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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

November 17, 2005

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS (ACRS)

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RELIABILITY & PROBABILISTIC RISK ASSESSMENT

SUBCOMMITTEE MEETING

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THURSDAY,

NOVEMBER 17, 2005

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The meeting was convened in Room T-2B3 of Two White Flint North, 11545 Rockville Pike, Rockville, Maryland, at 8:30 a.m., Dr. George E. Apostolakis, Subcommittee Chairman, presiding.

MEMBERS PRESENT:

GEORGE E. APOSTOLAKIS	Chairman
MARIO V. BONACA	ACRS Member
RICHARD S. DENNING	ACRS Member
THOMAS S. KRESS	ACRS Member

ACRS STAFF PRESENT:

ERIC A. THORNSBURY	ACRS Staff, Designated Federal Official

ACRS STAFF PRESENT (Continued):

ASHOK C. THADANI	Deputy Executive Director, ACRS/ACNW

NRC STAFF PRESENT:

CHARLES ADER	RES/DRAA
PETER APPIGNANI	RES/DRAA/OERAB
MICHAEL CHEOK	RES/DRAA/OERAB
NILESH CHOKSHI	RES/DRAA/OERAB
DON DUBE	RES/DRAA/OERAB
ELI GOLDFEIZ	RES/DRAA/OERAB
CHAD HUFFMAN	RES/DRAA/OERAB
CHRIS HUNTER	RES/DRAA/OERAB
STEVE LONG	NRR/DRA
DON MARKSBERRY	RES/DRAA/OERAB
JEFF MITMAN	RES/DRAA/OERAB
LYNN MROWCA	NRR/DRA/APOB
DAN O'NEAL	RES/DRAA/PRAB
JAMES VAIL	NRR/DRA/APOB

ALSO PRESENT:

ROBERT BUELL	Idaho National Laboratory
STEVE EIDE	Idaho National Laboratory
JOHN SCHROEDER	Idaho National Laboratory

C O N T E N T S

PROCEEDINGS

(8:33 a.m.)

CHAIRMAN APOSTOLAKIS: The meeting will now come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards, Subcommittee on Reliability and Probabilistic Risk Assessment.

I am George Apostolakis, Chairman of the subcommittee.

Members in attendance are Mario Bonaca, Rich Denning, and Tom Kress.

The purpose of this meeting is to discuss the standardized plant analysis risk model development program. The subcommittee will gather information, analyze relevant issues and facts, and formulate proposed positions and actions, as appropriate, for deliberation by the full committee.

Eric Thornsbury 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 November 1, 2005. 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.

We will now proceed with the meeting, and I call upon Mr. Nilesh Chokshi to begin the presentations.

MR. CHOKSHI: Thank you.

And I would like to begin by thanking the committee for reviewing our station blackout study as a part of the SPAR model development program and giving us feedback with respect to fire attributes which are used by the committee in the evaluation.

I think in going forward not only on this project, but in other SPAR model developments, this experience will serve us well in looking at the fire attributes and use them as a bench product against theoretically to measure our progress and monitor, you know, how we are meeting those fire attributes. I think it will serve as a good check as we move forward.

I also want to thank you for giving us opportunity to discuss SPAR models development in detail, I think, and this is really a good time for us to do that as we are in the formative stages in several areas of model development. I think as you will go through the presentation, you will see that.

As you will see here, we're going to cover the full spectrum of the SPAR model developments, internal events, external events, LERF, low power shutdown, and they are at varying stages. You know, they are in varying stages in their degree of maturity and in their sophistication.

I think as, again, the committee noted in the quality report, the SPAR model development is making use of the existing state of the art and is very closely tied to the plant specific plant PRA models. So one of the key factors in development of models is the availability of the plant models and the nature of these models.

So as a result, I think in each of these areas there are different types of challenges, you know, in terms of what technical approach to be used, how to develop models where there are no plant specific models available, and what do you do about the performing QS, the approach used and internally arranged was a bit different because of the availability of models, the maturity of the practice is much developed.

So I think we are looking forward to getting feedback on some of these challenges and thoughts, you know, as you move along the development of these other areas.

What I would like to do is now introduce the team which is going to be up here today and tomorrow, and from the staff you'll have the principal staff members who are project managers in each of the technical areas.

I think, as you know, Dr. Pat O'Reilly for many years led the staff team, you know, in this and also the oral SPAR model development program.

Don Marksberry is here, and I think he has taken over that responsibility.

We also have principals from the Idaho National Laboratory and Brookhaven who will give detailed presentations on some of the aspects, and I think it's leading off at the level of internal events. I think it's very important. You'll see a lot of details and how that is being developed.

So from the staff we have Don Marksberry. Selim Sancaktar is going to talk about external events. Eli Goldfeiz is living the live model development, and Jeff Mitman will join us, just simply the branch, and he's leading the low part in shutdown effort.

And from Idaho, we have Dr. Buell and Dr. Schroeder. Schroeder doesn't talk about the leaders of the internal events.

And Dr. Lehner will be here tomorrow.

Mike Cheok is going to lead off the presentation with all of you. We also have Don Dube, and we would like to give you some perspective on lessons learned from the use of SPAR models in the MSPI activities, and I think Mike is going to discuss that as sort of an area I don't what to agenda.

I think I'd like to before I have Mike talk about the overview, I'd like to make one point. I think to me it's very important. You know, people you are going to hear from and today I introduced, they are the project managers, and they are obviously in each of the model development, but there are many other contributors in terms of many activities, you know, directly or indirectly.

And also as Mike is going to very shortly -- this is a very integrated effort involving SPAR model and input development, which you are not talking today, and also the strong user application interface and feedback mechanism.

Everything I think we do in my branch, offering expert evaluation is very closely tied to the SPAR models. So you'll see that, and you will see clearly when Mike shows what we do and how these thing are. So it just follows you throughout.

And so it's integrated. So I think hopefully when we go through these presentations, you will see some of the perspectives clearly, and with that, Mike.

MR. CHEOK: Good morning. We'll be touching upon a lot of topics, as you see, and these topics are, I guess, preagreed upon in our agenda. The one new topic that Nilesh touched upon is the one on the MSPI lessons learned.

The agency currently is implementing the mitigating systems performance index. As part of this implementation, we are doing a review of the licensee's PRAs and comparing the results from those PRAs to SPAR models, and as a result of this comparison, we are coming up with a lot of good insights and lessons learned, and we would like to share this with this committee.

So if you would like, we would like to a half an hour slot with Don Dube to discuss the MSPI lessons learned.

CHAIRMAN APOSTOLAKIS: You say you are comparing your results with those of licensees, PRAs. I thought you are doing it routinely as part of the SPAR development. So what is this comparison?

MR. CHEOK: We are doing that anyway, and we will discuss some of our QA activities as part of Idaho's discussions today. What we're doing in the normal basis is going to the plants, looking at their PRAs, and now looking at their cut sets and comparing cut sets.

This is another level of detail. We're looking at influence measures. The bow and bar (phonetic) measures that are used in MSPI, and they give us a different perspective as to what components in the plant can become important.

And in theory if you compare the high level cut sets, you would be looking at perhaps the top 90 to 95 percent of your CDF for some initiating events that will not contribute as much to your CDF, but they could have components that could become important, and they will show up in your (unintelligible) importances (phonetic).

We do not see that many differences, but the differences we do see are quite enlightening.

MR. DENNING: the answer to the question, George though is probably yes, right? We do want to hear the MSPI.

CHAIRMAN APOSTOLAKIS: Especially from Dube.

MR. CHEOK: All right. What are SPAR models? SPAR models are small event trees, large fault PRA models. They are plant specific in that they model plant specific system configurations, and to a certain extent they model small --

CHAIRMAN APOSTOLAKIS: What did you say? You said model fault trees? Say it again.

MR. CHEOK: They are small event trees and large fault trees. So they're similar to the cap during a neutral models and not quite similar to the risk MAN models. They are standardized in other areas, and we will discuss the standardization later on today with INL.

We used the SPAR-H methodology to estimate human error probabilities, and we will discuss SPAR-H in December, in a December subcommittee meeting. Component failures and initiating event probabilities and frequencies are based on national generic plant experience data for older models.

We would like to point out that the purpose of the SPAR model development program is to provide the NRC staff with literally available and easy to use PRA models for use in performing risk informed regulatory activities, and that's basically our sole objective of the program.

CHAIRMAN APOSTOLAKIS: So the idea was that the complete PRAs are not easy to use; is that the point?

MR. CHEOK: Well, we are not saying the complete PRA is not easy to use, and I wouldn't even imply that the SPAR models are not complete PRAs. I would like to think that they are complete PRAs. They are standardized and they have similar methodologies. Thereby the staff can now, if you're familiar, one SPAR model you can use it for all 72 plants. You do not have to use different methodologies for each different plant. You do not --

CHAIRMAN APOSTOLAKIS: What would be the difference, say, between two PRAs that the SPAR model would eliminate and standardized? Would one PRA be produced by risk MAN so it has huge event trees and small fault trees, and you do your SPAR model for that plant or you switch the other way? Is that one of the differences you are eliminating?

MR. CHEOK: That's one of the differences we eliminate.

CHAIRMAN APOSTOLAKIS: Are there any others?

MR. CHEOK: Well, the other differences would be how people would classify the basic events, the terminology, how you would enter the standard methodologies as to how we would classify basic events by the component name, the tag number, and failure mode. Other different plants and utilities would have different terminology that we would have to learn, same with initiating events, human failure events.

The other things would be the standardization, and we'll talk about this later on. It would be the standard success criteria that we would use. We would have you assume two out of two PORVs, for example, for feed and bleed.

The licensees may use other models to justify perhaps one out of two PORVs for feed and bleed.

CHAIRMAN APOSTOLAKIS: But is there any detail in the licensee's PRA that is not inspired?

MR. CHEOK: The licensee's PRAs would tend to be a little bit more detailed than SPAR in terms of breaking down a system into different components. We may not be as detailed in terms of the number of basic events in the whole model, but we will capture all of the main initiators and during our plant visits, and during the MSPI evaluation process, we would add support system initiators that are important.

MR. DENNING: Is it the human reliability analysis you would expect to be in more detail or more specific for the utilities PRA or is that not true?

MR. CHEOK: We would expect that the utility PRAs would be more detailed than ours because they will have access to their own EOPs and plant procedures that we may not have access to.

MR. DENNING: And component failure data, you didn't mention that, but that is another.

MR. CHEOK: Correct. The other thing, the utilities would use plant specific data. We would use our generic data for the whole industry for each plant mode.

CHAIRMAN APOSTOLAKIS: Why?

MR. CHEOK: I think in a sense, that's part of our standardization objective when we want to compare results across the 72 plants. We would like to think that it's not being influenced at this point by plant specific data. We can obviously incorporate plant specific data into our models, and we have done that on event specific cases doing ASP analysis. When we are analyzing a very specific event, we will apply plant specific data if we think that it's appropriate.

CHAIRMAN APOSTOLAKIS: I mean, this comparison across the industry is not very clear to me because you can compare on the basis of CDF and LERF, and the dominant contributors. You don't have to have the same component failure distributions to say, oh, now they're comparable. I mean, you do have the two major metrics. So you could compare that way.

I mean, the whole idea is to have plant specific PRAs, isn't it? The standardization can go only so far.

MR. CHEOK: Well, we are trying to achieve an optimum balance between standardization and being plant specific, and I think -- and I don't want to steal too much thunder from our INL staff. They will discuss standardization to a lot bigger degree than I am doing now, and I will sit in the side and we will discuss this again later when they come up.

CHAIRMAN APOSTOLAKIS: Rich, did you want to say something?

MR. DENNING: Yeah, I'll say it now. I'm sure we're going to come back to it. I think it's really a very interesting philosophical question as to what the best direction is here, and at least from where I'm sitting now, I really like the idea of using the generic data, but with sensitivity studies.

You know, you do the generic study and then you look and see what did the plant itself really predict for the similar thing, and then you try to understand what the reasons are for the differences.

But again, I'm sure this is something that's going to be an important philosophical question for us.

CHAIRMAN APOSTOLAKIS: The generic data may not apply to that plant.

MR. DENNING: Well, that's true, and I think with sensitivity studies, I think you always go back and try to understand, well, what's the difference between --

MR. CHOKSHI: You're going to see some of these as a part of the presentation as well, this kind of comparisons, and we invite you to come back to this point, I think, after you see this.

DR. BONACA: How do you deal with updates? I mean, the plants change and they have data PRAs.

MR. CHEOK: That's an issue that we are, in essence, struggling with. We update our models each revision, Revision 2 or Revision 3 and enhanced revision. As the plants update their PRAs, there is really no requirement for them to come to us, to give us what they use for the updates.

CHAIRMAN APOSTOLAKIS: Unless you have a significant determination process.

MR. CHEOK: Correct, unless we have an SDP or an ASP finding, and they will come and tell us, "Oh, by the way, we changed this configuration and you should do it," and we will do it at that time, but there's no formal process at this point.

CHAIRMAN APOSTOLAKIS: The use of generic data, of course, eliminates the influence of safety culture, doesn't it?

MR. DENNING: Well, it certainly averages.

MR. CHEOK: I would agree that it averages since it is generic data.

All right. Evolution of SPAR models. SPAR models evolved from the two event trees we originally used as art of our ASP program. We had one event tree for PWRs and one for BWRs. In Revision 2 we basically went to a 72 model set, one for each plant site. It linked fault trees and event trees.

In Revision 3 we had support systems, more initiating events, and uncertainty analysis capability. In this case we basically have uncertainty distributions for each of our parameter estimates and subjected the models to benchmarking against the licensee's PRA.

And we are now working on low power shutdown, external events and LERF models as part of the effort.

CHAIRMAN APOSTOLAKIS: Now, all of these models are in SAPHIRE, right?

MR. CHEOK: All of these models use the SAPHIRE code engine to run. That's correct.

CHAIRMAN APOSTOLAKIS: Now, you k now that several years ago there were proposals from Franz to go to BDDs, binary decision of Bayesian decision diagrams or binary decision diagrams, and slowly that approach is catching up in this country.

I was informed that a few weeks ago there was an EPRI report that was issued on BDDs. Now, I realize that switching to a new code is going to create a lot of problems for you because you already have the models, and so on.

On the other hand, wouldn't it be a good idea to have a small project somewhere where a team of you guys looks at this new approach and decides, you know, what we're doing is good enough or we may do this ten years from now.

What bothers me about it is that, you know, a lot of people especially at conferences talk about these things, and we, the agency, seem to be oblivious to all of that or we're rejecting it out of hand.

The truth of the matter is that they claim you don't need cutoff frequencies, okay, because you can solve the exact problem. There is a price you pay for that, of course. One is that I don't believe they produce minimal cut sets automatically. You have to do some things together, which, of course, for us is a major drawback because we really want to understand the modes of failure.

But I would suggest that you gentlemen get a copy of this EPRI report. I have it electronically if you want it.

MR. CHEOK: Yeah.

CHAIRMAN APOSTOLAKIS: Oh, you have it.

MR. CHEOK: No, if you can send it.

CHAIRMAN APOSTOLAKIS: Sure. I'll give it to Eric, and maybe, you know, some time in the future next year you come back and say, "Yeah, we investigated it. We analyzed it, and we concluded A, B, C."

You may very well conclude that what you're doing is good enough, but at least we'll have some ammunition to defend it, considering, of course, the effort it would take to change all of these models out to a new code. I mean, the benefit, cost-benefit, Nilesh, I mean, these are new ideas for this agency, right?

The record should show that I was smiling when I said that.

(Laughter.)

CHAIRMAN APOSTOLAKIS: Okay, Mike.

MR. CHEOK: All right. As Nilesh said earlier, our branch does offering experience risk assessments, and this is an integrated effort. We know that we analyze data in three cuts. The first cut is at the industry-wide performance level, and we do that in terms of industry-wide performance trends.

A second cut is to provide plant specific performance indicators.

And the third cut basically is to go even one level below, and that's to analyze the risk significance of operating events. So where do we begin?

At the beginning of this chart we collect data from sources such as the licensee event reports, the monthly operating reports, the INPOs/EPICs database, and FAR events from various sources, and we do look at the ROP, reactor oversight process, input from SSUs and now MSPI.

We collect and code this data using our integrated data collection and coding system and input this data into our RADS database and our CCF database.

We also input all our data into the NRC Website to be available for all staff to use. We are in the process of putting this Web site to be available for external stakeholders.

We use this data in our SPAR models, and we use our SPAR models and our data, like I said earlier, in several programs, the industry TRANS program, the ROP, the ASP program, inspection programs, and in licensing reviews.

CHAIRMAN APOSTOLAKIS: What is RADS?

MR. CHEOK: I'm sorry?

MR. CHOKSHI: Reliability and data --

MR. CHEOK: RADS would be --

CHAIRMAN APOSTOLAKIS: Can you go back?

MR. CHEOK: Back? How do I do that?

CHAIRMAN APOSTOLAKIS: There's another arrow. One more.

MR. CHEOK: Yes. Okay. RADS?

CHAIRMAN APOSTOLAKIS: Yeah.

MR. CHEOK: RADS would be the reliability and availability data system.

CHAIRMAN APOSTOLAKIS: And availability data. Now, I think that when one implements the significance determination process, one really needs details, doesn't it? Because these are findings that are not typically in PRAs.

Is that when you take your SPAR model and then you work with a utility to make sure that that detail is there?

MR. CHEOK: We try to do that. To the extent possible we will basic -- our staff in the regions and NRR would use the SPAR models to come up with the finding, and in many cases -- I would say most cases -- it would match what the licensee would come up with.

CHAIRMAN APOSTOLAKIS: Now, this process has three phases or something.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: Phase three is the most detailed one.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: That's when the licensee possibly disagrees with you, and they want to argue that, you know, things are not the way you think.

So I assume at that level you really have to go down to the details.

MR. CHEOK: Well, not quite. Phase two is basically the use of notebooks, plant notebooks.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. CHEOK: And then phase three is when we say phase two is a little bit too conservative. Let's do a PRA model.

CHAIRMAN APOSTOLAKIS: Yeah, that's what I mean.

MR. CHEOK: And in that case we will do our own SPAR model analysis and the licensees in most cases would do their own analysis using their own models, and as I said earlier, in many cases they would actually match, and the results would be the same.

If they are not the same, then we would try to reconcile the differences, and at that point, you know, we would make changes to the SPAR models or perhaps even suggest to the licensee that their PRA models are different because of certain things.

CHAIRMAN APOSTOLAKIS: Do we know off hand how many cases like that you have? I mean, does that happen routinely or is it very rare?

MR. CHEOK: I think I'll defer this to Don Marksberry. He works a lot more with the ASP analysts.

In terms of phase three analysis, are you talking about how often we use the SPAR models or how often --

CHAIRMAN APOSTOLAKIS: How often do you disagree with a utility?

MR. CHEOK: I guess we'll get you the statistics, George, but I don't have it off the top of my head.

John. John might know.

MR. LONG: My name is Steve Long. I work in the Office of Nuclear Reactor Regulation, and I do some of the significance determination modeling.

Basically if the results are not green, we usually end up in a discussion with the licensee. A lot of the argument comes down to not what is in either the licensee's IPE or a SPAR model, but in some particular aspect that's not really a detail yet modeled and how to model that. The worse the color, the more arguments we get into, but there's quite an incentive to get a green if you're a utility company.

So there's almost always some sort of discussion back and forth on the modeling anything that's not green.

CHAIRMAN APOSTOLAKIS: So it's not that

the utility's model is more detailed. It's that usually both models don't have some detail that the utility feels is important.

MR. LONG: Well, some things will turn out to be green because we will look at the utility's model and we'll figure out that we like the way they model it and we agree that it gives the right answer or reasonable answer and it's green and the discussion is over.

CHAIRMAN APOSTOLAKIS: But wouldn't you change the SPAR model then?

MR. LONG: The SPAR models are not really a collection of everything we've ever done in the past for a particular plant because you end up with a lot of detail which is done on sort of an ad hoc way, maybe not a very complete way, and it's not uniform across the model in that level of detail. You're just going down deep in one thing for one particular set of conditions so that you've already sort of solved the model. You've focused on certain sequences. You maybe have focused on certain cut sets, and now you're just extending the modeling for those particular sequences or cut sets.

And the way you've done that may not even be applicable for a full model solution. So you just have to be careful, and we would create an intractable problem, I think, for our contractors if every time that was done we told them to maintain that at a quality level. Then from then on we would quickly build up a morass of details that you couldn't count on for the next event actually modeling the situation accurately.

CHAIRMAN APOSTOLAKIS: Okay.

MR. LONG: Does that make sense?

CHAIRMAN APOSTOLAKIS: Go ahead. That's fine. Thank you.

MR. CHEOK: John Schroeder from INL will report some insights on this. When we have a SPAR model help desk, so to speak, and when analysts from the headquarters or from the regions have problems or have differences with the licensee models, they could call INL for some guidance, and John can give you some input.

DR. SCHROEDER: Yes, I can offer a couple of comments on that.

CHAIRMAN APOSTOLAKIS: Name, please.

DR. SCHROEDER: John Schroeder, Idaho National Laboratory.

I provide a lot of support to the region personnel when they enter into these conferences, and what often happens is that the licensee comes to the table with a set of cut sets that they believe reflects the risk from the condition or the event, and the SRAs have another set of cut sets that have been produced by the SPAR model.

And in the cases where those disagree, and how often that happens is probably -- I mean, we get calls on this sort of thing probably at least one or two a month, sometimes it may be only one and a quarter, but frequently there are issues, and what will happen is the SRA will look very closely at the cut sets and there will be recoveries. There will be system alignments represented in the licensee cut sets, and the SRA typically comes from an inspection background. So they will use their inspector's skepticism and investigate those things.

And those things that they buy off on will be fed back into the SPAR model to readjust their result, and if those things have generic applicability, they'll go into the baseline model and stay there.

If it's a special case, unusual details, a one time only type circumstance, then those things will be discarded and not maintained.

CHAIRMAN APOSTOLAKIS: So by and large

then your team, Nilesh, is satisfied with the current state of the SPAR models. You don't expect any revolutionary change any time soon.

I mean, we all appreciate that here and there you have to tweak the model a little, but by and large, you believe that every unit in the United States now has a good SPAR model for internal events.

MR. CHOKSHI: I think so. You know, the process you have implemented, I think, is working out.

CHAIRMAN APOSTOLAKIS: Okay. How many years did it take to get there?

MR. CHOKSHI: Oh, that --

MR. DENNING: How many man-years?

CHAIRMAN APOSTOLAKIS: Calendar years. I mean, started what, in the early '90s?

MR. CHOKSHI: Looking for that, Don.

MR. MARKSBERRY: Don Marksberry, Office of Research.

It started around 1994 with the Rev-1 models, and the total cost so far is $7.2 million for the iterative approach, and each time we went to a rev model we were happy at that time, and then something new comes about, and then we up the details of the model to fit.

CHAIRMAN APOSTOLAKIS: Something new in

what sense?

MR. MARKSBERRY: Different purposes, such as the ESP program. We wanted higher fidelity models to do more analysis.

DR. BONACA: That's a bargain.

CHAIRMAN APOSTOLAKIS: Seven million?

DR. BONACA: Yeah.

CHAIRMAN APOSTOLAKIS: Reported in the context of what we spent elsewhere.

DR. BONACA: I have a question. We heard about cases where there are disagreements. There are a lot of disagreements, except for minor details, and the observations that you draw from SPAR are agreed to by the licensee.

What's the success rate?

MR. DENNING: Let me ask a slightly different question maybe, and that is, you know, you looked at kind of the general agreement at the high level, CDF level, and now you're looking at the cut set level. Do you see significant differences? As you look intensively at cut set level, do you see significant differences that require modification?

DR. SCHROEDER: This is John Schroeder again.

Some of the plots that we'll present later on in the presentation address this in a global way. We see a lot of differences and big differences in relatively unimportant components. We see very few differences in really important events because from the beginning of the SPAR model development process, we have been trying to calibrate our models against what is risk significant, and the more we learned, the deeper we had to go.

So what you'll see in the importance comparison plots is a triangle where there's tight agreement on very important events and increasing scatter as we move down into very low importance events.

Now, the issue becomes when you do a significance determination or ASP analysis that the baseline risk or the conditions in effect for the analysis change what is important, and that requires a certain attention to those low probability events that wasn't received early in the program, and that generates the discussions and the investigations on the part of the SRAs, and that generates modifications to the SPAR models.

CHAIRMAN APOSTOLAKIS: Okay.

MR. CHEOK: Okay. The next slide would be the users of the SPAR models, and we have already discussed a lot of this. Obviously we use it as part of the SDP Phase 3. We use it in ASP analysis. We use it to improve the quality of PRAs through the ASP program, through MSPI.

You know, we find a lot of things that may or may not be modeled in current PRAs. For example, common cause interactions of events and operator recovery actions. These are things that we notice through use of the SPAR models, and we can feed it back to our models and to the licensee models.

We use it to perform analysis in support of generic safety issue resolution. For example, on GSI-189, which is the combustible gas control issue and GSI-191, which is the PWR sump issue, we use it to support risk informed reviews of licensing amendments, and we use it to provide an independent capability to evaluate risk issues across plant populations. For example, the MSPI effort and also the LOOP/SBO study, which the subcommittee has reviewed.

Agency interfaces. We involve our users a lot for the SPAR model development process. The SPAR model users group, SMUG, was formed in 1999, the members from Research, NRR, and the regional offices. This group basically provides the direction for how we develop our SPAR models. They form the SPAR model development plan, and this plan has been approved by all user management organizations.

We currently have two NRR user need requests for SPAR model development. We attend SRA counterpart meetings twice a year to perform training, to provide guidance on the use of SPAR models. I think this is important. It think it's very important to continually train our users.

Two, I think it's very important for us to continue to update our models depending on what the users want and what they tell us they want.

And I think it's important to get feedback from all of our users.

DR. KRESS: Do you have severe accident models in SPAR with fission products?

MR. CHEOK: We currently do not have fission product severe accident models. We have the LERF models, but that ends in a release, and we do not have --

DR. KRESS: Are there any plans to go in that detail?

MR. CHEOK: Well, not in the SPAR program. I think there are other programs that may go into that arena, but not through SPAR.

DR. KRESS: So you would never then

consider Level 3 either?

MR. CHEOK: I guess I wouldn't say "never," but we are not considering that at this point.

And again, the last bullet basically says that we do have a help desk which John Schroeder talked about where all SPAR users can call us for support when they need it.

Program development activities, and I'll go through these quickly. In Level 1 internal events at full power, we do have 72 Revision 3 SPAR models available, and we are in the process of enhancing these models, and we'll talk about these today.

We have low plant shutdown models. We have ten models completed with on-site QA for four models completed. We intend to have four more completed in FY '07. We will talk about these tomorrow.

The Level 2 largely released frequency models, we are intending to complete ten models by 2008 for the ten lead plant classes. Currently we have three models completed, and for external events which covers fires plus seismic events, we currently have six models drafted. This is the most recent of our efforts. We are in this for six months. We have six models done, and will continue to refine the model development process as we go along.

MR. DENNING: One thing I'm not understanding here is what are your objectives. I know it's difficult to go back, but go back to the low power shutdown models. Do you plan to have a low power shutdown model eventually for every plant?

MR. CHEOK: At this point, no. We probably will end up with between 15 to 20 models. As Nilesh said earlier, these models are very dependent on our reactions with the licensees, and whether they have staff that can help us out in these models, especially in cases like low power shutdown, which are very plant specific.

If licensees do not have these models, it will make it harder for us to come up with models of our own.

DR. BONACA: But wouldn't your developing these models spur the licensees to develop their own?

MR. CHEOK: It may. You're right. I mean, the fact that the licensees think that the staff has one, maybe they should have something that would I wouldn't say counteract, but to have their own models, but I guess I kind of answered that for sure.

DR. THADANI: I think it seems to me,

Mario, that that's an important point because the PSA conference in September, NEI, indicated that they thought that the low power shutdown models were not that important, that they had lower priority.

And so I think this could be an important --

CHAIRMAN APOSTOLAKIS: Because they have a lot of human actions, and we know that human actions are very reliable.

DR. THADANI: Yes.

MR. DENNING: I mean, obviously one of the issues is can you get the funding to do it. I mean, obviously there is an issue here, and I think it's an issue that, you know, the ACRS doesn't get directly involved with, other than if we recognize the need, then we make a lot of noise about it, and so as we look at the low power shutdown and also the external events and this type of thing, I mean, my own feeling is that they are extremely important and that our objective should be to have each of -- SPAR covering each of these models and then the question is are there really enough funds to do it, as well as keeping everything updated and this kind of stuff.

But I'm curious as -- and you gave a good answer as to why it's difficult to do this, but it does seem to me that our objective should be to have a full complement for every plant, and I'm curious. Is that what you really think?

MR. CHOKSHI: And I think you will see that, you know, maybe as you'll pulling through that one of the objects is to sort of see if there is a way to develop those things, and how robust and how useful, and you will see in some of the detailed presentations the type of issues that come up, you know, how you can be sure that it's capturing enough plant specific features.

They're so plant specific, externally --

DR. BONACA: And that's a decision, I mean, depending on how the average is being managed.

MR. CHOKSHI: And what applications we are trying to make of it.

CHAIRMAN APOSTOLAKIS: So the goal here is to have eventually a good set of Level 1 and Level 2 full power and low power shutdown model for each plant. Is that the goal?

MR. CHEOK: The goal is to have enough models that we can use, and I was going to answer your question that way, that we can use on a regular basis to assess events or to help in licensing applications. As we go along, we may find that we are depending a lot more on our lower power shutdown models or a lot more on our external events models, and if that's the case, then it would give us the justification to continue to develop these models for the full set of plans.

But, on the other hand, we do not use these models as much and we can adapt one model or one plan to the next plan in the time we need to use it and perhaps we will stick with a representative step.

CHAIRMAN APOSTOLAKIS: You are talking about the mechanics of doing it.

MR. DENNING: Well, maybe, George, but the question that you've raised, I mean, that was exactly what got us into this discussion, is we looked and saw that as far as their established goals, they're much more limited than saying we're going to have one for every operating plan, and that's the question. Is it necessary? Is it a technical -- and I guess we're hearing kind of two sides of this. One is that not all of the plants have them or a lot of the plants don't have them so that it makes their job that much more difficult to develop them.

But then I guess the most recent just made is perhaps if you look at classes of plants and have models for those, that when you get to the other specific one, you can do that.

But let me make one more point and that is that as the ACRS looks at these various risk informed decisions that are being made now, virtually every time we address that the question arises as have they really also looked at -- and everything is oriented towards internal events, and you say, "Well, have they really looked at low power shutdown? Have they looked at seismic? Have they looked at fire risk?"

And the answer is no a large fraction of the time, and we certainly aren't comfortable with that situation at the moment.

DR. BONACA: But it seems to me one thing that one could certainly gain from this number of models of low power shutdown is an understanding of whether practices used in different plants, a similar design may make a difference to risk because really we don't know that exactly.

Now, I'm not at all familiar with -- I'm not saying that they are all using different approaches to the refueling, but there are differences, and that would be certainly an important objective.

CHAIRMAN APOSTOLAKIS: Yeah, because unless I misunderstood you, one of the major results of the flurry of activities in the '80s and '90s to do PRAs was that they have to be plant specific because there are features in one plant that you don't find in another.

You know, there's something bothering me about this continuing debate on whether low power shutdown models should be developed, and we'll see if there is a need. I recall there was a report, a very good report, in fact, that was developed as part of the ATHENA project several years ago that listed all sorts of human errors during shutdown operations.

So how do we do a significance determination process for these? I mean, if we don't have the model, it seems to me we're going to arm wave a lot, and in other words, there is evidence that stuff happens during low power shutdown, and because of the state of the plant, it may be more risky. Right?

So it seems to me that there is an incentive to do this. Now, again, Michael started talking about the mechanics of it and the resources and so on, but maybe if you start using your models which may be crude at the beginning, then the licensees will see the light and say maybe it's worthwhile developing something more detailed here.

MR. CHOKSHI: I think, yeah, that's important. We are learning more and developing as we apply to the situations, I think, and this is what we're waiting to see.

CHAIRMAN APOSTOLAKIS: But my point, Nilesh, is that there is evidence. First of all, one major piece of evidence is that PRAs have shown that the contribution to core damage frequency from low power shutdown operations is comparable to that from power operations. That's already a major incentive, and the second one -- in fact, I think that was the last time when the PRA community was surprised by a result, about 15 years or so ago. All right? That was a surprise.

And second, as I said, you know, there is evidence, I mean, produced by this agency that a lot of things happened there and because, you know, the vessel may be open and so forth. It's important to understand those and have a tool to evaluate them.

MR. CHEOK: And I think the agency supports the CRS obviously in terms of --

CHAIRMAN APOSTOLAKIS: Do you have any evidence for that?

MR. CHEOK: If you look at Reg. Guide 1.174 and 1.200, it basically states that we should consider all modes of operation and everything else, and it's our job, I guess, to provide the tools for the staff to be able to carry out --

CHAIRMAN APOSTOLAKIS: Mike, you're touching a sore point with me because we always use those words "consider."

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: Since 1998 when the regulatory guide came out, and that word has more meanings in the English language than any other word.

DR. KRESS: Let me make a comment about low power and shutdown tools. There's two types of low power and shutdown risk. If you're doing a significance determination process, you have a good idea of the plant configuration and you can do that for given events for a given plant, but a lot of the need for low power and shutdown risk is to have just like we do with full power an integrated risk over the lifetime of the plant. This is what we end up with. We do it on a per year basis, but it's actually an integrated risk over the lifetime of the plant.

Now, over the lifetime of a given plant, the configuration during shutdown varies markedly over different configurations for different times. Now, in order to actually model that in a low power and shutdown risk, that you're interested in that aspect of it, you're going to have to have a database. You're going to have to go to all of these plants and look at how long they're out, what equipment is out, and get some sort of a database on all of these configurations and somehow average them or get plant specific ones, and that doesn't look like an easy task to me. It looks like a development of PRA that's needed, and nobody seems to be working on that part of it. That's what bothers me.

MR. CHEOK: I think we agree with you. It's a challenge and to get it to be plant specific enough to give us good insights for the overall risk and even for evaluating events as they arise because they are so plant specific and so issue and event specific.

MR. CHOKSHI: I think you will also see it in the schedules, why it takes so long to develop, and you know, it's also a burden on QA with license established, much more involved for low power and shutdown. So that's I think the simple point in that availability of licensing staff may not convey that, but it's a major effort.

CHAIRMAN APOSTOLAKIS: What do you mean contingent on availability? Just start using it.

PARTICIPANT: That's the QA part of it.

CHAIRMAN APOSTOLAKIS: Just start using it. You know the recommendation from President Johnson.

MR. CHEOK: All right. Are we ready to move on?

Related topics -- I'm sorry.

DR. KRESS: Before you move on I notice on the previous slide your focus, probably rightly so, is on LERF, but quite often this committee is interested in late containment failures, or maybe even the conditional containment failure probability.

Now, that is a little harder to analyze because with LERF you can do this Brookhaven simplified approach which just requires thermal hydraulics, but for late containment failure you're going to need a different approach, I think, and I think somewhere along the line you need to start thinking about adding late containment failures to the SPAR models.

MR. CHEOK: We have -- and I guess John will talk about this tomorrow a little bit more -- our LERF models defined such that we can proceed to the late containment failures and the large lates quite easily so that the endpoints are there.

DR. KRESS: Yeah, I don't want --

MR. CHEOK: It's just not developed.

DR. KRESS: -- our conditional containment failure probability, which includes large and small.

MR. CHEOK: Right.

DR. KRESS: But I think these are good things to think about, how to model.

MR. CHEOK: We have thought about it, and like I said, the capability is there to expand to the large lates.

Related topics, and George brought this up earlier. The SPAR model development process is very closely linked to the SAPHIRE code development and SAPHIRE Revision 8 will be an important tool for using the latest SPAR models. We will demonstrate the SAPHIRE and SPAR models a little bit later today.

And proposed future ACRS presentations. In December we'll be coming back to talk to you all on the SPAR-H methodology as part of your HRA subcommittee meetings. We are proposing that in the summer or spring of next year that we would come to you to talk to you about our collection of data and how we use industry data and SPAR models and in the rest of our programs. Again, we will work that out with you if you're interested.

And Dr. Sieber recently had inquired about a staff briefing on SECY 05-0129, which is our annual SECY on the status of the SPAR and ASB programs. Again, if the committee is interested we can come back at your request.

CHAIRMAN APOSTOLAKIS: Yes. In fact, I'm glad that you have your schedule up there because I'm sure we will discuss this later, but we plan to be involved in your activities as much as we can and give whatever advice we can.

So perhaps after the review of this subcommittee meeting, you will come to the full committee meeting at some point where, February? And maybe we can have a letter then on the overall program, and then maybe we can have individual meetings, especially SPAR-H.

I have great interest in SPAR-H, and then write individual letters as appropriate.

MR. CHOKSHI: Yeah, because I think during the discussion a lot of talks about what we should be looking at and what are this -- it is sort of best if captured in ACRS later and then maybe coming to full committee we can, you know --

CHAIRMAN APOSTOLAKIS: Absolutely, absolutely, but I think it's a model that -- it's an effort, not just a model; it's an effort on the part of the agency that is becoming now central to the agency's activities, and I think we will all benefit by having this exchange maybe every three, four, five months.

MR. CHEOK: Okay. I'd like to turn this over to INL for presentations.

CHAIRMAN APOSTOLAKIS: Which I hope will finish faster than you, Mike. You're always so slow.

(Laughter.)

CHAIRMAN APOSTOLAKIS: So slow.

MR. DENNING: Did you notice how clever he was that he planned just enough time even though we dragged it out? I think he's right on schedule.

CHAIRMAN APOSTOLAKIS: He's right on schedule. Oh, if he's been here before.

Oh, this is nice. This is part of SPAR?

DR. KRESS: Oh, throw that in.

DR. BUELL: That's Idaho.

MR. DENNING: It's not like Idaho today.

DR. BUELL: I'm Robert Buell from the Idaho National Laboratory and this is John Schroeder, and we're here just to provide some overview and some depth of discussion for the SPAR modeling project, some of the history and as well as some of the issues that we're working on now and possibly some future tasks.

DR. KRESS: You guys lost your two Es.

DR. BUELL: Yes.

DR. KRESS: Good, good.

DR. BUELL: We're just a laboratory now.

So anyway, we were asked to talk about the SPAR models and where we've been. We've broken that down into seven topics that's on your agenda. You have those seven topics. They deal with standardized structure, and that's what I'm going to be presenting right now. Then we go into a model demonstration that John will present, and then I'll come back and do major assumptions in our modeling of the SPAR models, as well as some of the quality review procedures and techniques that we use as we develop these SPAR models.

We also have some of the modeling issues that we've found. We've been around as part of the STP plant visits, and we've gathered a lot of intelligence, a lot of insight from looking at a broad cross-section of the PRAs out there, and we're trying to incorporate some of that into our models also.

And then John will talk about modeling for uncertainty, some of the uncertainty issues that we've identified and how we're dealing with those.

And then finally if we have time we'll just give you a sample of our model documentation and what we do there.

CHAIRMAN APOSTOLAKIS: Yeah, the modeling parameter uncertainties are of particular interest to this committee. And I've seen a write-up of nine models where you describe how you reconcile the differences between your --

DR. BUELL: We'll make sure to save plenty of time for that then.

CHAIRMAN APOSTOLAKIS: So there should be plenty of time for this, yes.

DR. BUELL: Okay, good.

CHAIRMAN APOSTOLAKIS: Because finally somebody is looking at model uncertainty.

DR. BUELL: We look at both the parameter uncertainty and the structural and John will go into that in a little more detail.

CHAIRMAN APOSTOLAKIS: I know you do. Parameter uncertainty is not that crucial.

DR. BUELL: Okay. Just a brief background. You've already heard some of this, but this is just history. Basically this whole program even though it wasn't the SPAR models per se, but it had its genesis back in the late '70s with the daily events manual. That's when we started in some sim. flight event trees that had split fractions.

We took that and used that as a starting point and converted that into the SPAR 2QA models after we had a review of Sandia. That became the 2QA models.

At that point they did not have any support systems. They had a very limited set of event trees.

We took that to the next point in the 3I models. We added additional event trees. We added support systems. We also did a preliminary review by going to all of the STP visits throughout the country. We gathered information and additional insights during that point.

We rolled all of that up into them, and then we called them Rev. 3 models at that point.

CHAIRMAN APOSTOLAKIS: So this is what we have now.

DR. BUELL: What we have now are Rev. 3 models. That is correct.

CHAIRMAN APOSTOLAKIS: And 3P is in progress.

DR. BUELL: That is in progress. Those

are the ones where we have done the detailed cuts at level review.

As part of the Rev. 3, we didn't give it a new rev. number, but we did go through all of the models and add new steel LOCA information after the log information was approved. We added that to all of the models, the steel LOCA information.

We also went in and had a significant effort to link all of the data to template events that we could rapidly update in a batch routine. So now we have the ability to go in and rapidly update all of our data throughout the models, as well as the consistency issue.

With as many analysts as we had working on the project, as many data sources as we had, sometimes there were some inconsistencies with in the data. By linking them all, the templates having one master list now, we're able to maintain a real consistent set of data.

We also updated some of the -- as part of the seal LOCA logic we went ahead and typed that we updated some of the LOOP and SBL logic since they were interrelated in many cases.

CHAIRMAN APOSTOLAKIS: So it seems that you're extremely reluctant to abandon Rev. 3. I, 3, and then P. When will you go to four?

DR. BUELL: Well, I will defer on that discussion.

CHAIRMAN APOSTOLAKIS: That's part of --

DR. BUELL: Yeah, there's a lot of discussion on that.

So anyway, right now we're on the Rev. 3. The P stands for plus in this particular instance. We just had to name it, and that has to do with the detail reviews that we're in the process of doing now.

CHAIRMAN APOSTOLAKIS: Good, good. Let's go on.

DR. BUELL: That's the history and the S in SPAR stands for standardized now. It used to stand for simplified back in the 2QA days. Now it stands for standardized. There's some real advantages to have standardized models, and some of them have already been discussed, but one of the advantages is you can use a single engine to drive these. Okay?

There's a variety of them out there, new prod cath (phonetic), risk MAN, and some of the secondary --

CHAIRMAN APOSTOLAKIS: What is it, GEM? I used to know.

DR. SCHROEDER: Graphical evaluation

model. It's sort of like a macro environment tailored to doing either event assessment or condition assessment, and it's used typically for the Phase 3 STP.

CHAIRMAN APOSTOLAKIS: So it's what, graphical?

DR. SCHROEDER: Graphical evaluation module.

CHAIRMAN APOSTOLAKIS: Thank you.

DR. BUELL: So we have a common tool that we can use. You can be trained on that. NRC has an extensive training program to train on that particular program so they can run all of the models as well as the peripheral analyses that we do.

CHAIRMAN APOSTOLAKIS: Apparently the industry is very much interested now in SAPHIRE because I was approached by a company several months ago, and they asked me specifically whether I had a student graduating who knew SAPHIRE.

DR. BUELL: Well, with the MSPI program there's a lot of interest in our models, and you have to run them all, but also SAPHIRE has been developed to the point now that it has a lot of capabilities that it never used to have.

So one of the advantages of

standardization is also uniformity of the models. By having uniform assumptions, uniform level of detail, all of these uniform construction techniques you can actually identify some of the real outliers as opposed to in some instances in the industry you can make an assumption that will obscure a lot of these differences in the building of your models.

I mean, like I say, with having that standard set of assumptions and such, you can identify outliers and have some confidence that those are real outliers as opposed to being based on assumptions.

One of the other key advantages of this complete tool set and the uniformity of the models is that we can do industry-wide looks. Let's say we want to look and see how a particular failure rate affects the overall industry or, you know, if we want to look at initiating event frequencies and how they impact the industry. We have the ability to run through those now and just look at all 72 models in short order and see what that does to the industry risk.

So next page there.

Some of the standardized elements I just started. I just touched on some of those that deal with methodology. It has been mentioned before that we're a small event tree, large fault tree linked set-up. Now if you see some of our BWR even trees you might not they are small event trees, but they're small event trees.

CHAIRMAN APOSTOLAKIS: What's small? What's a small event tree?

DR. BUELL: Well, small event trees typically is where you do not have the operator actions and the conditional failures in --

CHAIRMAN APOSTOLAKIS: But you still have the major headings.

DR. BUELL: Yes, you still have the major headings, but you can collapse those down in some plant PRAs to three or four nodes across the top, and you do everything hidden in the rules and in the combinations. We think we've struck an optimum balance there as far as what you see in the event tree versus what's hidden in fault trees.

CHAIRMAN APOSTOLAKIS: Right.

DR. BUELL: So anyway, we've got a standard set of assumptions, too, that we use to build or fault trees and our event trees, you know, the way we do common cause modeling, what type of components we model, what type of things that we exclude, you know, that type of thing so that we have a standard set of assumptions that we use when we build these models.

Did you have a comment?

Okay. We also have a standard set of initiating events, and that's based on published data. NUREG 5750 was the origin of that. Since then a few of the values have been updated, and that will be talked about this spring in the data analysis section.

CHAIRMAN APOSTOLAKIS: Now, again, coming back to the site specific nature of these things, in the PRA that I was involved in, we always found that the -- I mean, there was a standard list of initiators there for PWRs and BWRs, 15, 20 or so, but there were always two or three that were unique to that site, like if a truck drives and hits something which in other sites you didn't have.

How do you handle that?

DR. BUELL: Well, we'll get into that later as a part of the detail at that level review. Basically we have a threshold that if it's important, you know, and we define important as one percent of their contribution to their overall CDF, if they have a unique set of initiators like that, we will add that to ours and try to understand it well enough that we can model that.

But anything that they show that's

important that's outside of our standard set of initiators, we will add that. We try to capture all of the risk associated at that time.

MR. DENNING: When you talk about generic, if you look at like B&W plants and things like integrated control systems and failure rates for those, do you use that set of plants to come up with generic for like BMW plants?

Because I know that, for example, there have been periods in which they had a large number of failures and then they improved them, and so generically the failure rates of those are lower. When you talk about generic, does that mean generic for like B&W plants of a certain vintage or is it even broader than that?

DR. BUELL: It's broader than that typically. In some initiators the statisticians have looked at this at INL when they generated this report, and they've done all of the statistical magic on that and looked at, you know, if there's any pools of data that they should separate.

We have separated many of the initiators by Ps and Bs. Obviously that's a logical break, but beyond that typically we don't break it into any finer groups than that, and like I say, that is based on a statistical look by the statisticians at INL when they generated this data.

MR. DENNING: And they don't see a difference because it seemed to me that it really did have a big impact on frequency of turbine trips, you know, for just that particular --

DR. BUELL: Okay. Well, I can't speak to the details of it. Like I say, the statisticians will look at all of those issues and they felt they were grouped at the appropriate level. So beyond that, I don't have any insight on that.

And you notice I have a bullet there that says no support system initiating event fault trees. This is an issue that we're going to hit a little bit later or address in a little later presentation because this is an issue that at INL at least we feel needs to be addressed in the industry, and we have some feelings on that and some thoughts on that, and we'll discuss that in a little bit more detail later on.

Right now probably two thirds of the industry uses initiating event fault trees for some of their sports S (phonetic) initiators. The remaining third use a point value just like we do at this point.

So anyway, that's a point that we're going to discuss in more detail later.

The event trees, they're standardized to a point. They were based on standard event trees that came out of the groupings of the daily events manual, but as we get more and more detail in the models and we need more of that detail, we have to start taking into account more and more plant specific differences. So we I don't know if you'd call it deviate from that standard, but it's basically we have to pick up additional elements that are plant specific, and so we add that to our event trees.

So they were reviewed in the two 2QA level. We still use that as our standard, but, like I say, as we come across plant specific instances that need additional detail, we do add that into the event trees.

Fault trees, the key systems, the diesel generating system, the electric power system, RCCI/HPCI, those type of systems are based on logic that was put together as part of the system studies performed at INL several years ago. So we have that same standard set of logic there also.

Some additional standardized elements in SPAR model, failure data, that's something that's going to be talked about in much more detail in the spring. I just give you a highlight of that.

We recently changed to EPIX based data when we're on to the templates.

Did you have a comment?

CHAIRMAN APOSTOLAKIS: No.

DR. BUELL: Okay. We recently transitioned from basically old generic data sources and the system study information to a common EPIX based data set, and that 1998-2002 was a period of interest that we use as the pool of data.

We have a standard common cause failure methodology as well as application. The method you're probably all familiar with based on NUREG 5485, the alpha factor methodology. We use that completely throughout the models.

Data, the data for the common cause failure is the alpha factors themselves come from a mixture of data sources.

CHAIRMAN APOSTOLAKIS: I'm just curious. The alpha factor method produces long expressions for the probability of failure of, say, two pumps in parallel. Three it's even longer.

You use that expression?

DR. BUELL: That expression is used within SAPHIRE. SAPHIRE takes that and manipulates that, the code itself, and gives us the appropriate number.

DR. SCHROEDER: There's a SAPHIRE plug-in or module that automates those calculations. It requires as inputs the independent events in a group and the alpha factors for that group, and it generates the common cause failure probabilities using the methods from that NUREG. Those expressions are long, and they're hard wired into the calculational module that's good for six strains or a six strain group.

CHAIRMAN APOSTOLAKIS: So the multiple Greek letter method is not used anymore.

DR. SCHROEDER: That is correct.

DR. BUELL: The module has the capability to use that, but since all of the uncertainty parameters associated with the common cause calculation are calculated in terms of alpha factors. We use the data as provided.

CHAIRMAN APOSTOLAKIS: Now, have you seen a significant difference between the two models, the results of the two models?

DR. BUELL: Actually we have, and in a later slide we've identified ten significant issues where there is either variability within the industry or differences between us and the industry. The common cause is one of those with this latest update of the alpha factors. That has essentially went away or been much reduced, but in the past we had common cause factors that were significantly higher than the industry.

CHAIRMAN APOSTOLAKIS: I know that the alpha factor approach is more rigorous, especially in handling the data, the information, but you lose that nice feature of the multiple Greek letter of communication where you say, you know, the base failure rate is this. Now, you know, if this has failed, at least one other component has failed. So the probability is usually ten percent or something.

Then gamma is if two have failed; then at least one more has failed. In the alpha model you lose that, and it's not so nice. It's just an expression.

DR. BUELL: Well, that's all rolled up within that SAPHIRE plus, but all of the mechanics and the information needed to generate those are there, but, yes, they're not quite as transparent.

CHAIRMAN APOSTOLAKIS: It's not easy to communicate it.

DR. BUELL: That's correct.

CHAIRMAN APOSTOLAKIS: Now, you say you're going to come back to this?

DR. BUELL: Yes, in later slides we deal with this in much more detail.

CHAIRMAN APOSTOLAKIS: Okay.

DR. BUELL: Okay. The additional data points or data that we've updated is lost at off site power frequency and recovery data. This is an ongoing effort right now or just recently at INL to update all of that, and we've incorporated that into our models. Back there is a NUREG pending just in very short order with that new information in it.

And we used the SPAR-H methodology, NUREG 6883 for modeling our human errors.

CHAIRMAN APOSTOLAKIS: That's another thing we're going to spend some time on, right?

DR. BUELL: Okay. We're going to spend a little bit of time on it, but there's going to be a more detailed presentation in December, I believe. So that will be covered in detail at that point.

Okay. Next, please.

One of the big advantages of using this standardized structure is that we can look across the industry and we can do it in a relatively short order. Right now once we set up a model or a query as far as what we want to do to a model, we can utilize SAPHIRE macros to run all 72. I can set it up, push the button on my computer and come back in four or five hours, and we'll have an output. Now, you know, it may not be the right output, but there's all this tweaking you need to do.

But the bottom line is once you identify a series of issues in short order, half a day, we can end up with the results across all of our plants, and that --

CHAIRMAN APOSTOLAKIS: I don't want to take away your thunder, but it seems to me that even if you had 72 plant specific models that utilize, say, plant specific information, you could still produce in a relatively short period of time an industry-wide profile.

DR. BUELL: Oh, that can be done.

CHAIRMAN APOSTOLAKIS: What are we doing here?

DR. SCHROEDER: Let me address that at least in part. During the benchmarking process with the SDP notebooks we went on site and we watched the NRC question the licensees about what is your risk profile given this failure or that failure. In effect, we watched the licensees run these sensitivity studies, and to ask them to generate a result for, say, what happens when DGA has failed, they might disappear into the back room half the morning.

Their models are complex, and they are slow to run, and it requires a high level of expertise, and even at the licensees, they may only have one or two people on their staff that can do these calculations.

Now we have something that's similar enough across all models, and it runs fast enough that we have a large number of people that are trained that can do this. There is a body of expertise that can make this happen rather quickly, and I would suggest that licensees have nowhere near this kind of capability to respond rapidly.

CHAIRMAN APOSTOLAKIS: That's not a matter of the licensees having the capability. You should have it.

DR. SCHROEDER: Well, we would have to learn probably four different analysis platforms, and there's dreadful details in how to actually accomplish those calculations on each platform.

MR. DENNING: And you'd have to go and independently do every one of them, whereas with this common platform, it sounds like you may be able to make some --

CHAIRMAN APOSTOLAKIS: But you give us

something.

MR. DENNING: But you give up something, and that's part of what we have to discuss.

CHAIRMAN APOSTOLAKIS: That's what I'm afraid of. Speed versus accuracy.

DR. BUELL: Well, these are detailed models. It isn't that we're using an astandard model. I mean we have detailed, plant specific models, and I'll show you just a graph here in a moment of --

CHAIRMAN APOSTOLAKIS: Now, the seventh, does that cover all units?

DR. BUELL: That is correct. Some of the potential uses of this capability are some data sensitivities, if you want to do some sensitivities across the industry, MSPI importance measures. Let's say you wanted to look at, you know, the mean diesel importance across all the plants or unit specific diesels or whatever. You can look at that on an industry-wide basis and say, you know, this is the impact of that change or that sensitivity, and I think that's a significant issue.

Next page, please.

And this is the SBL study that just recently or is to be published shortly. This is just a graph that we pulled out of that. We've been running these different scenarios and combinations, but you can see it's got a CDF with an error band on either 95.5 band on those.

I might say this doesn't mean anything other than the fact that it's just an example of the type of runs we can do in short order.

CHAIRMAN APOSTOLAKIS: What are we looking at now? This is the 90 percent interval, right?

DR. BUELL: That's correct.

CHAIRMAN APOSTOLAKIS: And the mean value, and the reason why there is plant-to-plant variability here is the different number of diesels they have?

DR. BUELL: That's part of it. The number of diesels, the seal types they have in their pump seals, you know, the reliability.

CHAIRMAN APOSTOLAKIS: Is the loss of off-site power frequency more or less constant across the country?

DR. BUELL: That study has just come out, and Jonathan, do you want to address that?

CHAIRMAN APOSTOLAKIS: I mean, that's not the major driver I don't think.

DR. BUELL: No.

DR. SCHROEDER: It's not the major driver.

CHAIRMAN APOSTOLAKIS: I mean, there are

differences, but it's not the major driver.

DR. SCHROEDER: And I don't recall what was used in this curve, but when they actually did the loss of off-site power study, they looked very hard for regional differences in recovery times and loop frequencies, and they looked for differences by plant design, and they looked for any kind of difference that they could justify in the statistics, and they ran some of those numbers, and they made a lot of decisions about whether to represent the analysis with generic data.

And if you wanted all of the rationale for that, you'd have to get one of the people involved in the study that's --

CHAIRMAN APOSTOLAKIS: So there is more than an order of magnitude difference between the best and the worst, right?

DR. BONACA: Two orders.

CHAIRMAN APOSTOLAKIS: Two?

DR. BONACA: Two almost, yeah.

MR. DENNING: But the way you treat it now, there would be no difference in recovery time regionally. Like a plant that is likely to have hurricanes, potential for hurricanes, is not going to have a different recovery time.

DR. SCHROEDER: Right now in our base SPAR models we do not differentiate that.

MR. DENNING: But you can always go in and do that.

CHAIRMAN APOSTOLAKIS: So this graph then represents which failures, failures that can be restored in an hour and a half, two hours?

DR. BUELL: These are the ones that you actually have a plant blackout. You've had a loop and then you go to a plant blackout.

CHAIRMAN APOSTOLAKIS: Right. I understand that, but this doesn't say for how long.

DR. BUELL: That's correct. Within each one of these points you have some sequences that are two hours. Some you have the equivalent to operate; you might have four hours. So this is a composite for all of those different sequences for each plant.

CHAIRMAN APOSTOLAKIS: Because as Rich just said, if the loss of off-site power is due to an external event, it may take days or even weeks to restore it.

DR. BUELL: That's correct.

CHAIRMAN APOSTOLAKIS: Those losses of power are included here.

DR. BUELL: That is correct.

CHAIRMAN APOSTOLAKIS: The duration is not.

DR. SCHROEDER: The duration is. I'll speak to that. We have rolled into the baseline loss of off-site power model all classes of loss of off-site power. The recoveries and the frequencies, while the frequencies stand from what the statisticians gave us, but the recoveries are frequency weighted.

And in the last iteration of the model, I believe we're to four classes again. That's been subject to a lot of change, three classes, five classes, four classes.

MR. DENNING: But every plant gets the same thing so that the South doesn't have a different --

CHAIRMAN APOSTOLAKIS: This is the probability that in any one year, Plant X will have a station blackout.

DR. SCHROEDER: This is the frequency of blackouts for Plant X.

DR. KRESS: Core damage.

MR. DENNING: Core damage frequency from station blackouts.

CHAIRMAN APOSTOLAKIS: Yeah, core damage from station blackouts.

DR. BONACA: Curiosity. Just you have a small set of plants there with CDF on the order of ten to the minus seven. It would be low. What is so unique about those plants?

DR. BUELL: Well, there's a couple of plants out there that have hydroelectric backup which are extremely reliable, underground cables, those types of things. So there's a few plants at that end that have a unique configuration. It does account for that.

DR. SCHROEDER: What you would see if you started looking at the basis for that, and again, the authors of the blackout study looked at that pretty carefully, and they could tell you what's driving the risk at each end, but you have a lot of plants in the country that have four electrical division and blackout generators and other aspects to their emergency power system that drive it way down, whereas at the upper end you might have a plant that has a seal cooling weakness and only two divisions of AC power and no auxiliary backups.

I mean, that's the spectrum of things out there.

CHAIRMAN APOSTOLAKIS: Are the members interested in pursuing this in more detail in the future, this kind of study?

MR. DENNING: Yeah, but you know, that's exactly what we did look at in the station blackout, the specific one that we --

CHAIRMAN APOSTOLAKIS: We said there was another report coming up.

MR. DENNING: Oh, it's something coming up.

DR. BUELL: It's in draft stage right now. It's waiting to be published, and this may be the one that you're reviewing. I don't know.

MR. CHEOK: What the committee reviewed was the draft report that was provided in February. The final version of the report is coming out in December.

CHAIRMAN APOSTOLAKIS: Oh, so it's the report we reviewed. There is no more information.

MR. CHEOK: That's correct.

DR. BONACA: That to me shows the value of SPAR very much here.

MR. DENNING: Absolutely.

DR. BONACA: You have the ability of -- in fact, yes, I think it would be a good exercise.

CHAIRMAN APOSTOLAKIS: Well, they say we reviewed it, but, again --

MR. DENNING: Well, in a sense we've already seen this example.

CHAIRMAN APOSTOLAKIS: But I think we should go over it again, and maybe with the full committee. This is important. But I don't know. The worst plant is at what, one or two ten to the minus six.

DR. KRESS: Several worse plants.

MR. DENNING: Why did you say that? You've got one times ten to the minus five.

DR. KRESS: That's a fie, yeah.

CHAIRMAN APOSTOLAKIS: That's a five. You're right. And we get that even though we have a station blackout rule. Huh. I wonder what that was before the rule

MR. DENNING: That's a good questions.

DR. BUELL: Are there any other questions on that?

CHAIRMAN APOSTOLAKIS: No. Well, there are many, but --

DR. BUELL: We just put this up there just as an example --

CHAIRMAN APOSTOLAKIS: Little did you know.

DR. BUELL: -- of what we could do with

the capabilities of SAPHIRE and these automation techniques.

DR. BONACA: Now, just one last question. If I look at these curves, I mean, and I had the licensees here, would they agree to these results generally?

DR. SCHROEDER: No.

DR. BONACA: They wouldn't.

CHAIRMAN APOSTOLAKIS: No.

DR. SCHROEDER: The licensee that has this one takes great exception to that.

MR. DENNING: Where do you put it, incidentally.

CHAIRMAN APOSTOLAKIS: On what basis?

MR. DENNING: I mean, what would his CDF be for that? Do you know offhand?

DR. SCHROEDER: I don't remember the details. Do you?

DR. BUELL: I don't know what the CDF is, but the bottom line is that they take credit. They have a unique surface water system. The only BWR with that particular type of service water system, and because of that vulnerability or because of that design configuration, they're much more dependent on other systems and they use some of these other systems in ways that are not standard in the industry, and until they give us information, in our estimation it's very marginal use of it, and so until they get us information that they can validate their use of that, we're agreeing to disagree at this point and we're saying until you can provide documentation that we're satisfied with, we're not going to go there because that is a non-standard application or a non-standard --

CHAIRMAN APOSTOLAKIS: Which is what it is.

DR. SCHROEDER: And the NRC SRAs for that region have looked at the licensee's claims very closely, and they have not given us a decision on what they think ought to be done about the utility's claims.

MR. CHEOK: For just a quick perspective, we have been engaged with the licensee, and as Bob was saying, they do have different processes that we are not familiar with. We're asking for more documentation from them, and after we review the documentation and agree that it's feasible or the recoveries, we will incorporate them, but at this point we will have to wait to see what we will get.

MR. DENNING: But at this point it has

little relevance unless they come in with a risk informed request for change or something like that? Because the fact that it's one times ten to the minus five that we say it is and they say it was something else doesn't make any difference.

CHAIRMAN APOSTOLAKIS: No, but it makes a difference because there are CDF --

MR. DENNING: But if you go with a risk informed decision, then it could be a big --

DR. BUELL: It quickly comes to a head if there's a finding or an issue related to these design issues.

Next slide there.

Some more of the standardized structure. Basically we've already hit this or identified this before as small even tree, large fault tree, linked methodology. We have a standard set of initiating event candidates, and I'm not sure if all of these make sense to you, but they're basically -- and I'll go across the list -- it's a large LOCA, medium LOCA, small LOCA, and excessive LOCA or a vessel rupture, interfacing or intersystems LOCA, loss of off-site power, loss of condenser heat sink, loss of main feedwater, transient with PCS initially available.

And then we go into variance of the

transient tree here, the loss of AC buses, the loss of DC buses. Then we have loss of service water and loss of instrument air.

That's pretty much our standard look, and we had talked about before that this is the one percent rule. If you look down here at the bottom if we find a plant that has an initiator that doesn't fit within this category, then we'll add that with this one percent rule to make sure we cover the significant portion of the plant risk.

Something that's boiling water, reactor specific as an inadvertent open relief valve, and on PWRs there's two type specific initiators there, the steam generator tube rupture and the loss of component cooling water.

So that's our standard set, and like I say, we go beyond that if there's anything significant showing up in it.

CHAIRMAN APOSTOLAKIS: What is LOCCW?

DR. BUELL: Loss of component cooling water.

CHAIRMAN APOSTOLAKIS: That's a support system, isn't it?

DR. BUELL: That is a support system.

CHAIRMAN APOSTOLAKIS: So you are

including some support systems.

DR. BUELL: We include many support systems. The AC and DC buses, the service water, the instrument air --

CHAIRMAN APOSTOLAKIS: Well what did you say about support systems? They're not initiating events?

DR. BUELL: We do not have fault trees. There's two ways to generate a frequency or support system initiator.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. BUELL: You can either look at an industry average and come up with a point value, or you can build a fault tree based on a system unique configuration that will generate a probability. That's the difference.

CHAIRMAN APOSTOLAKIS: And why don't you do it that way?

DR. BUELL: Well, we're going to get to that shortly in one of these other slides, but number one, there are some developmental issues and some issues that haven't been completely researched yet, and we're looking at that, but there are some down sides of not having it in there, and we'll talk about those in a few minutes.

CHAIRMAN APOSTOLAKIS: Okay.

DR. BUELL: Next slide, please.

Okay. Within the event trees, we have front line system fault trees. Most of the fault trees, the critical fault trees are based on systems studies that were performed at the INL in years gone by. That includes the reactor protective system, the emergency power system, auxiliary feedwater, the high pressure coolant injection, and the RCI system.

Some of the other front line fault trees include or the modeling of those include active components. That's an obvious inclusion in the models, and the obvious or important operator actions, and then we use a standard set of fault tree guidelines to simplify those since there's a lot of information that we don't have, detailed information that we don't have, relay positioning and that type of thing.

We made some simplifications on some of the instrumentation information in our modeling. So there are some ways to simplify these, yet still retain the essence and the importance of these components.

MR. DENNING: When we look at the standardized system fault trees, for example, auxiliary feedwater or something like that, how many different versions do you have to have of this system fault tree to cover the spectrum of plants or are they --

DR. BUELL: Well, I believe there was 11 different systems, okay, and as time goes on and we need more and more detail and nuances, we modify those somewhat. If we find there's another back-up condensate source or another back-up long term cooling source or whatever, we expand those models, but I believe on AFW there were 11 system models originally, and we have taken those and made them plant specific, put the supports underneath them, plant specific supports, and you know, plant specific valving and that type of thing, but there's 11 basic configurations for that.

And we've touched on the common cause event modeling also, and some of the ways that we apply common cause we have our own standard set of rules that we look at. We don't typically put common cause across multiple systems. All of the common cause is within a given system. We have different types of components that we give common cause consideration to.

So we have, like I say, rules that allow us to model these in a standard format.

The support system fault trees are the ones that we just added in the last three or four years. We're expanding the level of detail of those, but some of the rules that go into those or some of the modeling detail is we typically don't take power all the way down to 480 volt, 120 volt, that type of thing. We typically leave them at the divisional level.

Now, as we need more and more detail, that's not hard and fast. We are realizing in some cases we have to add more detail to be able to get the understanding of the plant, and we have been doing that, but as a minimum we model it at the divisional level.

MR. DENNING: Now, a typical utility would go to a lower level, wouldn't it?

DR. BUELL: A typical utility would go to a lower level. They'd go to a 180 volt level typically, and like I say, we've been doing it more often than not now because we need able to do that be able to get the nuances of utilities model, but in the past, and we don't have all of the models at that level, but as we go in and look at them in the detailed level, we've been adding much more AC and DC power.

MR. DENNING: Okay.

CHAIRMAN APOSTOLAKIS: This is great though that you're doing this. I mean, I was worried the first time you said that we're not doing support systems because it really --

DR. BUELL: No, we model support systems in detail.

CHAIRMAN APOSTOLAKIS: They are so important.

DR. BUELL: You bet.

CHAIRMAN APOSTOLAKIS: Okay, great. Now, the next time we meet I would really like to understand why you guys felt you needed to develop SPAR-H and you did not use a female

MR. DENNING: Actually are you going to talk about --

CHAIRMAN APOSTOLAKIS: Don't smile, don't smile.

MR. DENNING: I know you mentioned. Are we going to talk more about SPAR-H today? Because I'm not going to be here in December, and I realize you're going to get into it, but there's philosophical questions about what we're trying to do with SPAR versus what a utility might attempt to do with its PRA that could relate to this, and I wanted to get into that.

DR. BUELL: Okay. Like I say, there's going to be another meeting on that in December, and I don't have the depth of knowledge to be able to address philosophical concerns or whatever on SPAR-H. I can tell you how we use it, how we apply it, but I don't --

CHAIRMAN APOSTOLAKIS: Yeah, we'll do that in December though.

MR. DENNING: I'm not going to be here in December, but I do want to say something and that is I'm going to be in Vienna. Isn't that great?

CHAIRMAN APOSTOLAKIS: Just send me an E-mail. I'll say what you want to say. Go ahead.

MR. DENNING: And that is that I think that there are different purposes for what the NRC is really using their PRA for versus the things, the breadth of things the utility can use its PRA for.

CHAIRMAN APOSTOLAKIS: Absolutely.

MR. DENNING: And that if you look at this question like ATHENA, that a utility ought to be using a really detailed HRA kind of approach because they ought to be looking at that emergency operating procedures and things like that, seeing what the impact of those is on their rates.

CHAIRMAN APOSTOLAKIS: Well, they're not using ATHENA though.

MR. DENNING: Well, no, but philosophically the reason.

Now, here, we're not -- "we" being you guys really -- you're not really going to the depth of looking at specific emergency operating procedures. You're coming up with -- and that really limits obviously what you can do and what your objectives are, and so I think that there's some objectives the utility should have for its PRA that differ from your objectives and that it doesn't make sense, you know, for you to go to an extremely complex human reliability model when, indeed, all you're going to be doing is kind of looking at generic values across a variety of plants rather than looking in detail at a specific plant.

The same may be true of common cause.

CHAIRMAN APOSTOLAKIS: Yeah, but that's where since they went to the alpha model there's no excuse now. That means they can handle complexity and --

MR. DENNING: But complexity is to some extent plant specific complexity that they're not going to get into, and I don't think that they have to. I mean have to because of philosophically what we're using SPAR for versus the variety of things that I think that a utility can use its PRA for that --

CHAIRMAN APOSTOLAKIS: Two or three years ago, Rich, the guys could develop a thing that came before the full committee. A major piece of advice they got was make sure you simplify so that people can use it. Okay?

So the big question is now has that happened, and do we have a de facto proof that it did not happen.

MR. DENNING: Did not happen because of SPAR-H.

CHAIRMAN APOSTOLAKIS: And we can put you on a video from Vienna, by the way.

Can we go to 12?

DR. BUELL: Okay. Basically this is a layout of our transient model for BWRs, which everything is built on with the exception of the LOCAs. It's a real quick run through there. We look at reactivity control. We look at reactor system or the coolant integrity, the SRBs, the open, stay open. We look at some of the high pressure injection sources if you don't have those. It's standard logic. You depressurize. You go to low pressure systems, and we have a variety of those as well as the VA, which is some alternate systems, you know, some of the back-up, the cross-ties, service water cross-ties and fire water and all of the other ancillary type systems that you can add.

We also have, as you are well aware, BWRs are typically heat removal limited. That's what will get you to core damage quicker than anything. So we try to look at all the different aspects of heat removal, and then finally we look at late injection, and this has to do with long-term injection, and it also has to look at potentially after containment fails, and we'll talk about that in later slides.

CHAIRMAN APOSTOLAKIS: Excuse me. You are starting now a relatively new topic, the assumptions, and I suspect we're close to the break time. So why don't we take a break now before you start talking about assumptions?

DR. BUELL: Okay.

CHAIRMAN APOSTOLAKIS: And we should be back around 10:30. That's the median.

Off the record.

(Whereupon, the foregoing matter went off the record at 10:11 a.m. and went back on the record at 10:32 a.m.)

CHAIRMAN APOSTOLAKIS: Okay. Let's go on.

DR. BUELL: George, can I say something real quickly before we start?

CHAIRMAN APOSTOLAKIS: Sure.

DR. BUELL: We have 13 more slides on standardized structure, and we go into a lot more details into each one of those event frees. We were just wondering if the committee wants to hear in detail about all of those event frees or do we want to just go ahead and finish the one event for Bs and one for Ps and then maybe skip to the demo? It's up to you all.

CHAIRMAN APOSTOLAKIS: I think that's a good idea. The committee members agree?

MR. DENNING: If we're hurt for time, yes, but otherwise --

CHAIRMAN APOSTOLAKIS: I think we probably are. So your proposal, Mike is what?

MR. CHEOK: My proposal is that we will go through the transient tree for the Bs and then one for the Ps and the assumptions, the major assumptions for the Bs and the Ps.

CHAIRMAN APOSTOLAKIS: Yes.

MR. CHEOK: And then perhaps we can go

through to the demo because later on I think we again come back through the major assumptions for all the models.

CHAIRMAN APOSTOLAKIS: Okay. So we are skipping then the slides that Bob is preparing now, is presenting now? Is that what you are --

MR. CHEOK: We will be probably going through two or three more of these slides and then skip about ten of them.

CHAIRMAN APOSTOLAKIS: Okay. That's a good idea.

DR. BUELL: Okay. For the sake of time, I'll skip even some of these bullets here.

On key BWR assumptions, event tree assumptions, I'm just going to hit the last two. Containment venting fails all injection. This is a carryover from some of the early modeling, and like I say, in a period of transition through a little more detailed modeling. That's not acceptable anymore. So what we're researching is putting some logic in there that allows that to be tuned depending on the specific plant.

Also the assumption that containment failure causes a loss of all injection, that's going to be coming up again in our top ten items, and I'll discuss this further, but there's a lot of plants out there that take credit for injection beyond containment failure, and NUREG 1150 also did that, and like I say, this is a transition issue, and I'll explain that later in detail.

Next slide.

The general layout of a PWR transient event tree, similar to the Bs we start out with the reactivity issue. Then we look at the secondary cooling through the steam generators with main feedwater and AFW, and all of these acronyms, they're all fault tree tops with detailed logic underneath them.

So there's detailed logic underneath each one of these tops here. Then we look at the reactor coolant system integrity. Did the pores open or stick open? And also, what's the status of the seals? And so we check that for coolant system integrity.

We looked at the high pressure injection and once through cooling, and then we look at secondary site cool down and depressurization, and finally containment heat removal, RHR and HPR. A pretty standard structure, real similar to what you'll see in standard PRAs.

So it's a --

MR. DENNING: If we looked at the event trees, it's that simple, and then all of the logic is down in the fault tree?

DR. BUELL: That's correct. If you'll count those up, those are typically the number of fault tree tops, you know, nodes across the top.

MR. DENNING: The event tree tops.

DR. BUELL: The event tree tops, across the top of your event tree, and then each one of them have a detailed fault tree underneath.

So some of the key assumptions here, you'll see the two pour is required for feed and bleed. This is an issue in about half of the plants in the country. About half of them say we require two pours. About half of them say we require one pour.

We globally require two pours, and there's a variety of reasons for that, number one of which we don't do detailed thermal hydraulics, and it appears that a lot of the thermal hydraulics that were done would lean towards the two pour of success criterion, and we'll discuss that in more detail later on.

But like I say, if we have successful feed and bleed, that gives us time to recover secondary cooling then at some point in the future.

CHAIRMAN APOSTOLAKIS: How do you

determine the success criteria?

DR. BUELL: Well, we rely heavily on NUREG 1150 for success criteria. Like I say, because we structure very similar to what they structure as far as event tree logic. We rely heavily on NUREG 1150.

CHAIRMAN APOSTOLAKIS: And 1150, they develop their own success criteria or they relied on the vendors?

MR. DENNING: I would say it's their own. I mean, I don't remember how much going back to vendors there was.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. BUELL: And typically most of the equipment that are used in the success criteria is real binary. I mean, you either have it or you don't and there's only a few instances where you would possibly need thermal hydraulics to ascertain whether you could get by with something. So that's typically not a real big deal.

Okay. What was our next slide?

DR. BONACA: Well, the question I have on the PORV, I do believe that some PORVs you have to show that they could, in fact, bleed. I mean, they could stay open for a lengthy period of time.

And are the licensees typically dealing

with that issue there or --

DR. BUELL: Are you talking about long term operations?

DR. BONACA: Yes.

DR. BUELL: The licensee, many of them look at that. We look at it as far as battery depletion. You know, when the batteries are gone, then the pours are gone also if you're talking about like a station blackout long term or if you lose air in some instances long term.

DR. BONACA: So the licensees do make a rational decision.

DR. BUELL: They do look at those issues also.

Okay, and we're just going to skip all of the rest of this. This is just some of the nuances and details of how we look at some of the component cooling water and such, some of the support system initiated and how we model that.

John is going to give you a demonstration of SAPHIRE now.

CHAIRMAN APOSTOLAKIS: Good.

DR. SCHROEDER: The SAPHIRE program is the main engine for all of the SPAR models, and it's used in conjunction with the GEM program, which are two aspects of the same underlying calculation of machinery. SAPHIRE is actually an acronym, and it stands for something like safety analysis package for hands-on integrated reliability evaluations. And GEM is the graphical evaluation module.

And there's not much graphical about GEM. I'll show you that, although the original design vision was to make it sell.

Typical SAPHIRE model looks very much like any other PRA model in that it has a bunch of risk related objects. It has end states. It has sequences, event trees, fault trees, and it has a lot of basic events, and primarily it's a cut set solver, but it also has some facilities to do off-line calculations to come up with common cause failure probabilities.

Off-site power recovery probabilities, de-solar recovery probabilities, and it can do some sums for -- you know, has utility options to come up with fail to run probabilities that are like compound curves, and I'll show you a little bit of that stuff.

When we start looking at a risk model, we typically start with event trees, and this is a typical list for a boiler. This is for the model that you saw in advance, the pilgrim model. Some of these are quite complicated.

The large LOCA is one of the simplest event trees that we have. This is an example of it. We would have an initiating event and then the front line system questions or concerns. Then we would resolve those into core damage end states, and in some cases these can be transferred to other event trees for further processing, and there are models for which we do that.

What I'm in now is a simple graphical editor. I can modify this. I mean, I can add branches and the like. I can access some of the major components of the model this way, for instance, the pressure pool cooling model, and then with that I can bring up the fault tree logic. I can modify the fault tree logic. I can modify the basic events. All of these are fairly common capabilities.

SAPHIRE has many user ease functions. I'll get to some of the add in capabilities later, but this is one that I think is fairly important to point out. The SPAR-H method is actually built into SAPHIRE. The design of SPAR-H was to provide something that an analyst could use to make quick assessments for the SDP or for ASP evaluations, and the capability looks something like this.

If we have a human related human action, we would be able to specify whether there's a diagnosis involved, and the event that I just happened to pick does not have a diagnosis. It's a step down the line in a procedure. The issue of whether the right procedure has been selected has already been determined. So it's basic. It's a basic action.

And what we would do is ask the user to make judgments about the performance shaping factors that apply, and they can do that by just entering in values over here.

Now, as part of our attempt to do better with uncertainty in the models, there is a capability here to hedge your bets, to say that the experience and training that's applicable to this event we believe it is high with a high level of confidence, but we could say that, well, maybe the analyst is only 90 percent certain that the experience and training is high.

He might say that, well, maybe I feel ten percent confident that it's only nominal, and you would get an uncertainty distribution out of this calculator appropriate to those inputs.

CHAIRMAN APOSTOLAKIS: So why don't you do that so we can see?

DR. SCHROEDER: Okay. I'm not sure that I can generate the uncertainty right here, but let's put this in.

CHAIRMAN APOSTOLAKIS: Would five percent low?

DR. SCHROEDER: Okay.

CHAIRMAN APOSTOLAKIS: Twenty percent nominal, and let's see now. Twenty-five --

MR. DENNING: Let's make it 75 percent.

CHAIRMAN APOSTOLAKIS: No, I want things sufficient, too.

MR. DENNING: It's automatic. You can't --

CHAIRMAN APOSTOLAKIS: Seventy?

MR. DENNING: Oh, now, wait a second. Can you do this?

CHAIRMAN APOSTOLAKIS: An insufficient five.

DR. BUELL: As a default we typically -- since we don't have that level of knowledge, we put 100 percent in whatever our shaping factor is.

CHAIRMAN APOSTOLAKIS: Do they add up to one now? Yeah.

DR. SCHROEDER: I think the module is going to enforce it one way or another.

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: Now, when an analyst does this, the advice given is that it is not sufficient just to throw in numbers. He ought to make notes on why he specified those numbers and the code would maintain these things.

And there's a possibility to do a dependency calculation as well, although just declaring the dependency here doesn't solve the problem. I mean, you have to go into a SAPHIRE rules capability and make sure that this dependent event is applied in the right place in the cut set, and that's something that takes a fair amount of training that's not a trivial action.

But at any rate, this event didn't mode any dependency on previous events.

CHAIRMAN APOSTOLAKIS: So what do we see how? It's seven ten to the minus four?

DR. THADANI: Right.

CHAIRMAN APOSTOLAKIS: And it's not going to show us the range?

DR. SCHROEDER: We can attempt to show the range here, but I am not sure.

MR. DENNING: Well, what you might do is if that's difficult is you could go through and change those again and see what it does to the value.

DR. SCHROEDER: Right. The nominal value is 5E minus four. When I distributed the degree of belief here, I changed it to 7E minus four, and Curtis Smith would be the person that would describe the algorithm. I don't know that the algorithm for distributing this is printed anywhere yet, whether it's part of the SAPHIRE documentation or not. That would have to come from the co-development people.

CHAIRMAN APOSTOLAKIS: But when we view this in December, presumably we'll have access to this, right? That's the whole point. Huh, Mike?

MR. CHEOK: I guess we can provide this again in December if you would like.

CHAIRMAN APOSTOLAKIS: We have a report on SPAR-H.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: That report does not explain these things?

MR. CHEOK: I don't believe it does because this is a nuance of the SAPHIRE code, but we can again bring this up.

CHAIRMAN APOSTOLAKIS: That's a key, you know. And you can do this with all of the PSF showing there, right? Complexity, available time, stress.

DR. SCHROEDER: And i can show that it was.

CHAIRMAN APOSTOLAKIS: Okay, okay. So you can't show us the uncertainty range right now, can you?

DR. SCHROEDER: I believe so. Let's try.

CHAIRMAN APOSTOLAKIS: Let's try.

DR. SCHROEDER: I specify those factors. The calculated probability now shows there, and normally this event would be calculated with the constrained noninformative, but if I go over here and look at the uncertainty distribution, it looks like I broke it.

Call Curtis.

CHAIRMAN APOSTOLAKIS: You broke it.

DR. SCHROEDER: When something like this happens to a suer and it happens --

CHAIRMAN APOSTOLAKIS: He calls Curtis.

DR. SCHROEDER: -- we call Curtis, but actually that's not the right answer. The right answer is -- I mean, that's the real answer, but it's not the right answer. The right answer is that all SAPHIRE users have access to the SAPHIRE Web site, and there is a trouble reporting system there, where events like this are logged, and when you log into the

SAPHIRE Web site, you register one of these observations. then it goes into the SAPHIRE tracking system, and the same process is now in place for the SPAR models, by the way.

It goes into a tracking system where they have to respond to this and fix it if they can. So I'm going to restart that here.

CHAIRMAN APOSTOLAKIS: Maybe you needed to put numbers on the other PSFs, too. Is that possible?

DR. BUELL: Well, I think typically we don't use that function in our base models. We default over -- we use a performance shaping factors, but we default to 100 percent for each one of them, but we typically don't have that level of knowledge of understanding of the particular action.

CHAIRMAN APOSTOLAKIS: But this is one of the more significant uncertainties, isn't it?

DR. SCHROEDER: In many ways, yes.

CHAIRMAN APOSTOLAKIS: Well, you had to go all the way back there.

DR. SCHROEDER: I had to restart SAPHIRE.

CHAIRMAN APOSTOLAKIS: Yeah, okay.

DR. SCHROEDER: Because that was a fatal, fatal error.

CHAIRMAN APOSTOLAKIS: I assume if the

operators don't know what they're doing, it's a fatal error, right?

DR. SCHROEDER: Yeah.

CHAIRMAN APOSTOLAKIS: In more ways than one.

DR. SCHROEDER: Okay. So I was sort of showing the large loca event tree and walking down --

CHAIRMAN APOSTOLAKIS: Yeah, let's look at that because --

DR. SCHROEDER: -- through many of the capabilities.

CHAIRMAN APOSTOLAKIS: -- we discussed that yesterday, too, didn't we, Rich? This is BWR.

DR. SCHROEDER: This is BWR.

MR. DENNING: Oh, you're wondering about like no credit for contained over pressure.

CHAIRMAN APOSTOLAKIS: Yeah, is there any place there where it asks whether the containment is intact?

MR. DENNING: Well, the containment venting gets relevant to that.

DR. SCHROEDER: It is implied. For instance, if you have --

CHAIRMAN APOSTOLAKIS: No. You have to have it before the core spray though, right?

DR. SCHROEDER: These are laid out more or less in time order for the demand. For instance, you would need to have core spray immediately, and then some time very shortly after that demand, you would need suppression full cooling, and if you had that, you're basically find.

If the suppression cool cooling system is unavailable, we would credit core spray -- well, in this case it's containment spray. Excuse me --, and since there's a fault tree linking going on here, about the only way that you could fail this guy and credit this guy is if the suppression pool cooling discharge valves were failed because the other components of the model are the same.

But then we come over here to containment venting. We're out in time a fair ways now, and we're trying to resolve the containment over pressure issue. If containment venting is required because we don't have any cooling and the containment is pressurizing, we will question vent, and then we will question the survival of any late injection.

Remember those.

MR. DENNING: That's kind of where it is though because it's a question of weight injection.

CHAIRMAN APOSTOLAKIS: No, but I thought

that the Loch Lepsian (phonetic) core spray do depend on whether you have a --

DR. SCHROEDER: But it's not their early performance. They perform Okay early. It's late then that they would fail.

CHAIRMAN APOSTOLAKIS: Or you could have it the other way. They put the NR system. They put the IP up front and they say if you have significant leakage, then you don't get the right NPSH.

MR. DENNING: That's right.

CHAIRMAN APOSTOLAKIS: So it's relevant both places, isn't it? That's what I saw.

MR. DENNING: No, but actually the failure in cooling occurs late. Even though it's preexisting, leakage from the containment that could cause -- I mean obviously it's not included in this event tree.

CHAIRMAN APOSTOLAKIS: The Web site of the NRC under GSI 193, for a fast, large LOCA, the LPSI and CS pumps fail within seconds if you don't have sufficient NPSA. So you don't even reach the lab.

MR. DENNING: They have sufficient NPSH early. It's late when they heat up the pool. You know, in this case we were looking at yesterday, you know, we don't want to get into this in any detail, but it's not -- that mode of failure isn't shown on there, but that I think is because every plant is taking credit for the NPSH being there and --

CHAIRMAN APOSTOLAKIS: Yeah, this does, too, right? This event tree?

MR. DENNING: Yes, this absolutely does, but in their PRAs they don't take into account the exercise which --

CHAIRMAN APOSTOLAKIS: But if I wanted to take into account, I would modify this because John told us you can do that. You can go back and change the branches and all of that, but right now it assumes that you have sufficient NPSH.

MR. DENNING: And obviously the things that we saw that Marty presented yesterday, he must have done that, right?

CHAIRMAN APOSTOLAKIS: He used SPAR. That's what he says. so he modified the three.

Okay. Let's keep going then and look at the probability again.

DR. SCHROEDER: You want to look at the probability calculations again?

CHAIRMAN APOSTOLAKIS: Yeah, just one example.

DR. SCHROEDER: Okay. Let's access it from a different place in the code. Typically when we deal with basic events, we come over here and bring up the basic event list, and a typical basic event is identified with nomenclature that comes from a NUREG. It's a fairly old NUREG, but at least it's some reference that can establish uniformity in the models.

In this particular basic event I have an AC power distribution system, and I have an AC bus, and I have a low power or no power failure mode, and a key detail in all of this is that this is a plant specific event, but it uses a generic event in its quantification. We link it to something called a template.

In this case the template is the AC bus component template. That defines the failure rates the mission time and the uncertainty parameter for that particular system, component, and failure mode, and there's an entire library of these things in every model. Part of our ability to use automation depends on this standard library of templates, and those would be visible at the end of a model.

They start with Zs. This is the template library, and it is anticipate that there will be a NUREG that describes how these failure rates and probabilities were determined because all of them have associated parameter uncertainties.

CHAIRMAN APOSTOLAKIS: So if we go to the human error matter we tried to do before?

DR. SCHROEDER: Well, we can go back to that one. Let's see. Which one did I -- RHR/SPC. Let's see. I think that was the one we tried to deal with.

CHAIRMAN APOSTOLAKIS: Okay, yeah. Five times ten to the minus four, yeah.

DR. SCHROEDER: That was the nominal. I didn't save the calculation when it crashed.

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: I'd hate to attempt to go into this one again because if there's some error in this model, we could just fumble around with that for some time. I could try to default here, but --

CHAIRMAN APOSTOLAKIS: Is it possible that you have to go to the edit there? No, down. Yeah, that edit.

DR. SCHROEDER: If you want to go to the human factor calculator, you can go back to it.

CHAIRMAN APOSTOLAKIS: Yeah, okay.

DR. SCHROEDER: And is there anything else here you'd like to see?

CHAIRMAN APOSTOLAKIS: Well, if we try to do what we attempted earlier.

DR. SCHROEDER: Okay.

MR. DENNING: Let's not do it the same way.

CHAIRMAN APOSTOLAKIS: Let's go to available time and see what it says. Okay. So let's put just enough, 20 percent, and nominal 60, and extra time, well, that's a difference, but 20, and see what happens now.

DR. SCHROEDER: Okay. We had change in the value.

CHAIRMAN APOSTOLAKIS: It went up.

DR. SCHROEDER: And I fear that if we try to go to the quick and dirty uncertainty --

CHAIRMAN APOSTOLAKIS: No, there.

DR. SCHROEDER: We got one this time.

CHAIRMAN APOSTOLAKIS: We got one.

DR. SCHROEDER: Okay.

CHAIRMAN APOSTOLAKIS: So the 95th percentile is 5.28 ten to the minus three, and the fifth is ten to the minus six. So there is a significant, three orders of magnitude, range.

Yeah, we certainly have to look at how these things are determined, Nilesh. At least you get some results.

Has there been any coordination here with the guys who are developing ATHENA?

MR. CHEOK: We have talked to them once in a while to see where they are and what we're doing.

CHAIRMAN APOSTOLAKIS: But they have not reviewed this in detail.

MR. CHEOK: Oh, they have reviewed them. We have provided the SPAR-H NUREG to them, and all the authors of ATHENA have given its comments and they have been incorporated.

CHAIRMAN APOSTOLAKIS: Okay. So anyway, for December it would be nice to address these questions. Okay.

DR. SCHROEDER: One of the other features of SAPHIRE that we rely on heavily, this is all related to the compound event. The HRA add-in is sort of an aspect of this compound event calculation, although that was a special case. The more general case when you declare a compound event, we come over here to this compound event tab, and what we look for is a series of libraries.

These are all special code capabilities that aren't necessarily needed by the general population of users, but have been developed for one special user or another. The SPAR model development program uses this common cause failure calculation.

It uses the plug utility calculation. It uses this four group LOOP DOL and then there's another LOOP recovery DOL that are used to calculate various quantities used in the SPAR program.

This particular event that I brought up is a common cause failure calculation. Other events that are very important are these off-site power recovery events. Again, we use the compound event to calculate those, and the inputs to the calculation would be the frequencies of each loss of off-site power category, the plant center, the grid, the switch yard, et cetera, and the medians for the assumed distribution, and the error factors for the distribution.

This will allow SAPHIRE, when it does its Monte Carlo solution to, in effect, calculate the recovery probability from a different trial or different curb definition. There's a family of recovery curves for each of these, and I can talk about that a little bit more when you go to our uncertainty calculations.

But the reason that we went to the DOL on this is that in any given SPAR model, they will probably use at least half a dozen of these events, and for event evaluation, it is frequently necessary to recalculate those for a class of loss of off-site power initiator.

The GEM module makes that happen without the user having to recalculate anything and enter new values. I will demonstrate that in a little bit.

Okay. So we have event trees, and we have fault trees and basic events. Let me show you a fairly complex event tree just to show you the range in size. The TRAN event tree will be hard to see here, but this is probably as large an event tree as there is in the SPAR program, and in fact, this event tree is much larger than you see here because these represent transfers for other aspects of the model.

For instance, this is another event tree for a stuck open -- you see in the text that describes that here. It's more legible down here. This is for one stuck open relief valve. This is for two stuck open relief valves, and this is ATWS. Those are really all technically part of this event tree, except those are reusable pieces that other event trees reference as well.

Now, in the SAPHIRE paradigm, you need to link those event trees to create sequences. So what we are looking at is really no more than a graphic, and when SAPHIRE creates the sequences, it stores them at a different place. You will come over here, and we can select sequences, and then we can look at our results through the sequences. This is what SAPHIRE solves to give us a core damage frequency.

And we have many editing capabilities within the SPAR model. We can display the cut sets for all of the sequences or groups of sequences, and this is a typical result, cut set list for the overall model. We can slice and dice this. There's a capability to collect cut sets. Say if I wanted to look at loss of off-site power cut sets that have a core spray check valve failure in them. I can apply that, and if there's anything that meet that criteria -- in this case there was nothing that met the criteria -- I could do that.

Something that would definitely be here would be like EPS failures, emergency power system failures. If we had a failure of the diesel to run, we could add that, and we'd probably get quite a few of those, and we can reference the full list, what's included in our particular slice of the result, and we can see what's excluded from the slice.

And more to the point, we can save this in an end state for later review and for additional sliding.

CHAIRMAN APOSTOLAKIS: And these are run

according to the frequency?

DR. SCHROEDER: yes.

CHAIRMAN APOSTOLAKIS: But, my goodness, look at that. All of them are very low.

DR. SCHROEDER: Well, I picked cut sets with a very particular criteria. You had to have a LOOP initiator and failure of just DGA. There are only 500 of these cut sets in the model, and if we were to look at how many cut sets are in the model, this particular model has 10,000 cut sets in it at this truncation level.

CHAIRMAN APOSTOLAKIS: Can we for this system now look at the CDF?

DR. SCHROEDER: We can look at the CDF for any system, but we have to --

CHAIRMAN APOSTOLAKIS: And for the whole plant, can we look at the system?

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: Yeah, let's look at that.

DR. SCHROEDER: We were looking at CDF for the whole plant. That was what I was showing you. There's more than one way to look at it. For instance, if we want to look at the CDF sequence by sequence and get the overall result, here is the total, and here is how it breaks down by sequence.

In SAPHIRE the sequence specified by a sequence number and the event tree name, and we use very standard abbreviations so that a person that has used the SPAR model for a little while would just glance at this list and automatically recognize that we had an inadvertent open relief valve or we have a large LOCA or a transient or a loss of condenser heat sink.

That's part of the advantage of standardization.

Now, the SAPHIRE environment that I've been demonstrating here is the main tool of the model developers. It's the main tool to maintain models, and it's the tool that you need if you're going to do a very detailed analysis.

But for most routine analyses, we try to make life easier for the user. We go to the GEM framework, and I went to the GEM environment here, but there's something else I want to point out. In all of the SPAR models we have this disclaimer, and there has been an issue with people grabbing a model and trying to use it without really understanding what the major issues associated with the use of that model were.

So in an attempt to mitigate against that, we've provided a screen that says, well, I know all about the limitations of this model and I'm ready to go on, and if I don't know all about them, I'm really supposed to come over here and look at them.

And there would be a summary like this that's plant specific for each model that says, well, you know, this is the number one hitter for us on this model. We really have an impact here that needs to be represented or accounted for or considered in our analysis, and these impacts are in ones, twos, and threes. Well, what do they mean?

This is what a one, two, or three means in the impact. An evaluation of this kind exists for all of the models, and it is the major part of our attempt to deal with structural uncertainties in the model.

CHAIRMAN APOSTOLAKIS: So this is the impact of the whole sequence there. Well, it's actually groups of sequences, right?

DR. SCHROEDER: This summary over here is based on the total impact of core damage frequency on the whole model.

Okay. So if I've looked at this and decided that I understand them, then I can go on and do my analysis. One of the key facilities in the initiating event assessment capability here, and the reason that that's important is because we get the substitutions for our class of loss of off-site power.

I need to declare one, and it might be something like a PC, plant centered, loss of off-site power, and I know that it's a loop initiator. I have a list here. This is special. The other initiators wouldn't ask this question, but I have an opportunity to tell the module what kind of loss of off-site power event I am dealing with, and if I select plant centered, I'm going to get a bunch of automated calculations.

The first thing it does is it goes through and sets all of my initiating event frequencies to zero and the LOOP frequency to one or true and false, as the case may be. And then it goes out and it recalculates all of my off-site power recoveries.

Now, GEM doesn't know which of these are used. It just goes and calculates all of them, and some of them will be hanging around and unused, but it will recalculate the ones that are needed.

CHAIRMAN APOSTOLAKIS: There is a detail there hour by hour of the recovery.

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: How is that used?

DR. SCHROEDER: Well, I can show you that, although it would be best not to show it in the GEM environment. I need to switch back. So let me do that. Let me cancel this process.

CHAIRMAN APOSTOLAKIS: I mean the result should be an integral value, right?

DR. SCHROEDER: Yes.

DR. BUELL: We put a full set of those hour by hour for 24 hours even though we don't use them all. It's just part of the library of events that we put in there. So that's standard for every model. We'll have every hour in there.

DR. SCHROEDER: Switch back to SAPHIRE again.

CHAIRMAN APOSTOLAKIS: But in a particular situation, you may have a thermal hydraulic calculation that says, you know, in 45 minutes you're going to be in trouble. Then you will go and pick the appropriate value for recovery of power.

DR. BUELL: Exactly.

CHAIRMAN APOSTOLAKIS: I see.

DR. SCHROEDER: This is how it works. this is the station blackout model for this plant.

CHAIRMAN APOSTOLAKIS: Yeah, yeah. Okay.

DR. SCHROEDER: And many of the things that we have to talk about today involve what the right time is to credit in this column. For this particular model, if we have a HPCI or RCCI success and we're able to depressurize at some point down the line and bring on fire water and extend our battery lifetime sufficiently by accredited load shedding procedures at the plant, we would have a 14-hour limitation --

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: -- recovery for the sequence.

In another sequence, we --

CHAIRMAN APOSTOLAKIS: So the quote then would be peak just --

DR. SCHROEDER: Well, that's already coded in the fault tree, and what the code needs to do, it's automated. See, the model developer has to do all of this.

CHAIRMAN APOSTOLAKIS: Right, but --

DR. SCHROEDER: There are basic events in there for each, and if we look at one of the graphics --

CHAIRMAN APOSTOLAKIS: But from the series of values you showed us, only the value corresponding to that time would be selected.

DR. SCHROEDER: Right.

CHAIRMAN APOSTOLAKIS: Okay, okay.

DR. SCHROEDER: In this particular sequence that I just selected the fault tree for, this would be the default, the smallest value in the model. All of the others are bigger than this. I could credit off-site power recovery in 30 minutes. I could credit the operator failure to recover a diesel in that 30 minutes, and then there's some credit for ability to align off-site or optional power supplies.

There's a blackout generator at this plant. There is another off-site line that they want to take credit for, and because this is a 30-minute sequence, there are probably operator actions in these that are more restrictive than the general case here.

At any rate, the calculation that GEM is going to do for you is going to change this number depending on what class of loop you had. For instance, if this was a grid related analysis that I was doing, this would be a very different number than if it was a weather related analysis that I was doing.

CHAIRMAN APOSTOLAKIS: Sure.

DR. SCHROEDER: And because that's difficult to calculate, GEM does it. In fact, SAPHIRE does it for the base case by doing a frequency weighted average of the loop classes.

CHAIRMAN APOSTOLAKIS: If I change something, how long will it take for the model to recalculate overloads?

DR. SCHROEDER: Not very long. I could generate this one here. I started to do that PC LOOP. We could look at this change set. What I was doing in GEM is reflected in SAPHIRE, and if I start to run this, I would get a result based upon just a nominal loss of off-site power.

And because loss of off-site power is a fairly complicated thing, I might want to change the truncation for that when I go to run it.

SAPHIRE is now making the values that I selected the temporary values to use in the calculation. If I come over here to the sequences, select all of the sequences and ask the code to solve it, I don't want to attempt to solve this model at D minus 12 anymore because I've changed the initiating event frequency by three orders of magnitude.

On a desktop engine, it might be reasonable to solve it here, but just for the sake of a demonstration, let me knock that back to -- I was trying to go for ten there -- and see how long it takes.

It's not working the problem, and each

time you see a flash down here, it's finishing up a sequence.

CHAIRMAN APOSTOLAKIS: Gez.

DR. SCHROEDER: And it's done. So if I wanted to see the results associated with that analysis, and I can sort them by the --

CHAIRMAN APOSTOLAKIS: I want to see the total. Can we look at the total CDF?

DR. SCHROEDER: Yes. That is there.

CHAIRMAN APOSTOLAKIS: So it was done in 15 seconds, right?

DR. SCHROEDER: Yeah, and this is the result.

CHAIRMAN APOSTOLAKIS: So the total CDF is -- and if I want to look at the uncertainty on that?

DR. SCHROEDER: If I want to look at the uncertainty on that, I'll have to write an additional calculation. I'll have to go to uncertainty, and I could probably run 5,000 samples fairly quickly.

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: But so that we're not here too long, I'll try it with 1,000, and down here you have the running sample count.

CHAIRMAN APOSTOLAKIS: This is straight Monte Carlo.

DR. SCHROEDER: I believe that's what I selected. The LSH option is available. Those are the only two options.

MR. DENNING: Now, what did it do before? It did a point estimate before?

DR. SCHROEDER: That was just a point estimate, and doing this sort of by sequence here, the project.

CHAIRMAN APOSTOLAKIS: It probably takes a minute or so. It did it?

DR. SCHROEDER: So now I want to display --

CHAIRMAN APOSTOLAKIS: No, the previous one, the uncertainty, yeah.

DR. SCHROEDER: Yeah, display uncertainty?

CHAIRMAN APOSTOLAKIS: Yeah.

DR. SCHROEDER: This is the result I have now.

CHAIRMAN APOSTOLAKIS: Now, in the previous one you had things like -- yeah, here, the cyrtosis, skewness. You are obviously working with statisticians.

(Laughter.)

DR. SCHROEDER: Right, although for someone who is not a statistician, we have current quantile display and we have a plot, and the plot is based on a fairly limited number of data points. In other words --

CHAIRMAN APOSTOLAKIS: Maybe we should have Regulatory Guide 1174 that uses the mean CDF and its cyrtosis.

(Laughter.)

CHAIRMAN APOSTOLAKIS: Huh?

MR. CHEOK: No comment.

CHAIRMAN APOSTOLAKIS: No comment.

PARTICIPANT: I thought that had to do with the Atkins diet.

(Laughter.)

CHAIRMAN APOSTOLAKIS: Great, John. This is very good. This is very, very good.

DR. SCHROEDER: There's one thing that I really wanted to show you in GEM, and to show it I really need to get to the back end of the calculation because I think it's an important feature. So let's try to go and do a real quick assessment here without changing anything.

And I'm going to change the cutoff even lower here. So it won't be a very meaningful calculation, but it will be fast.

CHAIRMAN APOSTOLAKIS: Now, you have done sensitivity studies to appreciate the significance of the cutoff value?

DR. SCHROEDER: Yes, yes, and we maybe don't do a sensitivity study on each plant each time because we make a judgment that E minus 12 is deep enough for all of the models, and generally it is more than deep enough.

And since the code only takes a minute or two to solve, if a person wants to knock that down to E minus 15, they can. In fact, when I benchmark a model, I often have to go to E minus 15 to make sure that very low importance events show up in the cut set. We don't ship it that way, but you know, it's a five minute calculation at my desk.

Now, the reason I wanted to show you this --

CHAIRMAN APOSTOLAKIS: So you take a break?

DR. SCHROEDER: Pardon me?

CHAIRMAN APOSTOLAKIS: During those five minutes you take a break?

DR. SCHROEDER: Yes. Get some more coffee.

I have a solution here from that calculation. These are the sequences that survive my very high truncation. There's not much there.

But I wanted to show you the reporting function, and it's fairly crude, but it's important because the idea in creating GEM was to have something that produced a quick report that totally documented the result.

In this case I had a conditional core damage probability which is the metric for initiating event assessments, a 3.5 E minus 6, but if I printed this thing off and stuck it in a binder someplace and somebody asked me how I got that result later, well, the model would have all of the details necessary or the report would have all of the details necessary.

For instance, I have the probabilities that the original base case had and then the current case has. The current case is namely my analysis circumstances. I have the initiating event value and then all of the recovery values, and if I had changed any other components in here, those would show up in the list.

Then I summarized the sequences in the conditional core damage frequency of each sequence that contributes to my result. Then I go and I tell the reviewer what the definition of the sequence is in terms of systems.

For instance, loss of off-site power, sequences 32-9 would actually be a blackout sequence, and a person would need to go and look at the station blackout event tree to understand that quickly, but if they didn't go to the event tree, they can see the sequence logic. There was a success of the reactor protection system with the failure of emergency power with a stuck open relief valve, with failure of the RCCI system and failure of the HPCI system.

And because I know what those abbreviations are, I didn't have to come down here and read it, but if I needed to know what the systems were, I would come down here and find out in my fault tree list.

This is just the fault trees that were actually used in any of the sequences that showed up in the results.

CHAIRMAN APOSTOLAKIS: Very good.

DR. SCHROEDER: Then I would come down and I would look at the cut sets associated with each sequence, and when I get all done with that I --

CHAIRMAN APOSTOLAKIS: Do you have an importance measure someplace?

DR. SCHROEDER: Not here, but that's because I didn't ask for that. I can go back and I can request those.

CHAIRMAN APOSTOLAKIS: No, that's fine.

By the way, I remember you're calculating Fussell Vesely, right? No, actually you call it something else.

DR. SCHROEDER: We calculate almost anything that anybody has thought of that they might want to see in the model.

CHAIRMAN APOSTOLAKIS: No, but you call it something else. You call it risk reduction work, right? At least in the earlier versions it was a risk reduction work. It still is.

DR. SCHROEDER: They get the same results, yes.

CHAIRMAN APOSTOLAKIS: Except you do some calculation, right?

DR. SCHROEDER: That's right.

CHAIRMAN APOSTOLAKIS: The fossil vessel.

DR. SCHROEDER: At any rate, if I go back --

CHAIRMAN APOSTOLAKIS: Now, since you've done all of these things, do you have a plot of the CDFs of all these reactors?

DR. SCHROEDER: I don't have one right --

CHAIRMAN APOSTOLAKIS: A base case?

DR. SCHROEDER: I don't have such a thing ready to hand out, but in effect, it can be generated rather quickly using the automation that we talked about earlier. It's just that we don't keep such a thing ready to hand out. We would have to go back to our desk and run the macro, and it would probably come out in 15, 20 minutes once it --

CHAIRMAN APOSTOLAKIS: I mean, if you get like the one you showed for the station blackout.

DR. BUELL: We could run that, and we have some automatic macros that will dump that out into a report function and --

CHAIRMAN APOSTOLAKIS: Okay. You can run it. Have you run it before?

DR. BUELL: At various times we've looked at that.

CHAIRMAN APOSTOLAKIS: And what was the conclusion? I mean, are there any CDFs that are close to ten to the minus four or higher?

DR. BUELL: There was a couple of them, but we've since knocked them down. There's none above ten to the minus four at this point.

CHAIRMAN APOSTOLAKIS: None?

DR. BUELL: There are some that are close, but there's none above ten to the minus four at this point.

DR. SCHROEDER: There was one plant that showed up right at the line, and they took great exception to that and have been arguing with us about it since, and pending resolution by the SRAs on what to credit at that plant, it could be substantially lower than that.

CHAIRMAN APOSTOLAKIS: Well, that's significantly different from the conclusions of the IPE project, right?

DR. BUELL: Well, there's been a lot of pencil sharpening in the intervening years.

CHAIRMAN APOSTOLAKIS: That was my question. Is it because of pencil sharpening or they actually did something? But this is not for you. I mean, somehow we will ask this question of somebody else. Nilesh, is that you? Is it your group?

MR. CHEOK: My guess is it's both. I mean, plants have done improvements since the IPEs, and they've done improvements as part of the IPEs, but there's also improvements in technology and how we define things, and that has brought down the CDF.

CHAIRMAN APOSTOLAKIS: So is it fair to say, Mike, there are no units in the United States that are above the goal for internal events at power?

MR. CHEOK: It's probably fair to say that SPAR models at this point do not show too many units or any units that are above the goal for internal events, but that's for the scope of SPAR models.

DR. THADANI: George, why is there ten to the minus four? A reactor year core damage frequency goal for internal events?

CHAIRMAN APOSTOLAKIS: No. This is the total

DR. THADANI: That's what I thought. So internal events would be some --

CHAIRMAN APOSTOLAKIS: Yeah, but we're calculating internal events only.

DR. THADANI: And to answer your earlier question, you might recall that there was a NUREG prepared that provides insight scan from IPE reviews and IPEEE reviews, and that describes briefly some of the things that the licensees have done.

CHAIRMAN APOSTOLAKIS: There were 19 PWR units whose CDF was above the goal.

DR. THADANI: Yes.

CHAIRMAN APOSTOLAKIS: So if now there's only one and even that is in doubt, that's a significant change, it seems to me. Somebody should come here and brief the committee about that. Is it a former IPE guys or somebody, or maybe you? Give us a profile from what you've got from a CDF.

MR. CHOKSHI: I think whoever does it will have to study it. We'll have to study and look at all of these pieces and --

CHAIRMAN APOSTOLAKIS: Take your time. Take your time. So tomorrow at noon, you'll probably do it.

(Laughter.)

CHAIRMAN APOSTOLAKIS: No, it's really an important insight because the committee, not just the subcommittee, the committee has been left with the impression that was created by the IPEs. I mean their report that Mr. Thadani just mentioned, and if now we have a change, it would be nice to know that, right? Because the IPEs didn't look at the low power shutdown either.

DR. THADANI: No, they did not.

DR. BUELL: There have been many plant mods in the intervening years. There's been a lot of --

CHAIRMAN APOSTOLAKIS: I appreciate that.

DR. BUELL: And even recently we just receive updates of plant mods.

CHAIRMAN APOSTOLAKIS: When NUREG 1150

came out and it was reviewed, that was one of the issues that was addressed. How are the results of NUREG 1150 different from those of the reactor safety study? And there was a significant reduction in all of the metrics, and that was a very nice thing to see.

And, again, it was really a combination of both better analytical methods and plant --

MR. CHEOK: And plant experience, operating experience. We show in our trending analysis that component reliabilities are going up and initiating frequencies are coming down.

CHAIRMAN APOSTOLAKIS: So you produced a report that made that very clear.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: But it seems to me that kind of information would be useful to the Commissioners as well. I mean, this gives a picture of the industry, right? This is where we are now.

MR. DENNING: But Dana is going to say, "Well, what's the seismic risk then?"

CHAIRMAN APOSTOLAKIS: Dana is not here. So he cannot say it.

MR. DENNING: No, I agree.

CHAIRMAN APOSTOLAKIS: No, but really, it's nice to see every several years that we are improving this. I mean, there was a very impressive result and figures were produced comparing 1150 with reactor safety study. Very impressive.

MR. DENNING: But it is as part of that important to say, "Well what has the plant actually done?" It has reduced it --

CHAIRMAN APOSTOLAKIS: Absolutely.

MR. DENNING: -- versus how much as sharpening your pencil.

CHAIRMAN APOSTOLAKIS: You have to understand that. So maybe, Nilesh, it's your group that will have to do this at some future time because you guys have access to all this, and all you have to do is go back to the IPE lessons learned, and they have a couple of tables. I mean, it's not a big deal.

MR. CHOKSHI: Well, also we're to look at this is plant journey analysis (phonetic). What are the features? Both sides you need to look at carefully and see.

CHAIRMAN APOSTOLAKIS: Yeah, yeah. See there is no other side. I don't think the IPE group exists anymore.

MR. CHOKSHI: Charlie's group will take it under advisement.

CHAIRMAN APOSTOLAKIS: Typical staff

response. "We'll think about it," which is okay. We really want you to think about it before you come here.

No, but I think that's important. It may even be worth issuing a report on that, a small --

MR. CHOKSHI: Well, I think it's very interesting as you said, a question inside that you can get.

CHAIRMAN APOSTOLAKIS: Absolutely, absolutely. Well, have we exhausted the usefulness of this example, John.

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: Wonderful.

DR. SCHROEDER: In fact, that's all that I had prepared to show. The only thing that --

CHAIRMAN APOSTOLAKIS: Well, I still hadn't seen though for this plant the CDF with its uncertainty. Can we see that?

DR. SCHROEDER: Oh, yes, we can see that.

CHAIRMAN APOSTOLAKIS: And then maybe LERF as well?

DR. SCHROEDER: No.

CHAIRMAN APOSTOLAKIS: Are you calculating LERF?

DR. SCHROEDER: I can't do that. That's

not incorporated in this model.

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: And that actually is an issue that we'll talk about later.

CHAIRMAN APOSTOLAKIS: Okay.

DR. SCHROEDER: It's a model maintenance issue.

CHAIRMAN APOSTOLAKIS: So let's just look at CDF.

DR. SCHROEDER: Okay. I'll have to resell (phonetic) the sequences here.

CHAIRMAN APOSTOLAKIS: Now, when you do these changes, the code preserves somewhere the base case that you've already done, right?

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: Okay. You don't have to go back and restore it.

DR. SCHROEDER: No. Well, in this case I'm recalculating it because it's not easy to copy the base case into the current case. It's really designed to go the other way for comparison purposes. The current case can be copied into the base case and used as a later reference, but when I want to reestablish the current case, I have to go and make a run, which I've already done.

CHAIRMAN APOSTOLAKIS: Okay. So let's look at it.

DR. SCHROEDER: And I have to do the uncertainty though, and I'll try 1,000 samples here. Like I say, I don't know how far -- okay. This is going fairly fast.

CHAIRMAN APOSTOLAKIS: So?

DR. SCHROEDER: Of course, the code is having to recalculate all of the probabilities in the model about 1,000 times for us, and it is taking some time.

MR. DENNING: While we're waiting, you know, we should have asked Dr. Shack's question earlier.

CHAIRMAN APOSTOLAKIS: I did I thought.

MR. DENNING: Did you?

CHAIRMAN APOSTOLAKIS: They said they follow 1150.

MR. DENNING: I guess that's right. So they're not doing anything new.

CHAIRMAN APOSTOLAKIS: Okay. Here we are. Base. Where are we looking, base or current?

DR. SCHROEDER: We're looking here.

CHAIRMAN APOSTOLAKIS: Okay. So it's ten to the minus five and 95th is what? A factor of five.

Okay. I don't like the skewness value, but that's okay. I think it's too high.

Do we really know that stuff so well, a factor of five? And this is a plot of what?

DR. SCHROEDER: Well, this is --

CHAIRMAN APOSTOLAKIS: CDF?

DR. SCHROEDER: -- the probability density function for the core damage frequency.

CHAIRMAN APOSTOLAKIS: It looks like normal, huh?

DR. SCHROEDER: And, again, that's not a lot of data points. It gets a little jaggy because this plot really only uses 20 or 30 points.

CHAIRMAN APOSTOLAKIS: Okay. Good. Let's move on.

DR. SCHROEDER: That was all that there was in the demonstration unless there was something specific you would like to see.

CHAIRMAN APOSTOLAKIS: Good, excellent. This was very good.

So what's the next subject?

DR. BUELL: Major modeling assumptions was the next topic.

CHAIRMAN APOSTOLAKIS: Are we going back now to your slides?

DR. BUELL: Yes, going back to the slides.

CHAIRMAN APOSTOLAKIS: And that would be Slide 31? Okay.

DR. BUELL: Okay. Given any PRA, you've got to make assumptions on how you model what are some of the key criteria. These are some of the major model assumptions that we use in the SPAR model. Okay?

And they're not ranked in order or anything, but this happens to be no recovery of DC power after battery depletion happens to be one of our most important assumptions.

CHAIRMAN APOSTOLAKIS: And why is that there?

DR. BUELL: Well, the reason that -- okay. This is a legacy item that has been ongoing since the beginning of the program, but what this assumption says is after the battery is deplete, we're not taking any credit for aligning power onto your emergency buses again after that point.

And there's a variety of rationale that goes underneath that. The fact that some of your emergency lighting could be out, the fact that you don't have remote control of your buses at that point; you would have to manually bring them on, you know, one at a time. It's a complex evolution.

CHAIRMAN APOSTOLAKIS: But I thought there was a significant time to core uncover after that.

DR. BUELL: There is, okay, but like I say, this is a limiting assumption right now that we have that we're looking at, and this is one of our -- not only is it a major modeling assumption, but it's a major modeling uncertainty as well.

CHAIRMAN APOSTOLAKIS: Now, is there also uncertainty to the time of battery depletion?

DR. BUELL: Every plant has their own battery depletion time basically.

CHAIRMAN APOSTOLAKIS: Seven hours, 12 hours? I mean, it's --

DR. BUELL: It goes anywhere from approximate two hours to I think the longest we model is 12 hours.

CHAIRMAN APOSTOLAKIS: So how do you handle that?

DR. BUELL: We handle that explicitly in the event trees.

CHAIRMAN APOSTOLAKIS: Do you use one value or do you put uncertainty distribution on these values?

DR. BUELL: There's uncertainty on the

recovery values, but there's no uncertainty on the battery --

CHAIRMAN APOSTOLAKIS: Why not? I mean, what if the licensee says 11 hours and you suspect it's more like seven?

DR. BUELL: We don't have any way to check that. Basically we have to rely on what they tell us.

CHAIRMAN APOSTOLAKIS: Can't you put that uncertainty distribution on the time?

DR. BUELL: We could run sensitivity studies on that. We would --

CHAIRMAN APOSTOLAKIS: But not uncertainty.

DR. SCHROEDER: There's no capability right now to build that into the Monte Carlo sampling scheme. It would require use of the plug-in capability.

CHAIRMAN APOSTOLAKIS: Isn't that another parameter though, John? I mean, why isn't --

DR. SCHROEDER: I said there's no capability now, but it could be built into the DOL. The plug-in capability is what we use to model these things because they are specific to our application. All it would take is a decision to go that direction and it could be done. There's no real difficulties there.

CHAIRMAN APOSTOLAKIS: Yeah, I mean that would make much more sense, it seems to me.

DR. SCHROEDER: Of course, the biggest difficulty is assigning the degree of belief to the distribution, you know, determining a model.

CHAIRMAN APOSTOLAKIS: But I think it's easier to argue about what the distribution is rather than argue about what the right point estimate is because then, you know, the stakes are higher. If you put probability, even a small histogram, it doesn't have to be a continuous distribution, you know. Two or three or four values, and you know, you weigh them appropriately. That probably would be a better and easier way of doing it.

DR. SCHROEDER: Okay.

DR. BUELL: And that's something that could be done, but right now we do not have that capability in there, nor do we --

CHAIRMAN APOSTOLAKIS: Okay. Well, we're here to help. We're here to help.

DR. BUELL: Okay. That's a significant one, and one of the reasons it's significant is like you indicated, you may have several hours beyond that point for core uncovery (phonetic) core damage, but we don't take any credit for that intervening period beyond the battery life.

CHAIRMAN APOSTOLAKIS: And that also could be something that would be handled probabilisticly.

DR. BUELL: That could be.

CHAIRMAN APOSTOLAKIS: Could be.

DR. BUELL: And we're going to deal with that particular issue later on. Common cause is not modeled across different systems. That's one of our assumptions.

CHAIRMAN APOSTOLAKIS: That's a standard assumption.

DR. BUELL: That's pretty standard. There are some plants out there that try to do that, but that's the exception rather than the rule.

Okay. Pre-accident human errors are not modeled.

CHAIRMAN APOSTOLAKIS: Really? That means during routine test and maintenance?

DR. BUELL: We do have fail to recover equipment from test and maintenance, but this refers to more like miscalibration of instrumentation level, instrumentation, those type of --

CHAIRMAN APOSTOLAKIS: But if they do maintenance and forget to reopen valves, that's part of it.

DR. BUELL: We have that in our model. That's explicitly modeled.

CHAIRMAN APOSTOLAKIS: So it's part of the human errors.

DR. BUELL: That's correct, for failure to recover equipment.

Okay. Basically we assume in station blackout and LOOP events that all run failures occur at time zero, and that's an issue that will come up later on again.

CHAIRMAN APOSTOLAKIS: But not in other initiating events? You don't assume that in others?

DR. BUELL: We do in other initiating events, too, but typically this is where it's most important.

CHAIRMAN APOSTOLAKIS: But, again, there has been a series of very interesting reports coming out of the same shop where analysts look at various incidents that have occurred, and they look not only at the unavailability of the thing, you know, on demand, but also the unreliability over a period of time, and then you can lump the two together if you want and say this is the unreliability of the thing, failed to start or it starts successfully and fails some time later.

So I'm a bit surprised that you're not including that.

DR. SCHROEDER: We are including that. I think there's a failure to communicate exactly what we're meaning by it fails to run at time zero. In a cut set for, say, loss of off-site power station blackout, you might have Diesel A fails to run and Diesel B fails to run. Both are characterized by fail to run in the first hour and fail to run during the 24-hour mission.

But that particular cut set at least with respect to recovery considerations, both failures occur immediately at the beginning of the loss of off-site power. We do not try to attempt to do the mathematics where Diesel 1 fails at ten hours and Diesel 2 fails at 15 hours.

CHAIRMAN APOSTOLAKIS: But then how do you calculate the probability of recovery, which is time dependent?

DR. SCHROEDER: That's right. We assume that there's a criterion that has to be met, for instance, the time to core uncovery and that it starts at time zero when the loop occurs and the clock begins running on that recovery.

There are mathematics that we have used in the past to try to convolve (phonetic) the probability distribution so that we assume -- we do an integration, in effect, of the fail to run distributions and the recovery time so that you get a credit for Diesel A running for one hour and Diesel B then failing at ten hours, and then the clock starts running on our recovery at zero to whatever your accumulated time is.

And if you integrate across all such times, you're basically doing a convolution integral, and we can't automate this easily. So we haven't applied it now, but it would in the worst case give us a reduction to 20 percent of the current run-run type of cut sets. It's just very --

CHAIRMAN APOSTOLAKIS: So that time you assume somebody has calculated, by doing the actual calculation that involves the time dependent failure of the diesels. I mean it can't be arbitrary. It has to be related to that.

DR. SCHROEDER: The time constraint for recovery is sequence and cut set dependent, and it depends on what systems have operated and what failures have occurred.

As I showed you in the station blackout

tree, this particular model might credit 14 hours, but in the particular cut sets, that particular 14 hour recovery is 14 hours from when the loop occurs. In a particular cut set for that sequence, it may mean that we can go 14 hours from when cooling is initially lost or when the diesels initially fail, and if we go to a convolution type technique, then we take credit for all possible combinations of run-run failures, one occurring at one hour and ten hours, two hours, 12 hours, all of that.

CHAIRMAN APOSTOLAKIS: But the assumption of 14 must include in it some estimate of how long the diesels might operate.

DR. SCHROEDER: The diesels in our model have to operate --

CHAIRMAN APOSTOLAKIS: Even though you don't include them.

DR. SCHROEDER: No, our diesels have to --

CHAIRMAN APOSTOLAKIS: You don't include the actual time of failure. You don't model the time dependent failure of the diesels. You are assuming that they fail at time zero, but then you have an assumption that as far as recovery of off-site power is concerned, we are interested in 14 hours. Is it going to be recovered in 14 hours?

That number 14 must have come from some kind of calculation.

DR. SCHROEDER: Right.

CHAIRMAN APOSTOLAKIS: And what I'm saying is that that number probably includes an average time for the diesels to operate.

DR. SCHROEDER: No, not in our models.

CHAIRMAN APOSTOLAKIS: So what did it come from?

DR. SCHROEDER: For a given sequence, like the sequence that I described that number would be based on the battery depletion time because for that particular sequence, the limiting issue is how long the batteries will support operation of the turbine driven systems.

CHAIRMAN APOSTOLAKIS: Well, yeah, assuming that you have no AC power, which is a strong assumption.

DR. SCHROEDER: Correct. Well, that defined in the cut set. I mean we have many cut sets for many different circumstances. In that particular scenario I would have cut sets for two diesels failing to start on demand, and I would have cut sets for one failing to start on demand and another failing to run, and then I would have one for the run-run failure.

The mathematics of the start-start failure are exactly correct. This assumption applies to the run-run failure where we say that the clock starts counting on recovery when the LOOP occurs, not when the second diesel fails.

CHAIRMAN APOSTOLAKIS: So that's ignored completely, the time until the second diesel failure.

DR. SCHROEDER: We ignore it in computing the recovery. We don't ignore it in computing the probability of diesel failure.

CHAIRMAN APOSTOLAKIS: But for the recovery, it probably makes much more -- has more impact.

DR. SCHROEDER: It has a big impact.

CHAIRMAN APOSTOLAKIS: And the utilities have not complained about this?

DR. SCHROEDER: Yes. Now, some of the utilities will actually do the convolution. What you'll see out there is those that have four redundant trains of emergency power feel no need to undertake the complicated mathematics. Those that have two trains feel a desperate need to undertake the mathematics, and they pretty well do it.

CHAIRMAN APOSTOLAKIS: Yeah, you don't have to do it exactly. I mean, you can have an estimate of an average time. It doesn't have to be a convolution, in other words. You take System 1 out of two systems. You have the failure rate of the diesel system. You say, "What's the mean time to failure of this system?"

It's five and a half hours. Okay. I'll use five and a half hours. So then the battery deletion issue starts after five and a half hours rather at the beginning.

That's a very simple way of doing it. You don't have to go to complicated mathematics. In fact, these formulas are available in books. So that's something that you may want to think about.

DR. BUELL: Well, that's one of our issues that we're going to address later on.

CHAIRMAN APOSTOLAKIS: So what you are listing here is modeling assumptions that you plan to revisit?

DR. BUELL: Some of these we'll plan to revisit if they're significant enough. Some of them definitely -- there are several of them here that we are going to revisit. Some of them we're just stating as a fact.

CHAIRMAN APOSTOLAKIS: Yeah, the CCF, for example, you don't have to revisit. I don't think there is any evidence that common cause failures across system have been a problem.

DR. BUELL: No.

CHAIRMAN APOSTOLAKIS: But the time to failure of the diesels I think is important because the recovery curve for the off-site power is fairly steep, as I recall. So by changing the time, you change the probability significantly.

DR. SCHROEDER: We have a side technical thread where we could demonstrate the method, but the bottom line is that for a typical run-run cut set that would be solved with convolution, the resulting cut set is about 20 percent of the result that you would get if you just assumed that the run-run failures occur at time zero.

So we're missing on those particular cut sets by maybe a factor of five, but while it sounds real big, those run-run cut sets are only a small fraction of all of the cut sets so that the impact on the model isn't that big. It's something less than that.

CHAIRMAN APOSTOLAKIS: Anyway, we can --

DR. BUELL: Anyway, this is one of the issues that we'll talk about later also, but the next item is failure of subsequent AC power recovery station blackout sequences can be neglected. Basically after you went to a station blackout once we get power back on, we stop the clock. We say we've got enough redundancy that the probability of those failures is negligibly small. That's just an assumption that we make.

CHAIRMAN APOSTOLAKIS: Good.

DR. BUELL: I know that's a little bit optimistic, but we have looked at that issue, and it's a pretty minimal impact.

Successful diagnosis is implied in all sequences with a couple of exceptions. One is a steam generator tube rupture where you have to diagnose which generator it's in. The other one is in ISLOCA events where you have to diagnose where your failure was and try to isolate it.

Those are the two exceptions to that, but in pretty much all of --

CHAIRMAN APOSTOLAKIS: What was the second one? The second one was?

DR. BUELL: Is an ISLOCA sequences where you're diagnosing where your rupture was and how to isolate that. Everything else we assume that you are in the right procedure and that you are following the correct path.

Okay. The next one is instrumentation and control, not explicitly--

CHAIRMAN APOSTOLAKIS: So how do you model diagnosis in those two situations?

DR. BUELL: You do not model those explicitly. We assume that they're followed. They're in the correct procedure at that point. They're big picture items.

CHAIRMAN APOSTOLAKIS: Oh. So then the statement is correct. The successful diagnosis is in naught (phonetic) sequences.

DR. BUELL: oh, with --

CHAIRMAN APOSTOLAKIS: In those two, in those two.

DR. BUELL: In those two exceptions we have an operator accident that we have generated based on --

CHAIRMAN APOSTOLAKIS: Probability?

DR. BUELL: -- yes, based on the input of trying to ascertain which generator you're in.

CHAIRMAN APOSTOLAKIS: So SPAR-H becomes more and more important every day, huh? Yeah.

DR. BUELL: So anyway, yeah, we do go through a detailed analysis.

CHAIRMAN APOSTOLAKIS: Who developed SPAR-

H? Who's the guy who will be presenting it?

MR. CHEOK: Dave Gooden.

DR. BUELL: The next one is instrumentation and control is not explicitly modeled for a variety of reasons. Number one is we don't have that level of information. The other one is typically it's not a driver as far as risk. Okay?

Errors of commission not modeled because you can get into an infinite number of combinations of that, and typically that's not been shown to be important at least in the PRAs.

CHAIRMAN APOSTOLAKIS: That's where ATHENA was supposed to help us, errors of commission.

DR. BUELL: Okay. Well, we don't model that as part of the SPAR mode.

Limited recovery modeling, this varies across the industry and the PRAs, but basically we don't look at recovery modeling with a couple of exceptions. In a station blackout we look at getting off-site power back. We look at getting the diesels back, and on a loss of service water, we look at getting the system back. We don't give it much credit, but there's some issues there.

Service water environmental issues are not modeled. This has to do with water quality, and that's something we're going to discuss in more detail later. So we can go to the next slide.

Okay. Some BWR specific assumptions. Containment binning, cause of loss of injection when you're on the suppression pool, that's something that we're looking at.

The next one, containment failure because of loss of injection, that's something we're in the process of changing actually right now. We're taking some credit. The early modeling that we did, the 2QA which was based on daily events, did not take any credit for that. The NUREG 1150 took credit for that. We're transitioning to more credit for that.

The problem is we have to depend on what the PRA people at the plant tell us as far as a success or failure probability on that.

Okay, and SORB --

CHAIRMAN APOSTOLAKIS: Rich, the time available for this is long, right? To cool. I remember it was four hours they said. They have to initiate cooling in four hours?

MR. DENNING: That's what was used by Marty.

CHAIRMAN APOSTOLAKIS: Yesterday.

MR. DENNING: Yeah.

CHAIRMAN APOSTOLAKIS: That's a long time.

MR. DENNING: That's correct.

CHAIRMAN APOSTOLAKIS: That's a long time.

DR. BUELL: And on PWR specific assumptions we're already addressed all three of these, except for the PORV challenge rate as not a plant or initiator specific, and that's a data issue that we haven't tracked down yet, but we make an assumption that it is constant.

Next page.

The next section is the quality reviews, and I can just continue on into that. The quality review of the new models, we've looked at the history before basically on the 2QA models. That was a peer review subcontracted out. Sandia and SAIC did the peer review of our Rev. 2QA models.

Okay. The next level of renew, we went to all the plants in the country as part of the STP process. We gathered information, fed that back into our models, and in the most recent level of QA is we're doing detailed cuts at level benchmarking against the PRA results that we gather from the plants.

So there's three different levels. As we expand the models obviously we need to do additional layers of QA, and we're doing that now.

MR. DENNING: Now, I'm not sure that as far as the term QA or validation of the models or verification -- validation of the models, I'm not sure that you haven't combined two concepts here in that under the second bullet, the QA reviews and detailed procedure and independent analyst, okay, that's QA. I mean --

DR. BUELL: Yes, this last step is not a formal QA per se, but it does give us assurance of correlation with the models or with what the plant is expecting.

MR. DENNING: Right, okay. Now, with regard to future change, let's go to real QA, and that's with regards to as you make changes in the models, what's the process of making sure that some person doesn't screw it up?

DR. BUELL: I'm going to deal with that in a future slide in a little more detail.

MR. DENNING: Okay. Then don't bother with it now.

DR. BUELL: Next slide.

MR. DENNING: And I wanted -- okay. I understand. You can go on.

DR. BUELL: In fact, this is the slide.

Right now whenever we go in and let's say an SRA calls us up. We're making a minor change, a small change. We've got this. We've added this piece of equipment, or we don't think that you've got the power supply or whatever modeled correctly.

What we do is we get that information and we incorporate that information, but we also have a couple of additional items. I maintain an open items list from previous calls or inputs from all the people that give us input. That didn't get incorporated that we have an open items list for basically that plant. What issues do we need to resolve on the next iteration?

So we go to that. We incorporate that information, and then once we're done with that information, we have a checklist of about 20 items that we go and say, "Did we do this? Did we do that? Do our results make sense?"

And so we go through this completion checklist. It has also got some documentation issues in there. Did we take care of that?

MR. DENNING: Who approves making a correction to a model?

DR. BUELL: If they're minor, if they're minor modifications, I do.

MR. DENNING: And is there somebody then that goes back? I mean, did you have a one-on-one overview or somebody goes back in and they check to make sure it was put in correctly?

DR. BUELL: I look at the results of the model that goes out. Every model that goes out I look at the results.

MR. DENNING: You look at the results.

DR. BUELL: The analyst does the analysis, and then I look at the results to make sure that they haven't changed significantly..

MR. CHEOK: And he has the follow-up to that. I think, every time a model gets changed the staff will also look at the results and go through the models to make sure that we understand the changes.

MR. DENNING: Okay. Is that a detailed review or is it kind of --

DR. BUELL: It depends on the level of the modification.

MR. DENNING: Okay. I'm just getting a feeling.

MR. MARKSBERRY: In some cases when modifications are made to support a detailed, then an ASP analyst or SRA would spend a week dissecting the results just to make sure that the results make sense.

So in most of the plant specific modifications, there is a very detailed one-on-one review of the mod.

DR. BUELL: And when we do global changes like we just did with the seal LOCAL modeling and that type of thing, it goes through a complete review process before we do any global type changes.

Okay. The next level is model configuration control. Right now this is an issue for us as we're expanding the models. You know, LERF models are built on the SPAR models. Low power shutdown models are built on the SPAR models. Some of these other peripheral applications are all built on the Level 1 SPAR models.

So as people start using the models more and more, controlling the base model is getting to be more of an issue, and we're looking at implementing some software controls, a library basic function that allows you to check out a model to use before you can make any changes to it. So that's just a programmatic issue that we're looking at.

A model of software currency. The software has a B&B process that they go through before they give us a new version of the model or a new version of their software.

As far as the model itself, we go through these steps and these procedures before we send it out and also to whoever we send it. Typically it goes through a detailed review also.

We also have a trouble reporting system that John alluded to or mentioned earlier. They can go in and formally file these issues, and we respond to those.

And then the next step is lower -- the process we're in right now is where we compare cut sets from the industry to our SPAR models in this proceduralized review, and we have a multiple page procedure that we go through when we do that.

The purpose of the work that we're doing now and these detailed cuts at level reviews is to identify significant differences between our models and their models and understand the reason why, and in some cases they require modifications to the SPAR models. Either we had incomplete information or the information that we had was out of date, old, whatever, and we can make some changes to our SPAR models.

We're not trying to mimic the PRAs. We're just trying to gather information from them, and this is a very efficient way of gathering that information, by looking at what they're saying is important and seeing if we have similar issues.

We have several steps in the review process. The first step in the review process is to gather that information. Typically the plants provide information all the way down to the normal truncation, the normal truncation. That entails ten to 30 or 40,000 cut sets, and we take that information. We reformat it, manipulate it to make it so that it will load into SAPHIRE, and then once we get it into SAPHIRE, it allows us to look at importance measures and do filters and sorts on it.

The next key step in this process is we identify approximately 150 of the most important basic events in their model. We take their basic event ID that corresponds to that model. We put that into an alternate field that we have in SAPHIRE so that there's a one-to-one link for these analogous events.

CHAIRMAN APOSTOLAKIS: Very good.

DR. BUELL: So we can generate a one-to-one importance comparison for 150 of the most important events, and if you pick these events correctly, typically there may be 500 events or 600 events that show up at their truncation level, but if you pick these events with a little bit of thought, these 150 events pretty much cover all of the systems, all of the major issues that you need to cover.

So like I say, that's the next issue or the next step that we do, is making that link, and then I'll show you how we use that in a moment.

MR. DENNING: One second though, and that is when you do that, do you often find cases where you don't have an event that corresponds to theirs?

DR. BUELL: Yes, and that's part of this whole process, is to try to understand why they have an event. We look at their importance measures, look at our importance measures.

In addition to just going down -- the first step we do is we just do a sweep through all of the systems, pick up the major components. Then we look at their importance measures, everything that they're saying is important. We're wanting to identify everything that we're saying is important. We want to identify it and make sure we have a good one-to-one correspondence.

But, yes, we have added events in our model because of what we're finding.

DR. SCHROEDER: Just as an aside on that, the truncation issue has become rather important because often we have components in our models that we know they have in theirs, but they don't show up in their cut sets. So we can't benchmark, say, our RHR trained C against their RHR trained C. If they would take a deeper cut, we could do it.

DR. BUELL: Most plants have a truncation level of approximately ten to the minus 11, but there are some plants out there that still have a ten to the minus nine truncation. At that truncation we don't have enough information to do a comparison of some of the lower level events.

MR. DENNING: Is this automatically a guarantee that the PRA is inadequate?

DR. BUELL: No, not in my opinion. I'm not --

CHAIRMAN APOSTOLAKIS: No, I don't think so.

DR. BUELL: I would not make that.

DR. SCHROEDER: And in fact, when you look at the top 150 events, you spent probably five, sometimes close to ten orders of magnitude on your component importances, and that's getting down to very, very small things, and Bob has plots that demonstrate that.

CHAIRMAN APOSTOLAKIS: I'm afraid we're going to have to stop now, a little ahead of schedule.

I have to do something. So we'll continue at 1:30.

MR. DENNING: So we will have an hour and a half you're saying?

CHAIRMAN APOSTOLAKIS: Yeah. I mean, the schedule was an hour and 15 minutes or whatever.

(Whereupon, at 11:58 a.m., the meeting was recessed for lunch, to reconvene at 1:30 p.m., the same day.)

AFTERNOON SESSION

(1:29 p.m.)

CHAIRMAN APOSTOLAKIS: We are back in session.

Now, tell us please what the Birnbaum measure is. I know, but I forgot. What is the Birnbaum importance measure?

DR. BUELL: the Birnbaum is an important measure that if you take the cut set with it set to true --

DR. SCHROEDER: Yeah, its' F of one minus F of zero.

CHAIRMAN APOSTOLAKIS: Quiet please. Yeah.

DR. BUELL: It's a cut set with it set to one or to true, basically fail, versus it to set to false, and it looks at the difference between that.

CHAIRMAN APOSTOLAKIS: It doesn't use probabilities?

DR. BUELL: No, it does not. Basically it takes out the -- that's one of the reasons they use a Birnbaum. It looks at the maximum spread. If that event was set to true and to false, it looks at the maximum spread that you'll get there and gets rid of that variability in the Birnbaum.

CHAIRMAN APOSTOLAKIS: Maximum spread in what?

DR. SCHROEDER: In the core damage frequency. It is the total core damage frequency with the basic event value set to 1.0 minus the total core damage frequency with the plant with the basic event set to zero.

CHAIRMAN APOSTOLAKIS: Is that the risk achievement worth?

DR. SCHROEDER: Risk achievement --

CHAIRMAN APOSTOLAKIS: Birnbaum does not deal with probabilities I don't think. What you described is the risk achievement worth.

DR. SCHROEDER: I guess I'd have to look at the false. The risk achievement worth ratio --

CHAIRMAN APOSTOLAKIS: You set the probability at one?

DR. SCHROEDER: It's a ratio. This is a difference.

CHAIRMAN APOSTOLAKIS: So it's just the difference.

DR. SCHROEDER: The difference.

DR. BUELL: From setting that event to true.

CHAIRMAN APOSTOLAKIS: And why is that

more important than RAW? I mean, RAW is the fraction of change in the CDF.

DR. BUELL: they're similar, and we could have used that.

CHAIRMAN APOSTOLAKIS: But everybody uses RAW. I don't understand why.

DR. BUELL: The MSPI program is using the Birnbaum also. So there's some correlation there.

CHAIRMAN APOSTOLAKIS: All right.

DR. BUELL: So where we left this last is we had linked these basic events, the analogous basic events come out of the PSA. We linked those to our equivalent events in SPAR models, and what we're doing in this whole review process is we generated some metrics, and these are metrics that tell us that we've spent enough time basically trying to understand the issue.

And one of the metrics that we looked at is when we look at theirs versus ours is our overall CDF within a factor of two. Okay? This is just the level of effort.

CHAIRMAN APOSTOLAKIS: Is this the mean CDF?

DR. BUELL: That is correct.

CHAIRMAN APOSTOLAKIS: Not the point

value?

DR. BUELL: Well, it's the point value as they report it to us.

CHAIRMAN APOSTOLAKIS: But there are differences between the point value. How is the point value estimated? By putting in point values for the probabilities and you don't know what they are, right?

DR. BUELL: Yeah, we have no information on their distributions.

CHAIRMAN APOSTOLAKIS: Can you ask them to give you mean values? I'll make them do it. Because the point values, I don't know. We want to use PRA, but we don't want to do it rigorously.

And your results earlier that you showed, John, there were slight differences between the point and the mean.

DR. SCHROEDER: Yes. It varies much from model to mode, but usually before we post a final model one of our completion checks is to run the uncertainty distribution and look at the difference between the point estimate and the mean, and for a typical SPAR model they're very close.

There are times when we spot a divergence in those two numbers, and when we do we suspect something's wrong and we look for it. There's something that probably isn't right in the model if there's a big difference between the point estimate and the mean.

CHAIRMAN APOSTOLAKIS: Well, if you have distributions that are very wide, in general the results are different. If you have distributions that have an error factor of three, then you don't expect much.

DR. BUELL: For this level of comparison we haven't looked at it in that depth. So when we're all done with this process, our overall CDF within a factor of two, we look at the conditionals for each one of the initiators. That broadens out just a little bit from about a .5 to a three range.

And then we have a dimensionless metric that we generated that I'll show you here in a couple of slides, and we use a .2 value. These were determined based on level of effort and how much time it takes to generate.

CHAIRMAN APOSTOLAKIS: Rich, I remember from 1150 that the CCDP was practically between zero and one. It was really a very wide conditional probability. I mean, most of the cases I looked at it was a very maybe not quite up to one, but it was way up there.

MR. DENNING: Well, what you're doing is you're just talking about the initiating event frequency.

DR. BUELL: That's right. This is a conditional setting the initiator to one. We're looking at the difference. Given you have an initiator, what's your residual?

And we compare that --

CHAIRMAN APOSTOLAKIS: Oh, it's still core damage.

DR. BUELL: That's right.

MR. DENNING: This is core damage.

CHAIRMAN APOSTOLAKIS: Oh, okay. It's not containment. Okay, core damage.

MR. DENNING: Yeah, I was initially confused about that, too.

DR. BUELL: Okay. So these are our metrics that we've generated, and that's just to tell us that we're close on the comparison or close enough that we can stop the comparison.

CHAIRMAN APOSTOLAKIS: But I don't understand that. Why are you allowing a higher number here? I mean, do you think that CCDPs are what?

DR. BUELL: As you get to lower levels of detail, the things that drive the differences sometimes are such that they're outside of our charter as far as how we model the models.

On the overall CDF, you know, you've got some of them that are a little more conservative in here, some of them that are not. Overall CDF, they balance out a little bit, but as you get to these lower and lower levels of detail, you know, the nuances tend to make them lighter as far as the comparison.

DR. SCHROEDER: Let me add a little bit about, you know, an aside to what we just said. This is one measurement per model. This is 15 or so measurements per model. This is 150 measurements per model.

So the number of comparisons implied by each of these levels is varying in the order of magnitude.

DR. KRESS: I guess George is wondering why the .5 still shows up in that middle bullet. Why isn't that different also?

MR. DENNING: Well, that would be a .3.

DR. BUELL: That would be a .3 if you're consistent on either side of it. We didn't want to be under, you know. If we're considerably less, if we're throwing a CCDP that's less than there, that's something you'd want to look at and not just accept it. If we're a little bit higher on that, then that's okay in our first cut, but if we're considerably lower than they are, we just thought we'd look into that a little more, in a little more depth.

CHAIRMAN APOSTOLAKIS: And the licensee provides you all of this information that you need?

DR. BUELL: So far they have. That is correct.

CHAIRMAN APOSTOLAKIS: You don't have to do any calculations yourselves.

DR. BUELL: No. We just take it; we format it and load it right into SAPHIRE. There's no calculations associated with that.

Next slide, please.

Okay. This is just a little more of a description of the method. Basically what we do, if our points or their points, if our model was identical to their model with values and logic, what you'd end up when you compare these Birnbaums, you'd have a Y equals X line, slope equals one. It would be identical. All of these points would be on that line. Okay?

We don't have any ideal cases out there. So what we've done is we've generated a metric that basically just looks at the distance these points lie from that Y equals X line, and we sum those up.

We also have a weighting factor because we have such a wide range. A lot of cases we'll have seven or eight orders of magnitude. You don't want one point that's a little bit off at the top end outweighing a million points at the bottom end. So we have a logarithmic scale, a weighting factor that we've looked at, and we incorporate into this metric. Okay?

The next slide.

Basically this is a before picture. This is a comparison of their model results to our model results without us making any modifications. Okay?

And if you'll look at this line here our metric, the distance from this line is what we're measuring and summing up to give us that metric. So as those converge on that Y equals X line, that metric is going to get smaller.

And right now that metric is 1.9, and we picked one that had a pretty broad range between what we started with and what we finished, and you'll see in successive slides that --

DR. KRESS: Do you add up all of the log distances and divide by the number, then take the analogue?

DR. BUELL: That's correct. So you'll see that there's quite a bit of scatter on this. Okay? This is the starting point before, right as we loaded the information into our models. Okay?

The next slide.

This slide you'll see that the scatter is collapsed along the line. We've made the logic fixes, but we haven't done anything with the data yet. Okay?

As part of this process, because there's two variables in any model, there's the data and the logic. To be able to just focus in on the logic, what we do is we build a change set that includes their data. It overlays our data with their data. It's just a temporary thing. That way the data values are not a variable any longer. We can just look at the logic.

We haven't done that yet, but this is the kind of math you would see after we made the logic fixes.

CHAIRMAN APOSTOLAKIS: So if I take the low point there between ten to the minus six and ten to the minus five.

DR. BUELL: Okay.

CHAIRMAN APOSTOLAKIS: This the ratio of

your Birnbaum over theirs.

DR. BUELL: And you can see because it's higher in ours that it's much more important in our model than it is in their model.

DR. KRESS: And that's for a specific basic event?

CHAIRMAN APOSTOLAKIS: Wait a minute.

DR. BUELL: That is correct. That's for one basic event.

CHAIRMAN APOSTOLAKIS: Theirs is higher. Therefore, it means that it's more important in your model?

DR. BUELL: No. These are the SPAR Birnbaums. That point right there is more important. It has a higher SPAR Birnbaum than it does a PSA Birnbaum.

CHAIRMAN APOSTOLAKIS: Well, so it's not a ratio.

DR. SCHROEDER: No, it is a plot.

CHAIRMAN APOSTOLAKIS: Yeah, yeah.

DR. SCHROEDER: It's just a plot of the X-Y values.

DR. BUELL: Yes.

DR. SCHROEDER: For instance, this point that you called out, the SPAR Birnbaum value for that thing is like bigger than E minus six. The PSA Birnbaum for that value is less than minus seven.

DR. BUELL: Is mid-minus eight.

So anyway, as we make the logic fixes, you know, based on what we're finding in the cut sets, we get a convergence as you'll see along this line. Okay?

And the final comparison that I wanted to show you is the same model that we have just seen in the previous slide without the data variability. We basically put their data in the change set, superimpose that on our model, and you can see there's a significant additional convergence on the model. Okay?

So each one of these successive steps shows a greater and greater convergence. Now, there's some of these points, and if you'll look at the metric, it's basically, like I say, you want that line to be a heavy black line with all of those dots. The greater the importance based on our weighting factor is basically an angle from this point, from the one-one point.

So the greater the angle, the more important the points, and these four points here are the most important points in the contribution to that metric. So we say, well, what are these points. What do they relate to?

We look into that and try to see what's driving those points, and that's what we do. This is an iterative process. We look at their cut sets. We look at our cut sets. These are the ones driving the number. What's going on here?

And we continue to look at that, and for these particular points when we go to the next slide, they do have a story.

CHAIRMAN APOSTOLAKIS: So the most important points are the ones on the upper quadrant.

DR. BUELL: Yeah, these because there's a weighting factor. As you get closer to one, you want a higher weighting factor. Those are more important with the higher Birnbaums.

If you've got something down here, an order of magnitude down here, ten to the minus seven is not as important as an order of magnitude difference at ten to the minus two. So we have a weighting scale that goes along that.

CHAIRMAN APOSTOLAKIS: Yeah, sure.

DR. SCHROEDER: This is the triangle I referred to in this morning's presentation where there's increasing scatter at the bottom that we don't attempt to address on the idea that it is just not worth our time.

DR. BUELL: Okay. So like I say, I mentioned that these four points have the biggest contribution to that metric, and if we go to the next slide, there is an explanation of what those events are.

This goes back to some of these events we've already mentioned, some of these differences and uncertainties. Okay? It comes about from having the diesel generator and DC bus failures are those points. Okay? That's the analogous points, but what the rationale is or why they're different is the fact that there's much more credit for recovery of off-site power in the St. Lucie model than what we give. Okay? They've generated their own curves through recovery of off-site power. We don't use those curves. We use ours that we've generated in the SBO study.

So what that does is that gives much more importance on the diesel generators because they can recover power with a higher likelihood. We don't. So our diesels are more important.

The same thing on the feed and bleed. ON a loss of DC bus, you fail our feed and bleed in our model because we require two PORVs. They only require one PORV. So a DC bus is not that important to them because it doesn't fail that additional heat removal bath.

But in ours because it fails feed and bleed, it's much more important in our models.

CHAIRMAN APOSTOLAKIS: So you will change your model then?

DR. BUELL: No. We don't change them. This is just an area we've understood the differences. We're not going to go there. We have a standard charter in the SPAR models. Two PORVs is our success criteria. Unless we get detailed thermal hydraulics, in fact, we haven't received any yet that we've incorporated, but we use a two PORV success criteria. That is our model.

CHAIRMAN APOSTOLAKIS: Wouldn't the licensee in this case provide to you that thermal hydraulic analysis.

DR. BUELL: If we pursued that further, we could possibly get that information, but for now we are, I guess, satisfied with using two PORV success criteria.

CHAIRMAN APOSTOLAKIS: Because you're not using it in any decision making situation, but if there is a need for an SDP at St. Lucie 2, they're going to fight you.

DR. BUELL: Well, at that point then the SRAs will make that decision, and if they come back and say, "We feel that there is sufficient justification to use a single PORV success criteria," then we would --

CHAIRMAN APOSTOLAKIS: Well, why don't you do it now? I mean, I don't --

MR. CHEOK: Well, George, I think the issue is a little broader than described. A lot of the licensees would be using the map code to justify the two PORV and one PORV success criteria, and the agency now has an initiative to look at the map code to see if it's sufficient in quality to be used for two-phase flow type success criteria determinations.

CHAIRMAN APOSTOLAKIS: The agency has never reviewed the map code?

MR. CHEOK: We have, I think, agreed to disagree at this point as to what the map code is capable of doing, but we said that --

CHAIRMAN APOSTOLAKIS: But was it ever reviewed?

MR. CHEOK: We looked at the map code, and we had several decisions in the past, in the IPD stage, where we said that we think that the GAP code is good enough to use to identify vulnerabilities, but for licensing applications, we will have to determine on a case-by-case basis.

DR. KRESS: Yeah, the map code now is a lot different than the one they had in IPE.

MR. CHEOK: That's correct, and we are looking at the newer versions of the map code.

MR. DENNING: But whether it's appropriate for use in determining success criteria is still an issue.

MR. CHEOK: That's correct, and I guess this is in a sense a little bit outside the scope of the SPAR model development program because it's a different initiative in the agency.

CHAIRMAN APOSTOLAKIS: You are not using any other code. We just see whether what they did with map is reasonable.

MR. CHEOK: At this point that's correct.

MR. DENNING: Do you also have a public relations concern here that obviously it's important to you that the utilities work cooperatively with you, and I would imagine that if you turn every issue into something that potentially looks to them like it's a question of inadequacy, that they would not be as cooperative with you, or do you not run into that at all?

DR. BUELL: We haven't run into that. The utilities have been very forthcoming with the information. That has not been an issue to date, and if you look at this, this has almost no impact on baseline CDF, but it does have importance when you look at a single component, you know, some of these individual components.

CHAIRMAN APOSTOLAKIS: Or their sequence.

DR. BUELL: Say again? Or on a particular sequence, and it has significant impact when you do a determination with one of these components involved.

CHAIRMAN APOSTOLAKIS: Have you found many instances where there was an issue of success criteria?

DR. BUELL: Typically not.

CHAIRMAN APOSTOLAKIS: Typically not.

DR. BUELL: this is one of the examples that at this point we just agreed to disagree on.

DR. SCHROEDER: One more observation on this particular one. The reason that it is one of our large structural uncertainties in the model is that if you go and look at all of the plants that credit one valve and all of the plants that credit two valves, there is no discernable reason why. They could be sister plants with virtually identical size and capacities and the like, and one of them will credit one PORV and the other PORVs, and when we look at that what we see is that, well, one guy had an adequate core damage risk without doing the additional analyses and the other guy didn't.

So they did an expensive analysis to demonstrate the capability, and we in Idaho don't have the ability to review those analyses and determine that they're adequate.

DR. THADANI: These valves are not really -- I mean are they test data in terms of performance of these valves under these conditions? I know the Germans tested them, but I don't know of any other place where they can say these valves would actually perform properly.

DR. BONACA: Yeah, that's the question I was asking before. I mean, would they stay open?

DR. BUELL: Well, it depends. Like I say, under some circumstances the PRAs themselves do not take credit formula if the supports are gone and that type of thing. We don't look at it beyond this level.

MR. DENNING: And we probably shouldn't either at this point since this is for review, but I think it's really interesting and something we have to keep in the backs of our minds here, and maybe there are some lessons to be learned here, but obviously it's not a SPAR question in that sense.

CHAIRMAN APOSTOLAKIS: What isn't?

MR. DENNING: It's a PORV question.

CHAIRMAN APOSTOLAKIS: No. The identity of the model is a SPAR, isn't it?

MR. DENNING: Yeah, but you know, when we get to these detailed questions of whether one PORV or two PORV is necessary, as they've been saying, they really can't get into that. That's too much of a distraction. You know, they have to put together the structural thing.

Now, eventually if the issue comes up where it makes a difference, then they have to get into it, and you know, NRR has to get into it.

CHAIRMAN APOSTOLAKIS: Well, I thought the idea was to have SPAR models that are reasonable presentations of the plants so we can use them. What you're saying here is, yeah, there may be situations where either the licensee or we are right, but we don't know, and whenever we have to deal with them on such an issue, then we'll decide.

But at the same time they are telling us that there are not very many instances where they have these differences. But I don't see. Maybe we can just resolve it now.

But Mike said that they are going to get the map code, right? And so perhaps there will be a resolution then. Always Mike comes with a solution.

DR. BUELL: Like I say, at that point we identify the top outliers and the reasons for those, and that's the extent of our comparison, but you can see throughout that progress or that progression that there's quite a convergence, and most of the differences are what we pick up in support system information, and that's what --

CHAIRMAN APOSTOLAKIS: So the Columbia seems to be different, 3.1, 6.3, 10 to the minus six.

DR. BUELL: Okay. What this table is is the SPAR CDF with our normal template data that we have, our final model with the normal data that we have. Okay?

The next column is the completed model, same model, only with the key data from the SPA, and then the final one is the results as reported by the utility themselves.

CHAIRMAN APOSTOLAKIS: So you're closer when you use that data.

DR. BUELL: Yes. As you can see, we put

their data in. These converge.

CHAIRMAN APOSTOLAKIS: But I still don't know why you have to give the column with the nominal data. I mean then your SPAR model should be the column before last. I mean if you agree with their data -- this doesn't imply that you agree.

DR. BUELL: Yeah, this doesn't imply. This is just a comparison. We're not saying we agree with the data or we disagree with their data. We have our own data analysis. Well, that will be taken care of in the spring. I'll just let it go at that because that's a whole discussion.

CHAIRMAN APOSTOLAKIS: And it's interesting that for some plants the PSA of the licensee gives a fire CDF, huh?

DR. SCHROEDER: That is often the case once we apply the new SPAR template set. Our CDFs tend to drop somewhat below what theirs are.

CHAIRMAN APOSTOLAKIS: Most of them seem to be below.

DR. BUELL: With the exception of about three of those, I believe, they're below, and one of the reasons for that, like I say, it will be elaborated on when the data is presented this spring, but most PRAs use old generic data that they update with plant specific data through a Bayesian process.

Okay. What that does is it shifts the mean a little bit toward the plant specific data, but essentially it's the old generic data. With the new data that we used, we used a current five-year period, and it is somewhat lower than what the old generic data is, and there could be a variety of explanations for that.

CHAIRMAN APOSTOLAKIS: It seems to me that plant specific data should be used no matter what Bayesian does. Plant specific data should be the appropriate ones to use, and since you have done the calculations,go with that.

MR. DENNING: Well, you're saying the plant specific data is correct, and that isn't necessarily true. I mean, I've seen plant specific data that just when you put it all together doesn't make sense.

I mean, I think --

CHAIRMAN APOSTOLAKIS: Well, then there should be some mechanism to make sure this doesn't happen, but I mean, again, if you look at the experience of PRAs the last 25 years, they're plant specific. They have to be plant specific.

DR. BUELL: Okay. Well, the plant

specific aspect of it, like I say, is just shifting that generic data a little bit.

CHAIRMAN APOSTOLAKIS: Sure.

DR. BUELL: And there's no standard out there for industry data collection and analysis as far as what events get thrown out for nonapplicability and that type. There's a lot of variability in the way the different PRAs calculate plant specific data.

DR. SCHROEDER: One of the uncertainty contributors that we have identified in previous slides and we'll get to again is this issue of generic versus plant specific. We don't exactly know which is the most appropriate. The data collection effort is demonstrating that depending on what snapshot you take, the plants can look either very good or very bad.

And if you take the wrong snapshot, just a random snapshot, a plant could look horrible, and there may be no real operational difference or quality difference between the plant in this snapshot and the plant in that snapshot. So what is the correct way to deal with that issue?

That is something that the data people are struggling with.

CHAIRMAN APOSTOLAKIS: What is it that

tells us that your nominal data are reasonable? You have thrown out some stuff, too. I mean, it's not that we are supreme beings and everybody hasn't been making mistakes.

MR. CHEOK: You're right, George. I mean, that's why I think we would like to come back to you in the spring and the summer to discuss with you our process.

CHAIRMAN APOSTOLAKIS: Mike is always asking.

MR. CHEOK: We do have a process.

CHAIRMAN APOSTOLAKIS: You must have been before this committee before.

MR. CHEOK: I think so.

CHAIRMAN APOSTOLAKIS: I think that's an excellent point, and you get the flavor of the questions you're going to get in the spring.

MR. CHEOK: Right. We're not a supreme being. You're right.

CHAIRMAN APOSTOLAKIS: I have seen PRAs when I was actually participating in the actual doing. In one plant you have the generic distribution, and for some components, in fact, there is a paper out of it. Based here and pushed the distribution so high because of that time we had to discotize (phonetic), it really pushed it outside the range. The plant was very bad from that point of view.

For other plants, it was what Bob said. In most plants, in fact, in most components, you have a slight shift, which is okay, but there are several plants where this happened, and in fact, the question that was raised then was is the plant really too bad or is the generic distribution too optimistic.

Have you seen that paper?

MR. CHEOK: I'm not sure. I mean, I may have.

CHAIRMAN APOSTOLAKIS: This is one of the very early papers that came out. Well, hell, it's my paper. Okay?

(Laughter.)

MR. CHEOK: I was going to say I wasn't born yet, but --

(Laughter.)

MR. DENNING: You'd better move on.

MR. CHEOK: Let's move on here.

CHAIRMAN APOSTOLAKIS: The quality of your comments reflect that. You're stealing mine, too.

DR. BUELL: Okay. this slide is just something for reference. This is not a rigorous analysis of this one here, but basically what I did is

I just took the mean of the ratios of the CDFs with the PSA data to the PSA CDFs with their data. So that kind of looks at the logic. I show that there's not much difference in the mean, and there's not much variance there.

I also did it with the nominal data, looked at that column versus the PSA CDF. You see that the mean drops down, which implies that the SPAR with our data, you know, and the logic being equivalent are the equivalence we can get is a little bit less, and that implies that our data, if you go down to these next two slides, our data that we're using now tends to be a little bit lower than their data. Okay? And there's a variety of reasons for that. I just picked a couple of them that are important.

The failure rates for the emergency diesel generators are typically a bit lower than what the industry is using. The turbine driven pumps is a little bit lower than what the industry is using. The transient initiating event frequency is a little lower. Those are contributors.

There are some that are higher, too, but in general these are things that drive it down lower.

Did you have question?

CHAIRMAN APOSTOLAKIS: Well, no, just a comment. I want to reinforce what you said earlier about, you know, how does one decide that something is a failure or not, how to handle it, to include it, not to include it. This is probably the most important issue in data analysis. Once you decide what the number of failure is, the number of tests is, the Bayesian calculation is a matter of seconds, and I remember in the old days they would send two or three experienced engineers, the company that was doing the PRA, to the plant where they would spend at least a week going over the logs and deciding what is a failure.

For example, when the utility replaces a component because it's about to fail, but it has not failed, is that a failure or not? Should it be included or not?

They replaced it. It didn't fair. It would have worked, right? But you know, being cautious they said, okay, we'll replace it.

This issue was huge in the PRA that NASA was doing for the shuttle las year because there, you know, being a one of a kind system, every time they see something they change the design process. So now the guys quit doing the PRA come in and say, "Well, this failure counts as .1 of a failure."

Why? Engineering judgment, you know. In other words, there are several reasons as to why you should reject or include an apparent failure in the database, and that is really a major issue, a really major issue, and maybe you guys can think about it a little harder because it does not affect on the plant specific information. It affects the distributions, too.

I mean, there is nothing magical about the reactor safety study generic distributions, and I gave you an example. In the plant there were many components, surprisingly many that had failure rates that were beyond the 95th percentile of the reactor safety study distributions, which created a question about the generic distributions themselves because one or two you might say, "Well, okay. This plant is really bad here," but consistently?

So I think this is something that as a team we should spend more time on in thinking about it. I don't know what else to say, but these are real issues. I mean, I know the NASA folks had a hell of a time, you know. The analysts would agree that, yeah, we'll count this as a failure. A week later we can't do that. Our managers disagree. They spend half a million dollars fixing this, and you are telling them it's still a failure?

And they had a point, too. They said, "Why on earth did I spend all of this money if the projection in the future accounts these things as failures?

So that is a very important point, and I'm glad we're getting back together in this way.

DR. BUELL: And this last bullet if you look at we have a mean of 1.1 with the PSA data in, suggests that we may be a little less optimistic than they are. We've got some things that are a little bit more conservative, possibly the two PORV success criteria, no recovery out for battery depletion, but you can see with that 1.1 mean that there's not much difference.

CHAIRMAN APOSTOLAKIS: I think this is a very -- my personal view now -- this is a very detailed and thorough process that you guys have developed to compare with the licensee because you are using analysis, you know, sensitivity studies and so on. That's very good. That's very good.

So ultimately the SPAR models will be represented.

DR. BUELL: That's the intent, but like I say, with specified differences that we just agree to disagree on until we get further resolution.

CHAIRMAN APOSTOLAKIS: Yeah, sure.

DR. BUELL: Okay. I'll just roll right into this next issue here. The modeling issue is being worked. Some of these we've already talked about at length. Some of them we haven't.

Where this list came from, we went around and visited all of the plants in the country basically as part of the STP process. During those visits we looked at and tried to keep track of issues that when we compare our model results to theirs we try to note the differences as we went from Plant X to Y to Z. We'd say, "Well, that guy did it this way. This plant is doing it this way and it doesn't seem to be any difference in the plant. Is that just an assumption driven difference or, you know, who is modeling it?" and everything.

But anyway, based on the information we gleaned during those visits, we generated ten items.

CHAIRMAN APOSTOLAKIS: Isn't it surprising that human error is not there? You mean they all agreed?

DR. BUELL: That wasn't one of the issues that was driving --

CHAIRMAN APOSTOLAKIS: Really?

DR. BUELL: -- was driving the differences.

CHAIRMAN APOSTOLAKIS: So maybe all of them use the EPRI mysterious method. I can't believe that human error is not an important modeling issue.

DR. BUELL: Well --

CHAIRMAN APOSTOLAKIS: Let's stop immediately all of the work we're doing here.

MR. DENNING: Well, you know, again, as we look at SPAR and what its use is, at the moment --

CHAIRMAN APOSTOLAKIS: No.

MR. DENNING: -- we're not going to have human error be an important element in --

CHAIRMAN APOSTOLAKIS: That's not what they're saying.

MR. DENNING: No, no.

CHAIRMAN APOSTOLAKIS: They're saying that these were differences between you and the utilities, right?

DR. BUELL: Yeah. Let me clarify that for a moment. You know, possibly there's some obscuring going on here. A lot of utilities use a dependent HRA methodology that rolls up four and five and six events into composite events, and they use them in different combinations, and there's, you know, almost an infinite number of combinations of these events that they roll up.

So the HRAs or the HEPs are hard to correlate and know exactly. You know, we have an operator action. They had an operator action, but because of all the dependency analyses and stuff that are going on, it's awful hard to do a direct comparison of our numbers versus their numbers.

Now, we didn't look at like a fossil vessel (phonetic) of all of the ATPs or anything like that in a rigorous way.

CHAIRMAN APOSTOLAKIS: But didn't you subject -- you just showed us a very nice and detailed staged or phased way of identifying differences, and the human error didn't come out there?

DR. BUELL: Well, this was based on information we gathered before we did any of these types of analyses. We're early into that detailed comparison process.

This was just a qualitative look at the plants that we visit.

CHAIRMAN APOSTOLAKIS: I mean, one of the striking results of the IPE lessons learned volume NUREG was that the wide range of human error probabilities was, in fact, in one plant the probability of failing to initiate standby liquid control was ten to the minus six or lower, and in other plants it was ten to the minus three, and they were almost sister plants. So that tells you that there is tremendous difference in modeling, and I'm surprised that it's not here.

DR. SCHROEDER: Well, I'd like to say something about that. When we do the benchmarking process, keep in mind the procedural steps we went through. One of the procedural steps in trying to align the logic is to apply their probability to our events, and when you do that, those disagreements in HEP values don't drive the metric. I mean by design of our process, they are taken away.

What is checked is that we have an event like their event, and it affects the overall structure of the model in the same way. When we ship the model, it goes with the SPAR-H method, and we don't really care what they have. What we do --

CHAIRMAN APOSTOLAKIS: I don't understand this.

DR. BUELL: Okay.

CHAIRMAN APOSTOLAKIS: I mean if you compare your PRA, your SPAR, with their PRA and you use a number like ten to the minus three from SPAR-H and they use ten to the minus six, wouldn't you catch that?

DR. SCHROEDER: We would, and if we go to our plots like on a first St. Lucie plot -- let me back up to that one if we can remember the page that we're on here.

There might be HEP disagreements in this range here. In fact, many of these things might be HEP disagreements because we have a human error event that looks like their human error event, for instance, failure to initiate SLICK (phonetic), and if we were E minus three and they were E minus two, or vice versa, that would show up as a big disagreement here.

But when we apply the PSA data, that difference would vanish if the logic model was the same.

MR. DENNING: Now tell me. That means you're effectively using their value for?

DR. SCHROEDER: For this part of the comparison we're using their HEP.

MR. DENNING: Yeah, I meant in that part of it.

CHAIRMAN APOSTOLAKIS: But that's artificial.

DR. BUELL: And we've been focusing, and the reason we do that is we've been focusing on the structural logic of the model as opposed to the value. So we've been purposely trying to get rid of the variability in the value so we could focus on the structure.

DR. SCHROEDER: And then when we finish we go back and put in our data set with our SPAR-H HEPs, and there may still be outliers related to those events, but we will simply agree to disagree on those.

CHAIRMAN APOSTOLAKIS: But you have not done this. I mean that --

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: -- is something that could be done, but you haven't.

DR. SCHROEDER: No, that's what we do.

CHAIRMAN APOSTOLAKIS: And I'm still surprised that you couldn't find it. I mean you found differences in CCF modeling, which you know, both of you have an event that says common cause failure of the thing. So it's the number that is different. So I can't imagine that there weren't any human errors that both of you had in the model, but the numbers were different.

DR. SCHROEDER: There are many of those.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. SCHROEDER: But they don't come to us in our reporting to you as a modeling issue we're concerned about because SPAR-H is our method and our numbers are our numbers.

CHAIRMAN APOSTOLAKIS: So you are saying this is not an issue because you have declared what you're going to do anyway.

DR. SCHROEDER: pretty much.

DR. KRESS: No, they declare SPAR-H as --

DR. BUELL: As the preferred method.

Let me throw out one example. These are our top ten issues. There is one HRA or HEP value that falls down about 15th or so as we rank these things, and that one issue deals with the initiation of decay heat removal in a BWR. You know, we have some ground rules that we use. Typically the utility uses an order of magnitude or so lower than what we use, and because BWRs are driven by decay heat removal and you have that common operator action to initiate those systems, that is one of the items that is on the list, but it's down further. It doesn't show up in the top ten. But that's the only one that we've identified.

CHAIRMAN APOSTOLAKIS: But if you guys

resolve that issue by declaring that you will use SPAR-H, why waste your time? Why didn't you do the same thing here?

For PORV, it's two. For CCF it's alpha. No issue. We're declaring that this is the way to do it. So what's different about human reliability that was handled that way from these?

MR. CHEOK: Well, George, I think even in the industry PRAs they have different methodologies to perform or to obtain HEPs.

CHAIRMAN APOSTOLAKIS: That's a modeling issue.

MR. CHEOK: That's a modeling issue, and we cannot, in essence, go to each PSA and adopt their value because then we are saying we will now not be standardized in our analysis because we are not exactly adopting a single --

CHAIRMAN APOSTOLAKIS: No, no, no, no, no.

MR. CHEOK: -- methodology. We're just saying the methodology --

CHAIRMAN APOSTOLAKIS: That's not what I'm saying.

MR. CHEOK: -- we'll adopt at this point is the SPAR-H for consistency throughout all of our models.

CHAIRMAN APOSTOLAKIS: But you can still identify it as a modeling issue.

MR. CHEOK: We could. You're right.

CHAIRMAN APOSTOLAKIS: Because what you just said supports what I'm saying. Even the utilities don't agree with each other.

MR. CHEOK: Agree. Okay. That's true. I mean, I --

CHAIRMAN APOSTOLAKIS: It is a modeling issue.

MR. CHEOK: -- I think what we're showing up there in the list of ten is the issues that we would work on.

CHAIRMAN APOSTOLAKIS: You know, this issue will never be resolved in this agency. Why? Because when we make important licensing decisions, we don't scrutinize it. We just accept what the licensee says.

When it comes to this issue, you're dismissing it because you're going to use SPAR-H. The decision makers, the Director of NRR or even the Commission, maybe are not even aware there is an issue there because nobody is telling them there is an issue.

And they look here at nine important

modeling issues. Human error is not there. You know, if I were Commissioner Merrifield, I would say at the next budget cycle eliminate all work on human error. My guys tell me that it's not important.

MR. CHEOK: It's a good point. I think you bring up a good point, and we will have to either caveat this list very well or --

CHAIRMAN APOSTOLAKIS: The reason why I'm reacting to it is --

MR. CHEOK: You're right. I agree.

CHAIRMAN APOSTOLAKIS: -- not just because of this, but as I said --

MR. CHEOK: You make a good point.

CHAIRMAN APOSTOLAKIS: -- licensing, utilities requested extend power up rates. We all know that the time available to the operator shrinks a little bit, and then what? Well, that's okay, you know, essentially, or the licensee says it goes down. It increases by ten to the minus 100, and everybody says that's fine.

Well, why then continue pursue doing a better job? There is no reason.

MR. CHEOK: You're right.

MR. DENNING: I think it would be interesting to look at your results and just ask the question: how important was human reliability modeling to the results? Because I think you've got the data to answer that questions.

DR. BUELL: We can probably extract that.

MR. DENNING: If you kind of looked at --

CHAIRMAN APOSTOLAKIS: That's a very good point, and also, have you guys consulted these reports we keep referring to, the IPE reports?

DR. BUELL: In what respect?

CHAIRMAN APOSTOLAKIS: In insights, in the insights gained.

DR. BUELL: Like in NUREG 1560 and those?

CHAIRMAN APOSTOLAKIS: I guess. You know more than I do.

DR. BUELL: Yes, we have looked at those.

CHAIRMAN APOSTOLAKIS: I mean they've clearly identified it as an important issue.

MR. CHEOK: I think we need to also realize that in the past five years or so licensees have gone through the certification process, and one of the first things that the reviewers look at are the HEPs and the HIPs, and sine the last five years, there's a normalization or a condensation of the HEPs so that we do not see that ten to the minus six was in the ten to the minus three range.

CHAIRMAN APOSTOLAKIS: No, I'm sure they changed that. They raised it, but still it was an issue.

I mean, is it this subcommittee or somebody else's subcommittee? We are meeting in December on human error?

PARTICIPANT: Yes.

CHAIRMAN APOSTOLAKIS: Might as well cancel it. It doesn't seem to be an issue, especially since you've not done it.

I'm serious. Why should I come here and waste two days on an issue that is irrelevant to the agency?

MR. DENNING: Because you don't know, but that's all right.

Okay. Incidentally, if you'd solve the fifth one, that would help, too, I think.

CHAIRMAN APOSTOLAKIS: Now, you se, it's so nice to number things when you have a long list rather than putting bullets.

DR. BUELL: Okay. We'll do that.

CHAIRMAN APOSTOLAKIS: So I have to count, number five.

DR. BUELL: Sump plugging (phonetic).

CHAIRMAN APOSTOLAKIS: Yes, sump plugging.

DR. BUELL: Well, like I say, these are the top ten issues that we've identified.

CHAIRMAN APOSTOLAKIS: You've seen the ACRS letter on that?

DR. BUELL: I have not.

CHAIRMAN APOSTOLAKIS: Then you will insist on putting it number one.

DR. BUELL: Okay. Loss of off-site power modeling, that was a big -- there's a lot of variability in the industry. We've got an approach now that we feel is adequate. You know, it may still vary a little bit from what the plants do, but there's a lot of variability within what the plants do.

So we have a solution. Maybe that needs to be tweaked or whatever, but we do have a solution for that.

RCP seal failure modeling --

CHAIRMAN APOSTOLAKIS: Are we going to discuss each one?

DR. BUELL: Yes. I've got to explain each one of these. I'll just go through them real quickly.

We've got the new WOG 2000 out there. We've incorporated that information in. Common cause modeling, it was being driven by alpha factors that we had, some old alpha factors a little bit higher than what the industry was showing.

Data values, we've got a standard template that we use now. We've converged some on that.

Sump plugging, you know all about that.

Support system initiating fault trees. We're working on a methodology or going to be trying to work on that this coming year.

Power recovery after battery depletion, we've touched on that one. You know, how much credit can you give? We don't give any credit. The industry gives some credit, and it has a significant impact at some plants.

Continued injection after containment failure. This is a BWR issue. How much credit can you take for your continued injection after you over pressurize and fail the containment?

PORV success criteria. We've beaten that one to death.

And the time to core uncovery, we're going to talk about that also.

Like I say, we've put the issues we've worked at the top and then going down the list, these are some of the ones that we still need to address.

CHAIRMAN APOSTOLAKIS: Now, these are being worked on because you found disagreements with the utilities?

DR. BUELL: Yes, disagreements between utilities in conjunction with disagreements between us and utilities.

CHAIRMAN APOSTOLAKIS: Okay.

DR. BUELL: So there was just a tremendous variability, and these were important impacts on the models. In fact, these are structural issues that have a lot of uncertainty between models.

CHAIRMAN APOSTOLAKIS: So I suspect then that the reason why errors of commission are not here is because nobody is doing it.

DR. BUELL: That is correct.

CHAIRMAN APOSTOLAKIS: Wouldn't it be though a modeling issue? Do you think that we have resolved that, that the operators now have procedures for everything? There is no possibility of misdiagnosing anything? Is that a settled issue or --

DR. SCHROEDER: Well, let's address that this way. The SPAR models don't necessarily reflect original research on issues. What they are is a compendia of things that we believe are mostly well known, and we wouldn't know how to do the errors of commission modeling. So they're not even on our radar screen.

CHAIRMAN APOSTOLAKIS: I agree. I agree, and it's not your job to do it. I fully agree with your scope, but when you say important modeling issues and status, you could say errors of commission TBD or somebody is working on them, not us.

Notice I view this as a more general list of modeling issues related to PRA, but apparently for you it means something else.

MR. CHEOK: The title should probably say modeling issues that are being worked on to make the SPAR models more uniform with the licensee PRAs.

CHAIRMAN APOSTOLAKIS: More consistent with licensee PRAs --

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: -- but if the licensees also miss something, then you'll be happy to miss it also.

MR. CHEOK: Well, remember we list it under model assumptions in the beginning. We understand that it's missing from our PRA or from our model, and we list it there, and it's something that we may have to work on later.

CHAIRMAN APOSTOLAKIS: Well, you know, this is the first time actually that I see a presentation from the staff where there is such a thing on the screen, "modeling issues." Most of the time we say, "Yeah, there are modeling issues we're going to do something about."

And in fact, I believe Mary Drewing is supposed to do something about it. Have you talked to her at all?

MR. CHEOK: Yes, we have been talking to Mary.

CHAIRMAN APOSTOLAKIS: So this is very good actually. I mean, I really like this, but it has to be -- well, first of all, as Mike said, the heading has to be very clear what you're trying to do, but this is an excellent opportunity to also say these are the modeling issues. Maybe you can have a separate list that says, "And here are broader modeling issues that nobody knows how to handle. We have made the assumption that you showed us earlier," and leave it at that.

MR. CHOKSHI: I think, you know, as you said, the problem that PRA issues, aging and other effects, we are dealing within the context of --

CHAIRMAN APOSTOLAKIS: I understand that, but it would be a good opportunity to document those, although the human error probability we were talking earlier about, I think, belongs here.

You're instigating very interesting discussion, gentlemen.

DR. THADANI: Yes. Let me add one issue, George, here and actually it's a question. If I take a plant, a BWR, you have a SPAR model for that plant, and I want to increase power level by 20 percent. I suppose I could take success-failure criteria from whatever the utility might say, but you can look at that information and see the changes in available time for operator actions and human reliability issues and estimate change in core damage frequency.

DR. BUELL: If we had that information from a particular --

DR. THADANI: The successful criteria you would need, yeah.

DR. BUELL: And if it was different from ours, we could feed that into our models and come up with --

DR. THADANI: So because the times will be narrower. So you could actually do a fairly quick calculation, it seems to me.

DR. BUELL: Well, depending on, like I say, the level of modification.

DR. THADANI: Sure.

DR. BUELL: But that could be done in the

SPAR model.

DR. SCHROEDER: That could be done, but it would also presume that you understand all of the consequences of that. I believe there's an ASP analysis currently pending that deals with issues of unforeseen circumstances of a power up rate, and we wouldn't have been able to catch those any more than anyone else would have.

DR. THADANI: Sure. No, I understand that, yeah. Your structure allows that is what you're saying. That's useful information.

DR. BUELL: Okay. I'll just go through these next ten slides relatively quickly because they deal with the details of each one of these. Okay. As you noted up there, we said we had updated the models for this particular issue. We've got new LOOP recovery curves updated, the most current information we have available or that can be generated

We have updated seal LOCA models. We've included that in all of the PWRs based on WOG 2000 and the other information as far as there.

We've changed our diesel generator mission time to a 24-hour mission. We had some statistical run time or our run times were based on some statistical analysis. We got away from that.

CHAIRMAN APOSTOLAKIS: So I don't understand. I'm sorry. I missed it.

DR. BUELL: We have 24-hour diesel generator mission time, a standard 24-hour mission time now. Before --

CHAIRMAN APOSTOLAKIS: So you would calculate the unreliability for 24 hours --

DR. BUELL: That's correct.

CHAIRMAN APOSTOLAKIS: -- and put it up front.

DR. BUELL: That's right. Before we had varying time based on the plant location and everything. It wasn't working out well.

CHAIRMAN APOSTOLAKIS: So now, you know, as we were saying earlier trying to figure out the mean value, if you have two diesels or three diesels, each one -- well, the mean time to failure is different though. You're going to get a long mean time to failure.

That's okay. Go ahead.

DR. BUELL: Okay, and as part of the data changes of the new template data, we have a two power diesel generator hazard curve for failure at one hour and greater than one hour, before it was a half hour to two hours, and then greater than that. So we've changed that.

CHAIRMAN APOSTOLAKIS: And that comes from experience or --

DR. BUELL: That's what we're getting out of the data, and like I say, I don't know the origin of that.

CHAIRMAN APOSTOLAKIS: You mean they do have tests where they run the business for 20 hours? I thought most of the tests were a couple of hours.

DR. BUELL: I'm not part of the data analysis.

CHAIRMAN APOSTOLAKIS: It's probably judgment.

DR. BUELL: I'm not sure.

CHAIRMAN APOSTOLAKIS: It's okay. It's okay. This is a preview of the questions for the spring in color, in vivid color.

MR. CHEOK: We'll make sure we study the tape before the spring so we can have all of these questions answered.

CHAIRMAN APOSTOLAKIS: I should make sure you do.

MR. CHEOK: We will make sure we do.

DR. BUELL: And this last item you just touched on again, and we have talked about before.

Some of the plants with only two diesels, they rely heavily on involving the failure distributions to buy more time. We don't do that right now. We have methodology to do that, but we have not applied that to our models, and that's just a judgment call as far as the effort to get where we need to go, and there are some other issues associated with that, but we have not implemented that in our models.

But that's another issue where we deviate from some of the plants. They use it, especially the ones with only two diesels. We have not incorporated that yet.

Okay. The next slide.

Everyone is familiar with the seal LOCA modeling, I'm sure. The WOG 2000, we have incorporated that into all of the Westinghouse plants. The core uncovery times are per the Westinghouse emergency procedure guidelines. It's a generic curve that we use. There is some variability based on the number of loops you have in that outer thing, but it's for our estimates. That's a pretty close estimate if we use a single curve.

CHAIRMAN APOSTOLAKIS: So what are you saying? When you say four seal failure modes with probability and associated leak rates, what does that mean?

DR. BUELL: You have different stages. You have staging within your seals, and they look at the probabilities of failing this first --

CHAIRMAN APOSTOLAKIS: Oh, so you're just describing what the --

DR. BUELL: It's within the WOG log --

CHAIRMAN APOSTOLAKIS: You're now telling us what the agreement was.

DR. BUELL: That's correct, exactly.

CHAIRMAN APOSTOLAKIS: Okay, okay, okay.

DR. BUELL: I'm just replicating the WOG 2000 information. We've also got the CE information in all of the CE plants, okay, and on B&W plants typically they're either a Westinghouse or a Combustion Engineering seal package in the Westinghouse plants. We have put the appropriate -- and we have just done this in the last months -- we have put the appropriate seal packages in the B&W plants.

CHAIRMAN APOSTOLAKIS: Okay. So what was the resolution?

DR. BUELL: The resolution was to put in the new WOG 2000 and the pending information.

CHAIRMAN APOSTOLAKIS: To use the WOG 2000 model for all?

DR. BUELL: That's for all of the Westinghouse plants.

CHAIRMAN APOSTOLAKIS: And the industry agreed?

DR. BUELL: Well --

CHAIRMAN APOSTOLAKIS: You're using the WOG model for CE plants?

DR. BUELL: No, no. There's a CE study out there that's pending, and we were directed to put that in pending final resolution on that.

CHAIRMAN APOSTOLAKIS: I don't understand what the difference was. What was the disagreement? I mean, your --

DR. SCHROEDER: Our previous SPAR models had nothing like the WOG 2000 model in them. They had an extremely simplified model that yielded very conservative results.

So when the NRC issued a safety evaluation report on the WOG 2000 model, we were directed to go ahead and put that in as a replacement for the old reactor coolant pump seal LOCA model that we had in the models.

CHAIRMAN APOSTOLAKIS: I was under the impression that there were at least two competing models for RCP of the came manufacturer.

DR. SCHROEDER: There is a Rhodes model yet, and that would be used for the very few cases in which there are not high temperature seal packages.

CHAIRMAN APOSTOLAKIS: What you're telling me is something different. You're saying we had a conservative model before. Westinghouse had this model, and then we were directed to go and use that.

MR. CHEOK: Well, we were directed -- yes, we directed INL to do that because we now have an agency position so to what seal models that we can endorse. When Westinghouse submitted the topical to use for their review, the agency reviewed the topical.

I guess I misspoke a little bit. The agency reviewed the topical, and we wrote a valuation report on that that says that we agree with your model. In that case we said that we now have an agency endorsed model, which we can now incorporate into the SPAR model for Westinghouse plants.

CHAIRMAN APOSTOLAKIS: And the CE plant is --

MR. CHEOK: Is close to endorsing a similar topical report.

CHAIRMAN APOSTOLAKIS: And BW plants would be one or the other.

DR. BUELL: They use one of those, too.

CHAIRMAN APOSTOLAKIS: It was never really an issue of model uncertainty in the sense that there were two or three competing models. Is that what you're saying?

MR. CHEOK: I think at one time five or six years ago there was a Westinghouse model and there was a Rhodes model and there was a Sandia model.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. CHEOK: And I guess there was disagreement as to which is the best model to use.

CHAIRMAN APOSTOLAKIS: Exactly. That's what I remember.

MR. CHEOK: At this point there is a submittal to the staff, and the staff has looked at the Westinghouse models and --

CHAIRMAN APOSTOLAKIS: Did Westinghouse compare their approach with those other models?

MR. CHEOK: I am not sure.

CHAIRMAN APOSTOLAKIS: Is it possible -- I mean, you mentioned names. Rhodes?

DR. BUELL: There was the Rhodes model. That was one of the models.

CHAIRMAN APOSTOLAKIS: Is that the fellow whose name is Rhodes?

DR. THADANI: Rhodes is the Westinghouse. He did that for Westinghouse. Limited testing was done in Canada, but basically you don't have data for beyond 30 to 45 minutes in terms of at these temperatures and pressures, performance of these seals, and so this is clearly large uncertainty in whatever model you use.

DR. KRESS: There was a workshop last week in Aux-en-Provence on uncertainties. You had some people there, and I went. There wasn't much new on model uncertainty, but there was one paper that talked about using something called the Dempster-Schafer theory on fuzzy numbers, and they claimed that that was a better way to look at model uncertainty because the distributions they use represented a whole family of distributions rather than just one, and that they claimed it to be a superior way.

I just wanted to call that to your attention in case you wanted to get hold of that paper from Basu. Sud Basu would have a copy of it, and you might look into it.

I didn't have time to read it in detail to see if their claims are real, but I know what they claimed. They claimed it was a good way to do it.

CHAIRMAN APOSTOLAKIS: Can I comment on

that?

DR. KRESS: Yeah, please.

CHAIRMAN APOSTOLAKIS: Don't do it.

DR. KRESS: Oh, okay.

CHAIRMAN APOSTOLAKIS: I think your statement was correct, that they claim.

DR. KRESS: Yeah.

CHAIRMAN APOSTOLAKIS: But we have enough problems with probabilities. You want to bring in Dempster-Schafer? We would have Dempster-Schafer in form regulations? Oh.

DR. BUELL: The next item on our list was common cause modeling.

CHAIRMAN APOSTOLAKIS: Well, it's not equivalent to MGL. They treat the data differently, don't they?

DR. SCHROEDER: The equivalency that we're referring to is that you can transform any alpha factor into an MGL parameter through a series of equations.

CHAIRMAN APOSTOLAKIS: But not the other way, can you?

DR. SCHROEDER: I don't know.

CHAIRMAN APOSTOLAKIS: That's why they developed the alpha factor. If they were completely equivalent, they wouldn't. It's the way you handle the data. Amazingly enough, it was a stupid way that MGL would handle the data.

DR. BUELL: Well, the bottom line is we were showing consistently higher common cause numbers than the industry was, and it ended up being a data issue, as we updated and expanded the data pool to appropriate levels. That issue went away.

CHAIRMAN APOSTOLAKIS: And you guys have this GEM thing that does the calculations. I'll tell you most analysts that do things by hand are terrified by the alpha factor model because you have a simple one out of two system, and they tell you here is an equation now that you have to use. Forget it. I'll go with lambda beta gamma and I'm done, you know.

PARTICIPANT: Point, one.

CHAIRMAN APOSTOLAKIS: Point, one. Actually there is strong evidence that the average is .1. Ali Moseley developed some curves, and you know, he was really remarkably close.

Only some valves tended to go to .2 in the BWRs, but then again, for PRA .1, .2, I mean.

DR. BUELL: Okay. Next slide, please.

Another issue that we identified was the data values. Typically in the past we had a little bit higher data, but also the data was old and there was significant differences sometimes in our data and their data on a variety of data failure types.

So there's been a significant effort over the last couple of years to generate new data for the SPAR models, and we've got that in now. A lot of it was based on system studies around 1990, and we've now used EPIX based data, and you're going to get a presentation on that in the spring.

MR. DENNING: Could you give us just a little bit. What does EPIX based data mean there?

DR. BUELL: EPIX is a database that is maintained by INPO that we have access to and we analyze data out of that. It's a real broad database, has failures, and I'm not a big guru on any of that, but that's the source. It's an INPO maintained database.

MR. DENNING: And what used to be national reliability database or something, did that evolve into that?

DR. BUELL: My belief is that that was the predecessor to this.

MR. CHEOK: EPIX replaced NPRDS.

CHAIRMAN APOSTOLAKIS: You know, the first paper that appeared proposing Bayesian update for generic distributions was written by Stan Kaplan and me in 1981. Why do I say that?

Because I have real problems with the update. I'll tell you what. It's a property of Bayes Theorem that no matter how wide your prior distribution is you need very few real data to make it very narrow. One failure in ten, 20 trials, whew, the posterior becomes very narrow.

But if you go to the reactor safety study which introduced the concept of generic information, they don't claim that the distributions are broad because of statistical uncertainty. They say they represent plant-to-plant variability, and a range of accident conditions.

Now, the plant-to-plant variability, you'd say, well, if I use plant specific data, that's fine because then I specialized in my plant, but what about these accident conditions. I mean the long tail of the log normally introduced was supposed to account for those harsh environments, but all of your data come from normal tests.

And what happens, of course, is you're wiping out the long tail by using Bayes Theorem because Bayes Theorem deals only with the statistical uncertainty due to the fact that you don't have, you know, a billion failures in a trillion trials, and this is something that as a community we never really paid much attention to.

But the truth of the matter is when you specialize distributions using Bayes Theorem, you are wiping out the long tail that the original guys in '72 said was there. I mean they justified the use of the log normal. They said there were two fundamental reasons. One was easy to work with analytically. At that time they didn't have the computers we have now.

And, two, it skewed to the right, has a long tail to account for these harsh environments, and these harsh environments disappear the moment you run two tests because the Bayes Theorem pushes everything down.

And one idea that I had is maybe we can separate this interval of high failure rates and don't touch it. Use it as a generic distribution. Don't update it with anything because you don't have any data from those environments, and then the rest of it update.

Now, somebody has to look into it in more detail, but it seems to me that this is something that we have perpetuated for the last 25, 30 years, and Bayes Theorem does what it's intended to do, but our generic distributions had a different meaning.

So I don't know if you guys want to think about it. Maybe we can talk again about it in June or whatever.

And, again, I appreciate that nobody has done it, but I think it's an important point or maybe you can come back and say we did it and we decided it's not that important. Because that has to be viewed in the context of another observation, that in terms of the useful results from the PRA, namely, the core damage frequency, of course, but also the dominant contributors; the failure rates lambda are not that important because of the extreme redundancy.

You see, it's common cause failures that are important. Human errors are that important, but whether you take a distribution of a lambda and you stretch it a little bit, the fact that you have two or three of those tends to diminish the significance of that change.

So in the context of that, we have to revisit the issue. Okay? And that's why we're paying more attention to model uncertainty and all of that, because we know that all success criteria -- I mean, these are big things. These are big things that do affect the results in the sense that the dominant contributors might be different.

But the pool failure rate, I mean, because for the shuttle that's not the case because they don't have that kind of redundancy, you see. We do.

By the way, can you believe the number of accident sequences contributing to the damage of the shuttle? And they were all almost equally important. In other words, single element minimal cut sets surrounding to 1,300.

I'll tell you. The next time you see an asteroid, kiss his hand.

(Laughter.)

CHAIRMAN APOSTOLAKIS: I mean, in PRAs for reactors, the dominant contributors are less than 20, and none of them is a single event sequence, right? None of them; 1,300.

DR. BUELL: Okay. This last item is a data value, but it's also a research issue that we're looking at. Basically service water, water quality, plugging. Nobody in the industry or very, very few people try to address that. Yet there's been quite a few plant shutdowns because of it, and from our perspective, that's a significant issue that needs to be addressed and needs to be looked at.

We're going through that this year. So

it's a data issue once we develop the way of looking at that and trying to do a study on that.

Here's your issue here that you'd like us to resolve. Sump plugging, all I did on this was there's been a variety of numbers bandied about. This is the last set of numbers that I heard. Maybe this is way out of date, but if you take our initiating event frequency times the conditional plugging failure, these are the potential impacts in our model.

So you can see if you sum those all up, you're about 1E to the minus five if the worst case happens in all of these.

CHAIRMAN APOSTOLAKIS: What does that mean? I'm not following that.

DR. BUELL: Okay. Basically what I did is I took our initiating event frequency over there where it says large LOCA. Okay? It's 5E to the minus six, is our initiating event frequency, and the numbers that I'm hearing, like I say, I know it's all replaced with no set number, but the last number I heard for a larger LOCA was .6 conditional of failing the containment sump.

So if you multiply those together, you have a potential 3E to the minus 6 increase in the CDF using our frequency in the last set of numbers that I heard.

Whatever this ends up being, if they're large numbers like this, it could have a significant impact. You're all aware of that. That's not new news, but it is a big structural uncertainty in our models right now.

MR. DENNING: What about the new large LOCA frequencies, that kind of stuff? You have not adopted that at this point, have you?

CHAIRMAN APOSTOLAKIS: The result of the expert opinion in the solicitations?

DR. BUELL: No, we have not.

CHAIRMAN APOSTOLAKIS: Maybe you ought to look at that.

DR. BUELL: Okay.

CHAIRMAN APOSTOLAKIS: You will find 20 different estimates. So good luck.

DR. BUELL: Okay. We're using the older data from NUREG 5750 right now.

DR. SCHROEDER: The last that was talked about I understood that was still in the review process.

MR. DENNING: It is.

CHAIRMAN APOSTOLAKIS: I don't know about that. I mean, the NRR guys are developing a rule based on --

DR. THADANI: the proposed rule is out.

CHAIRMAN APOSTOLAKIS: Huh?

DR. THADANI: The proposed rule is out on the streets now.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. CHOKSHI: And that report is in our component, the expert solicitation report. So --

MR. DENNING: It would certainly be interesting to see what the implications are because they're going to be big. I mean, I'm sure they're going to further reduce.

CHAIRMAN APOSTOLAKIS: No, but you say you're assuming ten to the minus six. That's on the low side, I think.

DR. BUELL: Five E to the minus six for large LOCA right now is the number we've got in our models.

CHAIRMAN APOSTOLAKIS: Five? It depends on how you combine expert opinions.

DR. THADANI: It's low, George. You're right. It's low if you look at the expert solicitation results. Plus I think this large LOCA is a break larger than what, six inches roughly, right? Basically, and if you look at the expert elicitation, this is off by more than an order of magnitude.

MR. CHOKSHI: Yeah, in that categories, you know, greater than six, you're right.

DR. KRESS: But your main message is that the effect on CDF is actually driven by frequency.

DR. BUELL: Well, it's a combination. It's proportional to frequency and the conditional plugging. So either one of those is going to adjust the number.

DR. KRESS: Yeah, but the condition plugging is -- I mean, we're only concerned about it for the large break LOCA, and it's .6. So that makes -- in PRA's place that's not much.

CHAIRMAN APOSTOLAKIS: Shouldn't you worry also about LERF?

DR. KRESS: Yeah, you should, but --

CHAIRMAN APOSTOLAKIS: That's where you'd probably see the bigger difference.

DR. KRESS: Yeah, it comes to kind of be a long-term cooling issue.

DR. THADANI: But it affects the core spray, too.

CHAIRMAN APOSTOLAKIS: The what?

DR. THADANI: The recirculation impacts

everything.

CHAIRMAN APOSTOLAKIS: Right, sure.

DR. THADANI: So I think George is correct. It will have also significant effect on LERF.

MR. DENNING: Well, will it or is it just going to be late and not lead to early failure?

CHAIRMAN APOSTOLAKIS: Well, I mean, if that's the case, you're saying that this is not a very significant issue, right?

DR. BUELL: No. I'm just saying it can be significant depending on what the final large LOCA number is, what the final conditional plugging number is.

Once that gets all resolved, it has the potential to be as high as -- in fact, if you increase the large LOCA probability, it could even be higher than that impact on the models. It could be a ten to the minus five impact on the models and increase.

DR. KRESS: I would be more than ten to the minus five.

DR. BUELL: Yeah, if you increase the large LOCA frequency it could be more than ten to the minus five.

CHAIRMAN APOSTOLAKIS: But you will not.

You will not. The expert opinion solicitation says it is low. I think I misspoke earlier.

DR. BUELL: Okay.

CHAIRMAN APOSTOLAKIS: The large range they show in that report is for LOCAs of a frequency of ten to the minus five because the larger pipes, what we now call large LOCA, have a frequency much lower than ten to the minus five.

So I don't think that number is going to go up significantly.

MR. CHOKSHI: No, but from the PRA standpoint, it's a 16 -- this is large LOCA, right?

DR. THADANI: Exactly.

MR. CHOKSHI: This is not a double ended pipe break.

CHAIRMAN APOSTOLAKIS: Eight inches.

DR. THADANI: It's six inches.

CHAIRMAN APOSTOLAKIS: Or eight. Anyway, yeah.

MR. CHOKSHI: So but in the expert elicitation, the number that they're deriving to the different categories.

CHAIRMAN APOSTOLAKIS: Yeah.

MR. CHOKSHI: So but if you look at the numbers from the six or 18 Gs, it's higher.

CHAIRMAN APOSTOLAKIS: It's higher. I don't think it's a very low number, isn't it?

MR. CHOKSHI: Not at that range.

CHAIRMAN APOSTOLAKIS: It's less than ten to the minus five.

MR. CHOKSHI: No. Well, we'll talk about this, what distribution, and which --

CHAIRMAN APOSTOLAKIS: Well, the aggravation of course makes a big difference.

MR. CHOKSHI: I think if I remember right for PWR, and their base case was a ten to the minus five was about seven inches.

CHAIRMAN APOSTOLAKIS: Eight.

MR. CHOKSHI: Yeah, seven or eight. You are right.

CHAIRMAN APOSTOLAKIS: And then NRR says 14. That's good.

MR. CHOKSHI: So three at ten to the minus five using the geometry was about --

CHAIRMAN APOSTOLAKIS: And plus I'm correct. No, but is this finding, Rich and Tom, consistent with the big deal the ACRS made on that letter on the sump performance?

DR. KRESS: Well, we thought there were issues of defense in depth that went beyond effects on

CDF

MR. DENNING: This is an accident within the design basis at least current.

DR. KRESS: Yes, it is design basis space.

MR. DENNING: And of course, that .6 is awfully close to "I don't know."

CHAIRMAN APOSTOLAKIS: One?

MR. DENNING: The .6 is "I don't know."

DR. KRESS: We actually thought for a large LOCA that the condition was probably close to one, and --

MR. DENNING: Could be.

CHAIRMAN APOSTOLAKIS: Well, that's why they're certainly here.

DR. KRESS: It's close enough.

MR. DENNING: Yeah, but if this remains as part of the design basis accident, if one were done, it had better be a lot lower number than that or we're not going to buy it.

MR. CHOKSHI: Once we resolve the issue.

MR. DENNING: Once we resolve the issue, it had better be a much lower number than that. Let's go on.

CHAIRMAN APOSTOLAKIS: Why? Is there a cutoff thing for design basis accidents?

MR. DENNING: Well, it's not .5. I mean, the probability that we would not be able to survive a design basis accident? I mean it has got to be a high degree of confidence. Point, five is not a high degree of confidence.

CHAIRMAN APOSTOLAKIS: No.

DR. KRESS: That is the problem.

CHAIRMAN APOSTOLAKIS: There you would have to postulate a single failure, right? It's a design basis. You'd do a different kind of calculation.

MR. DENNING: Analysis?

CHAIRMAN APOSTOLAKIS: Yeah.

MR. DENNING: Well, this is for a realistic analysis here, which is probably --

CHAIRMAN APOSTOLAKIS: You would say I have a large LOCA, and I will postulate the worst possible single failure, and I should be able to contain that.

DR. KRESS: That's what you do.

CHAIRMAN APOSTOLAKIS: This has nothing to do with frequencies.

DR. KRESS: That's right.

CHAIRMAN APOSTOLAKIS: This has nothing to do with frequencies. So I don't understand why it would be lower when we're done with it.

MR. DENNING: Well, okay. They do a realistic analysis. Okay? We do a licensing analysis for the design basis accident, right? For that licensing analysis, we put in a lot of conservatism and it survives, right?

Well, when they do a realistic analysis, then they're going to say, "Man, that's a really low number, this probability that it's" --

CHAIRMAN APOSTOLAKIS: Oh, you mean --

DR. KRESS: That was the reason we put in our letter that perhaps you ought to risk inform this issue.

CHAIRMAN APOSTOLAKIS: And then you go to these guys.

DR. KRESS: Yeah, that was the reason, because we felt like that on the basis of CDF and LERF that it probably wasn't that serious.

CHAIRMAN APOSTOLAKIS: And I have a hard time believe it's .6, the condition of probability. Huh?

DR. KRESS: Repeatedly.

CHAIRMAN APOSTOLAKIS: So high?

DR. KRESS: It won't be that high for a BWR.

DR. BUELL: Well, it generated that discussion on it, but the bottom line is that it could have some impact on the results.

DR. THADANI: Well, you had a real event with a BWR.

CHAIRMAN APOSTOLAKIS: Say again.

DR. THADANI: There was a real event at a BWR, and we know what happened.

DR. KRESS: You plugged it in and spall sump (phonetic).

DR. THADANI: It was called Barseback, and we have had some partial events called that.

CHAIRMAN APOSTOLAKIS: It's still called Barseback.

MR. DENNING: But it might not have been under different circumstances.

CHAIRMAN APOSTOLAKIS: They shut down one year. You remember that? Not because of this.

DR. KRESS: They fixed their sump.

DR. THADANI: Yes.

DR. BUELL: The next issue on our list here is support system initiating event fault trees. Okay. Right now the industry, probably two-thirds of them -- I'm just going off, you know, experience here -- probably two-thirds of them use initiating event fault trees if you carry that information into the model. One-third of them use a point value, and there's pros and cons of both, but right now we use a point value in SPAR models, and we use that value based out of NUREG 5750.

There's a problem with that. The problem is -- or several problems -- that you can get the right CDF out of it, but when doing the MSPI program and other programs, you don't get the correct event importance because you're not getting the contributor coming up through the fault tree on the initiating event.

CHAIRMAN APOSTOLAKIS: So you're supporting the fault tree approach.

DR. BUELL: We are, and we're looking at researching that and developing that methodology. Okay?

The other down side of using a point value is you don't have any latitude based on system configuration or levels of redundance.

CHAIRMAN APOSTOLAKIS: Sure.

DR. BUELL: You're just using a generic number.

CHAIRMAN APOSTOLAKIS: I don't think you need to give anything, any argument.

DR. BUELL: Okay. Well --

CHAIRMAN APOSTOLAKIS: It is a system. It has components. We analyze it.

DR. BUELL: Well, I'm just saying this is a model uncertainty because right now we use a point value. So we use the same that.

DR. BUELL: So we use the same number.

CHAIRMAN APOSTOLAKIS: But there's no excuse for point values. Then why don't they do the same with the high pressure injection system? Just because it's front line?

In a PRA if you have a system, you analyze it.

DR. KRESS: Like the control system?

CHAIRMAN APOSTOLAKIS: No. No, but this is of the kinds of systems we analyze.

MR. DENNING: I agree. It's made up of the same kinds of components.

CHAIRMAN APOSTOLAKIS: Yeah, hydraulic systems, you know, pushing water here and there.

DR. BUELL: Okay. Well, like I say, this is an issue that needs to be resolved at some point, and we're looking at doing that.

CHAIRMAN APOSTOLAKIS: You just declare it is all.

DR. SCHROEDER: One of the reasons this is an issue is that in visiting many, many plants, we saw the result of fault tree initiating event models that predicted service water failures much, much, much lower than we were seeing in the data.

So there was a huge question about whether those were valid, and if we undertake that ourselves, we have to be very careful to get something that is consistent with the data.

CHAIRMAN APOSTOLAKIS: No, but that means the fault tree calculations were not right.

MR. DENNING: Exactly.

CHAIRMAN APOSTOLAKIS: It doesn't mean that you should switch the point values. Like with anything else, you know, if you find discrepancies, you question why and I'm sure you will find the problem with their analysis.

DR. BUELL: And our feelings are, along with the same issue, and we're going to get to it in a minute, is that most plants do not look at the water quality issues. The common mechanism of storm surges and grass attacks and fish runs and the other myriad of things that will shut plants down --

CHAIRMAN APOSTOLAKIS: You know, I really think the major value of using PRAs is exactly what you just said. There are people on opposite sides questioning, debating detailed issues and so on. The actual numbers I'm not sure are that important, but now you will go to the licensee who doesn't do that and say, "Water quality is important. Have you thought about it? How do you handle it?" and so on.

I think this is really the value, that it's a framework within which all of these issues come up, and I think raises the level of safety that we have. I really like that, the give and take that you guys are having with the licensees.

MR. DENNING: Let me understand. With your old approach the frequency of turbine trips, things like that, would you not have modeled -- you don't model that? Currently you just put in a value for turbine trips or do you model?

DR. BUELL: No, currently we use a point value for every initiator. We don't do any fault tree specific modeling for those. Something like a turbine trip would be extremely difficult because of all the control systems and protective systems, but there are some other systems like service water and some of these other fluid type systems that are easier to model and you can approximate.

DR. SCHROEDER: Not to be misunderstood,

we have service water fault tree models now. We don't use them for the initiating event frequency determination. We use them in a support system capacity.

The reason we don't use them for the initiating event is that there are assumptions that might apply to a 24-hour mission that wouldn't necessarily apply to an initiating event calculation.

CHAIRMAN APOSTOLAKIS: So you would need a different analysis.

DR. SCHROEDER: We need a different analysis. It look very much --

CHAIRMAN APOSTOLAKIS: Well, that's fine.

DR. SCHROEDER: -- like the existing fault tree, but it might be different in key ways, and one of the things that we are planning to do is try to settle that, and we would like to do it by achieving a consensus with the industry, but in any event, we're going to do it in some way that makes sense to us.

DR. BUELL: And two of those issues are the basis approach or basic methodology. One of them is a multiplier method where you use a regular 24-hour mission time and you multiply it by a factor to get the extended mission time for the year, and there are some up sides and down sides with that.

And the other one is to have separate events for the year long mission time versus the 24-hour mission time, and there are up sides and down sides to that when you calculate importance measures and all kinds of things.

So there's no perfect way of doing this, but there is probably an optimal way, and we just need to look at that and determine that. And that will be going on at some point in the future.

CHAIRMAN APOSTOLAKIS: Very good.

DR. BUELL: We're down to the last couple here. Power recovery after battery depletion is an issue, and it has shown up in the MSPI comparisons. SPAR models right now give no credit for power recovery beyond battery depletion. Okay?

This is somewhat conservative, possibly conservative. It does have a big impact on the SBO CDF as well as the diesel importances.

MR. DENNING: I don't know the technical issue here. What's really the technical issue?

DR. BUELL: Okay. The bottom line is you typically do not do core uncovery for many hours beyond battery depletion. There's also additional systems that are not dependent on the batteries per se for injection.

You may have a plant that has a diesel driven AFW pump. That pump can continue to inject, you know. So you can actually also have seal failure. You might go out 18, 20 hours --

MR. DENNING: So you wouldn't give any credit at the moment --

DR. BUELL: We wouldn't give credit for that because we're saying when the batteries go dead, the complexity of the evolution to bring off-site power back into the plant without having remote control ability on those breakers --

MR. DENNING: And you can't really monitor and know what's happening.

DR. BUELL: Yeah, and typically plants have sketchy procedures at best. Some plants have better than others.

Because of all the uncertainty there, we have not modeled anything beyond battery depletion. That has been our standard for many years, but it's a big difference between us and some of the plants.

Now, a lot of the plants do go without and say we're going to cut it at that point, but there are some plants, you know, especially the ones that have like diesel driven AFW pumps, you know. They're saying, "Hey, I've got this system and I can't use it because my batteries go dead." So they want a credit.

Some of the considerations down here, you know, just off the cuff here, you know, diesel driven injection sources, you know, how much credit should we give for that? You know, availability and quality of procedural guidance. You know, some plants just say, "We'll give it 50 percent chance because we don't have detailed procedures. We're not going to take much credit for it," but they take a little credit for it.

There's other issues. You know, the duration of emergency lighting. Can you realistically say, "I'm going to get 20 hours of operation when I can't see anything in the plant"?

You know, switch yard battery life. There's batteries that a lot of plants have separate batteries in the switch yard, you know. Manipulating those breakers is much more complex than manipulating four kV breakers. You can go out and pump up the breakers with a small breaker. You don't do that with a switch yard breaker.

So there are some of these issues that we're looking at we're going to try to distill it down to the key issues and see if possibly we can't change that assumption that we fail at battery depletion.

But that is a big issue at some plants.

At some plants it's not an issue at all, but the MSPI program has identified this separately from us as an issue, and I think he's going to be talking about that later today, but we're looking at ways of resolving this and coming up with an optimal way.

Here's a BWR issue that is a significant issue at some plants. This issue deals with continued injection after containment fails on over pressure. You know, it fails. You've had a long term heat removal failure. You've pressurized the containment, and you fail the containment. If you have injections or, let's say, CRD or some other injection source, did you continue to credit after containment fails?

MR. DENNING: And when you say "fails," this is a hard vent that --

DR. BUELL: Yeah, this is either a rupture or a tear in the containment itself.

MR. DENNING: But not a hard vent?

DR. BUELL: Not a vent. We look at that separately.

MR. DENNING: Oh.

DR. BUELL: Now, that does have a similar impact at some plants, but that's a separate issue. So the bottom line is how much credit you give for that continued injection can significantly impact your decay heat removal importance for those components.

It can also significantly impact your overall CDF for some BWRs. So some of the related issues, you know, the environment, the steam, the depressurization rate, you know, if it just tears versus completely depressurizes, that eliminates some of your low pressure injection systems because if you sit there at 150 pounds and just bleed off enough pressure, you're never going to get fire water injection.

So there are some of these issues that need to be resolved and looked at.

NUREG 1150 gives complete credit for that. The old daily events manual didn't give any credit for that, and we're transitioning towards more credit, but we're looking at this issue in more depth.

The next slide.

Poor success criteria, we've already talked about this one. John mentioned also I've looked at as much information as I can find. I've looked at plants that have identical relief capacity. They have the same injection pumps, the same thermal output. One will take two; one will take one as a success criteria.

Now, that could be from the fact that they just didn't want to put the additional effort into the analysis or it could be that they ran an analysis. We don't know, but there's a big variability in that assumption.

CHAIRMAN APOSTOLAKIS: But you will find out.

DR. BUELL: Say again.

CHAIRMAN APOSTOLAKIS: You will find out.

DR. BUELL: We will look into it, but I'm not sure we'll get an answer soon on that one.

So next slide.

And this is the last of the ten issues. This is time to core uncovery. SPAR in the past has been conservative and went -- if you didn't have any information and you had no knowledge, you basically went to a half an hour core uncovery time. Okay?

That was a little bit too conservative. What we did is we went and did a literature search, tried to gather all of the old NUREGs, all of the thermal hydraulic analyses that we've come up with, put those in a master table, and take a composite or extrapolate between those studies, and most of the time now, even on a most conservative modeling it's closer to an hour.

And that brought us closer in line to what the industry was saying. So we identified that as an issue. We went and made a reasonable fix. Short of having any detailed thermal hydraulics, that's probably an acceptable fix.

MR. DENNING: It does seem that this is an analyzable problem, you know.

DR. BUELL: It is analyzable with enough resources, and is it worth that effort is a question that --

CHAIRMAN APOSTOLAKIS: Good.

DR. BUELL: So those are the top ten issues that we have identified by going to all of these different plants and comparing our models to theirs. We've got a resolution for half of them that's already incorporated. The other half we're working on getting those fixed.

CHAIRMAN APOSTOLAKIS: Now, you're beginning with your next slide, another topic, right? Or you're going to?

DR. BUELL: I still have one. I thought that was my last one. I have one additional slide here. No, I've got a couple.

MR. DENNING: A couple.

DR. BUELL: Did you want -- okay.

CHAIRMAN APOSTOLAKIS: No, but these were not part of the nine. Are these new?

DR. BUELL: Yeah, this is just a continuation of the general topic. I did a slide for each one of those, the bullets, and now I'm just looking at general.

MR. DENNING: So three more slides. After that would be a natural break point.

DR. BUELL: That's correct.

CHAIRMAN APOSTOLAKIS: Good.

DR. BUELL: Okay. I'll hurry through these.

We talked about the loss of service water initiating event frequency. A key element that we don't see being modeled in these support system initiators is water quality, and there's been 30-some plant shutdowns because of those, including a couple of service water failures. We just don't see that being modeled in the PRAs. We need to come up with some type of methodology that maybe they would incorporate or something we at least feel --

MR. DENNING: This is like organic contamination or some sort?

DR. BUELL: Yes. Debris loading silt, fish runs, that type of stuff, collapsed trash rakes, overloaded trash rakes, something along those lines.

MR. DENNING: Every one of them different.

DR. BUELL: Every one different, you bet.

Addition of low importance initiators. As we went to these plants there's a lot of them that were low initiators, one or two percent. We're adding that as part of this MSPI or the detailed cuts at level comparison.

We've changed our steam generator tube rupture logic to include some benefit or some credit for long-term RWST refill and continued injection. So we made that change.

General modeling of common cause, we've talked about that.

Simplified modeling of emergency diesel alignments. We've made some modifications. This is something that won't go away completely because of all the myriad ways you can align diesel, especially if you have many of them and a lot of cross-ties. We just don't have the resources to model every possible combination explicitly.

So what we do is we set an arbitrary alignment that gives us the most benefit, and then if there's an analysis, we let the analyst correct that alignment for the alignment that he's actually modeling.

So there's just no way for us to explicitly model every combination and look at that in the base model.

So recent changes to the model that we've made over the last year. We have put in the new CCF alpha factors. We've linked and included new template events. We've put in a new seal pump or RCP pump logic. We've put in LOOP initiator logic as well as off-site power recovery data, and we've converted from the per hour to per year. Nobody likes the per hour. so we made that conversion. So our results come out on a per-year basis.

CHAIRMAN APOSTOLAKIS: So the question is really who liked it.

DR. KRESS: Why was it there in the first place?

DR. BUELL: Not very --

CHAIRMAN APOSTOLAKIS: Why was it there in the first place?

DR. SCHROEDER: It was there because that was the format used in the daily events manual, and the only reason that it was there is that most of the conditions that they were trying to evaluate for X number of hours and it made the multiplication easy.

Along come computers, and you can automate all of that, and we took the opportunity of a global model update to change what had just festered for a long time.

MR. DENNING: I think we accept that.

CHAIRMAN APOSTOLAKIS: You know, there is always a reasonable explanation.

DR. BUELL: Future enhancements, things that we're looking at right now and things that we're doing. We're performing these detailed cuts at level reviews.

We're splitting the transient event trees into some sub-trees. That gives the analyst just a little better definition. They're not relying on all of these conditional probabilities.

We've added the new steam generator tube rupture logic, the credit for RWST refill for those.

We are giving more definition for multiple unit sites, for whether it's a single or dual unit loop. That affects the cross-ties.

We've added the consequential seal LOCA logic, and we're adding lower importance initiators, anything greater than one percent.

We're adding additional detail. Before in the PWR models, we had split fractions for main feedwater. Now we're trying to do a more detailed model, including the support systems.

We're standardizing the IS local methodology for both Ps and Bs; benchmarking the PSA test. That's our major task over the next year, finishing up or continuing these detailed comparisons.

We're also -- the HEP calculator that you saw John demonstrate in SPAR, that's a relatively new edition. Now we've got to go back and take all of our HEPs, put them into those shaping factors.

And we've talked about these items already at the bottom here. These are pending resolution of some outstanding issues. The initiating event modeling, as well as integrating all of these models into a single model that is based on the SPAR Level 1 model.

So that's some of the future plans we're going to be looking at during this next year or so.

CHAIRMAN APOSTOLAKIS: Great.

DR. BUELL: And I think John is going to talk to you about --

CHAIRMAN APOSTOLAKIS: Starting a new topic now. So let's take a break until 3;25.

(Whereupon, the foregoing matter went off the record at 3:06 p.m. and went back on the record at 3:30 p.m.)

CHAIRMAN APOSTOLAKIS: Are you ready?

MR. DUBE: Well, good afternoon. I'm Don Dube, and this is not a presentation on the MSPI. It's really on the PRA quality reviews that we performed as part of the MSPI implementation, and it kind of follows on the presentation by John and Bob regarding the SPAR versus licensees' PRA comparisons.

Along those lines we did something similar, although in a very compressed time and a much more narrow focus.

I'm just going to take one slide to refresh your memory on what the MSPI is and why we choose the Birnbaum as the measure figure of merit, and in words, the MSPI is a measure of the deviation of the plant system unavailability and component unreliabilities from baseline values. So it's really a delta.

But each unavailability or unreliability is weighted by plant specific risk importance measures. So the MSPI is the sum of an unavailability contribution and an unreliability contribution. For example, for the unreliability, a very simple expression here would be B_i times, in parentheses, the unreliability of, let's say, a diesel generator running minus the unreliability of a baseline diesel generator based on an industry average failure rate.

So it's a deviation of plant specific performance from the norm, but it's weighted by a Birnbaum average. The reason why we choose Birnbaum is because it falls out of the derivation, Birnbaum being a change in core damage frequency for a given change in unreliability.

And so when we perform the comparison, since the Birnbaum of a basic event is a figure of merit using the MSPI, it's ingrained in the MSPI calculation and algorithm. It makes sense that what we want to do is compare a Birnbaum value derived from the SPAR mode with the Birnbaum value the licensee has in their model and see if they make sense and if not why don't they make sense.

CHAIRMAN APOSTOLAKIS: Now, the B_i is what makes this plant specific?

MR. DUBE: Correct. It falls out of the plant PRA.

CHAIRMAN APOSTOLAKIS: Right, and baseline values are the plant values. The UR_i, the first term, is the plant specific unreliability. The second term, the minus term, is a baseline value that's an industry average.

CHAIRMAN APOSTOLAKIS: Oh, it's not a

plant specific value.

MR. DUBE: No, it's an industry average.

CHAIRMAN APOSTOLAKIS: In the ROP I believe we looked at the deviations from what the utility has told us or in the maintenance rule. Isn't that what we do?

MR. DUBE: Yeah, but this is -- the way the MSPI was set up, it's a deviation from the industry norm.

CHAIRMAN APOSTOLAKIS: And the industry didn't complain about that?

MR. DUBE: No. They helped derive this. No.

CHAIRMAN APOSTOLAKIS: Okay.

MR. DUBE: So that's all I want to say about that, but to implement MSPI it was decided that there were some quality requirements, PRA quality requirements, that needed to be set. So a PRA quality task group was formed of three NRC and two industry members. Mike Cheok and Gareth Perry were two of the five members, the names you're probably the most familiar with.

And they came up with a set of recommendations, and I provide this as background, why we did what we did. They established two requirements. The licensee should assure that their PRA is of sufficient technical quality by (a) resolving the A and B facts and observations from the peer review.

What every licensee did for their PRA is they had a team of reviewers from other contractors, consultants, and utility representatives, and they did a focused review on each licensee's PRA; came up with a number of facts and observations, the As and Bs being the most important because it could impact the PRA quantitative results, whereas like C, for example, might be a documentation issue.

So we said if you're going to move forward the MSPI, you need to resolve those or at least go through the ones that are not yet closed, that are still open and explain why it would not impact the MSPI approach, the method.

The second part was the performance self-assessment using NEI 0002 endorsed by Appendix B of Reg. Guide 1.200, which you've seen for the ASME level requirements identified by the task group.

So what they had to do was say supporting level requirements. There were 41 that were identified from the ASME PRA standard that says we believe these SLRs are important to the MSPI because whether you met them or not, these requirements could impact the MSPI in a quantitative way.

And licensees would have to do a self-assessment and say, "Yeah, we meet all 41 of these requirements," or if not, "this is why we don't think it will have an impact."

CHAIRMAN APOSTOLAKIS: Isn't the PRA review you're referring in A the one that is implemented using NEI 0002? I think that's correct.

MR. CHEOK: Yes, that's correct.

CHAIRMAN APOSTOLAKIS: That's correct.

MR. CHEOK: That's why we require the B part of it, so that they can reconcile the NEI 0002 to the ASME standards.

CHAIRMAN APOSTOLAKIS: Okay. So the Bs --

MR. CHEOK: B ties it back to the standards.

CHAIRMAN APOSTOLAKIS: -- thing into the picture.

MR. CHEOK: Correct.

MR. DUBE: Now, when the industry surveyed their members, they found a substantial number would not be able to meet both A and B and proposed an alternative to B which was that they do a cross-comparison of their PRAs, and I'll explain that in a little bit.

CHAIRMAN APOSTOLAKIS: I don't understand that. Why would they not be able to do this? I mean it sounds like straightforward to me. Do they give any reason?

MR. DUBE: I mean, it entailed quite a bit of effort to do both.

CHAIRMAN APOSTOLAKIS: So it's a likely amount of effort.

MR. CHEOK: I think it's a resource issue. That's correct. I man, they will require a lot more effort to be able to meet A and B than they thought was possible in the time that's needed for implementation.

MR. DUBE: In the time frame.

MR. CHEOK: Right.

CHAIRMAN APOSTOLAKIS: So a cross-comparison of PRAs is the alternative, but the PRAs as they are today may be missing a few system level requirements of the ASME code. So essentially you are defeating B, right? Because the PRAs, a lot of them were done, in fact, before the ASME code was issued.

MR. CHEOK: That's correct, but a lot of the PRAs have gone back and backfit to be consistent with the ASME code. So I think the process that Don will talk about is they will do a cross-comparison among themselves first before they make a submittal to us, and after they make the submittal to us, we'll make a cross comparison between their distribution and our SPAR distribution, and Don will talk about that.

CHAIRMAN APOSTOLAKIS: But the ASME SLRs are out. You are not going to go to the ASME SLR, right?

MR. CHEOK: That's correct, but some of the licensee PRAs would have gone through the ASME SLRs.

MR. DUBE: They may have gone through some, but not necessarily all.

CHAIRMAN APOSTOLAKIS: Again, a cross comparison of PRAs. PRA presumably are plants of a similar vintage.

MR. DUBE: Yes, right.

CHAIRMAN APOSTOLAKIS: So what if they compare with five other PRAs? One of them has included additional inputs and the four did not. What do they do? Do they say, "Well, we'll ignore the fifth one"?

MR. CHEOK: I think Don is going to explain this.

CHAIRMAN APOSTOLAKIS: Okay.

MR. DUBE: So the staff said fine, but to have further confidence, we performed an additional cross-comparison of the PRA Birnbaum values to SPAR values and developed a process to do that.

You might not be able to read this, but there was a logical, systematic process to identify outlier Birnbaum importance measures, and it started by compiling the industry Birnbaums, and for the MSPI that represents about 5,000 components or 10,000 Birnbaums if you have two failure modes per component; assigning them to plant groups based on similar plant designs and vintages; identifying whether they were in the appropriate group or not; if necessary, reassigning them; and then if there were a substantial difference between the Birnbaum values, they became candidate outliers.

CHAIRMAN APOSTOLAKIS: Is it the same as the figure that Bob and John showed us when they compared the Birnbaums of the SPAR with the industry PRAs? Is it the same thing?

MR. DUBE: Again, I have different -- the same concept, but different approach, a little bit different approach.

CHAIRMAN APOSTOLAKIS: Different approach.

DR. KRESS: They use the same metric?

MR. DUBE: We're using the comparison of the Birnbaum values, right.

CHAIRMAN APOSTOLAKIS: Well, that's what they did. So what's the difference?

MR. DUBE: Well, you'll see.

CHAIRMAN APOSTOLAKIS: Oh, I will. I will.

DR. KRESS: We'll wait.

MR. DUBE: If there was a candidate outlier, then we did forensic PRA and try to determine if it was because of an identifiable design difference, and if so, we reviewed the modeling of that. That's the first decision box there, the diamond.

If not, was it because of an operational feature, such as electrical cross-tie procedure, emergency operating procedure or something along those lines? And if not, was it because of an identifiable modeling method difference?

CHAIRMAN APOSTOLAKIS: Can we have a full page copy of this figure? It's impossible to read it. Not now, but I mean when I go home and I want it.

MR. DUBE: So the Westinghouse owners group and the BWR owners group did cross-comparison, and here I'm just showing one graph. It's a little bit busy, but one graph, and I kind of hid the plant names, although this is generally proprietary Class 3, which means it's not proprietary.

Each group of bars --

CHAIRMAN APOSTOLAKIS: Mr. Reporter, can you hear? Okay.

MR. DUBE: Each group of bars is one plant, and each individual bar is the Birnbaum value, and this is on the scale of ten to the minus six, ten to the minus five, ten to the minus four for the emergency diesel generators, and what you see kind of naturally falls out is that these are the group of Westinghouse and Combustion Engineering plants with two emergency diesel generators. These are the plants with three emergency generators, and these are the plants with more than three diesel generators.

And also plotted on here are mean values, median values. And what you see is the Birnbaum values is a strong function of plant design and for diesel generators, a strong function of the number of emergency diesel generators.

What that basically means is two diesel generator plants have on average Birnbaum values that are higher than three diesels, which is higher than four or more, meaning that the core damage frequency is very sensitive to the performance of a diesel generator.

And given that you have two diesel generators, one diesel generator is more important to a two-diesel plant than it is to a three-diesel plant or four. I mean, it kind of makes sense.

CHAIRMAN APOSTOLAKIS: Is the plot the birnbaum for a single diesel?

MR. DUBE: yes.

CHAIRMAN APOSTOLAKIS: Regardless of how many they have.

MR. DUBE: Right. And this sump asymmetry in some cases is three because they also included a non-safety related like a station blackout diesel to show its value just for purpose -- even though it's not in the MSPI.

CHAIRMAN APOSTOLAKIS: Let's take the two extremes or maybe the first one on the left and the third one from the end.

MR. DUBE: This one?

CHAIRMAN APOSTOLAKIS: Yeah, this one and the third one. No, the other one, all the way down, all the way to the right, the third one.

MR. DUBE: This one?

CHAIRMAN APOSTOLAKIS: The third one.

They seem to have the same Birnbaum. How can a diesel generator in a four diesel plant have the same Birnbaum as a diesel generator in a two diesel plant?

MR. DUBE: Well, this shows the category-to-category variation, but what it shows is within here there may be other plant specific -- it could be one of three things: a real design difference, a real performance difference in terms of failure to run and failure to start rates or a mod difference (phonetic).

CHAIRMAN APOSTOLAKIS: Most likely the latter unless the numbers are completely off. I mean how can, you k now, one out of two systems, a component has a certain importance. You know, one out of four you just have much less importance.

MR. DUBE: Well, what you find is it's a combination of the three, and the reason why we use the SPAR models as a benchmark -- Bob and John kind of mentioned that -- is that it removes two out of the three factors. It removes data because we're using the same performance data in the SPAR models. It removes modeling differences because we're using a standard process, and what you see in the SPAR model is what's left is really primarily design difference.

So what we do by comparing the SPAR Birnbaums with the licensee's Birnbaum is remove two out of those three differences, and --

CHAIRMAN APOSTOLAKIS: There may be real differences, right?

MR. DUBE: Yes.

CHAIRMAN APOSTOLAKIS: Still though, wouldn't it be interesting to find out why these two seem to be the same?

MR. DUBE: And that's what we do based on the process that we used, which was we were concerned with outliers where the industry's value deviated significantly from the norm within its group and significantly from the SPAR value, and we had a set of criteria that went through all 5,000 components; used a screening approach to say which ones had significant deviation, and then dove into the model, the cut sets and looked at the modeling differences; determined if it was a design difference or a modeling different that would explain the difference between the Birnbaum values.

CHAIRMAN APOSTOLAKIS: So you're investigating the causes.

MR. DUBE: The reason for the differences.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. KRESS: You're looking for something outside of the range of --

MR. DUBE: Outside of the norm.

DR. KRESS: -- outside of the red.

CHAIRMAN APOSTOLAKIS: Even within the class, significant differences, huh?

MR. DUBE: That's right, and when you dig down to it you find this particular plant, for example, might have installed independent reactor coolant pump seal cooling capability so that in the event of a station blackout they would line up with, say, fire water or some other system to cool the reactor coolant pump seal, or they may have had installed some other AC independent system. In other cases, you may find that they installed an independent cooling system for a charging pump that provides that cooling pump.

But you find that there may be very real design differences that explain one set of values from the other set of values.

If you can't explain it because of a design difference or because of a performance difference, what's left is a modeling difference.

CHAIRMAN APOSTOLAKIS: Very interesting, very interesting.

MR. DUBE: This was done for all of the components for all of the systems installed in the

MSPI, and then the Westinghouse owners group even went further. They looked, and we talked about changes like VOS-VOS like power frequency, and there they found it was a pretty tight distribution for a plant.

They also looked at small LOCA frequency, which varied significantly. They looked at conditional core damage probability, a contribution to core damage frequency from lots of service water, and according to their grouping, compared the results from --

CHAIRMAN APOSTOLAKIS: So, Don, you expect the industry to do this for all components?

MR. DUBE: All the MSPI in scope components.

CHAIRMAN APOSTOLAKIS: How many?

MR. DUBE: Primarily pumps and diesels.

CHAIRMAN APOSTOLAKIS: So how many of those are we talking?

MR. DUBE: Three thousand components.

MR. CHEOK: Now, remember we didn't expect them to do it. They proposed that they would do it in place of the two requirements we showed you.

CHAIRMAN APOSTOLAKIS: So 3,000 pictures like this is preferable than doing little B?

MR. DUBE: No, not 3,000 pictures. I

mean, this is two times. This is already what, a couple hundred or a hundred, a couple hundred right here. So it's not 3,000.

CHAIRMAN APOSTOLAKIS: Well, I mean, 3,000 divided by --

MR. DUBE: Yeah.

CHAIRMAN APOSTOLAKIS: That's interesting.

MR. DUBE: Well, so we --

CHAIRMAN APOSTOLAKIS: But the important point here other vendor groups will do the same thing.

MR. DUBE: These are group groups that are similar. B&W, since they're a small population it's hard to get --

CHAIRMAN APOSTOLAKIS: Yeah, but it's interesting that this is done by the owners group, right?

MR. DUBE: Right.

CHAIRMAN APOSTOLAKIS: Not by individual utilities.

MR. DUBE: We derived our own set of groups, and we actually for the six systems in the MSPI developed about 30-something groups.

The next shows one example of a group. Now, this is actually a histogram fitted with a curved fit to it because we had groups, cases we were overlapping four or five histograms at a time, and the typical histogram bar chart doesn't show up very well when you overlap it.

Really what this is is this point right here, for example, means that there are, in the industry, there are 55 diesel generators -- oh, by the way, this is from the category of diesel generators that are really more than two but less than or equal to three. So what that means is three diesel generator plants and kind of two and a half diesel generator plants.

So how can you ever have a diesel generator, but there might be a shared diesel between two units, and so we counted that as a half. It might have been a station blackout. It may have been, you know, a non-safety related, small diesel generator that provided limited AC power.

So we had a routine to do it, but basically it's three diesel generator plants is another way to look at it.

So this means that there are 55 diesel generators in this grouping with Birnbaum values between ten to the minus six and ten to the minus five, and you can go through that.

The blue is the industry distribution.

The pink is the SPAR distribution, and what this shows is for -- well, this graph says a lot of things, but just the shape of the graph says a lot of things.

The fact that the SPAR and the industry overlap says there's pretty darn good agreement on the Birnbaum values, and if you look at what is behind the Birnbaum value, what determines the Birnbaum value is a loss of off-site power frequency, the nonrecovery of off-site power and probability, the reliability of diesel generators, and equipment that you use to mitigate a station blackout, such as a steam driven pump.

This tells us that at least for this category of plants, there's pretty darn good agreement in the overall Birnbaum values, at least on the whole or the population as a whole for this group.

The width of the curve tells us a lot of things, too, because the fact that the widths are about the same tells u we have about the same variability, and since the SPAR only has design variability and the industry may have design and data and model variability. That kind of tells us that the way everybody is modeling loss of off-site power and station blackout kinds of sequences and the kinds of loss of off-site power frequencies that are being used and the kinds of diesel generator unreliabilities are probably not all that far different.

CHAIRMAN APOSTOLAKIS: Well, unless you look at the range, which is from ten to the minus seven to ten to the minus three.

MR. DUBE: Yeah, but then --

CHAIRMAN APOSTOLAKIS: Well, that's kind of different, Don.

MR. DUBE: But then you look at those and you say why is that, and it's probably because sine the SPAR value has moved out, differences in data and differences in modeling method, this tells you that there are probably still differences in design capability between a value here and a value here, when you find such things as I mentioned before, additional mitigation strategies for loss of off-site power or station blackout.

CHAIRMAN APOSTOLAKIS: Oh, I would say that it's a combination of all the things you mentioned. I don't know how you can conclude that everyone models it more or less the same.

It could be modeling differences. It could be design differences, right?

MR. DUBE: But not in the SPAR because the SPAR is using --

CHAIRMAN APOSTOLAKIS: Not in the SPAR.

MR. DUBE: -- the same modeling and the same overall generic data. So what can explain a plant here, a diesel generator here and a diesel generator here is it's involved. There are still additional design differences between three diesel plants that account for several orders of magnitude and susceptibility to a loss of off-site power event.

And you'll find that there are some two or three diesel plants where you have a loss of off-site power and failure of the diesels. You have limited battery capacity, limited steam drive aux. feed pumps, and the conditional probability of core damage is relatively high, whereas others, you still have three diesels, but they may have a number of mitigation features. You know, all it takes is one or two. Given a station blackout, it only takes one or two mitigation features to reduce the susceptibility by one or two or three orders of magnitude.

DR. KRESS: I think George's -- correct me if I'm wrong -- point was that the blue curve, if there are three different things that influence its position, shape, and location, some of those could be pluses and some of them could be minuses, and you end up by coincidence being that close together.

CHAIRMAN APOSTOLAKIS: That could be, too.

MR. DUBE: Could be.

CHAIRMAN APOSTOLAKIS: Could be. Don doesn't believe it though.

MR. DUBE: yeah. I believe it can be a combination, but --

CHAIRMAN APOSTOLAKIS: But also this supports, I think, very strongly what I said earlier, not because I said it; because it's a widely held belief that the PRAs really should be plant specific.

MR. DUBE: Should be what?

CHAIRMAN APOSTOLAKIS: Plant specific.

DR. KRESS: Yeah, that really supports that.

CHAIRMAN APOSTOLAKIS: This really supports that statement, right? I mean, if you have a plant where the band bone (phonetic) is on the order of ten to the minus six and another one close to ten to the minus four, as you said, there are real differences.

It can't be just analysis, and if I do a generic PRA, I'll probably be either unfair or you know.

DR. KRESS: You'll be unfair to some of them, yeah.

CHAIRMAN APOSTOLAKIS: So don't you agree, Don, that they should be plant specific?

MR. DUBE: Yeah, I come from that school to begin with, but --

CHAIRMAN APOSTOLAKIS: But you are trying to liberate yourself?

(Laughter.)

MR. DUBE: No, I think the SPAR has --

CHAIRMAN APOSTOLAKIS: Look at what the SPAR shows then.

MR. DUBE: -- has allowed us -- this comparison allowed us to rule out two out of the three --

CHAIRMAN APOSTOLAKIS: I understand that.

MR. DUBE: -- causes of variability.

CHAIRMAN APOSTOLAKIS: But even the SPAR variability is due to design features, right?

MR. DUBE: That's definitely true.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: Therefore, the PRA should -- plant specific means, you know, not just the data. The whole thing. It's a very strong statement support --

MR. DENNING: The structure is plant specific. The structure that they're doing is plant specific. It's the data --

CHAIRMAN APOSTOLAKIS: I am not implying any criticism.

MR. DENNING: I mean we come back again and again to what is really an important issue and one that --

CHAIRMAN APOSTOLAKIS: It is a very important issue.

MR. DENNING: -- we're going to debate for quite a while.

CHAIRMAN APOSTOLAKIS: It's very important issue, but this is really a nice figure.

MR. DUBE: Now, we were in a situation where we couldn't go through and review the modeling structure and data behind some 3,000 components that are within the scope of the MSPI. So we had a process to identify significant differences, and I'm not going to dwell on it, but here is a case where we identified a candidate outlier where I call it Plan B, had a Birnbaum value. This is the industry value. I show a vertical line, but it's basically around ten to the minus sixish.

CHAIRMAN APOSTOLAKIS: Would I care about that? Why would I care about that? That's a pretty good plant or am I missing.

MR. DUBE: The SPAR value said it was --

CHAIRMAN APOSTOLAKIS: Oh, it's for the same plant.

MR. DUBE: Oh, yeah.

CHAIRMAN APOSTOLAKIS: Oh, okay, okay.

MR. DUBE: -- three times ten to the minus five.

DR. KRESS: That one you should worry about.

MR. DUBE: So now we had a process where we looked at significant differences between plant specific values within a particular group. So we started by grouping them and say they have this feature of three diesel generators, but within the group, why would the plant be here and why would the SPAR say it's here?

And that --

CHAIRMAN APOSTOLAKIS: Aren't you duplicating what Bob showed us? I mean he showed a straight line, and he took the Birnbaum from SPAR, Birnbaum from the utility, and if it's way below the line, he does something about it.

MR. DUBE: It is similar. It's similar.

CHAIRMAN APOSTOLAKIS: They're the same. You're just showing it in a different way.

MR. DUBE: Whereas you're developing it on a systematic process for --

CHAIRMAN APOSTOLAKIS: You are not systematic.

(Laughter.)

MR. DUBE: -- long term over several years, by the time we received the data, we had basically three months to input the data, do this comparison, identify candidate outliers --

CHAIRMAN APOSTOLAKIS: But it's the same thing essentially though, and go through from 200 -- yeah. I mean, in the end we had 260-such cases where there was a significant --

CHAIRMAN APOSTOLAKIS: Really? That many? Two hundred sixty cases of this component?

MR. DUBE: Of significance variance between the licensee's value and the SPAR. And then we have to dig in and identify one of three things. Is it SPAR anomaly, a licensee anomaly? Is there a real design difference? Is there a modeling difference? Is it a data difference?

CHAIRMAN APOSTOLAKIS: And what were the insights that you drew from this?

MR. DUBE: That's coming up in two slides -- three slides.

CHAIRMAN APOSTOLAKIS: Can I wait for three slides?

MR. DUBE: Now, here's a case where we showed the distributions for RHR pumps for a two-pump system with a high pressure recirc. booster pump. What that means is for many Westinghouse plants and some B&W plants, in a high pressure recirculation mode, they have a piggyback mode where a low pressure pump draws from the containment sump and provides suction to a high pressure and safety injection pump, which then injects them to the core.

So for that class of plants with that capability.

MR. DENNING: And it's a subset of the figured that we saw before.

MR. DUBE: No, this is a whole -- this is for RHR folks.

MR. DENNING: Oh, I'm sorry. I'm sorry. Absolutely. I Understand.

MR. DUBE: This is one of 30 groups. Now what you see here, remember the size and shape of the curve. I mean, this is just for graphical aid, but it shows here the blue curve is the industry distribution. The pink is the spine distribution. You see an offset between the two.

And now you have to ask yourself why is there an offset. Why does there appear to be a bias in one or the other? And you have to ask yourself did the utilities for 103 plants all congregate together and systematically bias their values, and in this case to the high side. So why would they do that, or is there something in the SPAR model that seems to systematically bias it to the low side compared to the licensee's PRA models?

And you say, well, it's probably more likely the latter since it's using standard method, standard models, standard data. And when you dig into this particular case, you find that the licensees -- you know, this is driven for sequences of small LOCA where you rely on high pressure recirculation. So when you dig in a little bit deeper, you'll find that the licensees did use a distribution of small LOCA frequencies. In fact, it was quite wide.

But the SPAR models use a small LOCA frequency significantly lower than what the industry was using. In fact, the small LOCA frequency here was almost an order of magnitude lower than the average in the industry used, which because the dominant cut sets are small LOCA and failure of high pressure recirc. and so on and so forth, systematically bias the

Birnbaum values for these RHR motor driven pumps to the point that it shifts in the curve to the left, and when you dig into it, you find that the small LOCA frequency in the SPAR models for 4E to minus four, whereas most industry values use two or 3E to minus three, like a factor of --

CHAIRMAN APOSTOLAKIS: What is the reason SPAR used such a lower number?

MR. DUBE: The gentleman here might answer, but you know, when you looked into it, it's because of a different definition of small LOCA. This small LOCA is kind of considered the high end of the small LOCA pipe breaks, whereas many of the industry values included historical stop open relief valves and reactor coolant pump, mechanical seal failures, and the 400 and 500 gallon a minute kinds of leaks, whereas this was predominantly a pipe break, which could be several thousand gallons a minute, and I think that's what it is.

I mean, it's something we'll have to look into.

CHAIRMAN APOSTOLAKIS: So did the SPAR people change their frequency?

MR. DUBE: I don't know because I just saw this graph.

(Laughter.)

CHAIRMAN APOSTOLAKIS: So it's somebody else's graph?

MR. CHEOK: This MSPI comparison is ongoing as we speak and --

CHAIRMAN APOSTOLAKIS: This is not MSPI now. This is Birnbaum.

MR. CHEOK: That's right, but it becomes -- Don is going to pass this over to the SPAR model development people, and we're going to use these crash to help us as another QA tool, so to speak. That's why we thought this was an interesting thing.

CHAIRMAN APOSTOLAKIS: So we are seeing the relations here.

MR. CHEOK: Right, correct.

MR. DUBE: This is hot off the press.

But these vertical lines show that while the absolute values of the Birnbaums used by SPAR and industry were pretty much the same, it showed that the industry value was right at the median or mode, pretty much the median, whereas the SPAR value was to the high side.

So this would be another candidate outlier because if you correct for the fact that the SPAR is using appears to be a low loss of small LOCA frequency, the industry is an outlier because to correct for that, the SPAR Birnbaum is to the high side in the industry, is in the norm.

So based on our criteria and screening, this might have been caught. We would have taken a look at that, notwithstanding the bias introduced by, you know, what appeared to be a systematic small LOCA frequency.

MR. CHEOK: Now, this is a class case if you just looked at the Birnbaums from both the industry and the SPAR for a particular plant. You would think that they are almost exactly the same, and you would think that there would be no bias, but we're thinking that it actually could be different because the industry distributions are shifted, which makes this the plant specific values are biased.

MR. DUBE: This is not just a visual tool to aid us in identifying outliers and out of the 3,000 or so components we started with -- we screened that down to 260-something, and then myself, Peter Appignani, Jim Vail, and other contractors, some SRAs from the regions went through all 260 one at a time to disposition them and identify is it a real design difference. Is it a SPAR modeling issue? Is it a licensee's modeling issue?

DR. THADANI: Don, if I may just make a quick comment on back to what George said. The earlier slide when you talked about modeling of the sump issue, you had four times ten to the minus six increase in core damage frequency using SPAR model for small LOCA. If you had increased this by an order of magnitude, you would presumably get four times ten to the minus five.

CHAIRMAN APOSTOLAKIS: I thought it was large LOCA, Ashok.

DR. THADANI: Pardon me?

CHAIRMAN APOSTOLAKIS: I thought what they showed earlier was for large LOCA.

DR. THADANI: Three, three. No, they showed for large LOCA, medium LOCA and small LOCA, and I'm saying small LOCA contribution would have been four times ten to the minus five then if you follow.

MR. DUBE: But maybe not because it would have been the small LOCA from pipe breaks, which would loosen up the insulation, where if you add relief valves that dump into a quench tank for RCP seal, they may not have generated the debris. So --

DR. THADANI: They're safety valves also, but anyway.

MR. DUBE: So we summarize the licensee's

PRA issues into the following. After going through 260-odd candidates and narrowing it down, what did we find?

Well, some of these aren't quite candidate allied issues, but we had situations where open A and B facts and observations could possibly affect the MSPI, and we're holding these issues open until the licensees address them. We found 16 cases of that out of the hundred or so plants out there.

Model truncation and convergence issues, 14. What --

CHAIRMAN APOSTOLAKIS: Model truncation, you mean the cutoff frequency?

MR. DUBE: What we found is that a number of licensees could not lower their truncation value on their PRA quantification enough to insure that the model was --

CHAIRMAN APOSTOLAKIS: What's "enough"? Ten to the minus 12?

MR. DUBE: Well, some of them were using ten to the minus nine and ten to the minus ten.

CHAIRMAN APOSTOLAKIS: But it's not a sufficient cut of leverage, ten to the minus 12, I think.

MR. DUBE: But they couldn't get low

enough.

CHAIRMAN APOSTOLAKIS: Right. Isn't that what you guys told us?

DR. BUELL: We used ten to the minus 12, is what we used.

CHAIRMAN APOSTOLAKIS: So it just be sufficient.

(Laughter.)

CHAIRMAN APOSTOLAKIS: Boy, you guys are so modest today.

MR. DUBE: In some cases the model is so complex that the software just didn't accommodate going lower and lower. So they could not assure that the CDF was converged and that the Birnbaums were convergent, and usually you have to go even lower to converge importance (phonetic) measures like Fussell-Vesely and Birnbaum than you do to converge a core damage frequency.

CHAIRMAN APOSTOLAKIS: Now, the Birnbaum measure is related to the risk achievement worth, is it not?

MR. DUBE: Yeah, and it's proportional to the Fussell-Vesely, too.

CHAIRMAN APOSTOLAKIS: How can that be? Fussell-Vesely is a separate, different model.

MR. DUBE: I can show you algebraicly that they're --

CHAIRMAN APOSTOLAKIS: Are you saying that Fussell-Vesely and RAW are related?

MR. DUBE: Yes.

CHAIRMAN APOSTOLAKIS: No, they're not.

MR. DUBE: Yes.

CHAIRMAN APOSTOLAKIS: Let's go back then to the graded quality assurance and all that stuff. They're supposed to be independent. I mean they're related because they're referring to the same PRA.

MR. DUBE: Algebraicly the Birnbaum is equal to the Fussell-Vesely divided by the failure probability of the basic event, failure probability times the core damage frequency.

CHAIRMAN APOSTOLAKIS: And the Birnbaum is the core damage frequency times RAW, right? No? Oh, no, because it's a difference, but it must be related. Come on. It's one minus the RAW or something like that or RAW minus one.

DR. KRESS: You've got to have a two in there.

MR. DUBE: It's approximately equal to one plus Fussell-Vesely over P.

CHAIRMAN APOSTOLAKIS: No. Where P is

what?

MR. DUBE: Failure probability.

CHAIRMAN APOSTOLAKIS: No. Can't be. RAW and Fussell-Vesely are not related at all. Maybe you're confusing it with the risk reduction worth. That's related to Fussell-Vesely. Risk reduction worth is --

MR. DUBE: I'll show you the derivation.

CHAIRMAN APOSTOLAKIS: Oh, my God, yes. I do want to see. It can't be true.

MR. DUBE: Loss of off-site power frequency showed up in nine, and this is, as I mentioned, we found a -- generally the licensee's loss of off-site power frequency has agreed very much with the SPAR and within themselves, but we found cases where the loss of off-site power frequency were factors of three, four, and five lower than what you would expect, even one case where the licensee's plant was in the middle of the northeast blackout, and yet their loss of off-site power frequency is still an order of magnitude lower than --

CHAIRMAN APOSTOLAKIS: What is it that makes them an issue, these? Because they disagree with SPAR?

DR. KRESS: They become an outlier.

MR. DUBE: We could not explain it, and it was at first cut an outlier because it was not a bona fide design difference. It was the use of an initiating frequency or a failure probability or a modeling issue that was I guess you would say outside the norm.

CHAIRMAN APOSTOLAKIS: Well, that was based strictly on the industry developed code, not the SPAR.

MR. DUBE: We used the SPAR curve and the industry curve to provide us a screening criteria for first identifying differences at a high level, and then we dug down into the issue to identify why is there a difference, and in these cases we would find that the licensee used -- the reason why the Birnbaum is different by an order of magnitude is because the licensee's losses of off-site power frequency is an order of magnitude lower than the norm.

CHAIRMAN APOSTOLAKIS: But you didn't compare a high percentile of the blue curve with a low percentile of the blue curve and try to figure out what is the difference.

MR. DUBE: No.

CHAIRMAN APOSTOLAKIS: It was between industry and SPAR.

MR. DUBE: Right. That was just our starting point.

CHAIRMAN APOSTOLAKIS: Okay, all right.

MR. DUBE: Low loss of service water frequency issues, here we even saw greater variability, and Bob alluded to it, but we saw cases where the experience base loss of service water frequencies like 4E to the minus four. Yet there were some licensees one, two in one case, one almost three orders of magnitude lower than that. They were in the realm of below ten to the minus six per year, which was once in every million years.

DR. KRESS: Yeah, that's never.

MR. DUBE: It just stood up. I mean, it just doesn't pass the standard.

And these issues were found by doing these kinds of screenings and zeroing in on what the difference is.

This has to do -- and I won't get into too much detail -- is that as Bob mentioned, if you don't have a support system, initiate a fault tree like a loss of service water fault tree. You could underestimate the Fussell-Vesely contribution. So there are five instances of that.

Here, Bob mentioned this as well. The

licensees took credit for reactor pressure vessel injection after containment. Now, it's possible that these might get resolved. At the time that we had to generate the summary list we had not yet received analysis and justification for that.

DR. KRESS: Now, do some of these plants show up in more than one of these?

MR. DUBE: Yes. Yes, some of them show up in at least -- I've seen some in at least three of systems or three -- I mean, if you add them all up, it's less than one issue per plant, which isn't too bad. That tells you a lot right there.

Station blackout mitigation strategies having to do with the way they might have modeled recovery of off-site power, the way they may have taken credit for mitigation strategies, some AC dependent pump, for example.

Off-site power recovery issues, Bob mentioned this, taking credit for operating circuit breakers which are DC powered after battery depletion. It's kind of a catch-all and explains --

CHAIRMAN APOSTOLAKIS: Well, that doesn't -- I mean, it was explained to us earlier that the time to core uncovery after you lose complete power is not included in SPAR. So that may have something to do with it, too.

MR. DUBE: It could. For example, one licensee said that their procedure would be something along the lines of if they're running out of battery power and they're operating a turbine driven aux. feed pump, it would be to run it full out, fill the steam generators all the way to the top before they run out of battery power to control the turbine.

And if you consider decay heat in eight or ten hours into an event, that buys them a lot of time before you dry out the steam generators, given that time. So there are some issues like that.

This is kind of related, control of turbine driven power. One case of a low line to DC bus initiator frequency, and missing test and maintenance on a basic event diesel generator.

So this is our list of PRA issues that we developed focusing just on MSPI specific components and trying to understand the reasons for the differences.

Any questions on this?

And then the final one is a summary of the generic FAR issues, and most of these have already been covered by Bob and John, but I'll just summarize them. We did find, but we appear to have introduced -- remember that curve where I showed a bias where this appears to be possibly because of a low small LOCA frequency. We found a case of an opposite bias in the other direction because of what appears to be a high loss of emergency AC bus initiator frequency, which appears to be an order of magnitude higher than all the industry values.

I'm not quite sure why. It could be having to do with the counting of the number of buses that could possibly be affected. It could be a number of reasons that may not account for recovery.

It looks like the emergency AC bus initiator frequency in SPAR is representative of a spurious opening of a circuit breaker, whereas the industry values tend to be more bus fault failure rate, which is generally an order of magnitude lower, and that might account for the differences there.

But there is a difference of systematically of about an order of magnitude.

Bob mentioned the pressurizer PORV success criteria. I kind of differ a little bit. I kind of have a different perspective because, you know, I did manage best estimate LOCA success criteria for two PRAs, Connecticut Yankee and Millstone 2, and we did multi-man-year RELAP 5 analyses to develop success criteria for feed and bleed, and we saw that it can vary. You know, it's a function of the pressurize of PORV relief capacity, the thermal power, whether one had relatively low head-high head safety injection forms like a CE plant may have only 1,200 psi shutoff safety injection pumps, where many Westinghouse plants have high capacity, high shutoff charge pumps.

And we found differences that can be plant to plant variation in success criteria. It is possible to feed and bleed with one PORV in some plants. In other plants it might require two PORVs just because of the relief capacity and the differences in high head safety injection.

And we saw differences there between SPAR and licensees. So in a couple of cases we asked the licensees to provide us information, and Duke Power sent us a 1,000 page calculation of RELAP 5 where they showed two PORVs would be successful, and under a number of circumstances one PORV would be successful as well.

So I think the jury is still out, and it's a good opportunity here for additional research into the success criteria.

DR. THADANI: But, Don, on the B&W I thought there was only a one inch PORV in B&W plants so that they have very limited capacity, don't they?

MR. DUBE: B&W, we saw a difference. We saw cases with one and some cases with two PORVs successful.

DR. BONACA: It also depends, as we were discussing before, on the entry time. I mean, it depends on a number of parameters.

MR. DUBE: Yes.

DR. BONACA: For some plants like the C plants, I mean, they have the PORVs. They're successful in fitting only if you can fit early enough.

MR. DUBE: Yeah, that's an important criteria which is how early do you attempt to feed and bleed because what tends to happen is when you lose your decay heat and pressurize, the pressure goes up, and you can open a PORV, and if it can't relieve capacity, the pressure keeps rising, and it goes above the shutoff of the safety ejection pumps and it will never turn around.

That's why a CE plant with 1,200 PSI HPCI pumps and very low capacity charging pumps, timing is everything. You take it early enough and if you also use the steam generator atmospheric dump valve, you can crash the RCS pressure to a low enough pressure that the safety injection pumps start injecting, and then they start injecting cold water, and you get a positive feedback situation where injecting cold water further cools you down, which further depressurizes, which gives you more cooling water, which further depressurizes you and cools you down, and you can self-sustain that.

Whereas Westinghouse plants with high head shiving (phonetic) pumps with 2,300, 2,400 PSI cutoff aren't as sensitive to that because if you open a PORV, you get the pressure down and then can inject almost enough flow to meet decay heat at the PORV's shutoff, and so you tend to find that C plants are more likely to have two PORV success criteria whereas many Westinghouse plants with high head charging pumps could possibly do it with one PORV.

All right. So enough of that issue. We did find modeling asymmetries. We're in some of the earlier SPAR models they modeled only loss of DC power on one bus and not the other bus, and that cause asymmetry in the Birnbaum values. I think that has since been corrected, but at least the models that we use, that accounted for a significant number of variation.

Bob mentioned the single value loss of

service water frequency. I think that's an issue. Whereas, you know, there are plant-to-plant differences and we saw cases in the industry values where they had bona fide design reasons, site reasons why one could account for differences in loss of service water frequency, and maybe an order of magnitude, you know, or one and a half orders of magnitude could account for that.

I'm not quite sure, and I don't personally believe three orders of magnitude differences in loss of service water frequency.

But we found a couple of cases of higher failure probability for local manual control of turbine driven aux. feed pumps, whereas the licensee had provided us an approved procedure and a training program where they routinely train on this process. They might justify a lower human error probability that's in the SPAR model, for example.

At least back in the spring when we collected the data, some of the B&W plants had old sealed LOCA models. This has since been corrected in the last month, but you know, that did account for some of the differences in the SPAR model.

I mention the small LOCA frequency. In several instances where the SPAR did not model test and maintenance for some point performance.

I mentioned most of these issues are being addressed, but you know, we kind of independently verified a lot of this.

So where am I? I guess summary is the process we used was narrowly focused on some 3,000, 5,000 components within scope of the MSPI. It was a three-month focused effort on understanding the differences between the SPAR values and the industry values, trying to disposition the differences as being a bona fide design difference, data difference or modeling differences, and where it appeared to be a licensee modeling issue, it's an issue that we've put on the table for requesting the licensee to provide further justification before we disposition it or it may not be dispositioned.

CHAIRMAN APOSTOLAKIS: You're done?

MR. DUBE: Yes.

CHAIRMAN APOSTOLAKIS: Can you remind me what the MSPI is used for?

MR. DUBE: It's a performance indicator for measuring the performance of six systems.

CHAIRMAN APOSTOLAKIS: It's replacing which performance?

MR. DUBE: Safety system unavailability.

CHAIRMAN APOSTOLAKIS: Okay.

MR. DUBE: It's strictly unavailability.

CHAIRMAN APOSTOLAKIS: So it includes the reliability over a period of time.

MR. DUBE: Right, right.

CHAIRMAN APOSTOLAKIS: Very nice.

Any questions to Don from the members?

(No response.)

CHAIRMAN APOSTOLAKIS: Thank you very much.

DR. THADANI: Outstanding work.

CHAIRMAN APOSTOLAKIS: As Dr. Thadani noticed, expressing a personal view.

(Laughter.)

DR. KRESS: Not necessarily that of the committee?

CHAIRMAN APOSTOLAKIS: Because the committee will -- what will the committee do?

DR. KRESS: We don't. We just make recommendations and comments.

CHAIRMAN APOSTOLAKIS: Yeah.

DR. KRESS: To the full committee.

CHAIRMAN APOSTOLAKIS: For deliberation by the full committee.

DR. KRESS: Yeah. That might very well be something we'll say.

CHAIRMAN APOSTOLAKIS: But did Dr. Dube speak with sufficient clarity and volume?

DR. KRESS: The clarity was good. The volume was --

CHAIRMAN APOSTOLAKIS: The volume was kind of low.

Oh, my God, you guys again. Alone this time, John?

DR. SCHROEDER: I think he's got laryngitis by now.

CHAIRMAN APOSTOLAKIS: How much time do you need?

DR. SCHROEDER: Well, I don't have a lot to say about this particular subject.

CHAIRMAN APOSTOLAKIS: Wow. You know we have a lot to say about this particular subject.

DR. SCHROEDER: I understand that.

CHAIRMAN APOSTOLAKIS: Go ahead. Thank you.

DR. SCHROEDER: In the next few slides, I'll try to tell you where we're at with respect to modeling uncertainty in the SPAR model program.

As in any other PRA, we try to account for both data uncertainty and modeling uncertainty.

However, out quantification code gives us the tools to deal with data uncertainty fairly easily and modeling uncertainty is still very hard.

The data uncertainty I think we have fairly well in hand. We have a standard template list that gives us our failure rates and tries to model the failure rates with appropriate uncertainty distributions.

The uncertainty distributions these days are largely gamma functions for rate related parameters and beta distributions for the demand related items. Human error probabilities are largely the constrained, noninformative prior type distribution.

Now, there are other data uncertainty items within the SPAR models that we are capable of dealing with. The initiating event frequencies, the component failure rates, and a few other things are coming from the data template set that is being developed for us and that there's going to be a NUREG issued on.

A couple of other items. The off-site power recovery, the diesel generator recovery failure distributions are a little harder to calculate uncertainty distributions on. For those, the statisticians have provided us with uncertainty distributions on the parameters for the recovery curves.

And using the off-site power recovery module, we can then propagate, in effect, the family of curves through the model.

CHAIRMAN APOSTOLAKIS: Now, what do you mean by data uncertainty? I mean, you as a SPAR developer and user have these needs? Is that what you mean?

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: Because some of them are model uncertainties. Some are parameter, right?

DR. SCHROEDER: When I'm talking about data uncertainty, I'm talking about failure rates and the uncertainty parameters that describe them. There's also --

CHAIRMAN APOSTOLAKIS: These are not all failure rates. I mean, recovery parameters, these are not a failure rate.

DR. SCHROEDER: The off-site power recovery curves are not failure rates, but they're something for which data has been collected, and there is a model for the distribution, be it log normal or

YABLE (phonetic). I think the current generation of models uses a log normal model, and when I say modeling uncertainty, I'm not talking about the choice of statistical model for the data value or for the curve.

When I talk about model uncertainty, what I'm talking about basically are structural issues rather than choice of distribution or selection of parameter to describe the distribution.

One more source of uncertainty that kind of crosses over into model uncertainty is whether we use plant specific or generic data in all of this data uncertainty analysis. We don't know exactly what the right approach is, and that is being studied now, and I'm not sure where it's going to land.

It is fairly easy for us to take plant specific data and plug it into these models because of our generic template set, and on many failure rate issues or initiating event frequency issues, plant specific values are calculated, but it's sort of a management decision as to whether those are appropriate to use in the SPAR program.

I can't say much more about those items than that. We can do the Monte Carlo analysis. We have failure rates. We have uncertainty distributions on the failure rates, and we can propagate those. There will be a data report that describes those in more detail.

CHAIRMAN APOSTOLAKIS: I mean, I do appreciate the issue of structural uncertainty, but it seems to me that model uncertainty where you have a multiplicity of models, you guys are resolving very quickly by just approving one model or taking one model.

I mean, we like Westinghouse. We really don't care about human error because we have SPAR-H, and I don't know that -- I mean, I'm pretty sure that a lot of that is justified, what you do, but I wouldn't dismiss those uncertainties offhand.

You know, the structure of uncertainty is extremely important, as is incompleteness, but I don't know. I get the feeling that you are really dismissing that.

MR. CHEOK: I'm not quite sure you're dismissing them, George. I think we understand that they are there, and I think one of the keys to decision making is to know where your uncertainties are and to understand that their contributions to your decision is such-and-such.

So they're not quite dismissing them. I

think what you would like for us to do is to maybe quantify it more.

CHAIRMAN APOSTOLAKIS: No, no, no.

MR. CHEOK: We are not, in a sense, quantifying the uncertainties.

CHAIRMAN APOSTOLAKIS: I like the idea of starting with a decision. Didn't we talk to you about something we did?

MR. CHEOK: You might have.

CHAIRMAN APOSTOLAKIS: One, one, seven, four, for example.

MR. CHEOK: That's correct.

CHAIRMAN APOSTOLAKIS: If the licensee comes in there and says, "Look. I did my calculations and this is the point on the diagram," the famous diagram, and then you ask yourself, okay, they use the human error probability, for example. If I change that, would I affect the decision?

MR. CHEOK: Sure.

CHAIRMAN APOSTOLAKIS: And then you ask the second question: is it reasonable to change it by that much?

And I was much surprised when I saw an SER, in fact, where they were reviewing one of the submittals, and the licensee used the value for the relevant human error of .5. I don't care. If I make it one, it doesn't really matter.

So even though there is model uncertainty in the human error part --

MR. CHEOK: It doesn't matter.

CHAIRMAN APOSTOLAKIS: -- it doesn't affect this decision because the licensee used the high value.

MR. CHEOK: Absolutely.

CHAIRMAN APOSTOLAKIS: So it's the two elements that are very important. Okay?

By the way, I think there are two papers. There is a very interesting just one that I remember, a paper by several authors from PLG, the old PLG, where they documented several cases where different model assumptions made a big difference to their PRA. And you know those guys were doing a lot of PRAs at that time. It's a 20 year old paper.

But you know --

DR. THADANI: I can give you a more recent example, George, and Mike knows this very well. It's the steam generator tube failure event at Indian Point. When you brought and model uncertainty, and this analysis was done, redone, to fold in some uncertainties, particularly human reliability model that was used, you came to different plausible conclusions about that event and whether it was red, yellow, white, you know.

This is a big issue, and I think, Mike, you recall that. You might recall the results as I do.

MR. CHEOK: Yes.

CHAIRMAN APOSTOLAKIS: No, but I think, Mike, back to your point, the thinking up until recently was, indeed, to do what you said, develop a whole probability distribution across models, which is, of course, very difficult to do, although we do it. I mean, the expert opinion elicitation process does that, right? For seismic or for pipe failures and so on.

But now that we have decision rules like 1174, it's much easier to handle it because the first thing you do is you're asking yourself how important is it to the decision.

MR. CHEOK: Correct.

CHAIRMAN APOSTOLAKIS: Even if I raise it to one, I move a little bit. So why should I care?

So I think this -- and in fact, there was a paper from NEI or somebody at the recent PSA conference in San Francisco, where they follow an approach like that. Okay?

MR. CHEOK: Right. And I guess that's the smart use of what we would call a sensitivity study.

CHAIRMAN APOSTOLAKIS: Absolutely, absolutely.

MR. CHEOK: You're saying I'm trying to bound my answer by plausible parameters, and if it doesn't make a difference to my decision, then this parameter is not important.

CHAIRMAN APOSTOLAKIS: It's a decision focused or decision centric approach because ultimately what matters is the decision.

MR. CHEOK: Right.

CHAIRMAN APOSTOLAKIS: That's what really matters. I mean, that was really an eye opener. When I looked at that and the guy said we put a probability of .5, I said there goes the issue then. Who cares?

If they had put ten to the minus three though, it would have been different.

MR. CHEOK: I think what was lost a little earlier when Bob and John was showing you the caution screens at the beginning of the SPAR models, one of the objectives of those screens were the total user. This is our assumptions, and these are the items that could impact your answers if you are using the SPAR models to evaluate this event and your event concerns one of these issues. Then you have to be somewhat careful because our models, the answers from these SPAR models are somewhat sensitive to these issues.

CHAIRMAN APOSTOLAKIS: That would certainly -- well, first of all, for them it's a little difficult because they are not really dealing with any decision. They're just developing a model.

But having something like this would be an excellent starting point because ultimately what you need is the decision making context, which you don't have right now unless the licensee comes back to you and saying, "I'm requesting, you know, to eliminate a diesel," or something. So that you cannot anticipate.

But you can have a nice list of issues, modeling issues that could, could affect the decision without passing judgment on whether they do or not.

MR. CHEOK: Right.

DR. SCHROEDER: I can show you that list.

CHAIRMAN APOSTOLAKIS: Well, I'm sure you'll have a contribution.

DR. SCHROEDER: If you'll allow me to, I'll do it right now.

During the plant visits -- I need to start at the beginning of this, Guy -- during the STP review and during our detailed model reviews, we started to see many things coming up over and over again that seemed to make a big difference in our results versus the licensee's results. We didn't just sit down and try to guess at what the issues were. We just started to keep track of the things that were causing differences in the models and the things that maybe were different from one licensee to the next because in some cases we might think we're right and we don't care what they think, but we're keeping track of the issues anyway.

And we came up with a rather long list of those issues. They're identified across the top row here. Most of these are on our top ten list, but this is how we got the top ten list.

CHAIRMAN APOSTOLAKIS: Well, that's a very good start, yes.

DR. SCHROEDER: And it's a fairly comprehensive list.

CHAIRMAN APOSTOLAKIS: It's wonderful. Is that documented anywhere or it's still in progress?

DR. SCHROEDER: Well, this is done, but this is in the applications now. When you go through that issues list, when you log into a SPAR model and you have to get through that disclaimer screen, what you basically get is a summary if you are opening the Calloway model. You would get a summary of that row of this matrix, and these numbers in here are what we described earlier, the one, two, and three.

They're our attempt to quantify the impact of this issue on that model. In other words, it could change your core damage frequency by 50 percent or 100 percent, and we also kept track of the particulars at a given model. We have these annotations in here that say, well, why did we get this result at that plant.

CHAIRMAN APOSTOLAKIS: No, I think this is very good. If you look at, for example, the third or fourth column from the right, number of calls required.

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: I would say that's a structural uncertainty issue.

DR. SCHROEDER: Right.

CHAIRMAN APOSTOLAKIS: It has to do with success criteria and all of that.

The one next to it though, no, on the left, "credit for RPV injection following containment failure in BWR models," you have one event now, injection, right? But there may be differences of opinion as to what the probability of that is. That's the model uncertainty I'm referring to.

DR. SCHROEDER: The way it actually works out in our model is that there are end states that we quantify as core damage that the licensee insists are okay, largely because of the --

CHAIRMAN APOSTOLAKIS: Oh, so it's a different thing. It's still --

DR. SCHROEDER: It's still a structural issue, success criteria issue.

CHAIRMAN APOSTOLAKIS: Well, then the credit for recovery of off-site power is one of those.

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: Because both of you have the same event.

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: But there is disagreement as to what probability value to use.

DR. SCHROEDER: In particular, that's --

CHAIRMAN APOSTOLAKIS: That's a model uncertainty.

DR. SCHROEDER: This first one here --

CHAIRMAN APOSTOLAKIS: Of one kind, of one kind.

DR. SCHROEDER: This value K is a bright illustration of that.

CHAIRMAN APOSTOLAKIS: I think you have a great starting point there to put together a nice report or white paper summarizing these things in the language that I'm using, and you know, for guidance in the future.

DR. SCHROEDER: What we did is kind of took an average of the values for each of these columns and used that to sort of prioritize these issues, and those that affected a lot of plants and had the potential to change the core damage frequency a lot became our top ten issues --

CHAIRMAN APOSTOLAKIS: Sure.

DR. SCHROEDER: -- that we needed to address and resolve.

CHAIRMAN APOSTOLAKIS: That's great.

DR. SCHROEDER: And resolving an issue doesn't mean that we will agree with the licensee on it. It means that the NRC will establish a position that they have strong confidence in.

Now, in the meantime, we have no real mechanism to automate any of this in the context of the SPAR model. In the HRA, we showed you how a degree of belief might come into the calculation, might actually be something that we could handle with automation and the calculational tool.

But these issues really at present need to be handled by sensitivity or some sort of off-line consideration that the analyst does when he goes to draw a conclusion about whatever it is he's analyzing, and that's the state of uncertainty in the SPAR model.

CHAIRMAN APOSTOLAKIS: There's another element here that we are not including, and there's a good reason for that. It's irrelevant to you. But if we come back to the earlier comment about decision making, you see, what matters there, again, if you go to 1174, the famous diagram with the regions; what matters is not just the CDF and how sensitive it is to model uncertainty. It's the delta CDF, okay, because many times what you find is that the CDF itself, it's a little sensitive. Even if you double it, it doesn't really matter.

But if you start doubling or tripling the delta CDF, you may very well go above the line and enter the forbidden region. So you need, you know, both, and I think what these gentlemen are addressing here is really the model uncertainties that affect the CDF itself.

MR. CHEOK: Sure.

CHAIRMAN APOSTOLAKIS: And there may be different sensitivities when you start talking about delta CDF.

MR. CHEOK: Agree. Yes, I agree with that, and I guess it's actually a harder thing to deal with because that is more issue specific.

CHAIRMAN APOSTOLAKIS: It is very issue specific. That's true. That's very true.

Didn't we talk to you about all of this, Mike, or you were not there?

MR. CHEOK: I as there.

CHAIRMAN APOSTOLAKIS: Oh, you just wiped it out of your mind. It was some university people talking?

Okay. Good. Anything else?

DR. SCHROEDER: Not on model and parameter uncertainties.

CHAIRMAN APOSTOLAKIS: Okay. So what else would you like to tell us?

DR. SCHROEDER: Well, we're really done with what we had planned to present.

CHAIRMAN APOSTOLAKIS: Wow.

DR. SCHROEDER: There is a slide or two on model documentation, but I don't know whether you consider that valuable or not.

CHAIRMAN APOSTOLAKIS: Okay. Very good. any questions from the members or other people present?

(No response.)

CHAIRMAN APOSTOLAKIS: Well, gentlemen, this has been extremely informative. Thank you very much, and we'll see you again tomorrow. Is that what it is?

DR. SCHROEDER: Yes.

CHAIRMAN APOSTOLAKIS: And we seem to be finishing sooner than scheduled because you don't have much to say, huh?

MR. DENNING: It's because we're so cooperative.

CHAIRMAN APOSTOLAKIS: We're so cooperative. Well, I really appreciate your coming here and presenting this. This was a really good piece of work, and our comments are given in the spirit of being constructive, even though we may not sound that way sometimes, but I think this is good.

MR. CHEOK: And we actually appreciate the comments, especially on these issues, and tomorrow when you're doing models that are kind of in the formative stages, I think it's important that we get your comments at this point.

CHAIRMAN APOSTOLAKIS: Good. No, that's wonderful. That's wonderful.

Thank you.

DR. SCHROEDER: Thank you.

CHAIRMAN APOSTOLAKIS: And this meeting is recessed.

(Whereupon, at 4:46 p.m., the meeting in the above-entitled matter was adjourned, to reconvene at 8:30 a.m., November 18, 2005.)

CERTIFICATE

This is to certify that the attached proceedings before the United States Nuclear Regulatory Commission in the matter of:

Name of Proceeding: Advisory Committee on Reactor Safeguards Reliability and Probabilistic Risk Assessment Subcommittee

Docket Number: n/a

Location: Rockville, MD

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.

William Click
Official Reporter
Neal R. Gross & Co., Inc.

STANDARDIZED PLANT ANALYSIS RISK (SPAR) MODEL DEVELOPMENT PROGRAM

Presentation to the Advisory Committee on Reactor Safeguards

November 17, 2005

Nilesh Chokshi, Branch Chief
Michael Cheok, Assistant Branch Chief
Operating Experience Risk Analysis Branch
Division of Risk Analysis and Applications
Office of Nuclear Regulatory Research

OUTLINE OF PRESENTATION

- Overview – Nilesh Chockshi & Mike Cheok (RES)
- Level 1 Internal Events – Robert Buell & John Schroeder (INL)
  - Standardized Structure
  - Model Demonstration
  - Major Modeling Assumptions
  - Modeling Issues being Addressed
  - Model and Parameter Uncertainties
  - Model Documentation
  - MSPI Lessons-learned (?) – Don Dube (RES)
- External Events Models – Selim Sancaktar (RES)
- LERF Models – John Lehner (BNL) & Eli Goldfeiz (RES)
- Low power & Shutdown Models – Jeff Mitman (RES)
- Wrap-up – Mike Cheok (RES)

2

WHAT ARE SPAR MODELS?

- SPAR models are plant-specific PRA models that use:
  - Event trees to model accident sequence progression.
  - Fault trees to model plant systems and components.
  - Human reliability analysis (HRA) module to estimate human error probabilities.
  - Component failure and initiating event data based on national plant experience.

3

PURPOSE OF SPAR MODEL DEVELOPMENT PROGRAM

- To provide the NRC staff with readily available and easy-to-use analytical tools for use in performing risk-informed regulatory activities.

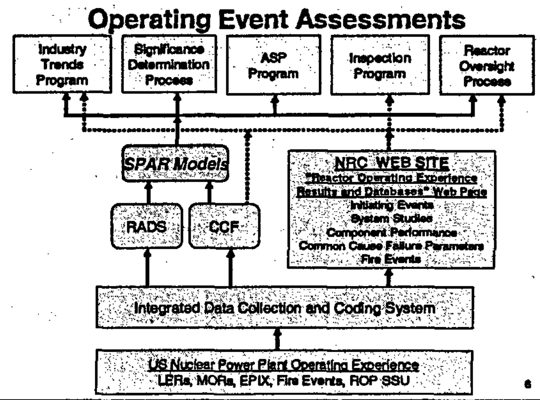
4

Evolution of the SPAR program

- Evolved from event tree – based models used at the start of the ASP program
- Revision 2 consisted of a set of 72 event tree/fault tree linked models and subjected the models to internal and external QA review
- Revision 3 is adding support systems, more initiating events, uncertainty analysis capability and subjected the models to benchmarking against licensee PRAs
- LP/SD, external events and LERF models are currently being developed

5

Overview: Use of SPAR Models in Operating Event Assessments



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USES OF SPAR MODELS

- To evaluate risk significance of inspection findings in SDP Phase 3 analyses.
- To evaluate risk associated with operational events/conditions in ASP program.
- To improve the quality of PRAs.
- To perform analyses in support of GSI resolution (e.g., GSI-189 and GSI-191).
- To support staff's risk-informed review of license amendments.
- To provide independent capability to evaluate risk issues across the population of plants (e.g., verify MSPI; LOOP/SBO study).

7

AGENCY INTERFACES

- SPAR Model Users Group (SMUG) organized in 1999 – Members from NRR, RES, Regional Offices.
  - Provides technical direction for model development.
  - Produced SPAR Model Development Plan – approved by management in user organizations.
- SPAR Model development supported by two NRR User Need Requests
- SRA Counterpart Meetings - SPAR model training, guidance, etc. extensively discussed
- INL Help Desk function to support SPAR model users – extensively used by regional, NRR and RES analysts

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SPAR MODEL DEVELOPMENT PROGRAM ACTIVITIES

- Level 1, Internal Events - Full Power:
  - 72 Revision 3 SPAR models currently available.
  - 72 Enhanced Rev. 3 SPAR Models in FY07.
- Level 1, Internal Events – LP/SD:
  - 10 models completed. Onsite QA of 4 models completed.
  - 4 LP/SD SPAR Models in FY07. QA contingent on availability of licensee staff.

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SPAR MODEL DEVELOPMENT PROGRAM ACTIVITIES (Continued)

- Level 2/Large Early Release Frequency (LERF):
  - 3 models (PWR w/large dry containment, BWR Mark I & PWR Ice Condenser) completed.
  - Models for 10 lead plants by 2008.
- External Events (Fires, Floods, Seismic events):
  - Six models have been created by NRR/RES team.
  - Continuing to refine model development process.

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Related Topics

- SPAR model development is closely linked to SAPHIRE code development - SAPHIRE Version 8 will be an important tool for using the latest SPAR models for event assessment
- Future/Proposed ACRS presentations
  - December 2005 – SPAR-H
  - (proposed) Spring/Summer 2006 – SPAR Data
  - (proposed) Spring/Summer 2006 - SECY 05-0192 dated 10/24/05

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Idaho National Laboratory

INL

SPAR Model Development & Maintenance: Level 1 Internal Events

ACRS Subcommittee Meeting

Robert Buell
John Schroeder

November 17, 2005

Topics

- Standardized Structure
- Model Demonstration
- Major Modeling Assumptions
- Quality Review of New Models
- Modeling Issues Being Worked
- Model and Parameter Uncertainties
- Model Documentation

Standardized Structure

- Standardized Plant Analysis Risk (SPAR) Models
  - Evolution of the models
    - Initially a plant-specific implementation of the Daily Events Manual event trees
    - Revision 2QA – Peer review by Sandia National Laboratory, largely subcontracted to SAIC
    - Revision 3I (interim) – Upgraded during SDP notebook review process
    - Revision 3 – New Seal LOCA model, updated data/templates, updated LOOP/SBO
    - Revision 3P (plus) – cut set level review

Standardized Structure - continued

- Advantages of standardization
  - Common tool set – SAPHIRE/GEM is the engine for all model development
  - Common skill set – NRC training program assures that all model users have the skills to use the common tool set
  - Uniformity of models helps identify true outlier plants
  - Automation makes industry-wide studies feasible (*e.g., the station blackout study*)

Standardized Structure - continued

- Standardized elements of the SPAR models
  - Methodology
  - Assumptions
  - Initiating events (based on NUREG/CR-5750)
    - No support system initiating event fault trees
  - Event trees (based on peer reviewed class models and consensus elements of PSAs)
  - Fault trees (based on published system studies when possible)

Standardized Structure - continued

- Standardized elements of the SPAR models - cont
  - Failure data
    - EPIX based template set (1998 – 2002)
    - Common cause failures
      - Methods (NUREG/CR-5485)
      - Data (NPRDS, LERs, EPIX) (1990 – 2001)
    - Loss of offsite power frequency/recovery data (NUREG/CR-5496, 2005 Update to 5496)
  - Human reliability analysis and recovery modeling (SPAR-H, NUREG/CR-6883)

Standardized Structure - continued

- Standardized structure allows rapid testing/analysis of industry wide issues. This is a significant new tool for regulatory studies.
  - SAPHIRE macro capabilities, in conjunction with standardized structure allow analyses on all 72 SPAR models in a short period.
  - The recent SBO risk study (NUREG/CR-TBD) is an example of these capabilities.
  - Other potential industry wide examples include
    - What-if data sensitivities
    - MSPI importance measure analyses
    - Etc.

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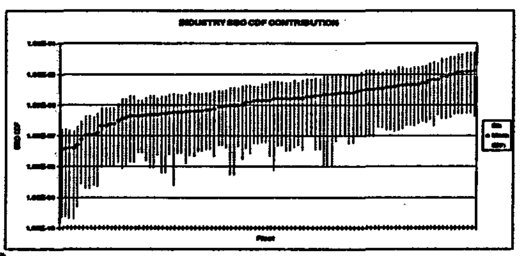
Standardized Structure - continued

- Example of recent analysis of SBO risk using SPAR models



8

Standardized Structure - continued

- Small event tree/large fault tree (fault tree linked)
- Standard set of initiating event candidates
  - LLOCA, MLOCA, SLOCA, XLOCA, ISLOCA, LOOP, LOCHS, LOMFW, TRANS, LOVAC, LOVDC, LOSWS, LOIAS
  - Boiling Water Reactor (BWR) specific
    - IORV
  - Pressurized Water Reactor (PWR) specific
    - LOCCW, SGTR
  - Others added if greater than 1 percent contribution to total CDF in licensee model

9

Standardized Structure - continued

- Frontline system fault trees
  - System studies are the basis for RPS, EPS, AFW, HCI, and RCI.
  - Other frontline fault trees include
    - Most active components
    - All obvious operator actions
    - Fault tree guidelines used to simplify models in a standardized way
  - Standard CCF event modeling

10

Standardized Structure - continued

- Support system fault trees
  - Limited division level AC/DC power model
  - Fluid systems models (SWS, CCW, etc.) same rules as frontline models
  - Air and HVAC systems added as needed
- Human Reliability Analysis – SPAR-H
- Limited recovery modeling
  - Offsite power/diesels
  - Power conversion system
  - Support system initiating events

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Standardized Structure - continued

- BWR general plant transient event tree structure
  - Functional groupings and frontline fault trees
    - Reactor shutdown (RPS)
    - Reactor coolant system integrity (SRV)
    - High pressure injection (MFW, RCI, HCI)
    - Depressurization (DEP)
    - Low pressure injection (CDS, LCI, LCS, VA)
    - Residual heat removal (PCS/CND, SPC, CSS, SDC, CVS)
    - Late injection (LI)

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Standardized Structure - continued

- Key BWR event tree assumptions
  - SORV sequences are counted on the IORV event tree.
  - Early suppression pool cooling is required to support RCIC/HPCI operation.
  - Containment venting fails all injection with suction on the suppression pool. (Many LI models include the CVENTED variable.)
  - Containment failure causes loss of all injection. (Many LI models include the CFAILED variable.)

Standardized Structure - continued

- PWR general plant transient event tree structure
  - Functional groupings and frontline fault trees
    - Reactor shutdown (RPS)
    - Steam generator cooling (MFW, AFW)
    - Reactor coolant system integrity (PORV, LOSC)
    - High pressure injection or once through cooling (HPI, FAB)
    - Secondary side cooldown and RCS depressurization (SSC, PZR)
    - Residual heat removal (RHR, HPR)

Standardized Structure - continued

- Key PWR event tree assumptions
  - PORV challenge rate is not plant-specific or transient-specific.
  - Two PORVs required for feed and bleed
  - Success of feed and bleed provides time to recover steam generator cooling.

Standardized Structure - continued

- Other transients are based on the TRANS event tree
  - A unique sequence flag set is assigned to each initiator.
  - The sequence flag set defines the impact vector associated with the initiator.
    - When the initiator may be recovered, fault tree flag sets may be used to define the impact vector.
    - Choice of fault tree flag set vs. sequence flag set is made to minimize the number of special use fault trees that may be required.

Standardized Structure - continued

- BWR Loss of coolant accidents (LOCAs)
  - Large LOCAs
    - Reactor shutdown (RPS)
    - Vapor suppression (VSS)
    - Low pressure injection (LPI, LCI, LCS)
    - Residual heat removal (SPC, CSS, CVS)
    - Late injection

Standardized Structure - continued

- BWR Loss of coolant accidents (LOCAs) continued
  - Medium LOCAs
    - Reactor shutdown (RPS)
    - Vapor suppression (VSS)
    - Depressurization (HCI or DEP)
    - Low pressure injection (LCS, LCI, VA)
    - Residual heat removal (SPC, CSS, CVS)
    - Late injection (LI)

Standardized Structure - continued

- BWR Loss of coolant accidents (LOCAs) continued
  - Small LOCAs, IORVs
    - Reactor shutdown (RPS)
    - Vapor suppression if included in PSA
    - High pressure injection (MFW, RCI, HCI)
    - Depressurization (DEP)
    - Low pressure injection (CDS, LCS, LCI, VA)
    - Residual heat removal (PCS/CND, SPC, CSS, CVS)
    - Late injection (LI)

Standardized Structure - continued

- BWR Loss of coolant accidents (LOCAs) continued
  - Intersystem LOCAs
    - RHR letdown line 2-MOV failure initiator
    - Pipe integrity
    - Diagnosis
    - Isolation/Recovery
  - Excessive LOCAs
    - Initiator frequency 1.0E-7
    - Mitigation failure set to TRUE

Standardized Structure - continued

- PWR Loss of coolant accidents (LOCAs)
  - Large LOCAs
    - Accumulators (ACC)
    - Low pressure injection (LPI)
    - Residual heat removal (LPR)

Standardized Structure - continued

- PWR Loss of coolant accidents (LOCAs) continued
  - Medium LOCAs
    - Reactor shutdown (RPS)
    - High pressure injection <u>and</u> steam generator cooling (HPI, AFW)
    - Accumulators <u>and</u> steam generator cooling <u>and</u> low pressure injection
    - Cooldown and depressurization (SSC, PZR)
    - Residual heat removal (LPR, HPR)

Standardized Structure - continued

- PWR Loss of coolant accidents (LOCAs) continued
  - Small LOCAs
    - Reactor shutdown (RPS)
    - Steam generator cooling <u>and</u> high pressure injection (FW, AFW)
    - Once through cooling (FAB)
    - Cooldown and depressurization (SSC, PZR)
    - Residual heat removal (RHR, HPR)

Standardized Structure - continued

- PWR Loss of coolant accidents (LOCAs) continued
  - Intersystem LOCAs
    - HPI, LPI, RHR initiators
    - Pipe integrity
    - Diagnosis
    - Isolation/Recovery
  - Excessive LOCAs
    - Initiator frequency 1.0E-7
    - Mitigation failure set to TRUE

Standardized Structure - continued

- SGTR
  - Cognitive/Diagnosis failures
  - Reactor shutdown (RPS)
  - Steam generator cooling (FW)
  - High pressure injection and steam generator isolation (HPI, FAB, SGI)
  - Cooldown and depressurization (SSC, PZR)
  - Terminate or control injection (CSI)
  - Alternate heat removal (LTHR)
  - Residual heat removal (RHR)
  - RWST refill (RFL)

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Standardized Structure - continued

- BWR Loss of offsite power/station blackout
  - Recovery of offsite power is questioned prior to demand for RHR on LOOP event tree.
  - Recovered sequences not developed (Peach Bottom is special case)
  - SBO always starts at time zero.
  - Emergency power system fault tree is based on simplified lineup.
  - Alternate alignments shown on SBO event tree
  - During a SBO HPCI/RCIC maintains level only until battery depletion.

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Standardized Structure - continued

- PWR Loss of offsite power/station blackout
  - Recovery of offsite power on LOOP event tree is based on timing of RWST depletion (~6 hr).
    - Two hour recovery allows recovery of condenser (4 hr) and SG cooldown to the condenser followed by RHR.
    - Six hour recovery corresponds to RWST depletion and swapover to recirculation.
  - During SBO the time available for recovery is based on the WOG-2000 leak rates.
  - The battery depletion limitation is a significant limitation on time available for recovery.

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Model Demonstration

- SAPHIRE (Systems Analysis Programs for Hands-on Integrated Reliability Evaluations)
- Project logic models
  - Event trees
  - Fault trees
  - Data

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Model Demonstration - continued

- Graphical Evaluation Module (GEM) automation
  - Initiating event assessment
    - Code sets observed initiator to TRUE, others to FALSE
    - Code recalculates LOOP recovery values for observed LOOP class
    - User defines observed failures, degradations
    - Code makes any required CCF adjustments

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Model Demonstration - continued

- Condition assessment
  - User provides duration of observed condition
  - User provides observed failures/degradations
  - Code makes CCF adjustments
- Common-cause failure adjustments
  - NUREG/CR-5485, Appendix E
  - Component failed (Equation E.11)
  - Component out of service (Equation E.12)
- Standard reports for each assessment type

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Major Modeling Assumptions

- General
  - No recovery of AC power after battery depletion
  - CCF not modeled across systems
  - Pre-accident human errors not modeled
  - Run failures occur at time zero.
  - Failures subsequent to AC power recovery in SBO sequences can be neglected
  - Successful diagnosis is implied for all sequences
  - Instrumentation and control not explicitly modeled (implicit in data)
  - Errors of commission not modeled
  - Limited recovery modeling (SS initiators)
  - Service water environmental issues not modeled

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Major Modeling Assumptions - cont

- BWR specific
  - Containment venting causes loss of injection with suction on suppression pool
  - Containment failure causes loss of all injection
  - Suppression pool cooling failure will force early depressurization (loss of HPCI/RCIC)
  - SORV events are included in IORV event tree
- PWR specific
  - Two PORVs are required for feed and bleed
  - Success of F&B allows time to recover SG cooling
  - PORV challenge rate is not plant or initiator specific

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Quality Reviews of New Models

- SPAR Model Review History
  - Peer review performed by Sandia National Laboratory, largely subcontracted to SAIC, led to Revision 2QA.
  - Enhancement/expansion of the models occurred during the SDP notebook review process, led to Revision 3i series of models. QA review using detailed procedure and independent analyst.
  - Most recent modifications incorporate improved RCPSL models, the latest available LOOP/SBO information, and the latest available component failure rates. The resulting model cut sets are now being benchmarked against licensee PSA cut sets.

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Quality Reviews of New Models - cont

- Model QA procedure
  - Open items list
  - Completion check list
- Model configuration control
  - Revision Control Software (being studied)
  - Model/Software currency
- Trouble reporting system on SAPHIRE web site
- Proceduralized detailed cut set level review

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Quality Reviews of New Models - cont

- Detailed cut set level review - cont
  - Purpose of the review
    - Identify the significant differences between PSA and SPAR logic and modify the SPAR models where appropriate
  - The main steps in the review process
    - Obtain a deep cut of the licensee's cut sets and basic event definitions and values
    - Perform a SAPHIRE data-load of the cut sets
    - Identify 150+ of the most important events in the PSA and SPAR models

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Quality Reviews of New Models - cont

- Detailed cut set level review - cont
  - Establish link between licensee events and SPAR events by coding licensee event name into SPAR basic event "Alternate Event Name" field
  - Build a change set that applies licensee probabilities to SPAR events
  - Load SPAR importance report and PSA importance report into comparison spreadsheet
  - Generate Birnbaum comparison plot
  - Identify the outliers and make modifications allowed by SPAR policy and precedent

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Quality Reviews of New Models - cont

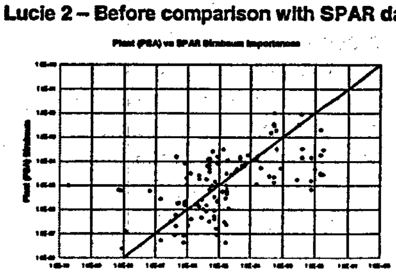
- Detailed cut set level review - cont
  - Comparisons are made at various levels of detail
    - Ratio of SPAR model overall CDF to licensee's CDF should be in the range of 0.5 to 2.0
    - Ratio of SPAR model CCDP to licensee's CCDP for each initiating event should be in the range of 0.5 to 3.0
    - Statistical comparison of SPAR basic event Birnbaums with licensee's Birnbaums should be less than 0.2 using comparison metric.

Quality Reviews of New Models - cont

- Detailed cut set level review - cont
  - Comparison metric is average "distance" or "angle" from the line X=Y on the comparison plot
    - "distance" is weighted by log of the value.
    - Events with large Birnbaums contribute more to the metric than events with small Birnbaums

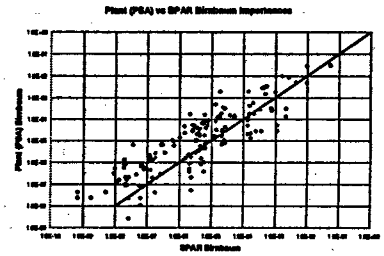
Quality Reviews of New Models - cont

- St. Lucie 2 – Before comparison with SPAR data (1.9)



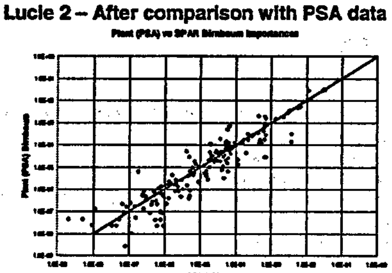
Quality Reviews of New Models - cont

- St. Lucie 2 – After comparison with SPAR data (.55)



Quality Reviews of New Models - cont

- St. Lucie 2 – After comparison with PSA data (.12)



Quality Reviews of New Models - cont

- Detailed cut set level review - cont
  - In the preceding figures significant outlying points have a story.
  - The dominant contributors to variance at St Lucie 2 involve CCF of the diesel generators, and DC bus failures.
    - St. Lucie 2 PSA has a much lower AC power recovery failure probability than SPAR model.
    - St. Lucie 2 PSA allows feed and bleed with one PORV.

Quality Reviews of New Models - cont

Plant	SPAR CDF – Nominal Data	SPAR CDF – PSA Data	PSA CDF
Columbia	3.14E-5	8.44E-6	6.36E-6
Indian Point 2	9.01E-6	9.22E-6	1.10E-5
Indian Point 3	8.70E-6	1.95E-5	1.14E-5
Kewaunee	1.63E-5	6.38E-5	3.83E-5
Oconee	7.42E-6	1.37E-5	2.28E-5
Palisades	2.73E-5	5.99E-5	7.00E-5
Pilgrim	1.29E-5	1.07E-5	6.39E-6
St. Lucie 1	4.51E-6	2.25E-5	2.27E-5
St. Lucie 2	3.59E-6	2.96E-5	2.15E-5
Susquehanna	4.06E-6	1.75E-6	3.06E-6
Turkey Point	2.70E-6	7.12E-6	4.25E-6

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Quality Reviews of New Models - cont

- SPAR CDF (PSA Data)/PSA CDF
  - Mean = 1.1
  - Variance = 0.2
- SPAR CDF (Nominal Data)/PSA CDF
  - Mean = 0.66
  - Variance = 1.9
- Mean of 0.66 with SPAR data suggests SPAR data have lower failure values than analogous PSA data.
  - Transient initiating event frequency
  - Turbine driven pumps
  - Emergency diesel generators
- Mean of 1.1 with PSA data suggests SPAR logic is conservative when compared to PSA logic.
  - No recovery after battery depletion
  - Two PORV success criteria

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Modeling Issues Being Worked

- Important modeling issues and status
  - Loss of offsite power modeling – Models updated
  - RCP seal failure modeling – Models updated
  - CCF Modeling – Models updated
  - Data values – Models updated
  - Sump plugging values – Pending NRC resolution
  - Support system initiating event fault trees (Working)
  - Power recovery after battery depletion (Working)
  - Continued injection after containment failure (TBD)
  - PORV success criteria during feed and bleed (TBD)
  - Time to core uncovery (TBD)

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Loss of offsite power modeling
    - Updated LOOP recovery curves
    - Updated RCP seal LOCA models
    - 24 hour emergency diesel generator mission
    - Two part emergency diesel generator hazard curve
    - Convolution of time based failures

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - RCP seal failure modeling
    - WOG 2000
      - Four seal failure modes with probabilities and associated leak rates
      - Core uncovery times per Westinghouse Emergency Procedure Guidelines
    - CE draft report
      - Three factors considered (timing, CBO, subcooling)
      - Core uncovery times per draft report
    - B&W plants
      - Westinghouse or Combustion Engineering seal failure models used

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - CCF Modeling
    - Alpha factor methodology
      - Equivalent to MGL methodology
    - Alpha factors recently updated
    - Conditional CCF calculations
      - Component failed (TRUE)
      - Component out of service (One)

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Data values
    - SPAR past - system study data (circa ~1990)
    - SPAR current - EPIX based data
    - Industry - Bayesian update of old generic sources with current plant specific data.
    - Data and methodology for inclusion of SWS environmental effects (water quality) is under development.

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Sump plugging values
    - NUREG/CR-6762, GSI-191 Technical Assessment: Parametric Evaluations for Pressurized Water Reactor Recirculation Pump Performance.
    - $LLOCA_{PWR}$ * 0.6 ~ 3E-6 increase in CDF
    - MLOCA * 0.1 ~ 4E-6 increase in CDF
    - $SLOCA_{PWR}$ * 0.01 ~ 4E-6 increase in CDF

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Support system initiating event fault trees
    - Point value
      - Underestimates event importances
      - Does not account for specific system configurations
    - Fault trees
      - Better estimate of event importances
      - Accounts for specific system configurations
      - Two general approaches
        - Multiplier method
        - Explicit events

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Power recovery after battery depletion
    - SPAR models give no credit for power recovery beyond battery depletion
      - Significant impact on SBO CDF
      - Significant impact on EDG importances
    - Considerations include
      - Diesel-driven injection sources
      - Availability and quality of procedural guidance
      - Capacity of water sources for continued injection, room heatup and other environmental concerns, duration of emergency lighting, switchyard battery life, etc

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Continued injection after containment failure
    - BWR issue
    - Industry credit varies widely (1.0 to 0.0)
    - Significant impact on importances of decay heat removal equipment
    - Issues
      - Environmental (steam)
      - Depressurization rates
        - Ability to inject with low pressure sources
      - Break location
      - Failure pressure, etc

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - PORV success criteria during feed and bleed
    - SPAR success is two PORVs in absence of detailed thermal hydraulic calculations
    - No consensus in industry PSAs
      - Industry approximately evenly split between one and two PORVs
      - No apparent correlation of PORV success to key factors such as relief capacity, injection pressure/capacity, etc.

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Modeling Issues Being Worked - cont

- Important modeling issues and status - cont
  - Time to core uncovery
    - SPAR timing to core damage generally based on thermal hydraulic data from NUREG-1150
    - LOOP/SBO RCPSL core uncovery based on information in Westinghouse Emergency Procedure Guidelines and Combustion Engineering documents
    - Miscellaneous timing data from other NUREGs
    - SPAR project does not perform detailed plant-specific thermal hydraulic analyses

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Modeling Issues Being Worked - cont

- Loss of service water initiator frequency
  - Support system initiating event fault trees
  - Service water system study (environmental issues)
- Addition of low importance initiators
- Allocation of all bus failure initiating event failures to a single bus
- Steam generator tube rupture logic
- General modeling of common cause (cross-products)
- Simplified modeling of emergency diesel alignments

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Modeling Issues Being Worked - cont

- Recent Changes to the Models
  - New failure data including CCF alpha factors
  - Global use of template events including alpha factors
  - New reactor coolant pump seal LOCA logic
  - New LOOP initiator and offsite power recovery modeling
  - Conversion of CDF from 'per hour' to 'per year'

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Modeling Issues Being Worked - cont

- Future Enhancements
  - Splitting Transient event tree into LOCHS, LOMFW & TRANs
  - Addition of new SGTR logic
  - Dual/single unit LOOP logic
  - Consequential seal LOCA logic in Westinghouse plant models
  - Addition of lower importance initiators (>1%)
  - Additional detail in PWR main feedwater fault trees
  - Incorporate standardized ISLOCA methodology
  - Benchmarking against PSA cut sets
  - HEPs calculated using SPAR-H interface in SAPHIRE
  - To be included pending resolution of issues
    - Develop/implement fault tree based initiating events for support system initiators
    - Integrate all SPAR based logic into single master model (Level 1, LERF, Fire, Flood, External Events, LPSD, etc)

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Model and Parameter Uncertainties

- Data Uncertainty (Standard template list)
  - Initiating event frequencies
  - Component failure rates
  - Plant specific vs. generic data
  - Offsite power recovery failure parameters
  - Diesel generator recovery failure parameters
  - Alpha factors

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Model and Parameter Uncertainties - continued

- Model structure uncertainty
  - Plant-by-plant list of major issues
  - Estimate of issue impact
  - Resulting issues include
    - Support system initiating event fault trees (e.g., SWS environmental issues)
    - Power recovery after battery depletion
    - Continued injection after containment failure
    - Sump plugging values
    - Success criteria (PORVs required during FAB, other)
    - Time to core uncovery

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Model and Parameter Uncertainties - continued

- Uses of expert/licensee's judgment
  - Continued injection given containment failure
  - Recovery of power after battery depletion
  - Operation of turbine-driven pumps without indication/control
  - Seal LOCA model
  - Large/Medium LOCA frequencies

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Model and Parameter Uncertainties - continued

Key Sources of Uncertainty	SPAR Application
General data source/uncertainty	Eide & Rasmuson data and uncertainty
Plant specific vs. generic data	Generic industry wide data
HRA Methodology	SPAR-H Methodology
Sump plugging values	Generic value used until issue is resolved
Support system initiating event fault trees (e.g., SWS environmental issue)	Currently use point estimates while researching this issue
Power recovery after battery depletion	Currently no credit given, evaluating giving credit in limited applications
Run failures occur at time zero	Convolution not credited, evaluating
Success criteria	2 PORV min for F&B, licensee's in general
Seal LOCA model	WOG 2000 guidance
Continued injection after ctm failure	*Moving from no credit to that of licensees*
Diesel generator run time	24 hour mission
Large/Medium LOCA frequencies	NUREG/CR-5750 values
Operation of TDPs without DC power	High screening value used

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Model documentation

- *Sections in main report*
  - Introduction
  - Initiating Events
  - Event Tree Models
  - Fault Tree Models
  - Basic Event Data
  - Common Cause Failure Model
  - Reactor Coolant Pump Seal Model
  - Loss of Offsite Power Model
  - Human Reliability Model
  - Baseline Results

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Model documentation

- Sections in main report
  - Introduction
  - Initiating events
    - Translation from early reports
    - BWR *summary table*
    - PWR summary table

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Model documentation - continued

- Event tree models
  - Descriptions
  - Graphics
  - Success criteria
  - Linkage rules/flag sets

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Model documentation - continued

- *Fault tree models*
  - Fault tree modeling guidelines
  - Fault tree notes and comments
  - System dependency *matrix*
- Basic event data
  - Template events
  - Compound events
  - Template event data table

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Model documentation - continued

- Common-cause failure (CCF) model
  - Introduction to the Alpha Factor Method
  - Use of the CCF library module
  - Mention of special use capability
    - Set CCF input to TRUE
    - Set CCF input to 1.0
- Reactor coolant pump seal failure model
  - Westinghouse plants
  - Combustion Engineering plants
  - B&W plants

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Model documentation - continued

- Loss of offsite power model
  - LOOP recovery failure calculations
  - Diesel recovery failure calculations
- Human reliability model
  - Alignment, control, and operate events
  - System hardware recovery events
  - Summary table
  - Recovery rule listing
- Baseline results

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Model documentation - continued

- Appendices
  - Fault tree graphics
  - Basic event data report
  - Compound event data report
  - Common cause failure event data report
  - HRA worksheets
  - Revision log
  - Simplified piping diagrams

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Topics for In-depth Discussions

- Initiating event fault tree issues and development
- Convolving time based (run) failures

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STANDARDIZED PLANT ANALYSIS RISK (SPAR) MODEL DEVELOPMENT PROGRAM

LESSONS LEARNED FROM MSPI PRA QUALITY REVIEWS

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U.S. Nuclear Regulatory Commission
November 17, 2005

1

What is the MSPI ?

- ***A measure of the deviation of plant system unavailability and component unreliabilities from baseline values, weighted by plant-specific risk importance measures***
- **MSPI = UAI + URI**
- **For unreliability:**

$$B_i \, (UR_i - UR_{iBL})$$

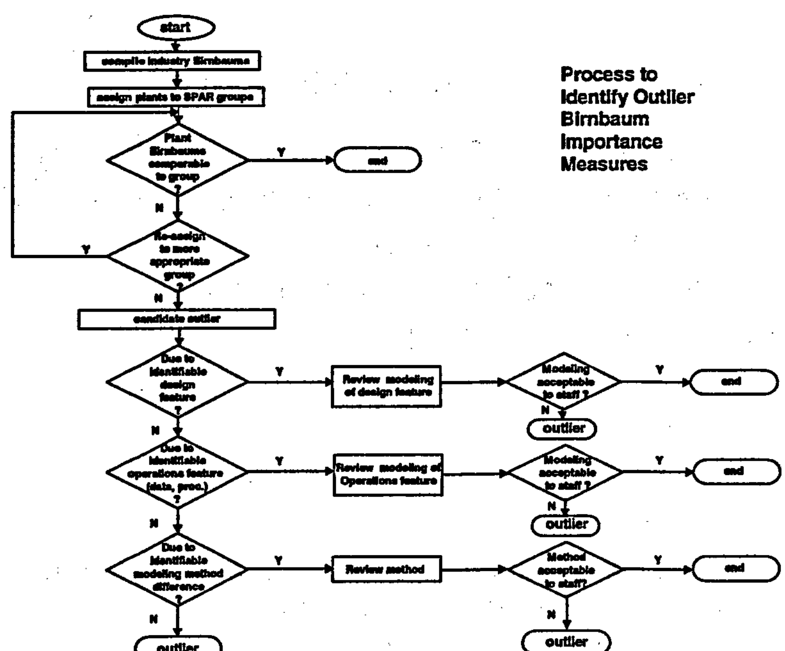
summed over all monitored components i in the system. The coefficients B_i are the component basic event Birnbaum importance values.

2

Recommendations of PRA Quality Task Group

- Licensees should assure that their PRA is of sufficient technical adequacy for MSPI by:
  - (a) Resolving the A and B F&O's from the peer review
  - (b) Performing a self-assessment using the NEI-00-02 process as endorsed by Appendix B of RG 1.200 for the ASME SLRs identified by the task group as being important to MSPI
- As alternative to (b) the industry has proposed and the NRC staff has agreed to rely on a cross-comparison of PRAs. The staff performed an additional review of industry values by comparing their PRA Birnbaum values to SPAR values.

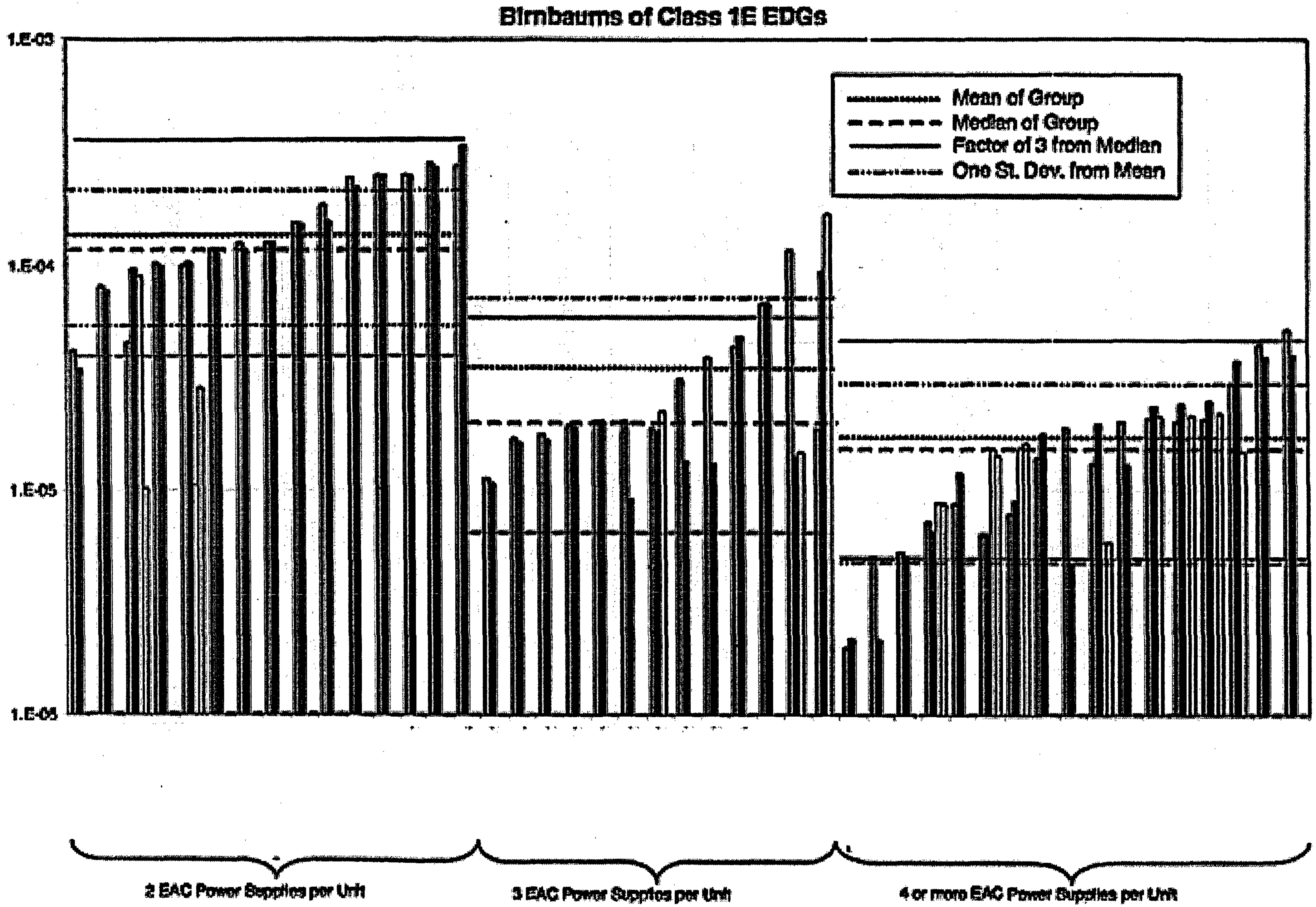
3

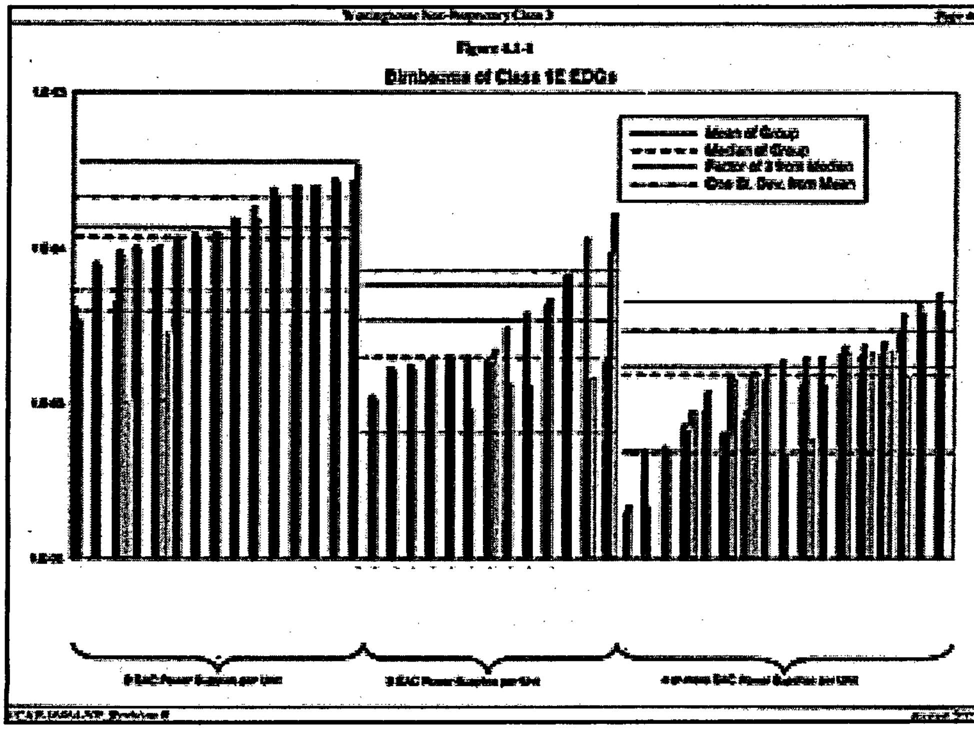


Process to Identify Outlier Birnbaum Importance Measures

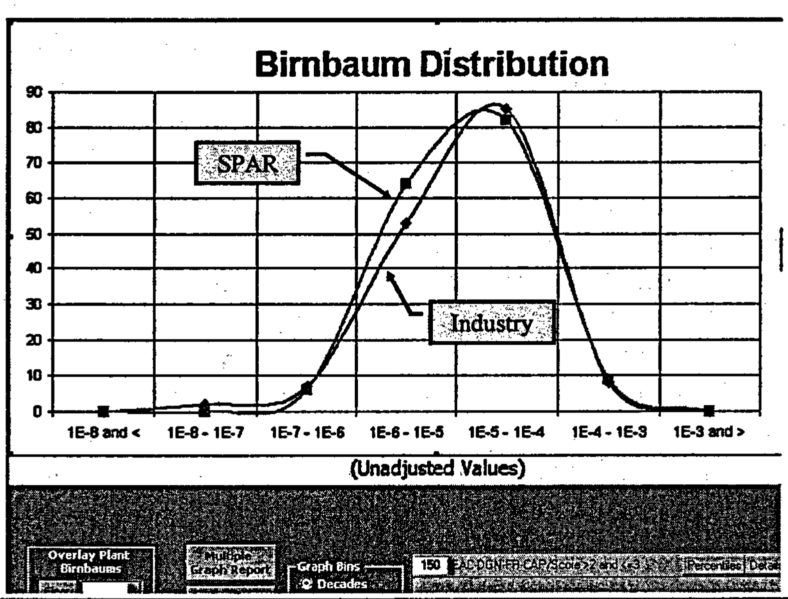
4

Figure 4.1-1


Birnbaums of Class 1E EDGs
1.E-03
1.E-04
1.E-05
1.E-06
Mean of Group
Median of Group
Factor of 3 from Median
One St. Dev. from Mean
2 EAC Power Supplies per Unit
3 EAC Power Supplies per Unit
4 or more EAC Power Supplies per Unit



Electrical Generators - Grouped Capability/Score >2 & <=3



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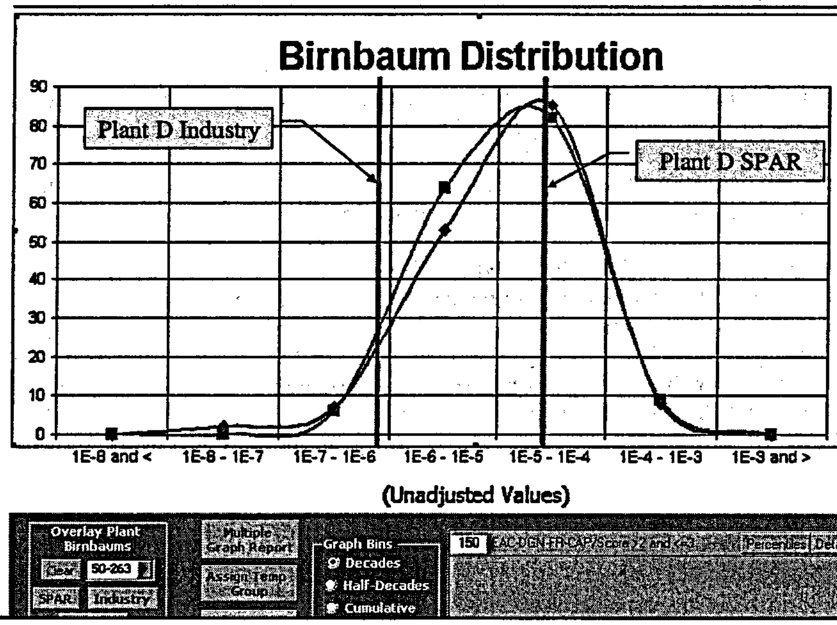
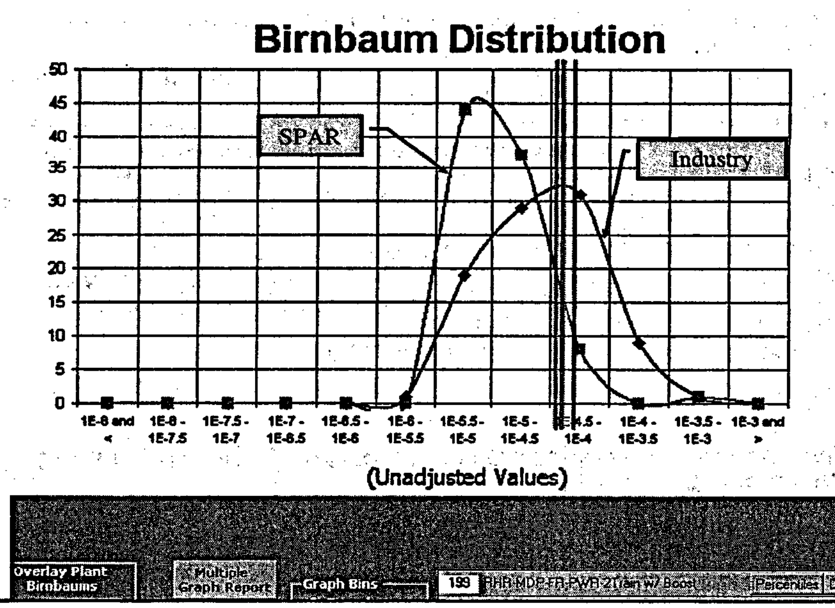
Electrical Generators - Grouped Capability/Score >2 & <=3



7

RHR MDPs – PWR 2 PP Systems w/ HPR Booster Function



8

Summary of MSPI PRA Issues

Open A&B Facts and Observations possibly affecting MSPI	16
Model truncation & convergence issues	14
Low loss of offsite power frequency issues	9
Low loss of service water frequency issues	5
Missing support system adjustment contribution to F-V	5
BWR 5/6 credit for RPV injection after containment failure	5
Station Blackout mitigation strategies issues	4
Offsite power recovery issues (after battery depletion, etc)	4
Unexplained model asymmetry issues	3
Common cause factor analysis issues	2
Control of turbine-driven pump without DC power	2
Low loss of DC bus initiator frequency	1
Missing test & maintenance basic event for EDGs	1

9

Summary of MSPI Generic SPAR Issues

- Loss of emergency AC power bus initiator frequency about an order of magnitude higher than industry average.
- Pressurizer PORV success criterion for feed and bleed is assumed to be two irrespective of plant design and analysis.
- Modeling asymmetries (e.g., loss of DC bus on only one division).
- Single value loss of service water frequency irrespective of plant site and design.
- Higher failure probability for local, manual control of turbine-driven AFW pump.
- Old RCP seal LOCA model for B&W plants.
- Small-LOCA frequency is lower than industry norm by nearly an order of magnitude because it does not include lower end of spectrum (e.g., small-small LOCAs).
- Instances where SPAR did not model T&M.

These issues are being addressed as part of the enhanced Rev 3 SPAR models.

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