
  - *Orthogonality of PSFs, whether to introduce or not*
- *Practitioner questions (How do I model this?)*
- *Issues for the field of HRA*
  - *(Decomposition, positive dependency, quantification, applicability to extreme events)*
- *Extend checkout beyond USNRC HQ and National Labs*
- *Should worksheets indicate pre- versus post-initiator distinction?*
- *Working with EPRI*

The Idaho National Engineering and Environmental Laboratory

END

Human Factors Research Program

ACRS HF/PRA Subcommittees

John Flack

J. Persensky

Oct. 9, 2003

1

Agenda

- Background
- Status of RES Human Performance Activities
  - Standard Review Plan
  - New Reactors
  - Halden Reactor Project
  - Risk Communications
  - Support to others
- Follow-up on ACRS Safety Culture Workshop
  - Background
  - International activities
  - Other activities
  - Theoretical underpinnings
  - Performance indicators

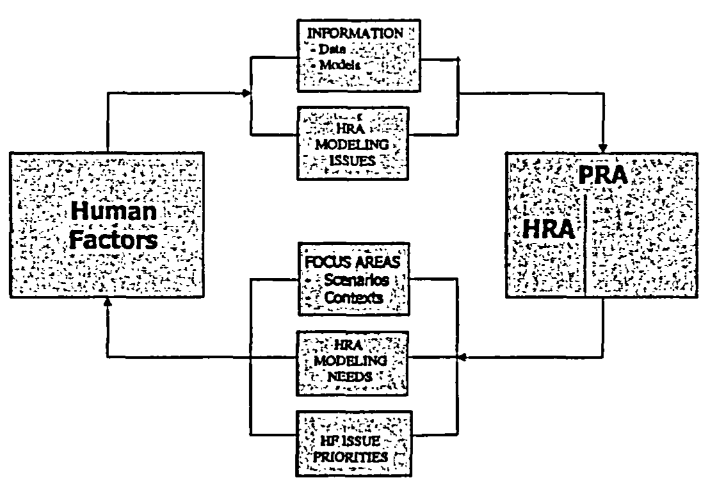
2

Background – Human Performance Program

- SECY- 00-0053, Feb. 20, 2000
  - Last formal program description
- SECY-01-0196, Nov. 1, 2001
  - Sunset program as independent document
- Oct 2002 HRA/HF Briefing
  - Described interface between HRA and HF

3

HRA/HF Relationship



4

SRP Revisions

- Chapter 18 - Human Factors Engineering
  - NUREG-0711, Rev. 1
  - NUREG-0700, Rev. 2
  - NUREG-1764
- Chapter 19 – Probabilistic Risk Assessment
  - NUREG-1764
- Scheduled for ACRS discussion Nov/Dec
- NUREG-0700 activities will be sunset

5

New Reactors

- Staffing
  - Function-based approach to 10CFR50.54(m)
  - Use of human behavioral modeling as a review tool
  - SRP Chapter 18 revision, NUREG
  - Will be scheduled for ACRS discussion early 2004
- Insights Report on the Role of Human Performance in Advanced Reactors

6

Insights Report on the Role of Human Performance in Advanced Reactors

- Objective is to provide insights on the role of human performance in advanced reactor performance from a safety perspective
  - Identify human performance issues associated with operation and maintenance that require research
  - Are new research facilities needed
  - Will new regulatory review guidance be needed
- Approach
  - Examine Concept of Operations and the Role of Automation
  - Review Existing Requirements
  - Identify gaps in regulations and guidance
  - Review Existing Human Performance Research Facilities

Insights Report- Overview of Interim Findings

- Lessons learned from human interaction with advanced, computer-based nuclear and non-nuclear systems
  - Impact on human performance is not obvious for advanced systems
  - New technology can be poorly designed from a HFE standpoint
  - New technology has unanticipated consequences
  - Personnel do not use HSIs in the way designers expect
  - Computer-based systems may change staffing, qualifications and training requirements
- New reactor concepts will significantly change human interaction
  - New concepts of operations (functional staffing models)
  - New failure modes of advanced automation and control technologies
  - New highly-integrated and intelligent HSIs that support high-level supervisory role of operations
  - New applications of technology to maintenance decision making, planning, and execution
  - Proper role and integration of more intelligent aids

Halden Reactor Project

- Simulator experimental research to collect empirical evidence on:
  - Factors influencing human performance in control room environments
  - Human system interfaces of advanced technologies and control room design to provide technical basis for guidelines
- Data for improved quantification of HRA
- Plant monitoring and operation and maintenance optimisation
  - Develop system solutions improving plant performance, availability and operational safety
- Annual summer schools educate HRP members
- Workshops and meetings on current research solicit members input
  - Innovative Human-System Interfaces and their Evaluation
  - Knowledge management

9

Risk Communications

- Guidance for use by staff when interacting with stakeholders
- Based on academic knowledge, practical experience, and best practices from other agencies/applications
- Modified for NRC environment

10

General Support to Others

- Fatigue rulemaking
- Fatigue Orders for security staff
- Davis-Besse Safety Culture inspection
- Best Practices guide for Safety Conscious Work Environment
- Human Factors review of MOX and Gas Centrifuge facilities

11

FY04 Activities

- **Guidance development for NRR**
- **Guidance development for NSIR**
- **Human Factors for new reactors Gaps from Insights report**
- **MOX and Gas Centrifuge Facility licensing**
- **Risk communications**
- **Halden Reactor Project**
- **Management of undocumented expert knowledge**
- **Human performance safety indicator**

12

Safety Culture: Follow-up to ACRS Workshop

- Background
- International Activities
- Other Activities
- Theoretical Underpinnings
- Performance Indicators

13

Background

- SRM-SECY-98-059, Options for assessing the performance or competence of management
  - Infer licensee management performance
  - Do not use licensee management performance or competency as leading indicator
  - Eliminated resources directed at developing a systematic method for inferring licensee management performance
- SRM-SECY-98-176, Options for assessing licensee SCWE
  - Continue policy of case-by-case assessment
  - Encourage or order self or third party assessment
- SECY-00-0053, NRC Program on Human Performance
  - Staff will continue to monitor and participate in industry and international activities
- SRM-SECY-02-0166, Options for revising NRC's process for handling discrimination
  - Continue to monitor efforts to measure and regulate safety culture
  - Objective measures that serve as indicators of problems with safety culture

14

ACRS Workshop

- Input from staff and major stakeholders
- Staff indicated that though we do have means to assess several of the aspects of safety culture we do not have a method to bring these together into a single assessment
- ACRS July 16, 2003
  - The existing regulations provide an appropriate framework for monitoring the impact of licensee safety culture on performance
- NRC Response Aug. 21, 2003
  - Monitoring international and domestic events and activities to develop objective measures will serve as a cross-check in confirming the appropriateness of the regulatory framework

15

International activities

- IAEA
  - **Workshop on Nuclear Safety Management and Safety Culture: Lessons Learned from Recent Events, June 2003**
  - **Technical meeting on the Role of the Regulator in Safety Culture, Sept. 2003**
  - **Consultant's meeting on Performance Indicators for safety culture, Sept. 2003**
- NEA – SEGHOF –Oct 2003
  - **Scientific approaches to safety management: state-of-the-art and workshop report**
  - **Technical opinion paper on Management of Change**
  - **Strategic plan – Organizational issues and safety management is a major element**

16

Other Activities

- INPO
  - SOER 02-04, Nov. 11, 2002
    - All plants doing self-assessments
  - Enhanced focus of Plant Evaluation reviews
- NASA
  - Columbia Accident Investigation Board report

    "NASA's organizational culture and structure had as much to do with this accident as the external tank foam"

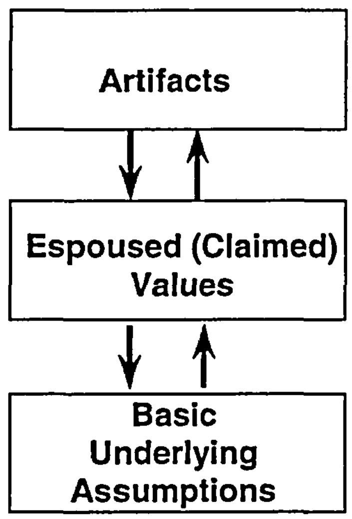
17

Safety Culture – Theoretical Underpinnings

- Schein
- Helmreich & Merritt

18

Schein Model of Safety Culture



Visible products,behaviors, organizational structures and processes

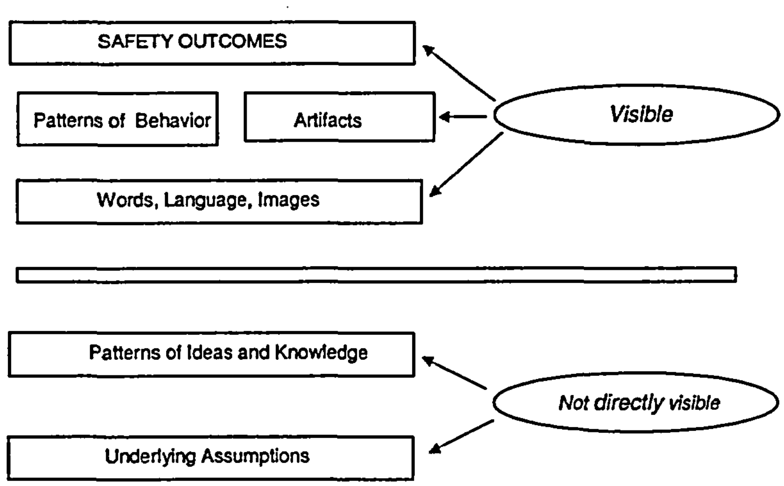
Strategies, goals, philosophies

Unconscious, taken-for-granted beliefs, perceptions, thoughts, and feelings

Schein, 1992

19

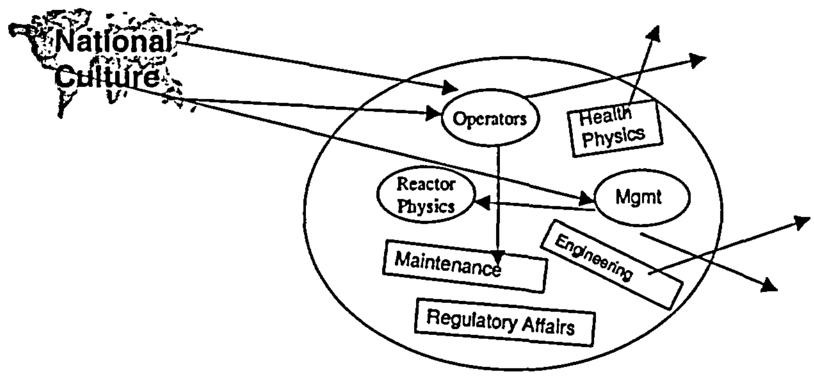
Structure of Safety Culture - Levels of Analysis



IAEA, 2003

20

Discordant organizational culture

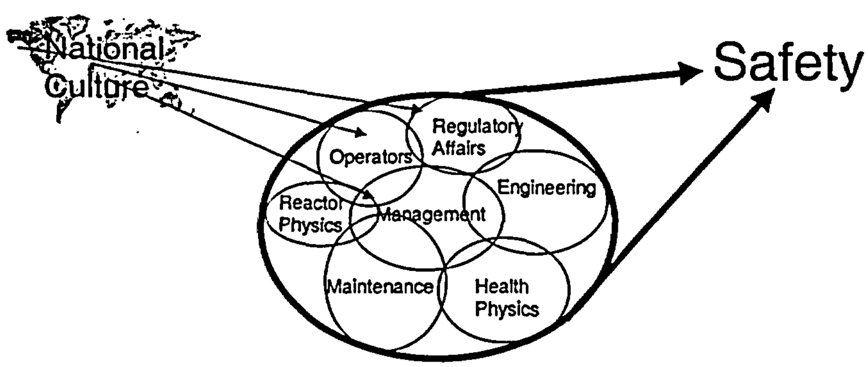


Reactor operators are 'divorced' from management
Senior operators are not good role models
'Blame and punish' approach to error
Inter-group conflict and divisiveness
Safety is uncoordinated and haphazard

Adapted from Schein, 1966

21

Integrated Organizational Culture

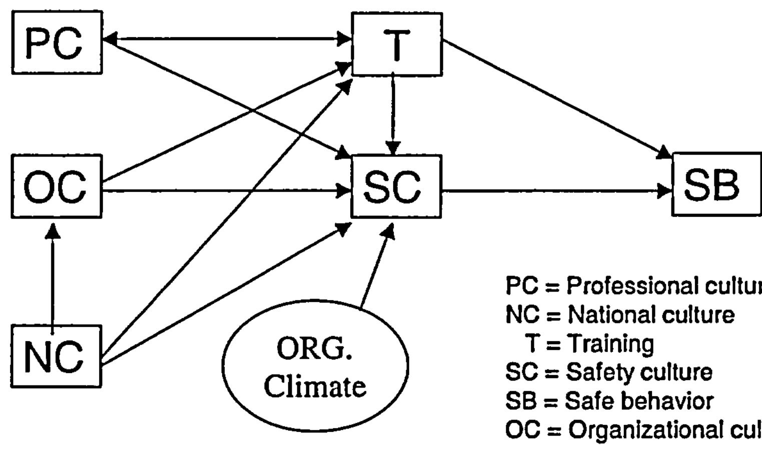


Management provides unifying leadership
Subcultures exist but cooperate
All groups strive toward same goal

Adapted from Schein, 1966

22

A Model of the Intersection of Cultures and their Outcomes

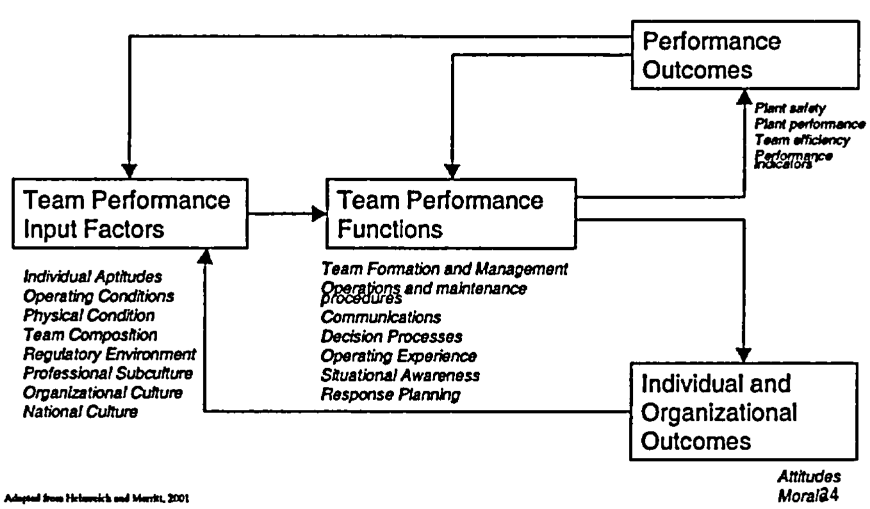


PC = Professional culture
NC = National culture
T = Training
SC = Safety culture
SB = Safe behavior
OC = Organizational culture

Adapted from Helmreich and Merritt, 2001

23

A model of nuclear power plant operator team performance



Adapted from Helmreich and Merritt, 2001

24

Potential Performance Indicators - CAP

- Percent issue identification
  - Self-identified
  - Self-revealing
  - Externally identified (QA/INPO/NRC)
- Issue history
  - Time in compromised state
  - Time to respond
  - Risk significance
- Condition report accuracy
- Root cause evaluation accuracy .
- Timeliness of CA completion
- Percent CR/person/group
- CA resolution rate
- Outstanding SRO evaluations of CRs

25

Potential Performance Indicators - SCWE

- Volume and trend of NRC allegations
- Volume and trend of internally raised concerns
- Volume and trend of NRC retaliation allegations
- Volume and trend of internally raised retaliation concerns
- Percent of anonymous concerns
- Backlog of concerns
- Percent of employees who are aware of and understand SCWE policy
- Percent of employees who understand their responsibility to raise safety concerns
- Percent of employees willing to raise safety concerns
- Breach of confidence
- Survey of ECP satisfaction/effectiveness

26

Potential Performance Indicators – Human Performance

- Individual error rate
- Human error resulting in plant transient
- Initial and requal exam failure rates
- Number of events during plant evolutions
- Rework rate
- Results of management observations
- Program and process error rate
- Number of workarounds/Duration of workaround
- Outstanding procedure change requests
- Number of temporary modifications/Duration
- Industrial safety performance

27

Other Open Questions

- Measurement
- Criteria/Thresholds
- Risk Implications
- Regulatory Approach

28

United States Nuclear Regulatory Commission

Digital Instrumentation and Control Research and Digital Systems Risk

Steven A. Arndt
Division of Engineering Technology
Office of Nuclear Regulatory Research

October 9, 2003

OVERVIEW

- REVIEW OF DIGITAL I&C RESEARCH PROGAM
- PROGRAM EXTERNAL DRIVERS
- RESEARCH AREAS
- NEW REACTORS
- FUTURE PLANS
- SUMMARY

DIGITAL I&C RESEACH PLAN

- SECY-01-0155 NRC Digital Instrumentation and Control Research Plan Published in August 2001
- Answered the Need, Highlighted in the NAS Review, for more Systematic Approach to Developing New Information and Regulatory Guidance
- Endorses by the ACRS and Commission
- Includes Research in Four Major Areas

I&C Research Program Goals

- I&C Research Program has the goal of improving decision making by increasing the efficiency, effectiveness and realism
- In support of this goal
  - Develop more consistent approach to assessment
  - Develop more effective analysis tools
  - Develop new guidance and update existing guidance as appropriate (for example new version of RG 1.168 on Verification, Validation, Reviews and Audits for Digital Computer Software)
  - Support user requests

PROGRAM EXTERNAL DRIVERS

- NRR User Need, Provided in March, 2000 and Reaffirmed in July, 2002
- DOE I&C and HMI Working group Recommendations, May, 2002
- Halden Workshop on Digital System Reliability, December, 2002
- EPRI D3 Working Group establish, 2002

United States Nuclear Regulatory Commission

DIGITAL I&C RESEACH PROGRAM

- Four Major Program Areas
- System Aspects of Digital Technology
  - *Environmental Stressors*
  - *Digital Requirement Specifications*
  - *Diagnostics and Fault- Tolerance*
  - *Operating Systems*
- Software Quality Assurance.
  - *Objective software engineering criteria*
  - *Criteria for software testing*

United States Nuclear Regulatory Commission

DIGITAL I&C RESEARH PROGRAM

- Emerging I&C Technology and Applications
  - *Predictive maintenance and on- line monitoring systems*
  - *Advanced instrumentation*
  - *Smart transmitters*
  - *Wireless communication*
  - *Computer security*
  - *Technology Review and Infrastructure including; developing and maintain interactions and interfaces, standards work and the review new technology*

DIGITAL I&C RESEARH PROGRAM

- Risk Assessment of Digital I&C Systems
  - *Digital I&C Failure Data*
  - *Digital Failure Assessment Methods and System Models*
  - *Digital Reliability Assessment Methods and Integration in PRA's*
  - *Digital System Risk Guidance*

WHAT IS NEEDED IN DIGITAL SYSTEM PRA's

- Research is Needed to Develop an Acceptable Method for Review of Digital System Reliability Models
- Required is:
  - Understanding of the state of the data
  - Understanding of the strengths and limitations of system models
  - Understanding of how digital system models can be incorporated into nuclear plant PRA's
  - Guidance for what is acceptable

DIGITAL I&C FAILURE DATA

- Several studies have been done on available data from other fields (MIL-HDBK 217F, NUREG/CR-6734, Telcordia, LER database, etc)
- Some analysis has been done to show general trends in numbers and types of failures
- There is a need to develop agreed upon methods for analysis of limited data and integration of data from other domains

United States Nuclear Regulatory Commission

DIGITAL I&C FAILURE DATA (Cont.)

- Research program to develop in-house database for RES analysis and use
- COMPSIS international database
- EPRI interested in working with NRC in this area
- BNL review of the strengths and weakness of existing databases in terms of their use in reliability modeling

Digital Failure Assessment Methods and System Models

- Several Methods Currently Being Investigated
  - University of Virginia Fault Injection Methodology
  - University of Maryland Software Metric Methodology
  - Halden BBN and Model Based Reliability Research
  - RETRANS tool
  - FMEA (BNL)

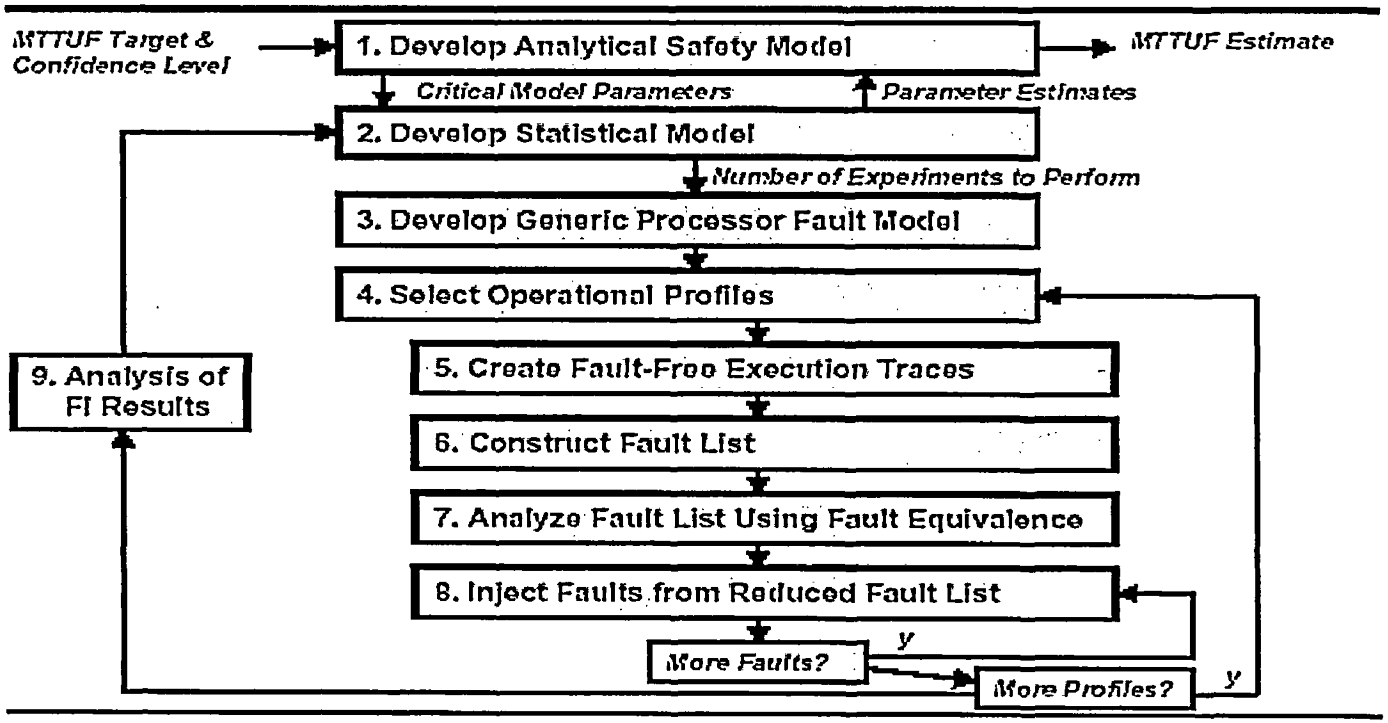
Digital Failure Assessment Methods and System Models (Cont.)

- University of Virginia
  - Based on digital system coverage
  - Uses detailed system modeling and fault injection as a method to estimate mean time to unsafe failure
  - Has been successfully use in other domains
  - Calvert Cliffs Main Feed Water demonstration project

United States Nuclear Regulatory Commission

Digital Failure Assessment Methods and System Models (Cont.)

Coverage Estimation Process Overview

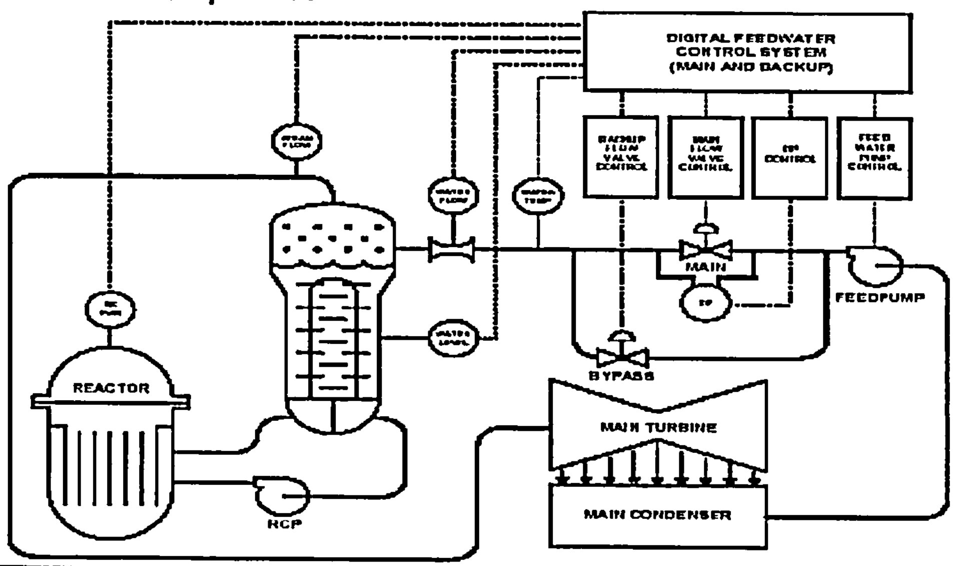


United States Nuclear Regulatory Commission

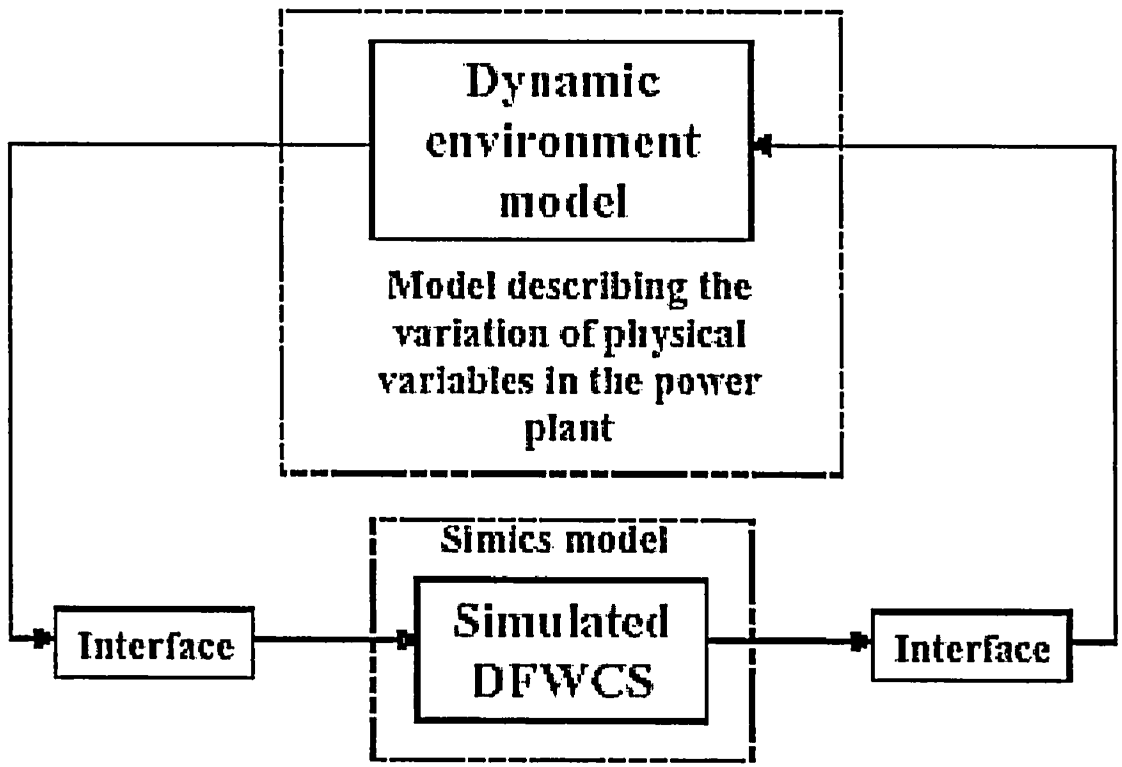
Digital Failure Assessment Methods and System Models (Cont.)

Overview of Calvert Cliffs DFWCS

- Purpose: control the water level in its associated steam generator from ~1% to 100% power

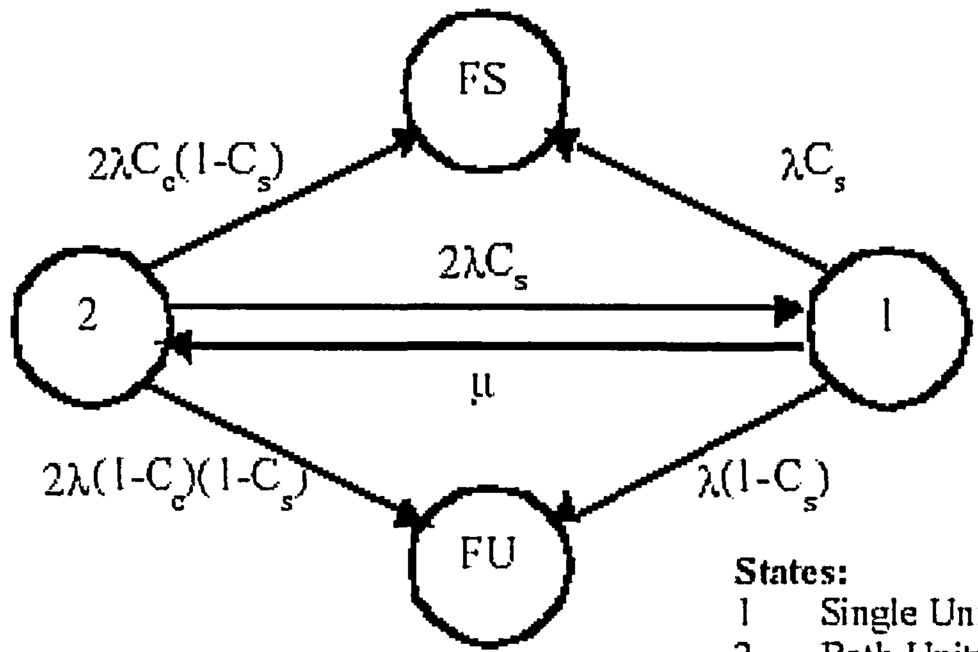


Digital Failure Assessment Methods and System Models (Cont.)



United States Nuclear Regulatory Commission

Digital Failure Assessment Methods and System Models (Cont.)



States:
1 Single Unit Operational
2 Both Units Operational
FS Failed-Safe
FU Failed-Unsafe

Digital Failure Assessment Methods and System Models (Cont.)

- Assume λ = 100 failures/million hours

Controller: C_s	Compare: C_c	MTTUF, hrs	S_{ss}
0.8	0.9	72,200	0.82
0.9	0.9	140,000	0.90
0.99	0.9	1,367,000	0.989
0.8	0.99	80,200	0.84
0.9	0.99	153,800	0.91
0.99	0.99	1,490,000	0.99

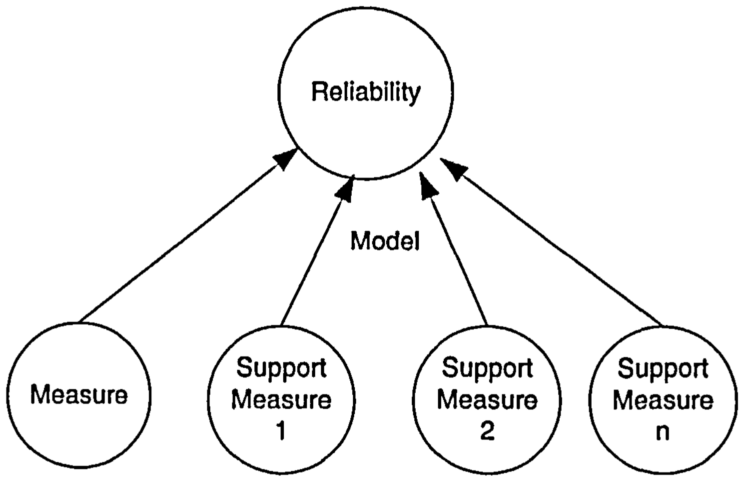
- Safety assessment process will focus on estimating C_s by injecting faults into the main DFWCS controller

Digital Failure Assessment Methods and System Models (Cont.)

- University of Maryland
  - Development of Software Reliability Prediction Methods
    - How software reliability is determined?
    - Product characteristics
      - Project characteristics
      - Development characteristics
    - Operational environment
  - Software engineering determine software reliability

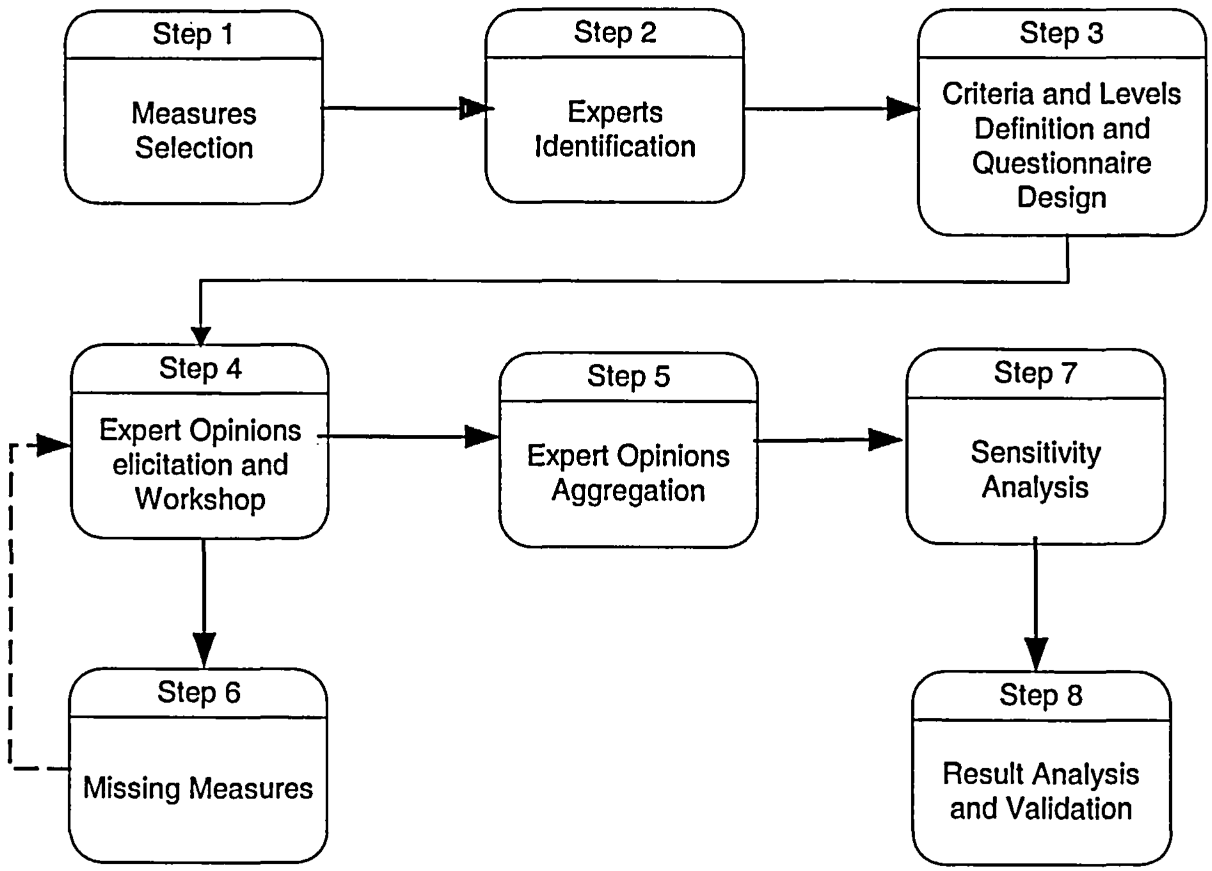
Digital Failure Assessment Methods and System Models (Cont.)

Reliability Prediction System (RPS)



5

Digital Failure Assessment Methods and System Models (Cont.)



Digital Failure Assessment Methods and System Models (Cont.)

Pre-selected Measures

Bugs per line of code (Gaffney estimate)
Cause & effect graphing
Code defect density
Cohesion
Completeness
Cumulative failure profile
Cyclomatic complexity
Data flow complexity
Design defect density
Error distribution
Failure rate
Fault density
Fault number days
Feature point analysis
Function point analysis
Functional test coverage
Graph-theoretic static architecture complexity
Man hours per major defect detected
Mean time to failure
Minimal unit test case determination
Modular test coverage
Mutation testing (error seeding)
Number of faults remaining (error seeding)
Requirements compliance
Requirements specification change requests
Requirements traceability
Reviews, inspections and walkthroughs
Software capability maturity model
System design complexity
Test coverage

Digital Failure Assessment Methods and System Models (Cont.)

Validation Results

Measure	Value	The number of Unresolved Defects	p_s	Pc	Original Rankings	Validation Rankings
Mean time to failure	1267.6 seconds	N/A	0.91849	0.029643	1	1
Defect density	11.72 defects/KLOC	9	0.92243	0.076548	2	2
Test coverage	94.6%	5 (4.8)	0.908	0.095238	3	4
Requirements traceability	78.6%	7	0.92243	0.076548	4	3
Function point	75.0	6 (5.6)	0.9980385	0.976649	5	5
Bugs per line of code (Gaffney estimate)	66 (65.6) defects	66 (65.6)	0.999972	0.999667	6	6
p_s(real)	0.916					

Digital Failure Assessment Methods and System Models (Cont.)

- BNL work to develop methods and tools needed to model digital systems in PRA
  - Capture the unique characteristics of digital systems
  - Use FMEA to evaluate digital features and identify the unique dependencies
  - Evaluate existing data bases and determine their suitability in supporting reliability modeling

Digital Reliability Assessment Methods and Integration in PRA's

- FMEA of Digital Features
  - Detailed FMEA
  - Develop description of the systems
  - Develop reliability block diagrams including digital feature and connections
  - Use current NPP systems (Common Q, Tricon, Teleperm, ABWR)
  - Review of unrecognized dependencies, fault tolerant features and level of detail need in modeling

United States Nuclear Regulatory Commission

Digital Reliability Assessment Methods and Integration in PRA's (Cont.)

- New program in FY 04 to look at integration issues and develop some technical consensus
- Develop pilot program for digital reliability methods in PRA's
- Assess the feasibility of using current models as "plug-ins" to current generation static PRA's

Digital System Risk Guidance

- Guidance on how to assess risk informed applications in the area of digital systems
  - Review of existing guidance
  - Development of guidance for the methods, data, and quality of analysis
  - Development of guidance for the completeness and scope of the analysis
  - Will used information developed by BNL as starting point

New Reactors

- First project on Lessons Learned from Evolutionary plants
  - Review of technical and regulatory issues encountered in new reactor construction around the world
  - Development of research questions for new reactors using current NRC regulations
  - Results include, new environments, advanced control systems, dependability features

New Reactors (Cont.)

- FY 04 project on development of risk models
- Other projects, in research program but not yet funded include:
  - Review of issues associated with multi-module plants
  - Autonomous control
  - New instruments, and advanced diagnostics

FUTURE PLANS

- Work to Complete the Demonstration Projects
  - University of Virginia, work on RPS
  - University of Maryland, work on RPS
- New Projects On Reliability Assessment Methods and Integration in PRA's and Guidance
- More Active International Cooperation in the Digital Systems Risk Area
  - Database Development
  - Halden Research
  - International Program
- New Reactors

FUTURE PLAN (Cont.)

- PRA Integration
  - Development of test cases and peer reviews
- Guidance Development
  - Review of risk informed I&C submittals
  - Input to other guidance
- New Digital I&C Research Plan

SUMMARY

- Current Research Program Includes Several Project on Digital System Risk
- Research is Focused in Several Areas, Including, Model Development, Data Collection and Guidance Development
- Several Programs being demonstrated with nuclear power plant systems
- Industry and the International Community are also moving forward in this Area

U.S. Nuclear Regulatory Commission

PRESENTATION TO ACRS SUBCOMMITTEE ON EARTH SCIENCES & EARTHQUAKE ENGINEERING RESEARCH

Andrew J. Murphy, DET/RES
301-415-6011

October 9, 2003

Outline

- Seismic Program Contribution to NRC Performance Goals
- Earth Sciences
  - Research
  - Regulatory Guidance
- Earthquake Engineering
  - Research
  - Regulatory Guidance
- Continuing & Emerging Issues

Program Contribution to Performance Goals

- Make NRC activities & decisions more effective, efficient & realistic
- Reduce unnecessary burden on stakeholders

Earth Sciences

- U.S. Geological Survey
- Univ. of California at Santa Barbara
- Update of Probabilistic Seismic Hazard
- Code Benchmarking & IAEA CRP
- Regulatory Guides

US Geological Survey

- Cooperative Agreement for Research
  - Areal Screening of Liquefaction Hazards
  - Fault Segmentation in Evaluating Fault-Specific Earthquake Potential
  - Re-evaluation of ground motion models for central & eastern US & Canada
  - Recurrence & Uncertainty in central US earthquakes

UC Santa Barbara

- Garner Valley Downhole Seismic Array
- Initiated by NRC – now part of a major NSF program
  - Seismic array
  - Pore pressure array
  - SFSI Structure
  - Active Component
    - Shaker for frequency response
    - Shaker induced liquefaction

SSHAC Update

- Ten-Year Update of Probabilistic Seismic Hazard Estimates
  - SOC for Appendix A rulemaking
  - Two estimates still an issue
  - Evaluation of USGS 2003 methodology & estimates
    - Work initiated in August, 2003
    - Preliminary estimate at end of CY 2003
    - Staff evaluation in late Spring 2004
    - Staff recommendation on how to proceed Summer 2004

U.S. Nuclear Regulatory Commission

Earth Science Research (cont.)

- Hazard Code Benchmarking
- IAEA Coordinated Research Project
  - Effects of Near-Field Ground Motion

U.S. Nuclear Regulatory Commission

Regulatory Guides

- R.G. 1.132 – "Site Investigations for Foundations of Nuclear Power Plants"
- R.G. 1.138 – "Laboratory Investigations of Soils and Rocks for Engineering Analysis and Design of Nuclear Power Plants"
- R.G. 1.198 – "Procedures and Criteria for Assessing Seismic Soil Liquefaction at Nuclear Power Plants"

Earthquake Engineering

- NUPEC Collaboration on Seismic Issues
- Seismic Response of Containments with NUPEC
- Assessment of Degraded Structures & Components
- Soil-Structure Interaction for Buried Structures

Earthquake Engineering (cont.)

- Support for NMSS
  - Seismic Response for Dry Storage Casks
  - Dry Cask PRA
  - MOX Facility Review

Collaboration with Japan

- Soil Structure Interaction Program
- Concrete Shear Wall Test Program
- Energy Absorbing Supports Program
- Equipment Fragility Test Program
- Seismic Response of Containments
- NUPEC has been reorganized
  - Two new units

U.S. Nuclear Regulatory Commission

Earthquake Engineering

- Regulatory Guides
  - R.G. 1.92 – "Combining Modal Responses and Spatial Components in Seismic Response Analysis"

Continuing & Emerging Issues

- New Data &Interpretations
  - East Tennessee Seismic Zone (GSI - 194)
  - Implications of Recent Earthquakes – Turkey & Taiwan
  - Coordination of New PSHAs - US GS & EPRI
    - Evaluation & Use
- New Technology
  - Buried or Deeply Embedded Structures
    - Ground Motion Input Guidance
    - Soil-Structure Interactions – Building & Interconnects
  - Fragility of New Structures & Components