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NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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SUBCOMMITTEE ON SAFETY RESEARCH PROGRAM

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THURSDAY

APRIL 16, 2009

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B3, 11545 Rockville Pike, at 8:30 a.m., Dana A. Powers, Chairman, presiding.

COMMITTEE MEMBERS:

DANA A. POWERS, Chairman

SAID ABDEL-KHALIK, Member

GEORGE E. APOSTOLAKIS, Member

OTTO L. MAYNARD, Member

HAROLD B. RAY, Member

J. SAM ARMIJO

ACRS STAFF PRESENT:

WILLIAM HINZE, Consultant

MICHAEL LEE

T-A-B-L-E O-F C-O-N-T-E-N-T-S

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

8:31 a.m.

CHAIRMAN POWERS: Let's come into order.

This is the first day of the meeting of the Safety Research Program Subcommittee.

I'm Dana Powers, Chairman of the Subcommittee.

Other ACRS members in attendance today: Said Abdel-Khalik; Professor George Apostolakis; Sam Armijo, Otto Maynard, Harold Ray.

We have benefit of Bill Hinze here as Professor emeritus of geology and geophysics at Purdue University who is our consultant.

Bill, thank you for coming.

The purpose of this Subcommittee meeting is to review and discuss elements of the Office of Nuclear Regulatory Research Program bearing on seismic hazard characterization and treatment of those hazards and siting and designing of new nuclear power plants.

The Subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate from this meeting for deliberation by the full Committee at a later date.

The intention, in fact, is to collect

information that will be included in the biennial research report that the Committee puts out. So barring things that need a more immediate deliberation by the Committee, we're looking forward to producing a section of the Research report as a result of today's 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*.

I believe we have received no written comments or requests for time to make oral statements from interested members of the public regarding the subject of today's meeting. But this is a Subcommittee meeting and I invite members of the audience that wish to contribute during the course of the discussion to attract my attention and provide that contribution as we progress through things.

As stated in the earlier *Federal Register* notice, a transcript of this meeting is being prepared and will be made publicly available in the near future on the ACRS website. Therefore, we request that anyone wishing to address this Subcommittee on the record use one of the microphones located throughout this meeting. We request that you identify yourself

and you speak with sufficient clarity and volume so that your comments may be readily heard and recorded.

The research in seismic has been the subject of previous ACRS reports on the Research program. And over the last year and a half Annie Kammerer has told me repeatedly that she wants me to look at all the nifty stuff that's going on in seismic and how great it is. And I have tormented Annie to no end by saying "Later, Annie. Later. Later." And somehow today we're going to get to do it, Annie.

DR. KAMMERER: Hey.

CHAIRMAN POWERS: And I have to say that I'm very much looking forward to that. Because we have had a chance to see some of the products that Research has begun through the early site permit process. But I had so much fun tormenting Annie in the interim, that I thought it might be useful to torment her just a little more so that we can have a better understanding of the context and the need the agency has for the seismic research program.

So we're going to begin today by getting presentations from the Office of New Reactors and from the NRR as well on where this seismic research actually gets applied and used.

So, first I'll ask are there any comments

that, Bill, you want to make or any of the members want to make before we get started on this process?

DR. HINZE: We're all looking forward to an expansion of the presentation that Annie made several months ago.

CHAIRMAN POWERS: You are correct, Bill, that we have had a taste of this. But I want to the nitty-gritty.

So with no further comments, I guess I'll call on Dogan Seber to --

MR. CHOKSHI: Can I make just a couple of comments.

CHAIRMAN POWERS: Absolutely,

MR. CHOKSHI: I wanted to say first, good morning. And I want to thank the Subcommittee for giving us an opportunity to provide, you know discuss our seismic research programs.

And also for Dana our perspective to give us an opportunity to talk about our division needs and the relationship to the programs.

Now, this is primarily a Research program. So we are, you know, we are going to provide the linkage how we see the regulatory needs.

One thing I wanted to mention that in these two days meeting you're going to hear more about

earth sciences related programs. We'll touch on briefly NRO needs for engineering, and for several reasons.

One reason is being that the earth sciences programs promise a significant part of Research activities and the needs -- in the short term and long term needs meeting the regulatory needs.

The second is that our invited guests at these meetings are going to talk about earth sciences related activities. So this gives you a complete perspective of all of the people involved in this research. But we're going to talk about some of the engineering results also, but I think this probably might be a separate discussion to go over the details.

CHAIRMAN POWERS: Certainly my belief is that we need to separate right now and discuss the research and the applications and the engineering has its place.

MR. CHOKSHI: That is right.

CHAIRMAN POWERS: But right now I want to understand the r\Research because this is an area we've commented on in the past and this is the area where quite frankly, my perception is that new life has been breathed into the research program here.

MR. CHOKSHI: Yes. And I think the one

very important point that I wanted to make. That I'm hoping that during this meeting that it becomes clear that we are trying to maintain a very close coordination between the user office and Research. And I'm using word "trying," because of the workloads on both sides. And the coordination does not always occur at the desired level. In some programs we have very close coordination. For example, earth sciences program we're getting, because of the way some activities are structured, there is a direct involvement of the user offices being on a steering committee, on the review groups. So we are more engaged. But to this point we are planning a retreat next month where we going to bring in the NRO and Research and NRR technical staffs. I'm going to discuss about the whole review plan and the review programs, all of the activities. And I'm hoping that this is a forerunner of joint meetings we'll hold.

I think that will serve as a better forum to get quite concentrated thinking,

CHAIRMAN POWERS: I'll just say that I think that's one of the innovations in the Research program where they do bring in staff, especially from the using organizations as part of their peer review process or oversight process or direction process. I

think that's an innovation that has merit and there's contributing in a lot of areas.

MR. CHOKSHI: Yes.

CHAIRMAN POWERS: And in fact, in our previous research report, the most immediate version, we commented positively on those programs that have taken that kind of a step.

MR. CHOKSHI: And, you know, one of the main purpose of this fostering group is to get a clear alignment on the priorities and needs. You know, Research plans are a vehicle which talks about a lot of different activities, but we need to have a clear alignment. And I'm hoping that's the goal. My primary goal.

And I wish you'd our goal before we came to you, but that didn't happen. But I'm hoping that we'll have an opportunity, sir.

So with this, I think we can turn to our presentations. And really again, thanks for inviting us.

CHAIRMAN POWERS: I think the floor is yours.

DR. DOGAN: Okay. Thank you very much.

What I'm going to try to do today is to inform you on how we look at the seismic reviews at

the New Reactor's office. And if you look at the agenda, it says seismic siting reviews. And I'm actually going to try to cover both siting and some portions of the engineering as it relates to our work.

With that, I'm going to start with this outline to give you structure and where I'm going with my presentation today.

On the siting part, we look at primary geology, seismic and geotechnical engineering aspects. And each one is a different chapter, and usually different people look at it. And we collaboratively work on it and as a team we eventually make our final decisions on those topics.

I'm going to talk what other main issues that we deal with in geology and what our members of the staff, I'm going to look into that.

Then I'm going to step into seismology and give some little bit issues related to seismic ground motion and estimation of SSE.

And throughout the talk you'll be hearing me referring to some of the discussions that you'll be having later on. You know this is related to Research's efforts in that area, in this area. So stay with me on those. I'll to emphasize those as I go. I may forget it, but I'll hopefully remember and

come back and remind you guys that it was a topic that we're going to be going.

And the component in the siting is the geotechnical engineering, the site characteristics and the local soil characteristics and rock properties.

And as I said, at the end I'm going to be briefly talking about the engineering areas of seismic review. These are usually beyond our branches. It goes into engineering. But it is related to some level too and it's, I think, appropriate to talk about.

MEMBER RAY: I'm going to guess that GMRS has something to do with ground motion. What?

DR. DOGAN: Yes, ground motion response spectrum.

MEMBER RAY: Got it. Thank you.

DR. DOGAN: And I'll have later on a slide to -- a pathway to how to recalculate on things on that. I'll be talking. I apologize for not putting the full definition.

As I said, I'm going to start with geology and then the outlines, and we'll go in that order.

Geology, of course, one of the most important things that we'll look at in the siting reviews. And this is done at multiple scales. This

is what this slides is supposed to represent.

It is regional scales. Basically the reviewers look at tectonic reviews and where the site is situated relative to continental scale or regional scale structures and may only try to identify how this site came about, what is the geology environment that influenced the site.

As you go --

DR. HINZE: If I may, can I interrupt before we go to questions, if I might.

In doing this, what kind of databases do you have access to in terms of your geological maps, in terms of geophysical data sets, et cetera? Do you maintain them or do you just have access to them?

DR. DOGAN: It is both. We do have several databases and geology maps. But as the applications come in, and of course the applicant does all the work that as they see for that site. And our task is to review what the applicant done and identify if they have left certain things out by looking at, first of all, our background and knowledge and references that we have. We have databases, we have -- recently we started using, for example some GIS databases and things, some of the applications.

And we have access to other resources. We

have access to community members and everybody. Basically, wherever the resources available, whatever point we do use that.

DR. HINZE: How do you assure yourself that when you do a review that you are looking at the most up to date, the best data sets available?

I know there are some data sets in the NRC databases that are a bit old, I'll put it that way.

DR. DOGAN: There are multiple things. Obviously, we heavily rely on the literature and the most current literature. So we always keep ourselves up to date.

And in the geology and seismology area we also work with the USGS folks and they're our contractors. We work with them and get their knowledge and input into the review systems, too. So that's how we try to answer --

DR. HINZE: So you rely on the USGS databases then?

DR. DOGAN: In some sense, but primarily literature and whatever is available in the scientific community. A lot of us came from the scientific community. We have connections. We know a lot of people. So we try to do our best in that area.

DR. HINZE: Thank you.

DR. DOGAN: You're welcome.

As I said, you know, this is the geology reviews are done at the multiple scales. And as you come closer to the site, like here is shown 20 miles with equivalent 320 kilometers, 25 miles and then one kilometer radius. And basically we'll look at in the final detail what the source region looks like or the site location looks like.

And this could be detailed analysis of geomorphological features and potential core surface faulting and site specifications and site characters. These are all the topics that a geology review reviewer would look into.

And another significant component of the geology review is to identify paleo-earthquakes or identifying utilization of paleoseismology resources.

One of the most commonly used feature that we're looking to, and a lot of the applicants are now using it to identify liquefaction features. Anne used them to estimate sources within the site or within close proximity to the site that may have some impact on the final probabilistic hazard calculations.

And what is shown on the left figure is a modern picture of the liquefaction factors features occur. And then on the right is a cross action,

actually, showing the paleo of liquefactions that identified for the new New Madrid seismic zone. And when you look at it these sand blows, so called, they can be datable because of the organic material in it and we're using those dates and looking at the sequences we can estimate that at least there was a large earthquake in the vicinity and we tried to estimate the magnitudes and things for that.

So staff looks into these kind of reviews, whatever the applicant provided in the color. We just analyze it work towards understanding of potential hazard sources within the site vicinity or in the regional area.

And seismology we look at several topics. And this is the one that actually will have a direct relation to research that you'll be hearing later on.

One of the first things that we'll look at seismic sources and definition of seismic sources near in a site, or near a given site. And we also looking to ground motion attenuation or relationships in that area, earthquake catalogue developments, site response calculations as well as of course the probabilistic hazard calculations.

I put this figure here just to give you an indication of how the original EPRI source models are

defined. And what is show here basically, central or eastern U.S. and six different models. These are what we define or what originally has been termed as the earth science team models. And you'll be hearing like Bechtel model or Law Engineering models. These are independent science teams that put together at the time, an earlier date, 1986, to develop each individual team's understanding of the tectonics and development of seismic sources relevant to central and eastern United States.

As you can see, although there are some overlaps between the sources, they represent in a sense differences of opinion of what these seismic sources are.

And one thing I want to emphasize is the date. That this report was published in 1986. Obviously since 1986 there has been a lot of new siting facts, scientific discoveries and activities and things. And then we also have to look into that. And when we look at reviews, actually our regulatory guides state that EPRI Seismic Owners Group, that what's the SOG refers to, can be used as a starting model. It is never so modeled that it should be just using that and stop there. Of course, you know we always look for updates to it as the scientific

community makes those discoveries.

Updates? What do you mean by updates? Here's an example that I put together just to give a little bit better idea, perhaps, to identify what we mean by that.

The one on the left is three of the six EPRI or science team models as showing the South Charleston seismic source: Weston, Bechtel and Law Engineering models. And then the updated model which has been reviewed by NRC staff, I believe -- yes, 2006 and is part of the Vogtle application. And now this is what the more generic representation of the Charleston Seismic source.

From the models larger scales sources with varying sizes. Now we look at the seismic source for the Charleston size earthquakes that happened 1886. The boxes represent uncertainties of the seismic sources as interpreted by the science teams. And the colors and the letters represents where the most weight goes to. For example, the green area here and when you do the calculations you assign 70 percent weight. So that's where most likely the source region is. But there are uncertainties in their estimations. And then the other yellow and cyan and magenta, or like magenta, pinkish color represents the other

potential possibilities with corresponding weights.

MEMBER MAYNARD: Who did the update?

DR. DOGAN: This was Vogtle's update and then staff reviewed it later on.

MEMBER MAYNARD: Okay. So they used the three on the left as examples there; updated both model information, provided that update?

DR. DOGAN: Yes. Because through, again, scientific discoveries, as I said the original EPRI model was developed in 1986. Since '86 to 2006 there has been a lot of changes, especially for Charleston and New Madrid on the characteristic earthquakes and how often these type of earthquakes occur. And, of course, the applicant knowing that had to modify the color because that's what eventually the most represented fault is at the time.

MEMBER APOSTOLAKIS: How does one go from the three on the left of that?

DR. DOGAN: It is not, actually. These are independent. One what used to be and the other one represents the new knowledge.

MEMBER APOSTOLAKIS: But they are using the information that's on the EPRI models?

DR. DOGAN: Perhaps to certain levels. But as I said, there are a lot more scientific papers,

updated literature that we can use and USGS and other people really looked at it and developed these models. And then this represents the summary of those models of current scientific knowledge at that point.

CHAIRMAN POWERS: My recollection is that what is found is that number of -- many more of these sand blows are identified out in these regions as part of various academic undertakings.

DR. DOGAN: Correct. And they're how often they come about.

CHAIRMAN POWERS: And the Vogtle folks found that literature, even did some of their own exploration for sand blows. And then based on that they say okay, well it looks like we should update whatever was done in the EPRI's report to look like this. Now that step is a bit like sausage making, I suspect. But results in this. And I mean for the early site permit or the early site permit for Vogtle we went through this in somewhat detailed.

DR. DOGAN: Correct.

CHAIRMAN POWERS: Staff basically found it acceptable.

DR. DOGAN: Yes.

CHAIRMAN POWERS: But not easily.

DR. HINZE: In terms of research it is my

understanding that the NRC has sponsored some research down in the Charleston area, particularly some GPS work for example that -- has done.

DR. DOGAN: I'm familiar with that. Maybe somebody in Research group could --

DR. HINZE: You know, what I'm trying to do is connect this to what we're talking about here in the research area. And as --

DR. DOGAN: I'm not familiar with the GPS support that NRC may have --

DR. HINZE: Well, it would be very helpful to me, at least, if as you continue your discussion if you could point out where research has assisted you in these efforts. And also, where you would be interested in having some additional research conducted.

DR. DOGAN: Sure. That's the direction I'm going.

DR. HINZE: That would be helpful.

DR. DOGAN: Yes. And at the end, yes, I will show.

DR. HINZE: Thank you.

MR. CHOKSHI: Just to add, I think historically and we have done a lot of activities in the Charleston area, you know, going back to when the

issues first emerged. And so this is the part of this 20 years reflects all that knowledge gained that joint activity USGS and Southern Carolina.

But I think we'll point out --

DR. KAMMERER: That's right. And we also have some ongoing work that I will talk about. But there certainly has been a lot of historical work done and there's at least one project that I think you guys will find very interesting that I will mention a little bit later.

DR. DOGAN: The next chart I'm going to show what has been done with these original EPRI source models throughout the years basically, starting with the early years. ESPs in 2003, several of those like the New Madrid and as one that I showed, at least the initial magnitude representation of the Charleston, not the geometrics, perhaps, but identification of new sources like the Saline River source in Arkansas and others.

And then in 2008 we looked into, actually we're still looking into Eastern Tennessee seismic zone. And we have a white paper.

And then the 2010 is the Research connection that Annie will be talking about, that new central U.S. source models, perhaps to replace the

initial EPRI models completely and then bring about new sources that we may be able to use in our reviews.

MEMBER RAY: A question.

DR. DOGAN: Sure.

MEMBER RAY: As a person from the western region, not central and eastern, I'm also interested in the fact that the central and eastern is treated as a distinct and separate study area or regime. And I guess my question would be does that continue?

And it seems like everything, it's almost like it's insidious that all of that knowledge is associated with just this region itself as opposed to the worldwide data that are constantly being produced as events occur. Is that a fair assessment?

DR. DOGAN: No, I would say so. There is in that western/eastern are separated different or treated differently. It's because of the tectonic environment.

And west being more actively tectonically, the Basin and Range and Sierra Nevada and then the San Andreas fault systems and things, it's a plate boundary process active tectonics.

MEMBER RAY: But are there no other regions like this in the world?

DR. DOGAN: In eastern U.S.?

MEMBER RAY: Central and eastern?

DR. DOGAN: Of course there are, yes. There are different analogues in central Asia. Australia you can say. Canada, northern Canada and thing. And maybe perhaps some portions of South America are analogues to that.

MEMBER RAY: Okay. Well, I just -- my observation then is I'd never seen any data as e talk about central and eastern that derives anywhere else but central and eastern. And that seemed odd to me.

DR. DOGAN: There may be reasons for that. Because a lot of things --

MR. MUNSON: Can I jump in here? Let me jump here.

We specifically explicitly use earthquake activities, catalogues, size, magnitudes, reoccurrences from the worldwide catalogue to inform our models of central eastern U.S.

DR. DOGAN: Right. That's what I said.

MEMBER RAY: Misperception on my part.

MR. MUNSON: Yes. And Annie will have slides on that issue later on.

MEMBER RAY: Okay.

DR. DOGAN: So this, again, is going to be main Research relations that you'll be hearing later

on today.

The other important part is in --

MEMBER APOSTOLAKIS: I'm just -- could you go to the previous slide.

DR. DOGAN: Sure. Here.

MEMBER APOSTOLAKIS: I guess from a third party perspective seeing these seismic source models change every few years --

DR. DOGAN: Yes.

MEMBER APOSTOLAKIS: -- the question is are they changing significantly? I mean, how does that effect existing reactors? And when you say "new central and eastern U.S. source models in 2010," how different are these going to be from previous models?

DR. DOGAN: I haven't seen the new models, so I cannot to speak to them. But any that come from the past.

MEMBER APOSTOLAKIS: I'm very concerned. I mean there seems to be a constant evolution.

DR. DOGAN: Well, it depends. For example, when you look at the Vogtle Charleston seismic source implementation, the primary impact is the recurrence rates at NSI for that. Now it's 550 years. used to be much longer range. That does change the hazard significantly.

Geometries, depending on where your site is, various calculations that you can't come in that, it may be different and it may be small changes, maybe large charges depending on the source regions and things.

So to answer that question it varies. It varies the modification, the level of modification you make and perimeters you use in your calculations, and how much they change.

MEMBER APOSTOLAKIS: But that's the analytical part?

DR. DOGAN: Right.

MEMBER APOSTOLAKIS: In terms of real reactors out there when you say that that the return period changes significantly, what does that mean? Do I do anything about them or --

DR. DOGAN: For the existing plants?

MEMBER APOSTOLAKIS: Yes.

DR. DOGAN: Okay. That would be a question maybe we'll ask --

MR. MUNSON: I don't know. You're aware we have a generic issue, one that IPEEE that looking into that issue right now for the operating plants. How the new information on these seismic forces and the ground motion models has impacted the operating

reactors and changed the hazard.

So, and of course we had IPEEE in the '90s and now we're looking at it again in this generic issue program.

MEMBER APOSTOLAKIS: And this generic issue would be resolved in the near future or --

MR. CHOKSHI: Yes. Research has an ongoing action plan of activities. You know, it's an active generic issues. I don't know the precise schedule, but this is being worked on right now.

MEMBER APOSTOLAKIS: Okay.

DR. DOGAN: Going back to ground motion, this is another topic that you'll be hearing that Research folks talk about under the next generation attenuation models. They're called NGAEs.

I just put an introductory slide here just to show how these models are built basically from the seismogram ground motions. And by combining multiple observations, eventually the ideal thing is to come up with a model that represents the ground motion of a future earthquake that certainly extends from a certain magnitude range.

And obviously that does have scattering with that comes into a lot of other issues like

dealing with the uncertainties, variations and sigmas and things from the mean values. But this is basically what the ground motion models is going to represent.

And again, and the original EPRI PSHA study done in 1989 they used certain types of ground motion models thought to represent the eastern central U.S. characteristics at the time.

Then again scientific community makes progress and there has been actually several research activities and published papers between this time frame '89 to 2004. And in 2004 EPRI conducted another study to look into what has happened in this time frame in terms of our understanding of seismic ground motion in models. And then compiled them, I believe there were like 13 of them, grouped them, categorized them and in a sense they built a consensus model, community consensus model. And then those are the ones that we use in our reviews today.

MEMBER RAY: I don't want to harp on this, I just want to get some clarity. Should I always understand when you're making comments are you just now did that we're talking about the very difficult problem of central and eastern U.S. only? And if there's ever a time when we talk about plate tectonic

origin seismicity that somebody that somebody else will stand up and say we've changed the subject now, or are we -- it's not clear to me in the lots of stuff I read coming into this meeting when we're restricting the discussion just to central and eastern U.S. and when we might be talking about something that has broader or application elsewhere.

DR. DOGAN: Better application in what sense?

MEMBER RAY: Well, in the west, for example.

DR. DOGAN: Like I say and mentioned the earlier ones, you deal with different tectonic environments and you have to treat them separately.

MEMBER RAY: All right. So again this discussion today and we'll be focused just on the central and eastern models?

DR. DOGAN: Correct. That's the, for example, the attenuation models and things.

MEMBER RAY: Well, that wasn't clear to me. And I guess that's why I'm --

DR. DOGAN: What you may be hearing later on and things, especially when Annie and Jon or others talk about the Research activities, because of the availability of data or lack thereof, and then we may

use global analogues that learn from some other regions and try to bring that something knowledge to eastern and U.S. Because we don't have magnitude at earthquake, for example, and recordings of it in anyway in the central and eastern.

MEMBER RAY: I understand. But I mean the point is I should always think that we're talking about is research associated with applications ultimately in central and eastern U.S.

DR. DOGAN: Correct. And the new models--

MEMBER RAY: And anything else is another subject for another time?

MR. MUNSON: Right. If I could jump in.

We, as you might be aware, we have like 12 -- I believe 12 to 15 COL ESP applications that we're reviewing, and all of them are in the central eastern U.S. So we're focusing on that.

MEMBER RAY: Yes.

MR. MUNSON: WE anticipate some western U.S. applications, perhaps, in the future. And those will be completely different animals in terms of how we review them, what the applicants need to do. And, you know, we're basically going to have to start from ground zero.

MEMBER RAY: I understand why that would

be -- I guess I would only suggest that at this point we're just now discussing isn't clear enough outside the community here. We're only talking about research and needs existing.

MR. CHOKSHI: Well, I want to make an important point that analytical framework is not different in terms of basic data, you know the investigations and what they are to do, is the nature and the details of the work they are to do, what they present is going to be different. But we have a regulatory framework for licensing plants. And, you know, that's restricted to only eastern and central. But what comes, the intent of an application may be quite different.

MEMBER RAY: Okay. But I look up here the title of this "Updates to Ground Motion Prediction Models." I think we're just talking about central and eastern U.S. there?

MR. CHOKSHI: Correct. Correct.

MEMBER RAY: Even though we don't say that?

MR. CHOKSHI: Yes.

CHAIRMAN POWERS: And we just don't care about the west.

MEMBER RAY: Well, I don't mean to put out

that they don't.

CHAIRMAN POWERS: They don't care about it, I'm telling you this.

MEMBER RAY: I don't care about it either. I just want to have some clarity in my own mind because I've spent so much time thinking about it from the standpoint of applications in the west that I need to think about it in this more restricted --

MEMBER APOSTOLAKIS: Are you annoyed that California is not the center of attention?

MEMBER RAY: I'm not, George. I'm only having to shift the gears in my thinking here to apply this just to the central and eastern U.S. Okay?

MEMBER APOSTOLAKIS: You have to go to the microphone.

CHAIRMAN POWERS: And identify yourself.

MR. LI: Okay. It's good question because--

CHAIRMAN POWERS: And who are you?

MR. LI: Young Li from NRO.

The central eastern U.S. and western U.S. different, not only on the tectonics. Also the seismic wave transmission.

So if the same earthquake occurred in the western, it spread out and the wave propagates very

close in coast range. In the central and eastern U.S. it can propagate very far away, like the New Madrid earthquake that occurred in 1811. But the church bell in Boston ring, ring.

So it's so different. Not just tectonic analysis and --

MEMBER RAY: Well, I accept that it's different. I'm just picking on what George's question implied. It isn't just that we don't care about the west because they're not going to build any plants, or they aren't talking about it, or whatever. But there are plants out there.

And if people say we've got some new way of looking at seismicity, but oh by the way it doesn't apply to the west. They have to start over again. You know, that's a relevant fact.

MR. LI: The general geography boundary between the central and eastern U.S. and the western U.S. is 105 degree.

MEMBER RAY: Yes, I do understand that, too.

MR. LI: Okay.

DR. HINZE: I'd like to build upon what Harold has been talking about.

I think that in view of the topic of this

meeting that perhaps we should give some thought as to what kind of research should be done now to prepare ourselves for the western United States situation.

The Reg Guides maybe have been written in a generic way, but you know, they refer to SOG and they refer to Lawrence Livermore's work and so forth.

So I really think that one of the things that we could consider doing is pushing for broadening the viewpoint to include what kinds of problems are we going to have along -- let's not have another Diablo Canyon problem, okay? The Hosgri fault, or whatever it is.

You know these are things that I think the Nuclear Regulatory Commission should be preparing itself for. And now is the time. Because it's not going to be an overnight type of adjustment.

So I would not only support you, Harold, but I'd encourage you to expand upon this.

CHAIRMAN POWERS: You have to recognize, though, broadening means diluting.

DR. HINZE: I'm sorry, sir?

CHAIRMAN POWERS: Broadening inevitably means diluting.

DR. HINZE: That depends --

CHAIRMAN POWERS: That does not depend.

That is a physical fact.

DR. HINZE: But you still have to set the criteria for what is most important. And I understand--

MEMBER APOSTOLAKIS: They have already done that. I think they have already decided that the eastern part is the most important.

DR. HINZE: Yes, and it is.

DR. KAMMERER: Can I -- Annie Kammerer, Office of Research.

Just one quick point. I mean I agree that we need to open and conduct the rest. We are, in fact, keeping an eye on what's going on in the west. I mean I think in addition to the two reasons that you mentioned, the fact that they're different environments and also that's where our applications are now. There is a lot of work that goes on in the west. And there's a lot of really good research happening there.

And some of the things that we are doing is really staying abreast of what's happening in that region. And keeping an eye on it.

And in fact a few times you'll see that we've piggy backed on some of the work that's going on out there.

DR. HINZE: Well, I think, Annie, that there's a sense that we know where all the earthquake zones are in the western United States because we have faults outcropping, because we have a lot seismicity. But let's remind ourselves that it was the 1935 Check bin that that -- Helena earthquake which, for the first time really brought about the view that we had interplate earthquakes. And Helena, Montana is in the western United States.

And so I think we need to keep ourselves broad here, if you will.

DR. KAMMERER: Okay.

MR. KIMBALL: Name's Jeff Kimball. I'm on the agenda for later today.

I think the question you're asking is legitimate, but it has to be the context of the nation's geosciences program for seismic hazard.

NRC fills a unique gap in the east because in fact, the east in the nation perspective does not get the attention that the west gets.

Geosciences in this country is predominately focused on the western U.S. from a seismic hazard, predominately in California and the western states, Washington, Oregon and Alaska.

So I think that, you know, you have to

keep it in that context. The USGS programs from a seismic hazard perspective are dominated to the west. There are the building code application issues are dominated to the western U.S. where the prominent risk is.

So I think, you know, the NRC looks at the big context of that, and in fact where the gaps particularly given the reactor locations is more in the eastern U.S., you know, by nature.

MEMBER RAY: Yes, I know. But the nuclear--

CHAIRMAN POWERS: I think we've covered this issue adequately. Let's let the speaker go on.

DR. DOGAN: I just want to finalize my presentation on this slide by saying that the NGAs model that you see here is year 2012 expected. This is something that you'll be hearing from the Research group.

MEMBER ARMIJO: What's NGA?

DR. DOGAN: Next generation attenuation models.

MEMBER ARMIJO: Okay.

DR. DOGAN: Because this was first modeled after the NGA, now so called West and following the western attenuation models.

I just put this slide here hoping that it may be helpful. Basically a pathway to GMRS there was a question of the ground motion response spectrum. In seismology we've used basically, this kind of summarizes the whole thing. And we'll look at the source models, ground motion models and develop our catalogues. From that we get the hazard curves. From the hazards we get the uniform hazard response spectra. And that's needed response spectra. An ultimate goal is basically by looking at the geology and seismic tectonic environments and active faults system and -- regions and estimate the ground motion response spectrum, which is the maximum expected ground motion for a given frequency at any site.

And then, of course, I'll mention a little bit later on when we get into engineering aspects. That ground motion spectrum is compared to the design spectrum and built for any design.

But I'd like to highlight that slide as, you know, as a summary slide.

Now I'd like to talk about basically the geotechnical reviews that our branches, our division handles. And these are basically the site-specific, once you decide, you know, plant or ESP site or whatever it is. And a lot of the work goes on at this

site location understanding the soil characteristics, rock characteristics, properties. And obtaining information actually, some of which is used later on in geology reviews. Some of it is used in site response calculations and seismology areas and things. So it's all interrelated aspects.

What I would like to highlight here the observations and laboratory observations in the next slide.

Field observations as the top right hand slide shows, primarily is based on drillholes and borings and drilling into the ground. It could be soil, it could be rock, what you obtain.

Certain properties like obtaining samples and rock corings and in-situ testing measurements for stress, strain and in strength in those drills. So our staff looks at what the applicant has done. They look at their analyses, their results, whether there is sufficient information is provided in the application.

And along with the field observations some geophysical measurements. These could be shear wave velocity measures, down the hole or across hole between two holes and then you can put sources and see if there's any chance in obtaining within layer shear

wave velocities.

And suspension logging, again, assumed to get the shear wave velocities within intervals.

Or without even using the drillholes, just using surface wave analyses and engineering applications that basically estimate the shear wave velocity structure profile in that so that we can use it. Here is a cartoon basically showing one of the down hole testing mechanisms.

CHAIRMAN POWERS: It is not uncommon in the course of examining an Safety Evaluation Report for the staff to come back and say well there haven't been enough drillholes taken.

DR. DOGAN: That's actually pretty common.

CHAIRMAN POWERS: And I have always been puzzled how the staff decides when does one have enough? Is that a judgmental thing or is there some presumably validated model that it's invoked in saying oh our uncertainty band is too large here and we need to know.

DR. DOGAN: You want to say something?

MR. MUNSON: Yes, I would say that it has a couple of facts related to this. One is the complexity of the site in terms of the subsurface. You know, are there several different distinct types

of subsurface layers.

The other issue would be many of the applications you've seen so far are co-located next to operating reactors and there's been a tendency for some of the applicants to rely on older data. And you saw that especially with Vogtle that we asked for new, you know, the site-specific data specific to the ESP. So those were some of the issues that you've probably seen before. But predominantly we look at how complex the subsurface is to determine how much sampling needs to occur.

CHAIRMAN POWERS: Well, and you beg my question there. Is there a model presumably validated that says okay this site is 90 percent complex and this one is 80 percent complex?

MR. MUNSON: Well, there's reg guidance in Regulatory Guide 1.198 that specifies how many borings need to be taken for each structure, you know at each corner. One deep boring down the center.

So we do look at. The applicants obviously looked at that also.

CHAIRMAN POWERS: But I think most applicants meet those minimums.

MR. MUNSON: Right.

CHAIRMAN POWERS: The perception is they

meet the minimums and the staff comes back and says well we need some more here. I'm just asking how you decide.

Now maybe the answer is it's strictly judgment. But maybe there's more.

MR. MUNSON: Actually, that would probably be a fair assessment. We do -- like I said, the uniformity of the site is a big factor. But we do look at -- there's a lot of hard and fast criteria. That we need to do six more borings because we didn't -- you know -- but yes it is mostly staff judgment.

CHAIRMAN POWERS: All right. Thank you.

DR. DOGAN: And the other part of the rock property basically is beyond field work. And when you collect the samples, the lab tests is another one. And you can qualify these under two categories, like classification tests, basically what is the soil that you got. Is it clay, is it sand, is it limestone rock or is it granite rock or whatever you got.

And also the engineering properties of these like mass density, moisture content and Poisson's ratio and, as I said, shear wave velocities you can also measure them in the lab and the lab samples. And also looking at shear modulus and damping ratios which eventually end up in site

response calculations to analyze normal air effects and effects on the GMRS.

So these are the things that staff looks at in geotech.

In the foundation stability area the staff looks at primarily two areas with a lot of subdivisions, bearing capacity and settlements.

Bearing capacity, you know it could be rock or soil areas, which basically says if I built the structure here and because of the joints or weakness joints and facts are we going to have some failure of the structure.

The bottom one, the settlement is more of a soil type settlement. It could have total settlement, the whole thing settling down as you built the structures or the differential settlement, one side of the site going down further than the other one. It could be a tilt or it could be a sag depending on the characteristics so staff carefully looks at that and makes the calculations or looks at the calculations done by the applicant and confirms or requests additional information as needed.

The settlement part is kind like unique part. It's also monitored during construction and even after the construction. So there is always a

hand in there.

The other components in the geotech --

CHAIRMAN POWERS: On this settlement issue that you bring up, is it common to find discrepancies or differences of opinion between the staff and the licensee on this issue?

DR. DOGAN: I'm going to my branch chief. I'm not sure if we have any, but --

MR. MUNSON: Obviously, we have the benefit or so far we've had the benefit of having co-located reactors so we have years of experience to look at settlement at the operating reactor in terms of how we evaluate the early site permit or the COLA application. But that is an area of concern that we do worry about connections between buildings and how those will be -- you know, pipelines that are connected between buildings and how those might be effected.

CHAIRMAN POWERS: The reason I ask is this is so connected with investment protection of the licensee that I would expect him to do a pretty conservative job here. What I'm asking is, well does he?

MR. MUNSON: We look at the factors of safety in terms of the rung. We have fairly high

factors of safety that we will require in this area.

CHAIRMAN POWERS: I would assume the licensee would do so, too, because this is not such a probabilistic or rare event sort of thing. Settlement occurs. And licensees would be loath to loose their investment based on this kind of -- they're not going to build a Tower of Pisa here. Or they're anxious not to build the Tower of Pisa. I would think they would do a very conservative job. And certainly in the case of Vogtle we saw a heroic effort undertaken to assure that they don't run afoul of this.

MR. CHOKSHI: I think you made a very good point, was the last conference. We had a presentation from an important soil applicant for an ESP. And one of those significant parameters they point out in site selection is geotechnical properties. There's so much -- you know, the whole foundation of the regulation. So I mean there is a lot of talk, and that's where the characterization has become very important, you know, that how do we make sure that the things like settlements and things are properly calculated.

CHAIRMAN POWERS: Yes, we do not want the Tower of Pisa as a representative of a nuclear power plant.

DR. DOGAN: Yes, I show that in a slide like that, a reactor site is tilting.

I just want to basically talk about these last issues in the geotech areas that people look at.

The first one is lateral earth pressures. This kind of relates to sliding that engineering folks look at usually. But then one of the pressures, calculations of those pressures and impact on the sliding is an issue that our division or our branches look into that.

Of course, the final one is liquefaction is something that you'll actually be hearing from the Research people that they have some development -- guidance development efforts in that. I just wanted to mention that here. Obviously it's one of the big geotech issues.

Here I want to switch to the engineering areas. This is not something that our branch per se does, it's early engineering division's task. But I'm going to talking about very briefly what happens to the reviews that we do, the results that we agree or disagree eventually accepted so called the SSE or GMRS. What is it used in the engineering sections.

Here we highlighted three main chapters, 3.7, 3.8, 3.10 and 3.12. And 3.7 is where -- that's

where the primarily engineering calculations and models are conducted. This is a bigger one that looks into GMRS. Compares it to the certified design response or design response spectrum and identifies the differences.

Of course, GMRS is by definition is calculated at the free surface. When you built a structure on top of it, that is no longer valid and that's where the soil structure interaction interface comes in, and that's what these views are focused on here. They calculate response and loads from a projected or future earthquake with a certain ground motion. So reviews look into those ground motion parameters of the time series of seismograms that they used and those analyses they're reviewed there.

And one of the things that they look at, foundation response spectra. As I said GMRS is at the surface but some designs may require response spectra to be calculated at different levels within the foundations. So these are the calculations are done here, and that's action in staff reviews it. Lower response spectra which you eventually use later on in like the last bullet, the piping and things. So these are the primary seismic engineering reviews in that area.

The first one, you know the products and things if you say like the loads and what we learn about these structures and the ground motion, maximum ground motion that effecting the site goes into design of the structures. So 3.8 looks at the reviews of these design structures and foundation stability and issues in that areas. When the largest ground motion occurs, what is the impact going to be and how we design so that that ground motion will be accommodated by the structure.

And if I go to the 3.10, seismic qualification of equipment, this could be equipment, mechanical equipment or electrical equipment, safety related equipment that will react, of course, respond to whatever the ground motion comes in. And the reviews here are related to that and modeling and what models are used. And their results. That's part of the engineering group looks at based on the GRMS and SSE safe shutdown earthquake determinations that comes out of our branches.

And the last one is seismic design of piping and supports. As I mentioned in the first one when you calculate the flow response from a certain ground motion, how does the piping and related structure support systems will function given the

design. There are certain models and things that engineering folks do and look at and review these applications.

I have tried to take you from geologist's observation, identification of sources to hazard, estimation of ground motions and very briefly mention about engineering aspects and how the engineering folks utilize the information.

So with that, I'm going to conclude basically by putting the summary slide up, which basically sets the stage for the remaining of the day and actually I believe tomorrow, too, what you're going to be discussing with the Research folks. And two of the primary items that we are interested is the development of new source models and the new ground motion models. As I tried to explain, those are very critical in our reviews and our final decisions.

Perhaps not as important, but it is very significant, very important part also identification of past earthquakes. And you'll be hearing from the Research people and what their efforts are in that area identifying historical or pre-historical earthquakes in that aspect.

And then in the geotech area, as I mentioned also throughout the geotech part, and there

are some efforts going on updating the geotech Regulatory Guides and clarifying certain things and additional responses. And then any and others, I'm sure they'll be talking about the details. On that we are very much involved and interested in that.

The last three bullets are the engineering aspects of it. The first one comes in the passive earth pressure. This is from the fact that new designs seem to be more embedded in the ground, a more sophisticated soil structure interface. Interaction needs to be looked at. The currently used methods sufficient, perhaps good enough but there are still gaps that need to be addressed and maybe from semi-empirical to perhaps more model based and observation information based models.

And ground motion incoherency. This is, I believe, also discussed here about a year ago as part of the high frequency ground motion and ISG interim staff guidance that we have. And I believe it's been active almost one year now. It's out there. And that basically says at the higher frequencies because these new plants are very broad foundations and the response is not coherent and kind of like helps, in a sense, reduce the amplifications of that but may add additional things like rotations and things. So that

needs to be understood a little bit better.

And the other one, the last bullet, is again this Regulatory Guide development effort is basically look at how to do this properly, the plant level seismic margins, probabilistic risk assessment based analyses and how it is going to be handled in the seismic margin analyses parts.

So I'm going to stop here.

MEMBER APOSTOLAKIS: So this is a Regulatory Guide --

DR. DOGAN: I believe, yes, it is.

MEMBER APOSTOLAKIS: It is a new guide?

DR. DOGAN: Is a new --

MR. CHOKSHI: Yes. It will be a new guide.

MEMBER APOSTOLAKIS: It will be a new guide?

MR. CHOKSHI: So right now they're looking at draft guide and then -- it's implementation guidance how to use some of the results to demonstrate margin and stuff here. And it's on a short term schedule--

MEMBER APOSTOLAKIS: It's what?

MR. CHOKSHI: It's one of the short term needs we need to track.

CHAIRMAN POWERS: Yes, we'll have to understand how that's divided between the Seismic Subcommittee and the PRA Subcommittee.

I think that was fairly useful to have an introduction on what kinds of issue that you encounter and where you're looking to the Research program. It helped me at least.

Are there any other questions you would like to pose to the speaker?

In the general subject of this western/eastern, I think I want to bring that issue back up when we come to our discussion period at the end of the day. And after we've had a chance to look at the Research program, we'll explore that a little further.

I'll thank you.

DR. HINZE: Can I ask one question, if I might, regarding your new ground motion. How significant is there going to be -- how significant will be the decrease in the uncertainties as a result of these models? And what is the basis?

DR. DOGAN: I think Annie will be talking about. But it's basically more observations that now are available and those are incorporated --

DR. HINZE: For example, the PGA you know

this one. There's a lot of uncertainty there.

DR. DOGAN: Sure.

DR. HINZE: And we can do it.

DR. DOGAN: I mean the goal is to reduce that uncertainty down by looking at more observations. That's the main --

DR. HINZE: Thank you so much.

MEMBER APOSTOLAKIS: All the new models lead for reduction in uncertainty?

DR. DOGAN: I wouldn't say all, but what we have is, you know, more upgrades and more information. So we can use those, have been used before, and try to come up with --

MR. MUNSON: Actually, if you look at the older '89 EPRI models, they had a smaller uncertainty. The uncertainty has gone up quite a bit. And I think if you look -- I think the latest findings are that uncertainty isn't going anywhere. So I think it's pretty much going to always be with us.

CHAIRMAN POWERS: It's not an unusual evolution. The models that we used for most things back in the 1960s had no uncertainty in them.

DR. KAMMERER: It's not that the uncertainty is going up. It's just that we are maybe realizing that before we were too certain.

CHAIRMAN POWERS: Right.

MEMBER APOSTOLAKIS: But I notice that you keep referring to the EPRI models. What happened to the Livermore work? Are we turning our back to it now?

CHAIRMAN POWERS: Well, there's been a unification.

MEMBER APOSTOLAKIS: Has there been?

CHAIRMAN POWERS: Sure.

MR. MUNSON: Well, that's what we're doing right now.

MEMBER APOSTOLAKIS: Oh, you're actually doing research some time ago, right?

MR. MUNSON: Well, yes. The Livermore models as you saw that timeline. EPRI was updated over the years and where the Livermore model hasn't been updated. It's still valid as a starting point, just as the EPRI '86 is valid as a starting point. So if an application chose to use Livermore and update it, that would be permissible. The staff would review that update.

DR. DOGAN: And none of the COLs or ESPs we have started with Lawrence Livermore models. And that's why the updates that you see on EPRI models in that range. It's their choice in that sense.

MEMBER APOSTOLAKIS: Okay.

CHAIRMAN POWERS: Thank you.

Annie, I guess you're up. Annie, I have ever intention of interrupting you at roughly 10:15.

DR. KAMMERER: Oh, okay. Great. That would be actually very good. Because I'm also down to the end of my coffee.

CHAIRMAN POWERS: Yes, me, too. I think it was Pam LeVay that said a mathematician is a machine that turns caffeine into theorems. Well, Annie is the seismologist that turns caffeine into seismic studies, right?

DR. KAMMERER: Yes. Right.

And to be fully transparent, I'm actually an engineer. I have a Ph.D. in geotechnical earthquake engineering from Berkeley and I'm following someone who came from UCLA. So --

CHAIRMAN POWERS: Uh-oh.

DR. KAMMERER: So there's something about the CEUS, the west is still also well represented here, I believe.

So as another point of clarification, I actually didn't harass Dana incessantly. It was only monthly.

CHAIRMAN POWERS: Very good. It just

seemed incessant.

DR. KAMMERER: So thank you all very, very much for this opportunity for us to present our work to present the work that we're doing with NRO. And for this opportunity to actually have a discussion about many of the items which we've sort of tried to have in the past and always run out of time.

I want to start, I think, by also seconding what Nilesh said when he began his presentation. There's a tremendous amount of coordination and cooperation between Research and the other groups. And I have to say NRO in particular has been extremely supportive and charitable, not only with their time in developing the list of items to be looked at, also in actually scoping out the work, and in participating in the work. I think you'll see a lot of the projects we have include a large number of groups, not only within the agency, but also our other fellow agencies. You'll see that we're working with industry on several of these items. And I think that that is really leading to some really very high quality products in the end.

I would note that Martha Shields from DOE is actually in the audience today. She's one of the ones that we've been working with on the CEUS SSC

project that you'll hear about. So glad to have her here, as well as the many other people who are involved.

So just to start out with a quick overview of the types of activities that the Office of Research undertakes.

Regulatory infrastructure development is clearly one of our key items. Regulatory guidance as well as new approaches and new tools that we're looking at. You've heard about a number of guides which are being developed. Of course, 1.208 was something that the guide seismic hazard analyses was something that has already been produced, but we're also working on a number of the geotechnical guides. These include liquefaction, the geotechnical investigations guides, the PRA-based SMA, possibly a new tsunami guide which will be separated out from flooding.

I didn't really want to put a list up because we are going to be having a retreat, as you heard, in about a month's time and we're going to be relooking at a lot of those and deciding where we want to go with a lot of them. But these are some of the key guides that we're working on at the moment.

In terms of the development of new

approaches and tools, I will highlight a couple of those. And that has also been a very close relationship. Because as we are developing these approaches and tools, NRO is using them and providing us feedback in real time, which is wonderful.

Another thing that we're looking at is evaluation of operating experience. One, you know key project there is Kashiwazaki, of course. That's something that we're trying to glean as much information as possible from.

We're also looking in terms of tsunami and some of the flooding which has occurred. The Indian Ocean tsunami there was flooding of an Indian plant. And so we're trying to really gain as much information as possible on these things.

CHAIRMAN POWERS: Let me turn to the Japanese earthquake. There is a huge amount of work going on in Japan. I mean, this was a devastating event for them. And so they're doing a huge amount on this. Is NRC participant in this or are you just awaiting the outcome of these sorts of things?

DR. KAMMERER: Depending on the different specific topics. Of course, it covers a whole breadth of work that they're doing from the hazard trying to determine why it was that this was such a surprise to

understanding how the plant performed. And then also looking at some of the parts of the plant where there was damage or things that we want to look at.

So we're looking at things sort of in a variety of ways. We have an ongoing dialogue with them. They've been over many times. We've been over in Japan. We are working through an IAEA extra program on Kashiwazaki that the entire international community is sort of coming together and doing some analysis based on a Japanese database of the ground motions.

The engineering properties of different portions of the plant that were impacted. And then also the information on what the response was. For example, they are providing structural information, information on the tanks which were damaged, information on the pool and the properties. So that we all are able to model them as separate groups and to come together and look at how well our tools performed.

There were a few things that we're very interested in. For example, one of the cranes that was damaged, they have done some very interesting, very large shake table tests in which they have actually put a crane on a shake table and you see the

crane lifting. And that was very interesting confirmatory analysis that they've done on their part, but we can learn from that. And I believe that they're doing retrofits on some of it.

So I guess all of the above depending on the different elements.

We've gotten some information faster than we've gotten other information.

MR. CHOKSHI: I'd like to add one more thing. That there's a desire on the Japanese part to communicate at the agency.

CHAIRMAN POWERS: Oh, yes. Oh, yes.

MR. CHOKSHI: So they have been very proactive in coming and talking to us, not only the technical but communication aspects, the changes in the requirements. To there is quite a bit of data both the regulatory side and the researcher side.

CHAIRMAN POWERS: I have to admit that they have seen, they have a desperate need to make sure everybody knows everything they possibly can about this. I mean I deal with people from the NSC and they keep inviting me to attend these conferences. And I say, no, no. Make Annie go because she'll understand what they're talking about.

DR. KAMMERER: Well, thank you.

So that is ongoing --

CHAIRMAN POWERS: It's also true, I think, that the experience in the Japan is much closer to the types of earthquakes that we would get in California--

DR. KAMMERER: Yes.

CHAIRMAN POWERS: -- then it is to the central and eastern United States. Is my perception correct there?

DR. KAMMERER: Well, I think that's true. The tectonic environment of Japan is very similar to California, much more so than the central and eastern U.S. In fact, you heard mention of NGA West and NGA East and the next generation of attenuation relationships. And for the west there is actually Japanese data that was brought into that database, again trying to bring in analogues from the rest of the world into the database. And so that is considered an active crustal tectonic region.

MEMBER ARMIJO: So would you include then based on that that the magnitude of the surprise that the Japanese had at Kashiwazaki we would expect if we were going to have that in the United States, it would be in the western United States but not in the central and eastern U.S.? Can we be surprised just as much in the area of interest?

DR. KAMMERER: I think in terms of the magnitude, we do look at a whole range of magnitudes. I would hope that the way that we approach seismic hazard here and that we do work in a probabilistic environment. We take into account many different scenarios versus just saying, okay, this is how the rupture -- this is what the earthquake that this plant is going to look at.

I haven't seen anything coming out about that would lead me to say that we need to change anything here. I believe that the way that we approach seismic hazard, that we would not have that kind of surprise. And we are dealing, as you heard, you know there's the generic issue program where we are looking at basically all the information we have now and reassessing the existing plants in terms of that.

And also one of the things you saw is there's a lot of site-specific investigation that's done. And I think -- you know, I hate to say too much. But I think that we have a much stronger program in terms of our facilities. We look at the broader near tectonic environment to a greater degree.

MEMBER APOSTOLAKIS: What was exactly the nature of surprise there that had to do with the

magnitude.

CHAIRMAN POWERS: Location.

DR. KAMMERER: Well, they didn't -- yes. There was evidence prior to the event that they had a lot of fault plates. They just hadn't quite connected them all into a single plain.

And the magnitude that a fault is of producing is a function of its area. All right. The more rock that's going to break, the more energy is released. And so they just hadn't identified that these series of faults were actually a single fault, basically was their problem. And they're looking at a lot of site side effects types of things. But given the trends that NGA West has produced, the ground motion prediction equations, if you actually put that fault there and just even run a deterministic analysis, you got those numbers as the median numbers.

So they're not necessarily -- if you'd realize that the fault was there and you said this is what it's capable of, you would have gotten those numbers.

MR. CHOKSHI: As one of the lessons learned, they are revising their seismic standards in predicting ground motions to take into account some of the things they learned. But I wanted to make a point

that from a ground motion perspective there was -- but you also have engineering lessons and some of them are very positive lessons. The plant on the whole exhibited very, very strong capabilities. So I don't want to look in isolation, you know.

MEMBER APOSTOLAKIS: But that as a result of the fact that we have significant margins.

MR. CHOKSHI: Exactly. So, I mean, you can learn from both is what I am saying. You can learn from the total picture. But definitely from the ground motion and they're revising as a standard in defining what kind of things you need to look at. They're specifically now building to, you know, looking at the active sources, you know hypothetical, and bringing also some other probabilistic perspective.

You know, I was earlier talking about that modeling research. They're also talking to us how these things are changing.

DR. KAMMERER: Yes, absolutely. And I mean it is the nature of the seismology and earthquake engineering that we learn from what happens in the world. Tectonics a global issue and it needs to be looked at globally. And so we always have to look at both the problems and the positive performance of

structures to really gain an understanding of what's happening.

MEMBER MAYNARD: I think you answered this, but let me go back over. Take the Japanese earthquake, for example. Did we take and apply and look at it as though if were siting a plant there under our criteria, would we have predicted higher numbers? Is that kind of the process?

DR. KAMMERER: I think that's fair to say. I think that's fair to say. That was a question I got, is did I feel that there was something that we needed to change in the way we did things in light of this happening. And I don't feel that that's the case. I feel very comfortable that we really have very strong standards and we're taking the right approach. And we would --

MEMBER MAYNARD: I believe that's probably the case. I always get nervous when -- I've heard many times that well that happened there, it couldn't happen at my plant.

DR. KAMMERER: You know, I don't think that that's the case at all. I mean, we do have plants on the west coast and we do continue to look at all of our plants.

CHAIRMAN POWERS: The other risk I think

is that one looks at the Japanese earthquake and say ah, that's the kind of damage I can expect at one of our plants. And it's just one data point. And it's susceptible to over interpretation.

DR. KAMMERER: I agree. There was a workshop in Kashiwazaki. I think it was about last summer. It was probably about a year ago. And the first finding that came out of that workshop is one cannot take the very performance of Kashiwazaki and apply it to your plant because plants are different. And unless you build that exact plant at that exact site, it's a challenge to do so. But there is a lot that we can about it, definitely.

Okay. So in terms of the confirmatory analysis, we are working every close with NRO on some of that. One example of this would be some work that we're doing in preparation of updating the liquefaction guide in that we are looking at some of the applications in house and applying a whole series of different ways to approach it to look at what kinds of numbers we get out. How much do they bury and really looking at what we can gain from the confirmatory analyses that we're doing now in terms of updating our guidance.

You heard about some of the other

regulatory programs that are being undertaken. I'm not going to talk about them in the rest of the presentation, but things like IPEEE, things like the generic issue program, things like that are also programs that are undertaken in Research, looking at advanced reactors.

Of course, codes and standards is always an activity for us. Some of the guides that we have coming out now: 1.100 relates to the IPEEE and other work. And this is true not only nationally but internationally. We work a lot with IAEA in updating their guidance. They've had a real push recently to update the international guidance as well, and we work closely with them in bringing the U.S. perspective into those updates.

And we are providing some assistance in reviews as appropriate.

CHAIRMAN POWERS: One of the problems with working with the IAEA, of course, is that we have a common denominator problem.

DR. KAMMERER: Yes.

CHAIRMAN POWERS: And whereas I think it's useful for them to see what we're doing in the United States in seismic, it's not apparent to me that we get anything returned from that.

DR. KAMMERER: Well, there are two things, really. One is the problem that we're dealing with member states. And so we bring our views and opinions. And to some extent, sometimes they get diluted because you do end up having a data document that all the member states buy into.

One of the things that you'll see when we're talking about the CEUS SSC's source characterization project, is we have an international program where we're bringing international observers to view that. And that came about because of some of the interactions with the international community and one of those elements was updating the seismic hazard guide and some of the comments that we were getting back from some of the other countries. And we thought well maybe if they are able to see us undertake of our processes, they'll better understand them. So there's that element.

And then the other question about us getting something back within the agency. I think when we have these international interactions we do always have to ask ourselves what comes back to the NRC and what are we going to get out of this.

In terms of the programs that we're undertaking right now what we're getting is

international operating experience information, really. In terms of both the seismic and the tsunami work we're getting to see what happening in the experience in other countries.

In terms of the tsunami, we're getting information on plant fragilities and things like that from the Japanese that we simply couldn't undertake here because our plants don't get hit by tsunamis, thankfully, as frequently as theirs do.

So I think there's two things. One is an effort to try to take not only our views, but to bring a level of education and opportunities for education to the processes. And then also to make sure that we are getting back --

MR. CHOKSHI: But I think -- if I can. You know, with the globalization and standardization of things we have a lot of international activities. And I hear in part -- the platform to harmonize some of the things. Because I think we're going to see a design being placed in those different countries. And so I think there is both, you know, depending on who has the lead, we learn from them.

DR. HINZE: There is a good deal of very interesting work going on internationally on some of these topics in the academic arena.

DR. KAMMERER: Yes.

DR. HINZE: And I'm wondering if through your work with the IAEA and other international agencies, do you have access that academic work? How are you getting into that tube?

DR. KAMMERER: Well, we are in some ways, as much as we can. Well, in terms of the tsunami we actually have some joint work that our folks that that were working with the USGS are actually working with researchers in other areas.

Like, for example, one of the things that we're looking at is the 1755 Lisbon earthquake which did impact --it did send a tsunami all through the Atlantic Basin. And so, of course, there are Portuguese researchers that work on that and we're interfacing with them to try and pull their knowledge to us and really just trying to do a congenial academic process in which we're working together.

And so things where it's specific topics where we're actually interfacing from folks with other countries.

In terms of, say, for example NGA East we're looking at global analogues and data that have come out from other parts of the world. And so we are talking to some folks from Australia. And having them

sort of -- getting data from them and bringing them into the process. Because, of course, they can use these ground motion prediction equations, possibly, in their region as well.

So far we've been doing it sort of a project-by-project basis. Really trying to identify work in other countries that relates to us and bring them in.

DR. HINZE: Does the IAEA attempt to bring this kind of work together or are you pretty much on your own?

DR. KAMMERER: Well, to some extent, yes. I mean they do bring in a lot of academia. I think there is a lot of opportunity for more of that in the future.

IAEA with the support of Japanese funding and now EU funding is initiating an international seismic safety center, which is going to be a new center at IAEA specifically to create that medium, that platform for more integrated work in this area. And it's just now getting started. And so we'll have to see sort of how it plays out. But we have a lot of opportunity through that to influence those activities and also to participate and to try and make that occur a lot more through IAEA.

I think they definitely have an interest in that occurring. And, in fact, they have formed a scientific oversight committee, and we have identified a number of individuals and recommended a number of individuals. And most of them are from academia and industry as well as regulatory bodies. So there is some effort to really bring all of the resources together through that activity.

Okay. So as of -- I guess at this point about a year and a half ago we put -- a couple of years ago, I guess you would say, we started an effort to take all of the research which was occurring at the time to look at the needs that were coming up as a result of at that time reviewing the ESP applications. And maybe some long term thinking as well, and to pull it all together into a sort of a document, and a specific plan forward. And so we did that what we've called the Seismic Research Program Plan, and the one that's currently out in the 2008 to 2011. And that was, I believe a public -- about a year and a half ago. It is a publicly available document on ADAMS. And we're going to be updating that document after the workshop or this retreat that we have next month. And so this is really sort of the vehicle that we have to pull up all the information in one place, make sense

of it, and put it out for the public to see what we're doing.

The program has been targeted on regulatory needs, for obvious reasons. You get to kind of the point Dana made earlier in terms of limited resources. You know, we're really focusing on the types of research that the NRC needs to do its job better.

There's been a very strong emphasis on stakeholder interactions. And that's true not only within the agency between Research, with NRO, NRR and NMSS. All of these groups were solicited for ideas for information. We sent the document back out to everyone to make sue that we had understood their needs. But the interaction goes farther.

Cooperation with industry. You'll see that there's several projects which are not underway in which we have a strong element of cooperation.

With other national and international agencies, the USGS had been a key partner in this. We're also working with NOAA, with IAEA, with JNES and other groups.

And we have strong effort to bring the broader technical community in. I'll talk in a minute about sort of the approaches that have really become

sort of the state of practice in the seismic community. And we've made a lot of effort towards reaching out and strong stakeholder interactions.

We looked at not only advancing the science, but also the key areas in which we could do work now to increase regulatory stability over the long term. This is a very important idea, not only for our staff but for industry as well. And by that I don't mean necessarily that everything is stagnant and never changes, but what we're looking at is really trying to put projects forward so that moving into the future changes our predictable and incremental and clear and transparent and well thought through, and people understand what's happening. We're trying to avoid surprises while at the same time staying really at the state of the art.

And we've included in this program both short term and long term projects focused on immediate needs as well as trying to anticipate what we were going to need in the future.

MEMBER ARMIJO: Annie, before you leave that chart your point on increasing regulatory stability, what is a situation today that is unstable that needs to be stabilized and from a regulatory standpoint? I mean where is the risk that people who

have got plants operating are going to come up, face new issues due to seismic that the plant's not capable of?

DR. KAMMERER: I think there have been a couple of areas which have been somewhat challenging, I suppose. I mean, we've heard a lot about the need to update some of the sources. And that was an area in which there is a lot of effort which was put forward both in terms of staff resources as well as industry. And, you know, I guess when I started a couple of years ago there were a number of fairly large items that we were trying to work through; high frequency at that time.

MEMBER ARMIJO: The question is, you know the plants that are built and they're going to have to deal with --

DR. KAMMERER: Yes. Yes.

MEMBER ARMIJO: -- whatever new facts come out. New plants with all this new information I would expect would have a much more stable environment going forward because of the new knowledge.

DR. KAMMERER: I certainly --

MEMBER ARMIJO: I was thinking, so, you know at what point is it stable enough? I guess that's where I'm getting to.

MR. CHOKSHI: Yes. No, I think the point you are making is very valid. For example, when we revised the probabilistic seismic hazard, that was -- one of the reason was going to then -- so we have a lot more stability in terms of predicting design basis.

And I think the example of the high frequency was good that we've been proactive. So when you got a size specific ground motion, we are ready to deal with it.

And I think I will also encompass efficiency into the stability. That a lot of these things to make it more efficient, so cut down the additional request for information and those type of things so the people are prepared. Expectations are clear in terms of what we need, and there's an alignment on the information.

DR. KAMMERER: Yes. To that last point, that's definitely one of the reasons that we are making a strong effort to work together with industry and our other agencies like DOE and USGS and bringing, really, everybody to the table so that all of the questions, the issues, the thoughts can be brought into the process as the products are being developed so that we don't end up with something be done, say

out in the industry that comes to us and which is -- this process, no we have to deal with it through RAI process. It's much more efficient to be bringing questions and ideas and issues out early.

MEMBER ARMIJO: Okay.

DR. HINZE: Before you leave this, Annie, can you just expand a bit about your concept of the difference between short and long term? Are there timelines on these? How do you use these?

DR. KAMMERER: I'd say, when we first put this document together I was thinking that some of these would be a lot more longer term than they ended up being, because it turned out we needed them a lot faster than we thought.

I'm really thinking, I suppose, in terms of what we have to implement really now to be very efficient versus things that we can look at. For example, advanced reactors. We have a little bit longer time frame on that then some of the things that we are looking at short term. Like, for example, RVT -- random vibration theory based site response software, which we really wanted in house as quickly as possible because our staff would like to have used that in reviews. And so there was sort of this immediate urgency, or high frequency, for example, the

coherency functions. Those were immediate short term needs versus things that are for the next generation or improved guidance, say, based on what we're learning now.

DR. HINZE: That gets to the matter of criteria and ranking, your use of money, if you will.

DR. KAMMERER: Yes.

DR. HINZE: And obviously you wanted to advance the sites, you want regulatory stability, you've got regulatory needs in terms of new rights or new regulations.

Can you clarify that for me, that list of program overview? Can you clarify that in terms of the criteria that you use in setting your priorities?

DR. KAMMERER: Well, you know, mmm. I'm not quite sure how to answer that. I guess that really a lot of how we prioritized our current program has been in terms of the applications that we have in house, and really the needs to address licensing needs first. And so a lot of that effort has gone towards very critical needs in terms of license decision making.

In terms of some of the longer work that we're doing, one of the ways that we have, I guess, tried to address the limited resources has been to

interface with other agencies and other groups that would also be interested in that product. And also have the luxury of a slightly longer time frame to work with us on that.

For example, so we have some of these short terms that we're addressing quickly, but --

MR. CHOKSHI: The responsibility of prioritize, primarily program offices our needs. And one of the factors in importance that depending on the needs, you also devise Research program which can produce answer for what is needed for that time but may have a long time focus.

DR. KAMMERER: Yes.

MR. CHOKSHI: So it's hard to clearly say here is my criteria. Because if I need certain information to make a decision, I'm going to try to get that information as quickly as possible. But, that doesn't mean that there you can go to further refinement or need to continue on.

So primarily the need comes from the program offices. And that's why, you know --

DR. HINZE: I guess I don't understand. I'm missing the point here, I guess.

MR. CHOKSHI: Well, you know, we talk about seismic sources. Things continually change, but

we have to make decisions along the way. If there is some one critical area like Charleston, you will focus on that first, you know, and then continue long term update, a systematic update of seismic sources. And you will see that.

So the needs try quite a bit. Not only in terms of resources, but also how you structure a program.

DR. HINZE: Well, you also have to evaluate how much -- I think and I'm sure you do, is you have an uncertainty band. And the question is do you really have a chance of decreasing that uncertainty band with what you're doing?

MR. CHOKSHI: Yes.

DR. HINZE: And for example, you know there's a question of whether you do Charleston or whether you do Eastern Tennessee, if you want to talk about seismic sources, you know I think you've got a chance of doing something with Eastern Tennessee. But so much work has been done on Charleston that it's going to be just wiggle room.

MR. CHOKSHI: And I fully agree with you. I was in Research for 19 years and that's always a balancing act that you have this regulatory view which drives to a large part, but you need to maintain that

focus, you know, of the systematic focus of where I go and what the future needs.

I guess one of the things through the Research plan we are trying to strike that balance.

DR. HINZE: You know, I know this is a difficult problem. And anyone facing a research program has that problem. But it seems in looking at your program plan, it seemed to me you avoided this question of prioritizing. And I think that you have to be up front about it. This is a very difficult task.

MR. CHOKSHI: Yes.

DR. HINZE: But you have to face it. And whether you like it or not, you are prioritizing.

MR. CHOKSHI: I actually agree with you. And that's why in the beginning I mentioned that the main focus of this when we get together next month is to now, as we have gone through with some experience, is to prioritize our needs.

DR. KAMMERER: Right. Right.

MR. CHOKSHI: And which you need to maintain both perspectives. Agency needs versus, as you say, systematical where we go, you know, which is the regulatory stability and efficiency and all those factors coming. But that's our main focus of the next

meeting.

MS. HOGAN: I'm Rosemary Hogan. I'm the Branch Chief in Research that is conducting this program.

DR. KAMMERER: She's my boss.

MS. HOGAN: And let me tell you, we do prioritize. We prioritize probably every revision of the budget during the budget process, but sometimes it changes based on different needs from the other offices.

We have also have other stakeholders. We have NRR and NMSS, so we have to balance that.

And one other point I wanted to bring up is that although Annie's slide says short and long term projects, perhaps a better bullet would have been short and long term deliverables. Because there definitely different deliverables for each project. And some of them are short terms based on the needs, and some of them well we continue the project and other deliverables are later on.

DR. HINZE: So you insert a time goal?

MS. HOGAN: There are schedules that are--

DR. HINZE: And that does not come through in this discussion on --

MS. HOGAN: Yes, that's true. We'll get

to that. And, of course, it is in the Research Plan and it is in our operating plan. And it will be revised as it's revised all the time.

DR. KAMMERER: Yes.

MS. HOGAN: So I think some of the deliverables you may touch on as she goes through her presentation.

DR. HINZE: All that helps.

DR. KAMMERER: Yes. And I think the current version of the plan that's out there now was written when we were sort of in very different space. It was written much earlier in the process then where we are now. And we've certainly learned a lot over the last two years. And I think that there are a lot of -- then we were just looking at so many issues. And so as we've worked through it and we've seen the applications, and we've seen what moves the needle, like you were saying. You know, what's in the wiggle room and what might really reduce some uncertainty. I think we're just a lot better informed now. And I am certainly better informed now. And so I think you'll see a lot more clarity on exact that when this next version comes out. We've really --

DR. HINZE: So there's going to be a next version after the retreat?

DR. KAMMERER: Yes. Yes. Yes. And we're getting a lot of that as really a prioritization for the next several years.

MEMBER APOSTOLAKIS: But a lot of these exercises and prioritizing seems to me depend also on what you get from the industry.

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: I mean they understand what was two years ago, three years ago when they came with the performance based approach, which was something that was fairly new to the staff.

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: So you guys had to adjust to that.

MS. HOGAN: That is exactly right. You know, we'll get --

MEMBER APOSTOLAKIS: It's not always what NRR wants or NRO.

DR. KAMMERER: That's right. Things do come up. And, yes, you'll see performance based risk-informed a lot in our coming slides. We're only on the second slide. But, you know, of course I came from the west coast and I did a lot of work at PEER and at Berkeley. So you know, I'd already been working in sort of a performance based world for a

while. And so --

MEMBER APOSTOLAKIS: Who was your advisor there?

DR. KAMMERER: Racey. And in my mind is Professor Chopra and Norm Abrahamson.

MEMBER APOSTOLAKIS: Ah.

DR. KAMMERER: So, yes. So I drank the performance based probabilistic risk informed Kool-Aid a long time ago.

So I've got it looks like five minutes to get through my second program overview slide.

So we've really tried to take on some very specific goals that we keep reminding ourselves as we talk about our program.

One is a systematic integrated program. Integrated research planning. And, again, that's with the program itself and also amongst offices and all the different needs.

We have really tried to focus on the issues with the highest uncertainties. And, of course, we have learned a lot about what those topics are over the last couple of years, but given limited resources that clearly has to be a key question we always have to ask ourselves is this going to move the needle or not.

We've really tried to make the program risk-informed and look at where the gaps may be in our guidance or in our knowledge in terms of what impacts the risk.

We've had a continual focus on making this both high quality and cost effective. We do have limited resources, but we never want to skimp on quality. And so it's very, very important that we always keep these in mind. And so we've used some techniques and some ideas to make that happen.

One is the idea of piggy backing and partnering. These are NSF terms, of course, I mean from academia. Something that we'd write into proposal to them a lot. Piggy backing being the idea that we keep an eye on the work which is already going on out there. And where it seems appropriate to do a little bit of additional work to really take what's been done and apply it to our needs and to the nuclear industry.

An example of this would be the random vibration theory based site response software that you're going to see me talk about a little bit later, which is being done at UT Austin. That actually originally started as a project for CalTrans, the California Department of Transportation because they

needed the same tool in house. And they were very interested in making it publicly available. It was being done through PEER through a lifelines project at PEER. And so they got to the point where they needed it, and then we basically picked it up.

So we basically got a product in the end which NRO is now using which was effectively the first two years were paid for by CalTRans. And so these are the kinds of things that we want to do.

And it's also had been beta tested by CalTrans, which was very nice for us.

The idea of partnering, as I mentioned, you'll see a lot of the projects that we have we're partnering with DOE. A couple with EPRI, with the USGS. And so that's a really an efficient way for us to not only make thing cost effective, but to get a lot more scientists and people involved, a lot more peer review.

DR. HINZE: Is there any informal or formal protocols with other agencies or groups whereby they would direct topics of particular interest to the NRC and its regulations to you and vice versa, NSF --

DR. KAMMERER: Well a little bit, yes. And we have had that happen a little bit. There's a program called the National Earthquake Hazard

Reduction Program, or NEHRP. And it's a specific topical area which is addressed by joint management through four agencies, which NIST is the head agency, FEMA, NSF and the USGS. They formed them as with this National Earthquake Hazard Reductions Program.

Through the USGS every year they have what's called the NEHRP's External Grants Program. And there were a couple of items which came up in that program where they said, you know, this isn't necessarily something that we're going to fund, but boy the NRC would be very intersected in this. And they did, the USGS actually did send those over.

And in fact, they were both funded. One is the work you're going to see in Charleston that's being done by Virginia Tech. And the other is going to be is work that's being in east Tennessee by the University of Tennessee. So those were a couple of projects that we did take on.

We're talking to the USGS in a way to figure out if there's a way that we can be formally involved in that NEHRP process. There's a lot of benefits to that. It allows us to get more interaction and more work at universities while not necessarily taking a whole lot more NRC staff time. So that is something that we are going to pursue more and

discuss more in the future.

DR. HINZE: That's really excellent. It's needed for the agency.

DR. KAMMERER: I completely agree with that. And we have really increased the work that we're doing at universities. Currently we have work at Virginia Tech, Tennessee, Berkeley, University of Texas at Austin and through the tsunami program, at Texas A&M. And so there's been a real move towards that area.

MS. HOGAN: There's another aspect of this is because we have our seismic research plan out on the website, we continually get -- well not continually. We've occasional get inquiries about it and then we get grants proposal. And some we incorporate into our program and some we don't. So there is an interest in the outside community to get involved and cooperate.

DR. HINZE: It would be nice if those could be disseminated through the proper place. Because some of them coming in to you, I suspect, are not of interest to the Nuclear Regulatory Commission.

MS. HOGAN: Well, they're usually pretty on target because they're looking at their seismic research plan and they know exactly where our

direction is.

DR. KAMMERER: And I do get a lot of inquires at conferences and meetings and things like this, would this be of interest to you. So there's a lot of times I say, well, you know that really is not something that's going to impact risk much, so --

DR. HINZE: It would be really neat for protocols to really develop this and make certain they don't fall between cracks.

DR. KAMMERER: Yes, I agree. I think that, and we actually talking to the Division of Contracts in trying to figure out a way to make a more formal process.

There used to be a university grants program here at the agency and so maybe looking at something like that again. Because we definitely are very interested in a lot of the work that's going on a universities and there's a lot of piggy backing even that we could be doing on NSF projects.

CHAIRMAN POWERS: I, on the other hand, am looking carefully at the clock.

DR. KAMMERER: Yes.

CHAIRMAN POWERS: And I'm going to interrupt you now for 15 minutes.

DR. KAMMERER: Okay.

CHAIRMAN POWERS: Since you've finished your program overview and let you move on to next generation and remind you that we do have a finiteness where a little bit --

DR. KAMMERER: Yes.

CHAIRMAN POWERS: Usually in Subcommittees than are in full Committees, but we have finiteness here.

DR. KAMMERER: Okay. You notice I only have 30 slides.

CHAIRMAN POWERS: Annie, I know you very well. One slide per hour is the usual factor by any factor here.

We will take a break until 25 of.

(Whereupon, at 10:21 a.m. off the record until 10:37.)

CHAIRMAN POWERS: Annie, you're on.

DR. KAMMERER: Okay. So one of the last things we ended with was the next generation approaches. And I think that this is something that we have really incorporated a lot. What I mean by next generation approaches is have the emphasis on community cooperation and consensus. And this is something that's really come into play in the seismic community, both the hazard side and the engineering

side in the last, say, ten years.

Sort of historically looking back, at the beginning the first nuclear wave the NRC and industry initiated a lot of pioneering seismic research. Really the beginning of the fields of seismic, counter seismic hazard and seismic engineering. And I see Leon Reiter back there who certainly played a big role in that.

Naturally, as there was a lot of interest in the beginning a lot of things happened and so of as the nature of science, you know, occurs you had a lot of work done on different areas. And over time as things progressed in high individual researchers you ended up with a divergence of tools and methods in some of the areas. And so as of about ten years ago there were some issues that had come about with different databases being used by different researchers, proprietary databases leading to what looked like epistemic uncertainty in some of the tools, things being published in gray literature and not available to the public, proprietary reports, proprietary software. And because of the nature of the seismic world and the need for people to work more closely together, this field which has now matured has really moved towards integration.

And so what we've seen in the last several years has been a lot of movement towards developing consensus through workshops and working groups and next generation approaches. And what that really means is all of the researchers, all of the key researchers in different areas, all the knowledgeable people in the same room to develop common databases and inputs to pool the information that people have and the knowledge that people have to create a common basis from which to move.

There's been a strong emphasis on community consensus where appropriate and where consensus can't be obtained on identifying all of the scientifically valid alternate approaches and to appropriate weight them based on their adherence to the data available. And I think that's one thing that really the SSHAC guidelines that we'll be talking about in the future has really sort of informed a lot of that thinking.

And, you know, a lot of the people that have been bringing this to the broader community are the people who were really familiar with those SSHAC guidelines.

One key element of all of this has been documentation of the thought process. I think we saw

in some of the discussions related to some of the applications there was a need to on the second-guess what some of the teams that undertook the EPRI side were thinking. And so one of the lessons we took from that and what a lot of people have brought in moving forward in this next generation approaches is a thorough documentation of the data that was used to make decisions. It's the uncertainties in that data at the point in time, and to really document why decisions were made.

And one of the outcomes of that in terms of regulatory stability is that when you got new information, you got a grad student who has gone out and trenched a fault and provided some new information. We can look and compare it to the information that the folks involved in the seismic modeling had and is that consistent with what they already had? It provides a framework by which to interpret new information and new opinions.

By bringing together the broad range of opinions it's also easier to understand outlier and to identify them, which is not to say remove them. But to understand how it fits within the broader question of whatever is being discussed. In some cases that might be appropriate, in other cases it really is part

of the community distribution of opinion.

I think one other really important element of the way things have moved in the broader community as it relates to NRC is that there's been a movement to identify not only best estimates, but also get real estimates of uncertainties. And in some cases separating out sort of the aleatory and natural variability from the modeling uncertainties and the types of uncertainties that could actually be reduced by looking at additional work.

So this is sort of a schematic of the different items which are in the Research Program. And you might recognize some of these slides. This has been pulled Dogan's presentation.

So the program incorporates the hazard and the engineering portions of it. You know, all of the different elements of the seismic hazard adjustment.

The sources and source characterization in terms of location and also in terms of what the different sources are capable of. The distribution of attitudes that we would see from them.

The ground motion prediction equations or attenuation relationships are really the same thing. The same thing, new name, which look at the distribution of likely shaking at your site given a

certain magnitude and distance of a specific source. Taking that and turning them into hazard curves and ultimately the response spectra that we're familiar with using.

Geotechnical engineering, of course, is as you heard a very important element that we're looking at. It's really looking at what do you get out in terms of shaking at the rock, what does the soil in particular say due to that shaking, how are the site characteristics influencing the incoming waves? And then what does that mean to the structure systems and components and what does it mean to the whole system, all of the soil structure interaction and the system's interaction?

So we really tried to start thinking about the whole soup to nuts approach to seismic risk.

In the program plan we've separated these out into separate areas. Of course the earth science and natural hazards which you all have heard a lot about so far and where a lot of the current research, ongoing research has been targeted.

The earthquake engineering portion of it. This is some construction, components and cell structure interaction. Of course geotechnics sort of sits in the middle of these two worlds.

And then also calling out certain international activities as well as regulatory guides.

So starting with and we are focusing sort of on the first part on the first part on the earth science and natural hazards.

I wanted to highlight these three projects, all of which are ongoing because I feel that these three projects, somewhat ambitious, taken together really provide us the state of the art baseline for really as we move into the next generation. So these include that source characterization. So what is the seismic source database? And that's being looked at through a project called the Central and Eastern U.S. Seismic Source Characterization project for Nuclear Facilities. You've heard about that a little bit. You'll hear a lot more about it tomorrow as Larry Salomone is going to present it. I'll talk about it a little bit in terms of the NRC perspective on it.

Okay. So that's the sources.

The second thing is okay, given this source producing some magnitude earthquake and the distance from my site to that source, what are the motions I'm going to see? And those are those ground motion prediction equations. That's being looked at

through a project called the Next Generation Attenuation Relationships for the Central and Eastern U.S., which is following up on a very successful program that was earlier taken called the NGA project. Now it's being called NGA-West. And actually, it's going to be followed by another project called NGA-Subduction which is going to be looking at Subduction in the Pacific Northwest.

So we're sort of now sandwiched in the middle of these three major projects.

MEMBER APOSTOLAKIS: Now this NGA project is that an NRC project?

DR. KAMMERER: Yes. We'll talk about it. But we sort of started the project but now it is a collaborative project among multiple agencies. And I'll talk about it in a little bit more detail.

MEMBER APOSTOLAKIS: Okay.

DR. KAMMERER: And then, of course, both of those fit into this framework which are the SSHAC Guidelines. This Senior Seismic Hazard Assessment Committee Guidelines which Dr. Ake and my group will be talking about in detail a little bit later.

That project was one in which we held a series of workshops where we got together people who had either been involved in the development of this

framework or had been involved in undertaking projects that had been performed using the framework. And it was interesting, because the first thing that all of these people, we had I guess generally abbot 50 experts in the room. The first thing that everybody says is we don't want to touch the SSHAC Guidelines. They are really an excellent starting point and we don't want to touch them. What we really need are guidelines on how to apply them. And I think that really says a lot for the group that put them together originally because everybody --

CHAIRMAN POWERS: All right. You can make my wife miserable if you want to. Ake was one of them

DR. KAMMERER: Oh really.

CHAIRMAN POWERS: I will get you for this, Annie.

DR. KAMMERER: Sorry. I think it shouldn't refer to your guys.

The way it's kind of worked is that the SSHAC Guidelines are sort of like the Constitution of PSHA and now we're writing the laws by which to undertake them.

CHAIRMAN POWERS: Like Moses.

MEMBER APOSTOLAKIS: I'll tell you those tablets were pretty heavy.

DR. KAMMERER: You're hear a lot about them, but to me that's been, I would say, one of the most interesting projects that I've been able --

CHAIRMAN POWERS: I want 10 percent of whatever he paid you to stay that.

Let's move on quickly.

DR. KAMMERER: Okay. So I'm going to start with the projects. I'm going to go a little bit into these projects.

The one in the middle. You saw this slide before. And, again, this relates to those ground motion prediction equations. So given the magnitude in distance what does that mean for my site? And we're looking at 2012, 2013 for these models, that timeline the deadline is actually has been set by the U.S. National Hazard Mapping Program. The USGS is one of our partners in this. And they have six years to get out the next set of maps, and they are intending on using these. And so this is sort what we're working towards in terms of the timeline.

Again, this is all about what does it mean for my site. And, you know, the important element is not only getting sort of these relationships in terms of the best estimate, but also that characterization of the uncertainty. So this is the product that we're

working towards.

This is covered out again, you know, in the idea of taking other people's great ideas and following up and piggy backing. What we're doing is piggy backing on a project called Next Generation Attenuation Relationship, which was a program out at the Pacific Quake Engineering Research Center, a person out at UC Berkeley. It's a nine consortium university center.

And the original study was funded by a variety of groups including CalTRans in which they tried to take all of these sort of whole suite of ad hoc relationships that were developed by a whole bunch of different people and come together with a unified database, talk about the assumptions that the different modelers were making which were leading to differences. And to try to develop a unified approach.

So the first thing they did was develop this really fantastic database and put a lot of effort into looking at all of the data and really making the database very, very high quality and looking at their technical basis and assumptions.

And you can see what some of the relationships or the spread of relationships look like

before and then after. And you'll see that the epistemic uncertainties, the differences between the models were reduced and they were better characterized.

Now I would mention that the goal of the project, that this project and our project is not necessarily to reduce epistemic uncertainties. Is that you don't want differences in your models because of a lack of data. And if you can bring a more robust data set and reduce your modeling uncertainty that way, that's very desirable.

MEMBER APOSTOLAKIS: Well, it appears though if you take literally what you have there that the result is not -- I mean you don't get the reduction in uncertainty, so maybe you have a better model because of new knowledge. You're getting it more because you have negotiated among yourselves and you have agreed on a standard database and assumptions. I mean the next slide also says that you will common standard assumptions.

So I'm wondering is this really true? Maybe I am not understanding very well what you're doing. But is it the situation where the groups finally got together and said enough is enough and let's agree on some common assumptions and data. And

then of course you will have smaller uncertainties and--

DR. KAMMERER: Well, an uncertainty with the data was a big part of that. And we said NGA-West, we're already undertaking pulling all of the data together for NGA-East. And we see it also in the CEUS SSC project. The first order of business, and really where a lot of the emphasis is going, is pulling together all of this information into a, in that case, a single GIS database where you can really look at all of these different types of data together.

So I mean I do think we have to be very careful in not somehow artificially reducing that scatter.

MEMBER APOSTOLAKIS: Yes.

DR. KAMMERER: Originally we actually did have the whole series of proprietary database so there wasn't that overlap. It wasn't that -- there were people working from the same database but somehow working baselining the different data points differently or something like that. There was really a lot of many more databases with fewer information, and there was a different level of care given to data processing.

MEMBER APOSTOLAKIS: This is something

that has bothered me for a while, not in the context, but I remember when were talking about model uncertainty in reactors. All of a sudden there a document that says there is no model uncertainty in bumps in failures because we have agreed to a common margin.

When the community or the different groups agree that this model is probably the best, does that make model uncertainty go away? And I see here again, you know, "mutually agreed," "standard agreed," "standard and complete." Is it the same situation?

At the same time, I don't want to knock it down because, after all, there are other areas where we are using routinely one model and the community has agreed that this is that model. So there is some validity to that argument, but I would hate to think that important model uncertainties go away as a result of a negotiation.

MR. CHOKSHI: But I think generally, I think is one of the results of better interactions and feedback activities. So the people with different interpretations --

MEMBER APOSTOLAKIS: And professionally I understand that.

MR. CHOKSHI: So I think that's a part of

the team's original, because they have this chance of lock model and developing understanding. And I hope that is what is reflected, not the --

MEMBER APOSTOLAKIS: It's a matter of removing --

MR. CHOKSHI: And that's what I thought you were trying to --

MEMBER APOSTOLAKIS: perception, so to speak. You know, I really never paid attention to your model, so I don't understand where you're coming from.

DR. KAMMERER: Yes.

MR. CHOKSHI: And we saw that. That's different. And we saw that in Livermore when we went back.

MEMBER APOSTOLAKIS: We did see that. But, again, by looking just at the words here I'm wondering -- this gentleman wants to say something.

MR. GRAIZER: If I can add a little bit to this.

CHAIRMAN POWERS: Identify yourself.

MR. GRAIZER: Okay. My name is Vladimir Graizer and I'm a seismic working for NRO, But I spent 14 years in California working for California Geology Conservator, which is formerly California

Division of Mines and Geology. And I got a chance to participate in NGA project for at least three or four years and looked what was happening. I just want to clarify.

The first step, and Annie has mentioned this for NGA-East. The first step was completely different from difference of opinions. It was a clear idea of cleaning the database. It was an idea of coming with the same data set. Because before what was happening all these modelers had an excuse to say oh I use different database, I use different data, I did different interpretation. This is not the case anymore.

They spent at least two years just to clean the database to come up with all information about faults, they're going to use about the distance from the fault, about the low velocity profiles; all of this stuff was summarized in one database, which is publicly available.

This is why basically they reduced this part all empirical data are very clean data. And this is why reducing uncertainty in this case was partially done because of the database which is much more robust.

MEMBER APOSTOLAKIS: So what you're saying

is that the reason we had a number of different of models was because people were using different data?

MR. GRAIZER: This was one of the reasons.

MEMBER APOSTOLAKIS: One of the reasons? Yes.

MR. GRAIZER: This was only one of the reasons. And different database, different interpretation. For example, magnitude. People were using -- was using before ML local magnitude. Now it's an agreement that everybody are using same moment magnitude. Nobody uses other magnitude in this generation.

They use same distance from the fault. Before, for example, some people were saying that oh I think that this fault, this first break happened at the distance of five kilometers. And another modeler was using distance of three kilometers. And they didn't talk to each other. They had different databases Now they use same database. They use same distance.

MEMBER APOSTOLAKIS: Which presumably is the real distance?

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: Yes.

MR. GRAIZER: Yes. It's the best estimate

of --

MEMBER APOSTOLAKIS: Well, I don't understand why somebody would say 20 and another guy three.

MR. GRAIZER: I can explain this, but it will take a lot of time. Basically in one sentence, it's much clean now. It's a consensus issue and they use best publications, best science available now for getting clearer direct answers.

MEMBER APOSTOLAKIS: I guess the question is is it still the case that different people may make different assumptions after they have the common denominators and everything?

MR. GRAIZER: Oh, yes.

MEMBER APOSTOLAKIS: These assumptions are reasonable, you know. And one guy thinks his assumption is dominate, the other guy thinks not. So do we still have situations like that?

MR. GRAIZER: We still can have a situation like that.

MEMBER APOSTOLAKIS: You do.

MR. GRAIZER: We do. If you look at the attenuation models, if you look at the real field, real field is very close. A comparison is beautiful, but if you look at the end, at the -- distances --

MEMBER APOSTOLAKIS: Right.

MR. GRAIZER: That's exactly what you are talking about. Because some people just are talking about lab's distance data to be biased, like -- they actually did use lab distance basis.

But okay. Short answer yes. But it mostly effect lab distances.

CHAIRMAN POWERS: So if I want to have low epistemic uncertainty, I locate my nuclear power plant as close to the source as possible, right?

DR. KAMMERER: Epistemic, yes.

And so I think a really important point here is they originally started this project trying to get to one relationship, and they never got there. And in part because of this, and in part because there was as they worked through this and you know it is undesirable for us to try and resolve some of these things which truly part of the epistemic uncertainty. And so they stopped it at five and we're really, you know, sort of taking the same approach.

You know, I think Vladimir's evidence to the fact that the NRC has been very, very fortunate to be able to get folks with a lot of experience that have come from other areas. He came from California Survey. We have a second CGS staffer that we were

able to recruit away who is over at NMSS looking at Yucca Mountain. And so we've been very fortunate to be able to have his expertise in house. And we're hoping that he will help some of the scientific overview for NGA-East.

Okay. And of course, as I just said, this is following up on the original NGA project approach. I was still in consulting at the time that this was really going on. And I found it extremely useful as a practitioner to have this project going on.

And we're still trying to keep the standard agreed upon assumptions or sets of assumptions. You know, as we move to the east the database is not as large, and so we're also going to need to be doing some modeling. And so there's a lot of questions that we need to work on in terms of some of the technical issues related to that. The database.

We started this work with a small development program which was undertaken to develop the project scope, to schedule budget and to bring in multiple sponsors in a broader -- our community. And I think that's where the project was the last time I presented to you.

So we have now completed that and we've

started the full project. The development of the project consisted of three workshops. The first one was an invitational workshop with all the people who were working on ground motion prediction equations to try and wrap our heads around what this would take in terms of the schedule and this project's scope.

The second workshop was with stakeholders and potential partners. And that was help in D.C.

And the third workshop in the development project was held out at the PEER center and was open to the entire seismic community. And we got a very large turnout for that and it was very productive.

And I want to mention in terms of the second workshop that was held in D.C., that was a time when we were exceptionally spaced challenged here in these buildings. And so even before we implemented the full project, we got some help from the NEHRP program and the NEHRP consortium. And NIST actually stepped up and held that workshop for us out at the NIST facility. You know, to help really be partners with us right from the very beginning. And we really appreciated that. It turned out to be a really fantastic workshop. We had a lot of different people there. And that really has led to cooperation amongst agencies.

So currently this project is being funded by not only the NRC, but also EPRI, DOE and the NEHRP Consortium, which is again the USGS, FEMA, NSF and NIST. And that's to improve the NEHRP program.

The USGS specifically is also providing in kind participation to both the development project and to the full project. So that was started, as of, I believe of September next year. And we're really moving down that path very quickly.

Even prior to the full project starting, we had identified some preliminary critical path activities. And we did start some technical work on those, principally with the USGS Dr. Ake you'll hear from a little bit later is the Project Manager working on those.

So some of the technical basis for the assumptions in the modeling, things like stress drop and we also did start an initial work in pulling together that records database.

We're currently working -- starting some work the Canadians to bring those databases together to really make these relationships from North America and not just the CE U.,S. And we're also working with Australia getting some Australian, India and other countries as well. And starting to do some of the

same sort of data cleaning work on the records that was undertaken for NGA-West.

So I wanted to touch very quickly on the CEUS SSC project. You'll hear a lot more about it tomorrow, but I wanted to just touch on it from the NRC perspective.

This project, we're in the middle of it now the CEUS SSC project. We're looking at a 20 ton deliverable for that. And again, this project is really a very cooperative project. There's participation from NRC, DOE, EPRI is actually the project manager, the USGS is participating with our support. And there are a whole array, a huge number of specialists in this area which are involved in this project in one way or another.

MEMBER RAY: Is industry funding the EPRI work?

DR. KAMMERER: Yes

MEMBER RAY: Okay. So that's their participation, industry?

DR. KAMMERER: Yes. Yes. And NRC and DOE and EPRI are the funding agencies under different precedent work. I think from our perspective it's going very well, which is not to say that we haven't had a lot of comments, interaction. And I think we're

the precipitatory peer review panel for this project. But in general, you know, we're really in the heart of it and it's going very well, but certainly there's a lot of work to do ongoing.

As you'll hear, it's a shock level-3 study and you'll hear details of what that means in the presentations upcoming. Again, the whole goal is to develop a new seismic source database to be used as a regional model. This will be a replacement for the existing EPRI SOG as a baseline. And it will serve that same purpose.

It's the starting point for the PSA for applications. The applicant will still have to study the local sources and incorporate their local information as they do now. So that's not going to change.

DR. HINZE: Will this have a chance of going into a reg guide like 1.208 as a starting point for analysis?

DR. KAMMERER: Yes. Yes.

DR. HINZE: Will that supersede the previous efforts?

DR. KAMMERER: Yes.

DR. HINZE: In the regulatory guide?

DR. KAMMERER: Yes. I would say so. I

mean that's really why we're putting so much effort into it is it's an opportunity for us to really put something in place which would make things much more efficient on both sides. So, yes.

And to the point where we got where we want to update that regulatory guidance, not only with this but many other things that we're talking about like the geotechnical engineering, we would definitely do that.

As I mentioned before, one element of this whole project which I think is extremely valuable is a program that we've put together, NRC and EPRI collaboratively, called the International Observers Program. And the idea here is to sort of have a structured program to invite people from other countries who are interested in this kind of work and they come from a variety of groups, either regulators or industry, or you know people that we thought would benefit. And to come in as observers to this program.

We meet with all of the international observers, program participants the day before the shock workshops, the CEUS SSC workshops to explain what's happened since we last saw them, to talk about how these particular workshop which they are about to see feeds into the broader program to allow them an

opportunity to ask questions. And the idea here is really to give people an understanding of how it undertakes a shock informed study to give them sort of some firsthand observational knowledge of how these would happen. And in some cases as they go back to their countries and undertake these kinds of things, to help them be more efficient in the work that they're doing.

And I tried to remember all of the countries that we have participating. France, Germany, Canada, Switzerland, South Africa, Japan. Is that all?

And we've also invited a number of young Americans in the field to really help to educate the next generation of researchers that are working in this area.

DR. HINZE: Are we getting any feedback from the international observers that is of use to us?

DR. KAMMERER: Well, you know, probably not. They find it very useful so we getting a lot of feedback in that they -- that type of thing. As far as information they're providing to us that will change the way we're doing things, I don't think that that's necessarily true. But that sort of wasn't the goal. The goal was to --

DR. HINZE: I understand what the goal was, but you know there is a reciprocity here.

DR. KAMMERER: Yes.

DR. HINZE: Do they write reports as a result or do they comment in written form as a result of participating in these workshops?

DR. KAMMERER: I think we'd like to have them to do that at the end and provide us feedback.

I think we'll eventually see it feedback in that some of these folks are going to take on some of these projects and we'll be able to also learn from their lessons learned; what went right, what went wrong as they're trying different things.

And certainly we're also including that now in the CEUS SSC in that at the very end of that, as you're of course aware, we're going to be doing sort of feedback and feeding back. Because we have recently undertaken this shock implementation guidelines project and out of that came a whole series of recommendations on sort of best practices on how to undertake these studies. These are being implemented in this project already. And so we'll also close that loop and say, okay, how well did these other ideas work in terms of the actual limitation. And eventually they will -- and some of these countries do

follow behind us and do these kinds of things, they'll feed back into us.

And we're hoping that in the future we get less -- we spend less time arguing at IAA workshops and things like that. That ultimately would be a very valuable outcome in the end.

MEMBER APOSTOLAKIS: So what would you do if the international observers object to something you're doing?

DR. KAMMERER: Well, it's --

MEMBER APOSTOLAKIS: Just because they're international that doesn't mean they're wise.

DR. KAMMERER: No. Well, I completely agree. I mean they're observers, they're not participants.

MEMBER APOSTOLAKIS: But what if you say well gee you guys don't know what you're doing in this area. Do you --

DR. KAMMERER: Well, there was some of that first. So now anything would be improvement. If we win some hearts and minds, then that will be a good outcome.

MEMBER APOSTOLAKIS: I think you have to be a little careful with what the role of these people will be.

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: When you receive public comments domestically you must respond, right? If you publish a rule or whatever, then the staff is under obligation to respond.

DR. KAMMERER: Sure. Sure.

MEMBER APOSTOLAKIS: You don't find yourself in this situation here.

DR. KAMMERER: Right.

MEMBER APOSTOLAKIS: So what exactly would these people do? What would their authority be? Do you have to respond to every single thing they say?

DR. KAMMERER: No, no, no. In fact, we haven't even been --

MEMBER APOSTOLAKIS: And so do they understand that?

DR. KAMMERER: Yes. We made it very clear at the very beginning that they were here only as observers and that they were here to, you know, better understand the process, to see us do it. But we made it very clear from the beginning that they were observers and they were here for their own edification.

So, yes, we have no obligation to respond to any of their comments. Again, some of this came

about because of the whole deterministic probabilistic fights that we were having. And, you know, some of the comments which were coming from the outside about shock. And we thought that maybe if they saw us undertook the process, it would be more -- they would understand it better, it would be less of a black art to them. You know, they would maybe even think it's great and apply some of these in their own countries. And we are actually seeing some of them in that direction.

So, you know, because this a shock level theory, and again you'll hear what that means in a minute, there is a significant need for a lot of ongoing involvement by a lot of parties. And so you'll see this slide again tomorrow, but I just wanted to point out that there is a lot of cooperation in this, not only in the management and the funding, but also really in doing the work.

There are a whole bunch of folks that are, you know, throughout this program. You know, because of the nature of this meeting I'll point out Bill Hinze is on our participatory peer review panel and has been a tremendous asset to us. And in frank is providing so much input --

CHAIRMAN POWERS: You're doing it to me

again, Annie.

DR. KAMMERER: I'm sorry. I'm sorry.

CHAIRMAN POWERS: I do have to live with these people.

DR. KAMMERER: No. I mean he's been a tremendous asset.

CHAIRMAN POWERS: Give him some marginally adequate --

DR. KAMMERER: He's been a marginally adequate --

DR. HINZE: Met expectations.

CHAIRMAN POWERS: Met expectations.

DR. KAMMERER: -- so he's been acting as a resource expert.

You'll hear from Jeff Kimball shortly. You'll also hear from John Ake shortly. Martha Shields, the DOE financial representative is here in the audience. And I'll point specifically that Cliff Munson is acting in the role of the NRC's technical sponsor representative, which is a really, really important role because he --

CHAIRMAN POWERS: He's got the money.

DR. KAMMERER: He is really the voice of NRC processes and procedures and rules in terms of this project. So his participation has been really

important.

We also have Gerry Stirewalt who is over there at NRO as a technical resource. And you'll probably recognize a lot of names from this list.

Don Moore our industry and Carl STepp industry who many of you are familiar with. Carl is the co-chair of the participatory peer review panel.

And Mark Petersen is the head of the USGS National Hazards Mapping Program. So there's actually a very strong peer review panel.

The participatory part does not mean that we're actually developing the model, but that we participate in review throughout the process. And as I said, we have put the capital on the participatory. We've been very, very participatory, I think more so than anyone participated.

CHAIRMAN POWERS: What you mean is your peer review panel has been suborned by the activity here?

DR. KAMMERER: I'm sorry?

CHAIRMAN POWERS: Meanness thought.

DR. KAMMERER: It's going very well.

MEMBER APOSTOLAKIS: Well, in many respects the ACRS is a performing participant. Because we are reviewing projects when they start, in

the middle, and at the end.

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: Right?

DR. KAMMERER: Yes, exactly. I would have to agree with that. And for some reasons as you guys, it works well.

So that's the main -- the sort of framework. But we also have a number of individual projects that we're looking at in terms of seismic source characterization. And what we focused on are some areas that we did feel had opportunities to reduce some of the uncertainties, significant reductions. And these were really projects that we took on for a variety of reasons. A lot of them are sort of bigger than a single application or plant or owner. And so it was something that was appropriate for us to do.

You've heard a lot about the paleoliquefaction and the liquefaction and so we have a fair amount of work going on in that area. Both with some of the work looking at New Madrid and better characterization of magnitude.

There are also east Tennessee. As I mentioned, that was a project which was actually sort of planned to us from the USGS. And there is also

some field work going on looking at paleoliquefaction facts which have been identified through use of -- good old Google.

There's also some work by the USGS in looking --

CHAIRMAN POWERS: Annie, am I correct in saying that the original EPRI SOG did not include east Tennessee.

DR. HINZE: No, it did.

DR. KAMMERER: It did. It did. This is really additional information that we're gathering. Looking at some areas which were identified as topics that could better inform our characterization of these sites and might end up in a reduced level of uncertainty.

So I want to mention the site points because it's really interesting work. You might be familiar through Yucca Mountain as the sort of idea of these naturally occurring seismoscopes or basically things in the natural world which might be able to constrain motion over time either as a minimum or as a maximum. You know, in that case you were looking at precarious rocks and using that sort of as a reality check on what the maximum motions could have been.

These speleotherms are these little straw

like features which occur in caves. And so we have some cavers at the USGS that we're looking for areas where you had these straw like features where you had -- you know, the entire cave had basically -- you have these features sheared off at the same time. And they can actually be dated sort of like tree rings.

So the idea is to look at those to try and get an idea of intensities out away from the source. And we did a little pilot study to see if they could actually find some, and they have. And so it's pretty interesting work. We're looking forward to seeing some of that work.

I mentioned that Charleston, and that's the Virginia Tech work and there was some seismic lines field work that were done quite a while ago. And at the time when they looked at these, what they were looking for was the actual rupture plain of the Charleston earthquake. And at the time, you know, computing resources and everything being what they were, they were inconclusive.

Well, Martin Chapman at Virginia Tech, of course pulled these things up. Looked at some additional lines that had been taken by Virginia Tech in the intervening years and used the more modern processing tools to relook at them and found some

really interesting information that might align with some of the physical elements of that earthquake, like the jogs in the roller tracks.

And so this was something actually that went into the NEHRP external grants program. And they said, hey, the NRC actually funded this work originally. It would be interesting if you went back to them with this. And so we had them come in and show us the original line and we are very interested. And so we actually did pick this up from the NEHRP project. And so right now we are doing reprocessing of all of that original NRC work to try to find the rupture plain and any other faulting that might come up. So it's a really nice project.

And this actually was presented at the CEUS SSC workshop when we were looking at the different types of data.

DR. HINZE: Is the USGS looking at their offshore work? I know there's been a lot of interest in the faults that occur out there and as a result the seismic zone has moved out into the ocean? Is anyone reprocessing that? Because that was pretty probative long time going?

DR. KAMMERER: I don't know. Not my knowledge either. It would certainly be very

interesting.

DR. HINZE: Good project.

DR. KAMMERER: Yes.

DR. HINZE: Because it might solve the problem of whether -- how far --

DR. KAMMERER: Right, how far off does it go?

CHAIRMAN POWERS: And equally interesting is for some reason there are seismic zones respect national boundaries, which I find remarkable.

DR. KAMMERER: Yes. We're definitely looking at changing that. Certainly, as I mentioned, NGA-East is going to be the North American attenuation relationships. And similarly we actually did have at the CEUS SSC workshop a Canada representative presenting the Canadian information as well. And so we're definitely trying to work a lot more collaboratively so that we don't have these differences across the border.

MEMBER RAY: You certainly have offshore data on the west, as you know of course.

DR. KAMMERER: Yes. Yes.

MEMBER RAY: Very extensive.

DR. KAMMERER: Yes. And we do have it as well -- I'll talk about it a little bit in terms of

the tsunami work that we're doing. There's been a lot of very high resolution multi beam which has been recently at the east by NOAA as part of the Law of the Seas work. And we're looking at that in terms of identifying potentially tsunamigenic land slides. And so that would be something that could definitely be brought in.

And in fact when the CEUS SSC project got started I did make a connection between our USGS people at Woods Hole who are helping us with this tsunami and the TI team, the technical integration team doing the work on this to see if there is anything and what we'd already done that they could use as part of this project.

You know, clearly we really always need to keep an integration with anybody else who might have information that we should use.

I guess I would mention speaking to Bill's quaestio earlier about the databases which are available to our staff in reviews. One of the things that Martha at DOE and I worked very closely on in terms of our funding for CEUS SSC is making sure that that database which is produced as part of that project is a publicly available product. Because as you know, there's been a huge amount of effort put

into that. And it is going to be one half of the product I think in and of itself in the end. And so we are talking to USGS or some other group in taking over really management of that. But it's a big database and so there's that opportunity.

And we are looking at some national project as well. We're working with the USGS in better understanding the advanced ANSS, the seismic system and how it interfaces in a variety of ways.

With the CEUS SSC project we are sponsoring paleoliquefaction guidelines. A white paper to be developed. And we're looking at intensity and magnitude correlations out in some of the offices in the west.

This is some ongoing work, which will feed into the CEUS SSC project in some cases or our long term.

One of the things which we have now completed and we're finalizing products on is in a workshop on maximum magnitude. M_{max} is basically when you look at each source and its range of possible magnitudes and how often things occur, M_{max} is where you cut it off. You say okay, it can get to be this big.

It's an issue for area sources in the CEUS

because we look at such long return periods, this comes into play. And sort for that reason there wasn't a huge amount of work before because if you look at the national hazard maps where you're looking at 500 years or 2500 years, there was an impression that it came into play a lot less where it does.

MEMBER ARMIJO: What is the return period you use to pick out M_{max}? Is it 500 years, is that the--

DR. KAMMERER: No. You look at what its possible of over any time period. So you have to look at the rates of these magnitudes per year versus the magnitude. But you don't cap it based on some return period. You cap it based on what the fault could possibly do, but you try to assign it a rate that reasonable with that. So, you know, you say it could be this big but it only happens every million years or whatever.

So basically there was a limited technical basis because there hadn't really been for a long time, again you had a lot of people looking in different areas, there hasn't been a lot of funding or emphasis on it. There hadn't been that integration. So what we did is we got all the people who had worked on it in the past into a room. For the most part we

were missing a couple of people. And we talked about all of the different approaches that we had taken in the past.

And the results of this workshop would have interested both the USGS hazard mapping group as well as the CEUS SSC project which is characterizing these sources. And so we had a lot of people involved with that.

MEMBER ARMIJO: Was your objective here to develop the optimum methodology for a particular characteristic site or is this to define maximum magnitudes for the U.S.?

DR. KAMMERER: It was for us to discuss the approaches and what people thought about the many approaches that had been used. So let me get to that in just a second.

MEMBER RAY: Before you do, though, what you just touched on is related to what I was trying to get at earlier. Where there are a lot of earthquakes in the west people feel like they have some better handle, I perceive --

DR. KAMMERER: Yes.

MEMBER RAY: On what the M_{max} would be than they do in the east.

DR. KAMMERER: Yes.

MEMBER RAY: And the NRC's recurrence interval is so -- well, you just pointed out it isn't recurrence interval, but anyway the time that you're concerned about is so long compared to what most people are concerned what --

DR. KAMMERER: Right.

MEMBER RAY: -- that I just wonder what the applicability of the existing databases that you've been referring to is. But now this is finally getting to the point of if you could derive an M_{max} in the east --

DR. KAMMERER: Yes.

MEMBER RAY: -- I guess it would be based on some model of the source that you derive from the--

DR. KAMMERER: Well, it turned out there is a whole bunch of ways to do it in the east. It's a lot easier in the west because you do have -- you can identify the faults and so you can look at the physical constraints and what --

MEMBER RAY: Right. Right.

DR. KAMMERER: the physics possibly are.

MEMBER RAY: But if you try and do it in the east I was just wondering, that's what I --

DR. KAMMERER: There's a whole bunch of approaches as it turned it. And so we went through

all of them basically. We had presentations on the pros and cons of all of the approaches.

So we started this workshop, even in preparation for the workshop by first coming up with a foundation document that reviewed all the past work and said that these are all of the things that people have done in the past including a lot of work that was done for EPRI, what the USGS had done, the papers that were published. So we look at all of those possible methods.

We also had the USGS undertake a sensitivity study to see how much is this feeding the uncertainty. And it turned out it was more than we had actually expected.

So we provided this foundation document so that all of the participants -- where we're not only at the work that they done, but the whole breadth of work that had been done in the past to all of the participants. Gave it to them beforehand and it was also downloadably to the public. It was downloadable to the public.

For this workshop we did sponsor some key researchers to participate, but we made it open to everyone. And we had a pretty good group. I think we had about, I don't know, 50 people maybe. Yes.

Including a lot of NRC people, a lot of industry people. It was a big group of people.

MEMBER APOSTOLAKIS: So what is the result here? Is it a process for developing the magnitude, the causes for developing a distribution for magnitude?

If I pick a plant, a site in the eastern United States and I want to estimate M in max, then the results of this workshop will guide me to collect information, to do evaluations and then at the end say it's a distribution of this shape --

DR. KAMMERER: Right. Exactly. So what we did, you know what we ended up with at the end after discussing all of these options was this consensus table. And we ended --

MEMBER APOSTOLAKIS: What you ended with?

DR. KAMMERER: Well, no, because it was a whole -- well, you'll see. But what we ended up with was separated into a bunch of methods and then a bunch of overall approaches.

So, first of all, how can you get all of the different possible distributions of the different things that you can look at that. And the second thing was how does that fit into an overall approach of getting your ultimate distribution or whatever

you're going to use.

So we talked about -- and I actually did bring the exact table we ended up. So we ended up separating things into things that we just don't -- methods we just don't find acceptable anymore. So what we did set out this is absolutely still a viable approach. And then some other things we say: These are promising but they're not there yet, and so maybe we want to bring them in, but with a very high level of uncertainty or a low weight, or whatever.

So, for example, one of the methods that we did not find acceptable is a method in and of itself is the past observation, because we're looking at these very long term events. And so unless you're maybe looking at Charleston or maybe looking at New Madrid or something, you can't just say well I saw -- although it's useful as part of the Bayesian updating approaching which we talked about. So we really separated into three veins.

Okay. We're just not going to use this anymore. This is absolutely going to be one of the ways in which we look at this, and then there are other things where we might want to invest some resources in improving techniques.

MEMBER APOSTOLAKIS: How many acceptable

methods were there?

DR. KAMMERER: I don't know. Maybe five or six.

MEMBER APOSTOLAKIS: Five or six?

DR. KAMMERER: In the end.

MEMBER APOSTOLAKIS: So if I use three of them, I'm going to get three different results or do the results tend to be similar?

DR. KAMMERER: I think generally they tend to be similar.

MEMBER APOSTOLAKIS: So it's just a matter of picking one that you like?

DR. KAMMERER: No, I wouldn't do.

MEMBER APOSTOLAKIS: I don't understand. I mean you have five acceptable methods. Is that a sign of model uncertainty again?

DR. KAMMERER: Well, there's just a lot of things. There's a lot of ways to do it. There's the empirical approach, there's the physics-based approach, you know. I mean, it's not sort of dissimilar from --

MEMBER APOSTOLAKIS: Why couldn't you have a meeting of the minds and say, well gee, you know these guys and these methods are doing this very well and try to mix --

DR. KAMMERER: I mean, it's untypical in the way that we'd approach something like geotechnical engineering. You have all these methods. You look at all the methods and you look at the results you get from all the methods. And you say, okay, this is the range that we may end up. So you don't want to just say it's one or the other. I mean, you want to look at a lot of them and see what your distribution --

MEMBER APOSTOLAKIS: Are you asking people to apply more than one?

DR. KAMMERER: Yes.

MEMBER APOSTOLAKIS: That we see from an applicant?

DR. KAMMERER: Yes, yes, sure.

MEMBER APOSTOLAKIS: Do you have to use all five?

DR. KAMMERER: Well, this is going to be done in terms of the CEUS SSC project. So it will end up as part of that source characterization database. And we may end up with multiple options, multiple branches of the decision tree that say maybe it's 5½, maybe it's 6. Well, probably not 5½. So we'll have a distribution and different ways to do it.

MR. MUNSON: If I could jump in. Well I just wanted to briefly mention we don't pick at M_{max}

for a site. Sites don't pick maximum magnitudes. They used to under the old deterministic approach. Now we use a probabilistic approach where we have a PSHA where we consider all seismic sources. And for each of those sources we have to pick a distribution of M_{max}.

MEMBER APOSTOLAKIS: That's right.

DR. KAMMERER: Jon, do you want to--

DR. AKE: Yes. This is Jon Ake with Office of Research.

I think your point's well taken. And as we move forward into the new updated seismic source characterization for these, that's clearly one of the directions we'll be moving. There are different methodologies to approach developing individual distribution for M_{max} and we probably need, and will likely be incorporating multiple different approaches because those represent truly epistemic uncertainty that we need to capture in the overall model and propagate.

So for each individual, as said, individual source zones you're liable to have multiple individual definitions of the maximum and the two distribution. So you capture, you know, the uncertainty in making that estimate as distribution

given, say, global analog as a viable approach. But that in itself is an epistemic uncertainty as opposed to the Bayesian updating, as opposed to looking at something like source dimensions.

So we need to propagate all of those things through the trees.

MEMBER APOSTOLAKIS: So this is still work in progress, right?

DR. AKE: Yes.

MEMBER APOSTOLAKIS: If I'm an applicant, I don't have your final work how to do that, you're still working with it?

MR. MUNSON: Well, individual applicants are using the EPRI SOG model. EPRI SOG used different approaches to identify ranges of M_{max} for sources. So the expert science teams, or science teams got together and decided this source should have an M_{max} from 6.7 to 7.2 with this weighting. So each source has different -- and by using six different teams we capture uncertainty.

MEMBER APOSTOLAKIS: Because this, as I recall, a critical parameter, is it not? It's an important parameter?

MR. MUNSON: Definitely.

DR. KAMMERER: It is an important

parameter.

MR. MUNSON: And I think if you're looking we've been very conservative in determining M_{max} for different sources.

MEMBER APOSTOLAKIS: Right. Okay. Thanks.

DR. KAMMERER: So it turned that we ended up separating all of these approaches into sort of individual methods to determine their number and then overall approaches. The approaches were global analogues. Again, you know, we don't have as much information in the CEUS as to what happened in the past. We needed to look up globally and to try and find similar tectonic areas. The Bayesian updating approaching was one that a lot of people found a lot of value in as a way to bring these together.

MEMBER APOSTOLAKIS: I don't understand why they are different. I mean, if you're doing Bayesian updating, don't you want to know what happened in other places?

DR. KAMMERER: Yes. And so what that generally is the global analogues are used as the prior and then you would look --

MEMBER APOSTOLAKIS: Yes. Okay.

DR. KAMMERER: -- at your minimum

magnitude and --

MEMBER APOSTOLAKIS: So these are not three different approaches?

DR. KAMMERER: No. They were just --

MEMBER APOSTOLAKIS: Things you are doing?

DR. KAMMERER: Yes. They were things that we were looking at. And then, of course, in the west we have the fault dimensions which is sort of the classical western technique looking at basically a physics-based approach.

So there was some discussion about geotechnical engineering earlier. And as you saw, there's a lot to geotechnics.

We have a couple of areas in which we're currently working. One is looking at the multiple methods in NUREG 6728 which look at the integration of site response directly into PSHA and actually making site response another integral in your PSHA calculations.

NUREG 6728 provided a good theoretical framework and provided several different options which increased in complexity, but also sort of in purity in terms of it being part of the PSHA. But, of course, they were only recently sort of implemented by different people as part of the new applications. And

so some differences in implementation have come up, even amongst the authors of 6728.

And so what we're trying to understand is how much of a difference does it make, how much does it move the needle? Are there areas of guidance that we can provide.

Another thing that we're doing is looking at the modeling tools for site response which are used currently. There are basically three general categories out there. Fully non-linear, things such as deep soil which University of Illinois has put out. The classical SHAKE and random vibration theory-based type response.

One of the benefits of the RVT, the random vibration theory, is that you don't have to use all of the time history analyses. And so it allows you to do a lot more realizations of, say, the site. It allows you to bring it into sort of a more advanced NUREG 6728 approach. And so we started with some work comparing these output of the different methods and also developing RVT software.

Again, the RVT software is something that CalTrans had originally developed for their own in house use. Once they were done we took over that project and we have expanded the software, brought it

in house for our own beta testing. We're adding additional capabilities in the software to better meet NRC needs. And we even had the doctoral student working on that come and do an internship with us last summer and it was very useful.

So these are our current ongoing projects.

And one of the things that is going to be a key topic of discussion at this retreat that we're having is where we are going in terms of geotechnical engineering. There is a lot of meat to it. And there are a lot of areas that we could be looking. I know every time that we talk about the agenda for that, Cliff and I look at each and the first thing we say is geotechnical engineering. And so this is something that I think we'll really be expanding upon in terms of where we're going to be going in terms of geotechnics moving forward.

So, again, geotechnics is sort of that boundary between the ground motion incoming and earthquake engineering. And so I'd like to just touch on some of where we are, either just starting or looking at going in the engineering side and also I've talked a little bit about our international activities and regulatory in terms of that because that's where some of it fits.

A lot of the way that we're looking at really developing, further developing the program in terms of seismic engineering is looking at where we are in performance-based, risk-informed framework. Of course we have 1.208 which is the front end of sort of a lot of the work of determining performance-based, risk-informed hazard inputs. And there's also ASCE 43-05 which is something that we would like to better integrate into our --- and so we're looking at ways in which we can do that. And we're doing a lot of review now into trying to determine how we want to move forward in terms of performance-based, risk-informed framework and what we do after Regulatory Guide 1.208.

I think a key thing that we talk about a lot is how this interfaces with seismic PRA. Because I feel like really, you know, if you're going to do risk-informed, the seismic PRA is where you really have to always be looking in the future as how does it integrate with the work in that area.

Some of the things that we're looking at in implementing the short term is looking at the different complex load effects in both the input and the response.

So non-vertically propagating waves, multiple dimensional effects in both the soil and the

structure.

And, of course, the high frequency and incoherent waves, doing some confirmatory work on that which follows up on a lot of the work that we have done over the last couple of years.

MEMBER APOSTOLAKIS: I guess I don't quite understand what you mean by the second bullet integrated application of seismic PRA in research. Can you elaborate a little bit?

DR. KAMMERER: Yes. One of the things that we are talking about a lot in terms of where we move forward, and I think it's going to be a big topic of discussion at our retreat, is are there things that we want to look at in terms of the performance-based work, the risk-informed work that I say point out areas of really keen interest in terms of the seismic PRA as well. You know, are there points that if you're going to do a seismic PRA where you have to incorporate this particular part and it has a very high level of uncertainty that we could be working on.

Like, for example, one of the things that is happening out in other areas of seismic research is looking at different parameters that are used for fragility or different approaches. And we just want to really look at what's going on in terms of PRA here

in the agency and elsewhere to see if there are special areas of interest. This is something that Nilesh and I talk about quite a bit.

MR. CHOKSHI: And I think it's more in terms of determining significance of things.

DR. KAMMERER: Yes.

MR. CHOKSHI: We want to use a risk-informed perspective. So, you know, then we value a certain research's results. So that we will make this a tool, a part of our tool to have --

MEMBER APOSTOLAKIS: So you do want the first bullet without the second --

MR. CHOKSHI: Exactly. Exactly. Right. So it's a different part of it.

MEMBER APOSTOLAKIS: Yes, right.

DR. KAMMERER: So maybe it's just stating the obvious, but you know it's something that we think about, we've been talking about it an awful lot.

MEMBER RAY: Well, do you use deterministic failure criteria, you know elastic plastic deformation of structures, for example, in looking at consequences?

MR. CHOKSHI: Our design process in there, if you look at the SRP requirements, those are deterministic, okay. But in terms of do you value it,

actually they are realistic responses and when the structure appears, we incorporate that in the seismic PRA.

MEMBER RAY: And there are data that enable you to do that accurately?

MR. CHOKSHI: Yes. In fact, that particular field is fairly mature and applied quite a bit.

MEMBER RAY: Okay. So displacements and so on that -- okay. That's --

MR. CHOKSHI: Yes. I mean, as you say, we have to look at both structural integrity type of failures as well as functional failures.

MEMBER RAY: Right.

MR. CHOKSHI: And so we have some test data on, for example, electrical equipment and we have studies for structures. And part of the thing that I think Annie's talking about it -- you know, and like anything else looked -- and you see there are things refined or need to be refined.

DR. KAMMERER: I think right now we're sort of in reviewing load on that.

In terms of the seismic engineering, the NRO reviews especially in the DE side are also informing our Research program. Some of the advanced

modeling techniques, the incoherency now they're looking at actually reviewing some of the applicant's applications which have come in which have the coherency function. And so looking at that.

Seismic instrumentation.

These are areas which when we speak to them at the retreat we'll be able to better I guess sort of develop the work that needs to be done.

There's also some work going on in terms of advanced reactor designs. Aging and degradation of materials under the new operating conditions. Our colleges Herman Graves have been working with degradation of materials and understanding what those mean.

Base isolation technologies and how we would approach review of base isolation.

As you heard, deep foundations and lateral earth pressures are some areas of interest. There's actually some very interesting work on lateral pressures which are being done in California as part of the Bay Area Rapid Transit to seismic analyses in which they're actually doing some physical testing. And so we might want to do some piggy backing on some of that work.

And looking at new construction techniques

as well. And so that's just being undertaken as part of advanced reactors.

A couple of things have come up in terms of Regulatory Guide 1.100 which is going to be out very soon, if not already. A couple of things -- and these are things that we're going to be addressing in house.

In-structure correlation coefficient and what that might be. There hasn't been too much work on that recently and we'd like to relook at that.

An NRO look of probabilistic reliability methods which again would feed back into sort of the work that's risk-informed and PRA-based.

And so those removed from the current version of 1.100 which is essentially a deterministic document. But we will be looking at that in terms of sort of this other part.

And international projects in terms of terms of seismic engineering.

There's a really nice project with GNES on testing on numerical modeling. Also Smart 2008 which is an international project looking at some data coming out of shaking table testing in France.

Kashiwazaki we've talked about.

And then the interface with international

regulatory guidance.

MEMBER APOSTOLAKIS: Do we still assume complete correlation on components of the same type at the same elevation? In other words if the fragility curve says .4 probability, condition of probability for this one to fail, that's the same probability that all of them will fail? We are still doing that?

MR. CHOKSHI: George, this is we put into more of the human qualification. This is the deterministic process.

MEMBER APOSTOLAKIS: Oh.

MR. CHOKSHI: When you test for two different directions of earthquakes, what should be the correlation of coefficient between --

DR. KAMMERER: Yes, yes, yes.

MEMBER APOSTOLAKIS: Ah. But we still do that, though?

MR. CHOKSHI: On the fragility. For adding on the PRA world on the presently theoretical components we still -- correlation. Right.

MEMBER MAYNARD: Most of the newer plants are incorporating much larger pools of water inside the containment. And depending on those are large volumes of water covered in some of this? Most of this seems to be more structurally oriented. We have

bigger pools at higher elevations.

MR. CHOKSHI: Yes. Those effects are modeled into the structural response analyses.

DR. KAMMERER: Right.

MR. CHOKSHI: And, in fact, those are recognized as one of the big effects.

MEMBER MAYNARD: I know they're factored into the analysis. I'm just wondering from the Research program is there any need or is that pretty mature --

MR. CHOKSHI: They're pretty mature. But you know -- associated with the larger bodies of like tanks and those kinds of things are fairly well understood.

DR. KAMMERER: Yes. Currently the only place that that plays into the seismic program is that the Kashiwazaki database does include information on the tanks and the pool, both. And so as we receive all of that, we will check the methods.

MEMBER MAYNARD: Is there higher dependency on the larger pools and there's also components in those pools --

DR. KAMMERER: Right.

MEMBER MAYNARD: -- that are being counted on.

DR. KAMMERER: Right. But certainly an area that could be looked at in terms of reliability.

I never get to tsunami, so I'm pretty much out of time. But I just wanted to mention that we also have a lot of tsunami work going on.

Again, we phased this into like immediate--

CHAIRMAN POWERS: Let me interrupt, Annie, and say that they're a contractor, USGS, and their first report on the tsunami I think you owe them a vote of thanks. That was an excellent report. I encourage members to look at it if you have not had an opportunity to see.

DR. KAMMERER: Yes.

CHAIRMAN POWERS: It certainly addressed the question that I put during the course of the early site permits to the extent that I think it can be. And I do recommend that report.

DR. KAMMERER: I agree. There was an original report and then they've updated it at the end of last year. Basically what that is is a summary of the source, all of the source information that we had.

Now they started with everything that they could collect in pulling that together with the idea that we needed a product sort of immediately as quick

as possible both for industry and also for our review.

And then we have longer term elements that we are now starting to work on. Right now we're working on eliminating data gaps through some actual field testing. And then working towards more of the probabilistic methods. So that's coming in the future.

And I guess just the thing I would mention is that a very nice occurrence now, the NRO staff in they hydrology branch, not this group but that other group, is actually working with the same set of researchers, USGS researchers and A&M for support of their work. And so it's a very nice interface because they did this work for us to try and get the tools in place which could be used. NRO is now basically working with the same group of people to actually do the modeling in support of the license reviews. And then what's coming out of there in terms of uncertainties and the real applications is feeding back into the Research program. And so it's a very nice interface between the Research activities and NRO activities. And it really is, I think, when we try to make products that are useful, it really is sort of the ultimate in that. And there's a whole slew of regulatory guidance which has come out of tsunami

program both in the past and moving forward.

And one of the future elements that we're going to be looking at is another NUREG CR on tsunami modeling tools and then also a tsunami regulatory guide.

CHAIRMAN POWERS: The puzzle why Texas A&M would be particularly adept at near shore modeling. That's the question that I had.

DR. KAMMERER: They're really good at land slides, too.

MEMBER APOSTOLAKIS: I thought Cal Tech was proposing to get an engineer research center to study snowstorms.

CHAIRMAN POWERS: And what?

MEMBER APOSTOLAKIS: Snowstorms.

CHAIRMAN POWERS: Of course. Why not?

MEMBER APOSTOLAKIS: The fact that New England won the center for earthquakes, they really were upset.

But are these regulatory guides coming before this Subcommittee?

CHAIRMAN POWERS: Would they come before this Subcommittee.

MS. HOGAN: The answer to that is yes, all regulatory guides come.

CHAIRMAN POWERS: I mean they come to the ACRS. He's asking an internal question on what subcommittee would look at them. And I would guess the Program --

MEMBER APOSTOLAKIS: Well, you select which ones --

CHAIRMAN POWERS: P&P would make the request and who they would request. It might really be in many Shack might be the one that looks at them. Okay.

MEMBER APOSTOLAKIS: Our Shack?

CHAIRMAN POWERS: Our Shack, yes.

MEMBER APOSTOLAKIS: I don't remember the last time we reviewed something related to seismic.

MS. HOGAN: 1.208.

MR. CHOKSHI: 1.208.

MS. HOGAN: It's the last time. That's a while ago.

CHAIRMAN POWERS: Yes. I can't anticipate which ones would come here and which ones go else where.

DR. KAMMERER: Yes. So these are a mix of NUREGs, USGS reports and NOAA reports.

Okay. So just to wrap it up.

We do have a research plan that's publicly

available and we are intending on updating that document shortly.

Our key drivers are really both the advancement of the state of practice and greater regulatory stability in the long term. And efficiency on both our part and the part of industry.

We continue to use an integrated risk-informed approach.

We include both short and long term planning or short and long term deliverables in the work that we're doing.

And we really do have a strong focus on consensus products or at least identifying the range of opinions and bringing all of those voices together and discuss that expert interaction, which you'll hear a lot about. And really bringing the multiple stakeholders and sponsors to the table. I think we've come a long way in terms of working with our other federal agencies and with industry in the last year. And I think it's produced a lot of really good results. And we really want to continue to look for opportunities in that direction.

CHAIRMAN POWERS: There's one feature I would highlight out of the entire program that you've outlined here is exactly that, is that you've gone a

long ways to get NRC and other agencies at least at the same table. Whether they're looking in the same direction or not, I don't know. But I think that's very good.

One of the things this Committee is going to need is a list of titles of what parts are active now.

DR. KAMMERER: Okay.

CHAIRMAN POWERS: And which parts are coming along. I mean, it's just a mechanical thing that we need to have in our hands.

DR. KAMMERER: Okay. Okay.

CHAIRMAN POWERS: And some of your plans are plans and some of them active.

DR. KAMMERER: Right. Right.

CHAIRMAN POWERS: And we need to have a distinction there.

It's just the way that the report is read by the Commission. They go through and look at what's active now.

DR. KAMMERER: That's great. And actually we just actually pulling that together as sort of some background information for the retreat anyway.

CHAIRMAN POWERS: And Mike will chat with you about some graphics that we need as well.

DR. KAMMERER: Okay. Great. And, again, thank you very much for the opportunity to come and show you some of these.

CHAIRMAN POWERS: We're not done yet.

DR. KAMMERER: So now I'll stop harassing you.

CHAIRMAN POWERS: You know I love it.

I do think it's useful for us to go ahead and take a break for lunch and come back. We have more this afternoon and then we'll have a discussion period to discuss what we've heard. I know Bill's raised some issues.

Did you want to raise your programmatic versus plan issue now just so that they can be prepared for it?

DR. HINZE: No. I think everyone is bushed right now.

CHAIRMAN POWERS: Okay.

DR. HINZE: I'd also like to raise a question for us that we've heard a lot, indeed almost exclusively about new power plants. We are seeing a lot of seismic issues raised here. And I don't hear anything about what is going to happen in terms of--

CHAIRMAN POWERS: That's a particular generic issue that, in fact, I kind of restricted out

of this meeting. Because it's a regulatory issue. And I wanted to give Annie a chance to lay out her Research program and not polluted by a particular regulatory issue. So I'm the one that's the guilty party here, not them. Because this is Research Program Committee. And we will get a chance to look at this one, I guarantee you.

DR. HINZE: Because Research certainly impacts.

CHAIRMAN POWERS: Yes. And in sense I deprived you of some of the context for all of the work that's going on by doing that. But I did it because that itself has its own set of particular concerns there. And I wanted to look just at this research program as an entity by itself. And so guilty as charged, but that's okay. I had promised Annie an opportunity to talk. And I know that's somewhat risky promising Annie an opportunity to talk, but she talks well. I enjoy her.

So let's break for an hour and come back at 1:00. It's not quite an hour, but close enough within the epistemic uncertainty of my clocks.

MEMBER APOSTOLAKIS: It depends on the Chair.

CHAIRMAN POWERS: And we'll hear more.

(Whereupon, at 12:02 p.m. the Committee meeting was adjourned, to reconvene this same day at 1:06 p.m.

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

1:06 p.m.

CHAIRMAN POWERS: Mr. Jeff Kimball from the Defense Nuclear Safety Board. Jeff, welcome.

MR. KIMBALL: Thank you.

By way of background, I've been at this for, in another month, it'll be 29 years.

CHAIRMAN POWERS: All right.

MR. KIMBALL: First four, or a little more four, were here at the NRC in Reactor Regulation back in 1080 to '84. I go back to the systemic evaluation program days with Leon.

Early the beginnings of PSHA were about that time.

From there I spent about six years working on the repository program both on the private side and the Department of Energy.

And then the past 19 working in some way related to the defense nuclear complex. Either for DOE or more recently for the Defense Board.

The topic, as you can see, is insights and experience with PSHA and performance-based design. It's a little bit of a different twist than you heard this morning. Although at the end of the presentation

I will bring it back to research priorities from my perspective. But in the course of this we'll also get into some of the, I will say, the PSHA issues that I believe exist today that are important to keep in mind, not just in terms of research but in terms of applying in this case Regulatory Guide 1.208.

And let me see if this works. How about that.

One of the key things this morning that was mentioned was regulatory stability. And I will touch upon that in the presentation.

I'm going to touch on four sites. I see this translation didn't get quite into the -- anyway, they're not quite lined up.

Anyway, I'll talk to you on four topics:

Performance-based design at the Department of Energy. And it's been around for a long time at DOE;

PSHA experience at the Savannah River site and why that's important in the context of executing performance-based design today, and;

Then PSHA issues relevant to the current application of performance-based design, and;

Then to say some closing thoughts related to the PSHA issues and high priority research needs.

I do apologize for the slides. Actually, I did this originally in PowerPoint 2000 -- the current PowerPoint. So I don't know if there was a translation issue putting it on your computer.

CHAIRMAN POWERS: Probably. We may behind the technology.

MR. KIMBALL: The hard copies I think are lined up.

CHAIRMAN POWERS: Are wonderful. Yes.

MR. KIMBALL: In any case, performance-based design in terms of history. You may have heard this. I'll probably speed through some of the beginning because, as I say, you may have heard it.

In the Department of Energy it was first published in 1990. The work actually goes back at DOE into the late '80s. But it was first formally published in a document from Livermore called UCRL-15910. Later DOE formalized that in a standard as DOE developed a more formalized standard program. That got published in Standard 1020 in 1994.

Most recently that standard from a seismic design perspective has evolved into the ASCE 43-05 and it definitely by going to ASCE got a broader community audience. The NRC participated on the Committee for example. And, in fact, as you're well aware the NRC

has essentially taken some of the concepts and brought it into Regulatory Guide 1.208 in their regulatory framework.

The key thing I want to mention here and what's common between all those documents from day one is that the concept of a performance goal. NRC has a concept of performance goal today. DOE has had it for a long time. And in a general sense it's a mean annual frequency of unacceptable performance. In Regulatory Guide 1.208 it's the FOSID. But everyone has that concept built into it.

And the second concept that's been --

MEMBER RAY: Excuse me. On that point --

MR. KIMBALL: Yes.

MEMBER RAY: -- because we were just talking about inelastic deformation

CHAIRMAN POWERS: Permanent.

MEMBER RAY: No, I do know that part. I would call it a deterministic criteria. It's viewed here as a failure criteria.

MR. KIMBALL: Well, NRC could best answer it in terms of Regulatory Guide 1.208. But classically and the standard view plan from a design perspective keeps things elastic. I think the context that if you establish the performance goal at the

boundary of where you would go in elastic, if I could say it, that you've still got quite a bit of margin or safety until you would get to loss of functionality for any kind of release condition. So I think --

MEMBER RAY: In a probabilistic world of consequences, how do you recognize what you just said?

MR. KIMBALL: I don't know you can quantify it directly. I can speak from my experience at DOE. And DOE does allow some amounts inelastic credit, if I could call it that. But you still get about -- until you get to a severe accident condition, you still get about an order of magnitude difference in frequency space. So if you set a target of a performance goal of one in ten thousand you're generally protecting from the severe accident perspective down to one in a hundred thousand.

Now if there are other accidents you have to look at, not that are the severest ones, that will be in between. But that's my general sense --

MEMBER RAY: No, that's very helpful.

George, did you have anything to ask?

MEMBER APOSTOLAKIS: I mean typically we-- I mean ideally one would like to have a distribution for capacity of the thing. So you wouldn't have it. But what we normally do is we have a regulatory limit

which is on the very low tail of this imaginary distribution. And it's like the 2200 Fahrenheit for the cladding. I mean, you don't have immediate failure. It's the onset. It's a regular --

MEMBER RAY: Yes. I'm just trying to get myself calibrated to the probabilistic outcomes where this is the input.

MEMBER APOSTOLAKIS: So there's margin -- margin built into the --

MR. KIMBALL: Well, you have to select a performance goal that protects the risk you're trying to -- you know, and that's the bottom line. And you're right about that.

MEMBER RAY: But I think your point about an order of magnitude difference between the severe accident and then the onset of --

MR. KIMBALL: As a generality.

MEMBER RAY: As a generality. Okay. That's fine.

MR. KIMBALL: The next slide will illustrate what's in ASCE 43-05 today. Better on your paper again. But in ASCE 43-05 they established for nuclear facility applications they have three seismic design categories. The seismic design category 5 or SDC5 is the one that NRC has basically hooked into in

Regulatory Guide 1.208. It shows that the mean frequency of exceedance or where you would set the design earthquake is set probabilistically and in ASCE there are two of them essentially at 1 and 2500 or 1 in 10,000 and then a mean frequency of unacceptable performance would grade between a 1 and 10,000 and a 1 in a 100,000.

The comments explain how the standard builds in that factor between the design earthquake and the performance. And it's through application of common codes and standards, or in the NRC's case the Standard Review Plan establishing conservative capacities and the whole process builds in that factor of safety essentially.

Now what I'm going to switch to here is that I'm now focusing on the probabilistic seismic hazard analysis issues. And from the history perspective, the early PSHA work at DOE focused on the central and eastern sites. And DOE does require site-specific probabilistic hazard at all its sites, including the western sites. But in the east, you know, it essentially used the early work computed Livermore Lab. And that early work was done as part of the NRC systematic evaluation program. So the birth or the origination of the PSHA that DOE did is

similar to what NRC was using for those early SEP sites. And that early work was published in 1984. You can see that's just past the time the SEP program I think had some of its publications. And DOE was using it. And you can see they were using it in advance of that UCRL document that came out in 1990. So DOE was actually using PSHA in advance of that.

That work was eventually replaced, just like we've heard in the reactor side, but it was replaced by both the EPRI SOG work and the Livermore work.

One thing I wanted to mention, is Livermore really has two dates associated with it. There was an original set of Livermore work. We spent an extensive amount of time at Savannah River trying to understand the differences between Livermore and EPRI. And you know there's a lot of history there. We found things out at the Savannah River site and came back to NRC at the time and basically said "Hey, here's what we found related to some of the Livermore that needs adjusting." NRC agree with us and between what DOE had done and then NRC sponsored work, NRC then redid the Livermore work in 1993. And that was put out in a NUREG publication.

So the Livermore '93 represents the most

update Livermore work, but an extensive amount went into trying to understand originally the differences between the two.

DR. HINZE: Were there changes made to that in the '93 one?

MR. KIMBALL: Absolutely. There were huge changes. Two main changes. One was at Savannah River we found that the original Livermore work, the experts had uncorrelated A and B values in the Richter recurrence curve, or the Gutenberg-Richter recurrence curve. And they were producing unreasonable recurrence times or certain seismic sources.

For example, at Charleston a magnitude 5 was every 80 days. That was actually sampled, you know if you looked at all possible runs that were done, that actually was picked as a run. And they were driving the mean hazard.

The other one that I know some people remember fondly was attenuation expert 5 was a big deal in the Livermore work.

In the '93 work Livermore used the expert panel to come up with what is called the composite attenuation model. So there were no individual expert models at that time. It was one collective attenuation model that was improved over the original

work.

Now the main message I want to give here is really on the top of the next slide. We talked about regulatory stability this morning. And when you're talking about a regulation that is a performance-based regulation, it is critical to get regulatory stability that you have PSHA stability. And if you think back at the Livermore, EPRI history that we've had if we were dealing with that, then we really wouldn't have regulatory stability because people are going to argue about which to choose, why are they different.

DOE understood this right away. And in the original work back in the '90s they directed that both Livermore and EPRI be used at the sites. And they required the sites to derive a Livermore hazard curve, an EPRI hazard curve and merge the two equally weighted together. And that was mandated by this DOE Standard 1023 in the mid '90.

It also precipitated DOE supporting what we commonly refer to as the SSHAC or the PSHA Guidelines that came out. DOE provided about 50 percent of the support for that work. But it was one of the driving factors because it said "Look, for performance-based design to advance stability, we need

better guidelines for PSHA. We can't live with what we see has happened in the past."

Now to show you that for the Savannah River site, the Savannah River site, it is a deep soil site, but the PSHA that was run at the site, and this goes back into the mid '90s, the PSHA was run for hard rock site conditions and we dealt with the site response or the site amplification through the soil separately. But it shows you the differences that we were dealing with at the time.

I have no seen systematic comparisons of these type of curves for all reactor sites. I've seen it for several reactor sites, but this is not uncommon for the mid '90 vintage, you know when you're seeing. Savannah River may be a little extreme, but you know for many locations Livermore and EPRI would show similar differences.

In any case, the first example repeat acceleration hazard curves and at about 0.2 g. You can see they're about 2.25 in annual frequency. It's not by the way, you know, a real huge number in annual frequency space if you're thinking of risk. But it is a difference.

Just stepping through the spectra at 5 hertz it grows to about --

MEMBER APOSTOLAKIS: Well, let me understand this. It may be 2.25 in the frequency doesn't sound like a big number, but I have a goal of 10 to the minus 4, then I should look at the difference between the g's.

MR. KIMBALL: Absolutely. And we're going to talk about this point as we get further in.

MEMBER APOSTOLAKIS: But that would make difference in cost.

MR. KIMBALL: That is a stability that you have to be mindful of. Exactly right.

MEMBER APOSTOLAKIS: Good.

MR. KIMBALL: Yes. Anyway, at 5 hertz it grew to about a factor of six and that's the largest difference for the Savannah River site. And at 1 hertz it's about a factor of five.

Now what's important is as we're going to talk about in a few seconds Regulatory Guide 1.208 for just a few minutes, the fact is that, you know, when you say these can be used as starting points, you can see that you're starting in a sense at significantly different places.

Now I don't think -- you know, I don't have confidence from a generic sense that it's been demonstrated that you could start with either one and

end up with the same thing. And we're going to get back to that point. I'm not sure how important it is now days, but it's kind of conceptually difficult, at least for me, given these kind of significant differences to see how this would apply today. Because I will touch upon that.

So what's important here, and this is I guess you could call it the Kimball guiding principle, but it comes from the SSHAC, the SSHAC Guidelines essentially. But the critical thing that that guidance has taught is that a PSHA, if you do it for any latitude and longitude, by the way, and that would include west, it must represent the legitimate range of technically supportable interpretations among the informed community. And then you would give the relative importance to that, to the different hypothesis among that range.

The key is if we don't follow this guiding principle today or tomorrow, then the mean PSHA is not only unsupportable, it's probably unstable. So that to me is the foundation of what we've got to say a PSHA is for any latitude and longitude.

In the CEUS project, speaking as part of the peer panel, we hammer this point home continually to the team doing the actual work. You know, they

have to keep this in mind constantly. This is what they are striving to get to.

Now in terms of Regulatory Guide 1.208, and that's as a general statement is an excellent document. And this is just paraphrasing a few important things:

It's very lengthy, but it requires that all information be considered in developing PSHA;

It forces an applicant to explicitly consider multiple sources of information when developing it;

It properly requires that PSHA be conducted with up to date interpretations, earthquake recurrence and attenuation models.

So conceptually in its own sense, in the words it has, they're good. But in terms of application when we get to the next one, it's not as easy as it sounds.

As you've heard, it does allow you to start with either EPRI SOG or Livermore as a starting point. The left side of the diagram though really is a conceptual way of saying well look, the legitimate range of technically supportable interpretations is quite broad. You have the scientific literature, you have work that's gone on from EPRI in that time, you

have states like the South Carolina Department of Transportation who have studies, and many states have done emergency response studies looking at probabilistic seismic hazard. You obviously have the Livermore and EPRI work itself out there. And then you have the USGS work. And those are the three dates of the National Hazard Mapping Program.

Now USGS, we need to recognize it takes on its own -- in the PSHA world it takes on its own unique issues.

The USGS national map, I will not kid you, is not a SSHAC-based PSHA. And the USGS will tell you that. But the important thing to remember about the USGS is that the workshop they hold, and they hold workshops, they bring together the technical community. And the USGS itself is a key part of the technical community. So if we go back to the SSHAC Guiding principle, you can ignore the USGS. The USGS body of information in the '06 time frame and even to the 2002 time frame, it was the only player in town. The new wave of applications had not started. There was not much going on in central and eastern US PSHA work generically. The USGS was the only thing that broadly pulsed "the informed scientific community." There was nothing else.

Now with the wave of work, obviously the applications themselves have had to address a wide variety of issues and they're getting into it. But my main point is that, you know, the USGS is part of the technical community and really can't ignore it.

The concept, as I say, for the Regulatory Guide to work properly you should be able to start with either one. As we've heard in practice, the fact is it's not that easy. The Livermore work has not been maintained by Livermore. The people who had that work are gone, they no longer work at Livermore. I'm not sure it would be almost physically possible to do the PSHA with the Livermore. I'm not aware of computer information on the source boundaries and reoccurrence. It may exist somewhere, but I'm not aware of it where it is. To recreate it would be extremely difficult, probably off the scale of the maps that exist. So, you know, there's a practicality issue here that's embedded in the reg. guide that just may not be real at this point.

The other point is obviously it's good to have a starting point, but the bottom line is the ending point, you know, for any given latitude and longitude. And Regulatory Guide 1.2 it makes it clear it's the ending point that's critical. You've got to

stand up and say for that longitude and latitude that that PSHA represents the informed community.

DR. HINZE: Excuse me, Jeff. As a result of this morning's discourse with Annie, I sense that this situation is going to change here shortly. Is this something that needs to be changed over and above accepting the CEUS SSC program?

MR. KIMBALL: I'll mention the CEUS as part of the presentation later on. But I think the point of this is that between now and when that product comes out, let's not kid ourselves of what the issues are with PSHA. I think is the main thing.

DR. HINZE: Okay.

MR. KIMBALL: Now it's true that if that project stays on schedule in the not too distant future we will have a better PSHA product for anyplace in the central and eastern U.S. But the current state of affairs, so to speak, with PSHA most recognized where we are today. And there's going to be a lot of work that goes on between now and when that project comes out.

MR. MUNSON: Jeff, before you leave that slide, I think that's an excellent slide because I would just like to point out in the ESP and COL applications they have used EPRI SOG as a starting

point. But they've also had to consider other PSHAs which are listed up there that have been updated.

So, for example, the TOP, South Carolina Department of Transportation, USGS; all those PSHAs are part of the sensitivity studies that have to be done for the EPS and COL applicants.

MR. KIMBALL: Let me stand up and point a couple of things on this slide. The implementation of this, though, is not so easy, I guess is one point I want to make. And on this slide, I don't which side to stand. I'll stand on this slide, so I'm sorry, Bill, I'll block you a little bit.

But in any case, what is shown here is the Savannah River site post-seismic scores and the upper magnitude distribution that is from the old Livermore work or the EPRI SOG work, or the Livermore TIP program.

Generally you can see in the blue, dark blue, light blue or the green that there's a fair amount of distribution and weight given to the lower end of the upper magnitudes. The red shows the USGS in the current USGS national hazard map for the same location, for what would the Savannah. And you can see a substantial difference.

Now the point with this is not that the

USGS work is correct, but having watched it now myself for the three cycles, and I've done it on a peer review panel for the USGS for the national hazard map, having been at those workshops and having my own sense looked at what the community is, the fact is the community is shifting away from this type of distribution toward that distribution.

Now, will it shift all the way to what the red is? I don't know. This central and eastern U.S. project will inform that, I guess is the answer to the question. But clearly if we use for the host source, and the host source at the site is not changing in the context of what's going on in the reactor side. You know, Charleston is changing, but that's at some distance away. This distribution may not represent the current distribution of the community today. In fact, I would say it does not. This is M_{max} for the host zone, you know it depends on which team we're talking about or which expert. But that is shifting.

Another way to think about the same problem, and I think it's in the back of the mind of the community as part of this, this just shows a carton that I put together showing earthquake magnitude and rupture area

MEMBER APOSTOLAKIS: Jeff, just a second.

MR. KIMBALL: Sure.

MEMBER APOSTOLAKIS: I'm trying to understand your previous slide. There are blue bars that are labeled as "Livermore '93."

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: Are these all Livermore '93?

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: So --

MR. KIMBALL: The dark blue.

MEMBER APOSTOLAKIS: The dark blue.

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: So there is a bar of 7.26 to 7.5 on the right.

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: Yes. So if I use Livermore '93, I guess I don't understand why I get a number of bars. Is it using different data or--

MR. KIMBALL: Each of the experts in Livermore, there were ten of them I believe, for that host zone had a weighted distribution and upper magnitude for that zone.

MEMBER APOSTOLAKIS: Oh, so these are --

MR. KIMBALL: This is the composite weighted distribution from that collection of ten

experts.

MEMBER APOSTOLAKIS: So these distributions then covers a very wide range?

MR. KIMBALL: Absolutely.

MEMBER APOSTOLAKIS: It starts at 5, is that correct.

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: You have a blue bar all over?

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: I see.

MR. KIMBALL: In fact in the Livermore you could see a little bit of a bimodal distribution I'd say, you know it's predominately centered around 5 3/4 to six and you have a little bit of a preference for people who think it could be a very large earthquake.

MEMBER APOSTOLAKIS: So there were two experts then who do probably deem that the USGS --

MR. KIMBALL: You could think of it that way. It may be more than two that have a small weight, but yes.

MEMBER APOSTOLAKIS: Okay. That's good. Thank you.

MR. KIMBALL: Now John may talk about this in the next talk. This is a generic thing before I

leave this slide, is 20 years ago when these distributions were created by the experts, they had methods in mind to develop maximum magnitudes for host sources -- are the ones that the approach today we would say is not a viable approach, some of them. I don't know that it's all of them, but there are some. And it's probably that effect would move this distribution to the right hand side.

MEMBER APOSTOLAKIS: So it is a case of the uncertainty going down? But it's going down in sort of the wrong way. I mean, it concentrates on the high values now.

MR. KIMBALL: Yes, I think I would probably say as a general trend, that's probably a true statement.

MEMBER APOSTOLAKIS: And that can be the result of having better information, better data. I assume the USGS uses the latest -- uses the 2007.

MR. KIMBALL: And Jon may talk about it. But the USGS relies heavily on analogues for their judgment. And it's one of the criticisms -- it's the why it's not a SSHAC thing. They've not particularly focused on the rare side of the hazard curve. In fact, I don't believe they would say use our hazard curves down to ten to the minus four or ten to the minus

five. So they haven't thought about that issue maybe as much as they would have to if it was being applied to a critical facility. So, that's the criticism that could be applied to the USGS.

Another context, though, of this issue that I wanted to give and say is in the next slide. And this is, you know, it's really meant to be a relative application but the purple is essentially the rupture area that would be created if you had about a magnitude 7 earthquake in the east. So you can see it's an extensive rupture. If it wasn't 20 kilometers wide and it was less, it would obviously have to be longer to fill that rupture area.

The point is if you think that a magnitude 5 on the other end essentially is what the biggest event that could be in a certain area, a certain tectonic environment, that's an extremely small rupture. And you can hide those features pretty much anywhere. And that's the dilemma. And I think that's what's moved some of the community -- not only the analogues that people have found throughout the world, but in looking at this and understanding source behavior they're saying look, these features can hide anywhere. We can't preclude something three by four kilometers.

The good news, by the way, on the other end is that you can see that the big features we should be able -- the truly big features we should be able to identify because they are a crustal extent, at least the seismic crust and they are many tens of kilometers long. So we should be able to see them. And I think that's what the paleoliquefaction is telling us. It's self-identifying where these big features are in some sense.

MEMBER RAY: Well, how about a collection or an aggregation of features like we heard about in Japan or like I could tell you about in another place? Are those as obvious as this purple thing ought to be?

MR. KIMBALL: I think in the west sometimes they're not is the direct answer to the question. I think sometimes you see complex ruptures, you know once you look at the surface and you say oh this looks like a rupture boundary, then you have an earthquake, it's more complex --

MEMBER RAY: But that wouldn't be likely in the east to have a series of small features that would --

MR. KIMBALL: Well, maybe this is the best way I can answer your question. One of the things

that's moving the community to bigger upper magnitudes is that exactly concern.

MEMBER RAY: Yes.

MR. KIMBALL: I mean I think that's the best way I could say it. That's in the mind of everybody is it's easy to get a magnitude of 5½ earthquake.

The second example as a general trend, this is -- actually I think it is the Rondout map. I didn't know which team it was purposely, but I think this morning I saw in the slide I could match it.

DR. HINZE: It's the best one.

MR. KIMBALL: Or you were on the Rondout team?

DR. HINZE: Right.

MR. KIMBALL: Oh, okay. That's good. See, I'm going to do you a favor, I'm going to pick on it.

CHAIRMAN POWERS: I appreciate that. I mean I get tired of doing it myself.

MR. KIMBALL: This is their seismic source map. You can see it is very detailed. The point is, this is common to past PSHAs. It's common to Livermore. It's common to EPRI to see this kind of detail. And I think, you know my experience with

again the community at large primarily expressed through what the USGS has done in their workshops and in the national map, is that the trend is away from this kind of detail towards larger zones.

Now the USGS has taken it to an extreme. The Canadians don't quite go that far, but they also have very far zone boundaries if you look at the Canadians. Broad areas. And I think the trend is in this direction.

Now the point of both of the last two slides gets back to Regulatory Guide 1.208. And, you know the way I would say it is the intent is laudable, but the implementation is complex. Any information related to the seismic source that impacts the hazard must be evaluated and incorporated. You know, that's what it says, and that's fine. But the new information requires somebody, be it the NRC or somebody else, to say that represents the informed community. And that's what's difficult.

Again, the inference that one could start with Livermore, at this point I don't think is practical. I don't know that anybody believes it's practical. It doesn't reduce the complexity, so from that context it's not going to help in some sense. And the fact is for any latitude and longitude that we

have to have an appropriate PSHA in today. And that bottom line requires the applicants and the NRC must ensure that if they start with EPRI, that if we have a PSHA that captures the range of technically supportable interpretations.

MEMBER APOSTOLAKIS: But if I go to conferences and if I talk to people like you, why can't I know the current views of the informed community?

MR. KIMBALL: You should.

MEMBER APOSTOLAKIS: Why is so difficult?

MR. KIMBALL: I don't know that it is.

MEMBER APOSTOLAKIS: I mean if you're applying to build a nuclear reactor someplace, I would expect you to do that.

MR. KIMBALL: Yes.

MEMBER APOSTOLAKIS: Why do you raise that as a difficulty?

MR. KIMBALL: Well, I sense it's a difficulty because without an objective measure of it -- well, you know if an applicant came to me and I said I reject your upper magnitude distribution for the host source that my site sits in, they legitimately say "What's your bases for the objection?" And that's kind of what Regulatory Guide

1.208 says. But now the fact is, as I say from my personal thing, is that the community distribution has probably shifted. I think we're going to see it in the central and eastern U.S. work. I think the M_{max} workshop Jon's going to talk about kind of guided us that it's shifting in that direction.

Now the key is today what's the basis for coming up with an alternate distribution. I'm going to touch on it, by the way, on the next topic. You know, what I would envision, and I'll just switch to it now, is maybe more sensitive studies being done than there are. And I don't know the applications. And I hear the talk about an application. But you could handle these kind of issues with sensitivity studies. You could say I'd like to test moving the lower bound of the -- you know, you can keep your EPRI distribution on M_{max}, but I want to start to pack that up and say what happens if you take all the probability less than 5 3/4 and you push it up to 5 3/4, does my hazard curve change. Or push it up to six and does my hazard curve change. And that way you're performing a sensitivity study that at least is measuring, I'll say the change that you judge the community distribution to be going without trying to replace it today.

MR. MUNSON: And that's exactly what we do in the COL or ESP application are numerous sensitivity studies. Because the difficulty, like Jeff is saying, is to do a full scale updated PSHA, you know, Livermore, EPRI they took years to do. How many dollars? But what we can do are these sensitivity studies.

MEMBER APOSTOLAKIS: But it seems to me the word "current" there creates problems.

MR. MUNSON: The what?

MEMBER APOSTOLAKIS: Current views, current. What is current?

MR. MUNSON: Well, we have to --

MEMBER APOSTOLAKIS: I mean, what if I choose to look at the results of the latest major effort, you know, like -- don't know what is, but something that's significant, not just one guy someplace doing his own thing and say, you know, this was done in 2007 or '05 or '06 but this is current. Now the fact that there may be a professor someplace saying that the magnitude may be different, I mean it's not. You know, he may be right, but I can't really rely or I should not be asked to use everybody's views.

MR. KIMBALL: Correct.

MEMBER APOSTOLAKIS: It says technical community, so that probably would solve -- I mean if I say, look, Mr. Kimball presented this slide it had the red bars and so on, this is current as far as I'm concerned. Now I come to you for approval.

I mean, there has to be some practical application to this.

MR. CHOKSHI: I think, George, that's exactly the point. In fact, we have discussions with industry where we will draw the line.

MEMBER APOSTOLAKIS: Oh, yes.

MR. CHOKSHI: You know, you can't just pick up anything. You have to first look at the pedigree of the information, for what purpose it was done, whether it's applicable to what you outline to do. All those factors come in. And then we select the sensitivity analysis which are germane, okay. Not just because somebody came and said I think that this is the one. And that's the particular -- you know when I heard Jeff what said this is very complex, it doesn't say you can't do it. But you can do it for the purpose you are trying to --

MEMBER APOSTOLAKIS: And I think it's the same reason why we make a distinction between the state of the art and the state of the practice.

MR. KIMBALL: Well I'm not here to tell you whether the right sensitivity studies are being done or not. I'm just telling you I think where we are today between now and the project you're going to hear about tomorrow that Larry Salomone is going to talk about, it mandates a stronger role for sensitivity studies. You know, to make sure that they have confidence in the PSHA and at a given latitude and longitude. And obviously the last point being that completing that study is important, obviously.

Since you are focused on research, I think the last few slides I'll close with are in fact --

DR. HINZE: Before you get into that.

MR. KIMBALL: Sure.

DR. HINZE: Let me ask a question. Is this difference between before and under, can you approach this with sensitivity studies? You know we talked about the EPRI study as being over source.

MR. KIMBALL: Oh sure.

DR. HINZE: And we can do the same thing with the sensitivity studies.

MR. KIMBALL: Absolutely.

DR. HINZE: Right.

MR. KIMBALL: And it requires someone to either coalesce the zones they want to do it with.

The EPRI work relative to let's say the USGS work in terms of where the USGS is --

DR. HINZE: Right.

MR. KIMBALL: -- there's a lot of commonality. Some of the terms are different, but in the original EPRI work if I had wanted to zone all of the eastern seaboard as one big mega zone, they had seismicity smoothing options and at least one of those options moved me right toward what the USGS is saying. So, you know, there's commonality if we break down the zone --

DR. HINZE: But there are differences?

MR. KIMBALL: There are differences, too. But there are commonalities to it. So you could do it either with the EPRI work itself to say, look, I want you to coalesce the following zones into one zone and don't do any smoothing. I think that would be the EPRI parlance for what the USGS does. And I want to see if that is a "team," I want to see a sensitivity study of where it is relative to the other six teams. If it's right in the middle of the pack, then the zonation issue is insensitive. If it's on the upper end or lower end, then --

DR. HINZE: I really like what you're saying because it gives us a chance to find the right

position, or at least a viable position, a practical position.

MR. KIMBALL: Anyway, I knew you were interested in high priority research teams. These are just my opinion. They're very consistent with what you heard Annie say. They fit right into what is in her Research plan. I've kind of given it my own priority here. It's a little different maybe then the NRC priority.

But the first one is the, and she mentioned it as part of the RVT site response modeling, but I call it the compatibility of rock and ground surface PSHA. And then associated issues if you have embedded structures of what's the right information at the foundation level.

At site response, you had talked about surprises this morning. To me when we have a earthquake in the eastern U.S. the number one surprise we will have is in site response. And we see it throughout the world. We see it in California that when we finally get data, site response is an overwhelming determinant of damage. We saw it somewhat at -- you know there's construction issues obviously in the poorer parts of the world, but site response plays an amazingly important role. It has in

the past in the east. A lot of the high intensities we see from big earthquakes in the east are on soil sites that are susceptible to amplification.

The east has a unique problem. We have really good granite or really good hard rock under these sites, Savannah River being a perfect case. The material under Savannah River has a shear wave velocity of about 10,000 feet per second. So even though it's a deep site at the resident frequency of that soil column, it rings. And it amplifies the motion by five, six, seven times. And this is not uncommon in the east. It's not like California where they call rock something you can almost crush. It is hard rock. And this site response is going to be very important.

So to me the first Research need, and as I say it's in their plan, is making sure we have site response models. making sure its properly integrated into a probabilistic seismic hazard analysis because that has its own issues. Making sure that the site data that you mandated is properly used to do the site response. Right now people collect shear wave velocity profiles and then create, I'll call it simulate velocity profiles to use in site response analysis. There is no criteria for creating those

profiles. It's a lot of judgment involved and there probably needs to be better criteria for those profiles created.

DR. HINZE: How about the structural aspects of the subsurface? Is that part of this, ringing, oscillating and so forth?

MR. KIMBALL: It would be inherent in it, yes.

DR. HINZE: Yes.

MR. KIMBALL: Absolutely.

And then, you know obviously it's a little on the red on this whole topic, but you know the ultimate use is is likely to be a soil structure interaction analysis, and making sure that interface is done properly. And I know there are issues being discussed at that arena today.

MEMBER APOSTOLAKIS: That worries me a little bit. What do you mean by "properly"? Do you mean it's done very conservatively? I hope you mean that.

MR. KIMBALL: Well, SSI today still has the mentality that really is embedded in ASCE 4 or the Standard Review Plan, depending on which you go to, that has this concept of three soil profiles essentially are used in SSI analysis. And you

hopefully pick enough variability in those three profiles to accommodate the uncertainty in you're interested in terms of the SSI or the soil -- the foundational response.

MEMBER APOSTOLAKIS: But that's not the conservative approach. I don't know the details of this.

MR. KIMBALL: That's the point of this is to make sure that if you're going to take three or a small set, that you're properly doing that to account for that uncertainty.

MEMBER APOSTOLAKIS: I guess I'll come to the title of your slide. When you say "high priority" is it high priority in the sense that I should be scared and try to do them as quickly as I can because what I'm doing now is not appropriate --

MR. KIMBALL: I would --

MEMBER APOSTOLAKIS: -- or is it high priority within the context of the research, you know you're prioritizing so we will be able to do things better, but I really don't have to worry about existing plants?

MR. KIMBALL: I think this is a little of both, myself.

MR. CHOKSHI: Let me address this a little

bit. Without the context of this time the design and stuff, standardization with a raw spectra, you know, without any preference to the site and you are using those kinds of motions. So it's not a question of conservatism. What we are currently doing is not unconservative. But the point that you want to maintain consistently between a probabilistic part of SSI analysis and the deterministic SSI analysis, that's good. And right now we are in the process, we are already in process of developing an ISG on that. We haven't had discussions with industry on how to do that, how to select those three, upper bound, lower and the this probabilistic profile so that we get consistent results.

And so we are only addressing this issue on a practical terms. So the research, if any, will be I would say more of a confirmatory type of things.

MEMBER APOSTOLAKIS: Okay.

MR. KIMBALL: The second one -- I'm sorry, George, were you done.

MEMBER APOSTOLAKIS: No go ahead.

MR. KIMBALL: I'm sticking to that hour. I see the clock over there.

The second one you've heard about this morning is advance the understanding of

paleoliquefaction sites in the east. I'm looking to my colleagues over here, but we're up to like 14 sites in the east. Are we up to 14 now?

PARTICIPANT: Seventeen.

MR. KIMBALL: Seventeen. Thank you. Seventeen sites in the eastern U.S. at this point have some evidence of paleoliquefaction. It's likely to be 17 locations we now know that there's a moderate to large earthquake. Some of these sites have repeated evidence of large earthquakes. And this is an intraplate environment. Does that make sense? I mean, that's a critical question. And paleofraction is very new. I'm particularly concerned that the techniques that people are using to understand how big these earthquakes are to cause this evidence is not well understood.

Site response, by the way, is extremely important at these sites. If they have high site amplification at these sites, maybe in fact the events are not what they think they are. So there's a lot of work with paleoliquefaction that's needed in terms of procedures for how to investigate the sites, to more thoroughly investigate the sites and ultimately to figure out to use this information into a PSHA.

The central and eastern U.S. project that

we're going to hear about tomorrow really cannot -- you know, they're going to do their best shot at handling this issue, but it's still going to be out there when they're done. This is going to take some time to really unravel.

CHAIRMAN POWERS: It seems to me that in discussing this you've raised two points. One is that I find evidence of paleoliquefaction that tells that there was some sort of ground motion. I have to ascertain how big that ground motion was. That's one question.

And the other question you raised was I find evidence of paleoliquefaction but I don't know but what that didn't come from something besides an earthquake? Is that what you're saying?

MR. KIMBALL: That could also be part of it, yes. Yes, right now I'm not aware that there is alternate theories out there for what people are seeing. But that question should definitely be answered if we're being misled for some reason that there's alternate causes. I think the investigators have tried to think about that. But it true, we may find that in fact we have been misled in certain places.

MR. SALOMONE: Larry Salomone.

In working with the researchers that have been observing liquefaction, they do see differences where they've gone back to original sites that have been identified as paleoliquefaction sites and do not agree that it was a paleoliquefaction event.

So, yes, to answer the question there are differences. And that's one of the things in terms of future research that I think is to get a procedural manual in terms of what to look for, and get it more systematic and disciplined in terms of the data that is being assembled.

MR. KIMBALL: I mean the general theme there, by the way, is the more paleoliquefaction we find in the east, the more incompatible it is with our basic understanding of intraplate environment being slow deformation, which we shouldn't be seeing the recurrence rates that we see in the plate boundary environment. What's going on at New Madrid or Charleston that we see in the paleoliquefaction cannot sustain itself for long periods -- when I mean long, you know many tens of thousands of years. It cannot sustain that. That is a plate boundary level deformation we are seeing there and it does not make sense ultimately.

The next one, Annie spent a lot of time, I

will not. But the next generation project extremely important. There are still considerable uncertainty in ground motion attenuation --

CHAIRMAN POWERS: Can you just can come back to the paleoliquefaction. It seems to me you leave out, the other issue is that paleoliquefaction evidence is hard to find. It's easily done.

MR. KIMBALL: Correct.

CHAIRMAN POWERS: And so don't I have a problem of I haven't found any; well I found a little bit of an evidence of some small one, how do I walk away and say okay, I don't have to worry about it anymore?

MR. KIMBALL: That's actually a good question. I think it's clear that lack of paleoliquefaction in a certain area is not the whole answer, and how much it helps you is yet to be determined. I did not put that on there per se because it seems to me that problem is going to have to be solved kind of at the grassroots level. They're going to have to get enough universities who are interested -- students interested in getting out in the field. But the only way to really solve that effectively is to get this to be a kind of standard thing that universities throughout the central and

eastern U.S. are going to have to do. Because you're correct. People tend to look where it's obvious. I mean we're dealing with a vast amount of territory, so trying to do a systemic is not really feasible at this point in time.

And you're correct. The lack of negative evidence is not necessarily going to help us.

CHAIRMAN POWERS: Especially on the east coast they've been destroyed. I mean, you'll never find them.

MR. KIMBALL: Right.

Annie talks on the NGAE, so I won't spend enough time.

The next one is not per se research, but I want to bring it up. I think Jon is going to mention it also. It's a concept I have been pushing, both the USGS and the NRC, and others. And it's what I call a community based PSHA for the central and eastern U.S. Now this idea is really -- I think if you're trying to get a cultural change out there, it's something that you'd better really better have the vision that's like ten years down the or more. Ten or 15 years down the road. And we've been through the PSHA issues, not just in NRC and industry with Livermore and EPRI, but we're now seeing it with the

National Hazard Maps and the USGS.

And the idea here is to all come together and create a community-based PSHA that all parties can use. And to do that we're going to have overcome some institutional issues, to overcome some cultural issues. But I've been a strong advocate for it. I think I've convinced some in NRC that this is probably the way to go. The USGS, we have a long way to go to convince them. But I think it's an important concept that should be pushed.

And as I say, I think Jon might mention it.

The fact is anyone of us, be it a utility, be it the NRC, be it the Department of Energy, we are going to waste resources I would contend if we don't do something like this.

At Savannah River we spent $10 million understanding the difference between Livermore and EPRI, and that's in 1992-ish dollars, early '90s. Why the central and eastern U.S. project is doing what they're doing is because it would be extremely expensive if they didn't come up with an approach similar to what -- this is an expensive endeavor that we're talking about.

So in the last slide --

CHAIRMAN POWERS: Before you go beyond this --

MEMBER APOSTOLAKIS: I'm trying to understand what the community-based PSHA is.

CHAIRMAN POWERS: Well, my inference here was oh what he's saying is an organization like FEMA ought to do one that everybody else just uses. Is that--

MR. KIMBALL: Yes. And what I've done here, and maybe this will help, George. And I'm not going to spend a lot of time because I'm now over. But I tried to give a framework for this approach. You know, what we could to think about how it could be managed, and that's what's shown on the next thing. And I just want to point out and then say a few things. But there is this idea of managing it. Obviously, it has to be managed properly. And that's really a government function, I think. And that would be some type of interagency group that comes together. I think naturally it should be led by one of the NEHRP participants, probably the USGS would make sense since they're responsible for the National Hazard Mapping Program. But that would have a working group. It would have a working group reporting to it, I called it the Seismic Hazard Working Group. But this

would be how it would be how it would manages. And essentially you would go from the research programs that are out there to having a regional focus on both seismic sources and attenuation. These would come into this, what I called the Community Based PSHA, which essentially be the National Hazard Mapping product. And then any agency or any applicant or any user could as they need to have a site-specific PSHA. They may be pulling information from the regional programs that don't go into the national map. They may essentially pull most of the information from the national map. But it would essentially be a way to avoid essentially different PSHA implying different answers for any location in the central and eastern U.S.

You know, if we're not careful, the USGS could be the next Livermore/EPRI waiting in the wings.

Now the fact is to make this work properly would take time. The time frame in my vision is at least ten or 15 years to make it work. You know to make this really work. So if we're not talking about the product that Larry is going to talk tomorrow, the 2010, but maybe the next product that comes after that would be something like this could be pushed. It may not be the next version of the National Hazard Map,

which I think is around 2013, but maybe it's the one after that. We could do this full integration.

To me the concept behind the SSHAC project is to strive to something like this, particularly in the central and eastern U.S. which we have -- you know the regional source characterization is pretty much the answer for most places. Site-specific studies unlike the west. The site specific studies do not modify the seismic hazard for any given latitude as a general statement. You get close to the Madrid and Charleston, maybe that will be true. But right now the regional studies are almost the whole answer.

That's it.

DR. KAMMERER: I wanted to mention something real quick with regard to Jeff's last slide. Is that he did actually present at our second workshop on the SSHAC Guidelines as far as updating. And there was a significant amount of discussion amongst the broader technical community in terms of this. And I think in general it got a lot of people thinking in light of this.

So I just wanted to mention that because it's not necessarily something that Jeff is thinking alone in a vacuum. Now there's now a lot of

discussion in terms of the potential for this in the future.

Now, as he mentioned, there are a lot of institutional issues perhaps to overcome amongst the different teams. But I think a lot of people saw value in a community product so that we don't end up with a USGS model and an NRC/DOE/EPRI model that are divergent.

CHAIRMAN POWERS: Any other questions for the speaker?

Thank you, Jeff.

MR. KIMBALL: Sure.

CHAIRMAN POWERS: I think you've given us something to think about here.

DR. AKE: Thanks a lot, Dr. Powers, for asking us to come in and talk about this project.

As you heard both Annie and Jeff indicate, this is a project that we have for -- the title of the project is Senior Seismic Hazard Analysis Committee (SSHAC) Update Project.

And I'll point out right off at the get-go, that this product is applicable for either side of the Mississippi River or 105 degrees.

The concepts we'll be talking with the so called SSHAC process are applicable not only anywhere

we would choose to do seismic hazard analysis, but it actually has been applied for things other than seismic hazard analyses in other places.

And we actually generally think the framework would be applicable to a lot of different things.

MEMBER APOSTOLAKIS: IS there a handout.

DR. AKE: Actually, it's under my glasses case is right there. I apologize.

The way I wanted to structure this is the following:

I wanted to go over briefly a little bit of a background of the original SSHAC Guidelines document itself. What led to it in the document itself.

I know the Subcommittee members are probably at least somewhat familiar with that, but I wanted to go over it just to make sure we kind of have a common understanding and to bring out a few particular points that I want to refer back to then in the discussion of the update project as well.

And that sort of leads into a motivation for why we conducted the present study. And that immediately then, the conduct of the study, the first real thing we worked on as progressed through the

study.

We're really looking at participants' observations from the previous major studies that have been conducted for a PSHA. And then based on those observations we developed sort of a laundry list of lessons learned and specifically with respect to implementation of the guidelines.

And then also the last thing I'll talk about in any detail is the idea of how you do updates, where and by, and how you do updates to the PSHAs in terms of recommendations.

I should point out that the recommendations I'm going to talk about are the recommendations from two draft documents that we've received thus far from our contractor on this project, who is the primary contractor with the USGS in Menlo Park.

And then I'll just wrap up briefly with where we are with the study and what the path forward is. What our timeline for finishing is.

I'm going to drop the long-winded and just refer to SSHAC, because everybody else is doing that and, hopefully, we're all good with that.

The other acronym you'll hear me use a lot is PSHA.

Originally SSHAC as Jeff has described before and Annie has previously to you, the SSHAC, the Committee itself was assembled to evaluate some of the differences between the original EPRI and Livermore studies and then to provide some guidance on the conduct of PSHA.

And I think the primary conclusion of the study, in addition to developing a list of problems from previous studies is outlined below in the bullets here. That most of the differences between the two studies were primarily procedural rather than major technical differences. But conduct of the study was very important. And that's one of the things that the report itself focuses on.

If you haven't read the study, it's a really, really interesting study. If you can nothing else, at least read the eight page executive summary as a real good encapsulation of the philosophical approaches to these types of studies.

If you must, there's the reference for it. You need book shelf space if you're going to get the whole thing, though. It's a major document.

Some of the studies or problems from previous studies that --

MEMBER APOSTOLAKIS: Is it available

electronically now?

MR. LEE: Yes.

DR. KAMMERER: It is now.

MEMBER APOSTOLAKIS: Volume 2 as well?

MR. LEE: Yes.

DR. AKE: But as of a year ago, it was not. But it may be now.

DR. KAMMERER: I thought you had it put in.

DR. AKE: I think -- I have not verified that they put it in. When I tried to print it out about a year ago --

MEMBER APOSTOLAKIS: On the website?

DR. AKE: Yes. It was not in ADAMS. And I had them scan it in, but I have not verified the whole thing is in ADAMS now.

MR. LEE: I think I have both volumes electronically.

DR. KAMMERER: I'm pretty sure it is because we made publicly available right before --

DR. AKE: Right. The objective was we were trying it make this publicly available before we had the workshops on this project.

MEMBER APOSTOLAKIS: I don't have Volume 2. I have Appendix J.

DR. AKE: I just wanted to point out a couple of a particular things, the problems identified in the previous studies in the original SSHAC study that we're going to touch on again later.

Insufficient face-to-face interaction amongst the experts is one of the key things pointed out in the early study. How do you treat outlier experts. And then the question of the applicable and appropriate amount of feedback with key things that were brought out in the study that we're going to come back to in a few minutes.

The report basically outlined a series of steps that are the important steps to pursing and conducting a good PSHA. Again, I'm not going to go through all of these in the interest of time. But a couple I do want to point out that I think are very important.

One, training for elicitation. And this is going to be a theme I'll come back to it a time or two.

A question of what we're doing in terms of these studies, is it in fact elicitation. But ultimately training of the role of the experts and evaluators is very important. And along those same lines, the idea of group reaction and individual

elicitation. Those were key things that were pointed out in the original study where we think are very, very important, although with some nuances at this point.

And then down at the bottom there, and this gets back to what Jeff brought out before, the role of outlier experts or rogue experts, if you will.

Aggregation and resolution of disagreements and the role of the technical facilitator integrator, specifically in the so called Level-4 studies, the TFI as both a facilitator and integrator.

I really am going to make the argument, I'll point this out again later I think although I don't have it on the slides, with the more appropriate conduct of the studies that we think we've seen thus far, we hope in the future, we really haven't had to face that hurdle again of the outlier expert. I mean, we're able to in general we feel come up with a broad assessment amongst all of our experts and evaluators that precludes us having to deal with the question of do I do downrate individual experts.

MEMBER APOSTOLAKIS: I'd like to say something on that. I think the slide really builds on other methods for expert opinion elicitation by merely

NUREG 1150. I mean, training the experts is not something that proposed. I think it's worthwhile, though, to point out some of the things that this report recommended. One is the use of experts as evaluators. Because in all the studies up until that time, eliciting expert opinion meant, you know, this guy has a model, bring him in to give us whatever he wants to give us. And as evaluator means that now he will have to evaluate my model, right? And he will have to understand my model to the extent that he can stand up and defend it. Defend my model. And that was kind of a revolutionary idea at the time because most people don't pay attention to other people's models.

So as evaluator, I think that was a very good that we proposed.

And the other thing was this workshop and not assign weights to experts. That was a major problem with the expert -- I think it was number five, the -- but number five.

Livermore was under orders to give equal weight to the experts. So all it takes is one guy who is a complete outlier. So the idea was that you should not first of all give weights to people. So, you know, to give weights to experts is not a good

idea, especially if you invite a guy to participate in workshops and then you give him .2. Yes, we love you but you're useless.

So and then this idea of frequent interactions and trying to come with a consensus model without really putting numbers that this type office gets a .3, that was I think one of the proposals that was -- and the technical integrator and the technical facilitator integrator, these I think were contributions.

DR. AKE: Well, I agree completely. And I wonder if you actually looked, did you already see my slides.

MEMBER APOSTOLAKIS: No. I was there.

DR. AKE: You just said a third or a quarter of my talk, actually.

MEMBER APOSTOLAKIS: So you're trying to--

DR. AKE: Well, actually, absolutely.

MEMBER APOSTOLAKIS: Oh, okay. Sorry.

DR. AKE: And the reason being that I wanted to point a couple of these things out because there's a lot in this original report. It's 1300 pages long, more or less. But there are sections of it here that we've outlined in this brief summary here that we really feel are appropriate and good things

for any good PSHA to be aware of. And George just pointed those out, at least a serious of them.

The last thing here that we're going to talk about a little bit is documentation. And that's actually -- you know, I don't think that's a real surprise to anybody. Ultimately the product is only as good as the document for it. Especially for some high profile undertaking like this.

All the panel members, I'm sure, know better than I am about the differences between epistemic and aleatory uncertainties. I'm not going to spend too much time on that. But one of the firm conclusions of the original report that you can't just talk about the total uncertainty as a bucket of uncertainty. One needs to evaluate what the aleatory components and the epistemic components are, recognizing that ultimately that's a time dependent assessment that as our knowledge base changes how we might partition those sources of uncertainties will likely evolve as well.

And as I say, you all understand this certainly probably better than I. But, however, I did want to summarize this a little bit in terms of the way it plays out within seismic hazard space just a little bit with an example. Because I think it gets

to a couple of questions we heard earlier this morning.

The aleatory variability days, obviously the randomness in the particular process. And way we treat that in PSHA is we try to the maximum extent possible bring that inside the hazard integral and integrate it out. And how that ultimately effects our hazard estimates, those are the things like the aleatory variability estimates within the ground motion models and some of the weight changes, those change the shape of the hazard curves. So those are the things that change slope and that sort of thing on our hazard curves.

The epistemic uncertainty, which is our knowledge-based certainty, we try and implement those through logic trees. And those lead us to different alternative hazard curves for each one of those different epistemic models and integrates the aleatory as well. So what that does is it leads us to a whole different suite of alternative hazard curves which is what we use to develop fractile estimates in our hazards.

And that's well and good. But the issue becomes one of trying to actually develop in a systematic procedures that allows us to keep track of

those aleatory and epistemic components without double counting them. That's is actually one of the lessons learned that I just -- when I was going through this this morning realized I forgot to put on a later slide. That actually in our lessons learned is one of the things we've identified as a real challenge is within the context of doing a good job of evaluating the different of sources of uncertainty, not double counting uncertainties. Because that certainly effects the hazard estimates at the end.

I wanted to try and illustrate that just for a second with an example. And actually, Jeff gave a good lead in here a little bit.

This is an example of a seismic source zone for the central and eastern U.S. from one of the EPRI source teams. And this you can see, you know, is a big chunk of the eastern U.S. And you can also see that the little squares in the plot on here are the earthquakes. And you can see the reoccurrence of earthquakes within this source zone, seismic source zone are definitely not uniform. And so we have different alternative ways we might choose to represent the rate of earthquake occurrence within this source zone. And they're identified on the three panels on the right where the threE dimensional plots

with the X and Y axes being latitude and longitude. And the Z axis as being rate.

The first of those different alternative models is to smear that seismicity out uniformly within that zone so you get a constant rate of occurrence of different magnitude earthquakes throughout the zone, independent of what latitude and longitude you are. And, of course, when we estimate that rate of occurrence, there is an aleatory variability, if you will, associated with that rate calculation because our data is not perfect. And that's indicated in the little distribution on the right side of each one of those three panels on the right.

Alternatively, as Jeff intimated an alternative way of looking at this problem is to say well the earthquakes are not uniformly distributed, so I want to look at these and have some general smoothing throughout this area where I get higher rates of earthquake activity in the areas where I have more earthquakes. And that would be represented by the bottom two panels there. One where you have some smoothing kernel that is fairly wave length and gently smooths the seismicity out. The other is to have something, you can't see this very well. I guess you

can see it on the one up here. These are 1 by 1 degree cells that you have a very granular approach to this where you calculate a rate in each one of those 1 degree cells.

So each of these three different manifestations of the way we can treat this problem represented epistemic uncertainty and we would put those into our hazard motels as different branches on the logic tree. Each one would have a different aleatory variability associated with it for that parameter.

MEMBER RAY: A question now that may be a little off point, may not. Do we correlate rate or frequency with reduced magnitude?

DR. AKE: No.

MEMBER RAY: For example higher frequency?

DR. AKE: No. That rate would be for each magnitude interval. In other words, you would calculate a rate of occurrence --

MEMBER RAY: Oh, I see.

DR. AKE: -- within that source zone for magnitude five to five and a half, six to six and a half.

MEMBER RAY: Okay. Got it. So it would be taken into account because you've sliced this

thing--

DR. AKE: Right. You have a different rate for each of those different magnitude bins, correct.

MEMBER RAY: Okay.

DR. AKE: Now the SSHAC document outlined four different study levels as being appropriate to conduct a high quality PSHA. Level-1 being the simplest, Level-4 most sophisticated. As you can imagine the cost and duration of the studies scale upwards. I've always argued that it's a very nonlinear scaling. It's a long ways from Level-1 to Level-4 in terms of the time of the study and the cost of the study.

There are two acronyms you see in here technical integrator and technical facilitator integrator. A technical integrator is where the action is in Levels-1, 2 and 3. What Level-4 is you now have formal expert teams that are doing the assessments. The TI is responsible, either the individual or a technical integrator team is responsible for doing the assessments and the evaluations in Levels 1 through 3.

The thing we are going to focus on for the rest of this, is really we're not going to talk too

much about Level-1 and 2. Most of what we have done in this project is focus on the Level-3 and 4 studies.

And obviously as we move from Level-1 to Level-4 we think we have an increasing confidence of truly capturing the community. Something I'm going to refer to here as the community distribution.

This is the mantra. So Jeff's version of this, this is the version that is directly out of the report to us from the USGS. And I think it's actually word-for-word from the original SSHAC document. Bill and I were laughing about this before at one point I think.

If you're going to participate in one of these you have to get a little laminated card with this on it. Because this is your goal that you have to -- this is what you work to every single day when you participate in one of these studies. You know, it doesn't really matter the scale of the study. The goal is the same to represent in unison now the center, body and range with the technical interpretations of the larger informed technical community. Would be if you could bring in the entire technical community and conduct a study, hopefully that's what you're going to represent by performing this type of study.

And you can see what we identify here at the center and the body and range in those sentences above.

And we kind of use interchangeable the term "the community distribution" and the views of the informed technical community. You'll see those in a lot of the documents used interchangeable.

And, of course, down in bold at the bottom here, we found that satisfying these expectations is difficult in practice. It's actually a very challenging thing to do. And part of that is --

MEMBER MAYNARD: Because we're human.

DR. AKE: Part of it is -- yes, the human and George alluded to this a little bit earlier. The way we ask people to participate in these studies to conduct themselves is almost at odds with, especially if you're an academic researcher, your mindset. Is we ask them to be rather than experts in their model, we ask you to become an expert in everybody else's model. And that is the idea of becoming the evaluator is you have to able -- I have to be able to defend George's and Mike's and Dana's and everybody else's model. If I'm going to incorporate those within the larger model that we're going to produce, I have to be able to understand and evaluate and defend the strengths and

weaknesses of all these different models.

MEMBER APOSTOLAKIS: So you're saying academics have a problem with that?

CHAIRMAN POWERS: Definitely.

MEMBER APOSTOLAKIS: There are models --

CHAIRMAN POWERS: I think you can progress ahead.

DR. AKE: Well, the first -- and that's what lead us to the particular project -- that's what led us to it to actually begin this project and start on doing this, is recognition that this was a challenging endeavor and the fact that these guidelines have now been applied in several large high level studies. The objective of this was to try and capture the experience that we had generated by conducting these studies.

And Annie pointed this out before, and I've underlined it on this slide and I want to reiterate it again. At the end we all have concluded that the basic process and framework and guidance in that original document is still very appropriate. The only issue with the document as it stands is its basically a conceptual document. And now that we've applied it, we wanted to try and capture the experience that we had gleaned from spending a lot of

money and time doing that. And so that the project is really mostly focused on the more practical implementation issues.

Our primary contractor on this is USGS out at Menlo Park and our principal investigator is Tom Hanks.

MEMBER APOSTOLAKIS: Well, actually your know it was always sort of implied that if you run an expert opinion study the final result reflects what the community thinks, but it was never stated as explicitly as this report did. I mean, we had five experts giving opinions and then the staff developed its division for the transition size as we would see in 5046. They never said this is a community, but it is treated as if it was a community. I mean, if we knew that there is a considerable respectful group of people who think otherwise, I mean the agency would take that into account.

So the value of this is that it made something that was sort of implied, made it explicit. It was never intended to ask them to create a metric by which you will measure how well you are fitting the community over there.

So, I don't know. You guys are making a big deal out of it, but maybe appropriately so.

DR. AKE: Well, actually that was the point of some discussion. And I have a slide that speaks to that in a minute, but understanding whether or not you satisfied that goal of representing it is one that, honestly, I think we decided at the end of the day that we have a number of different suggestions about ways to make sure you've done the best job you can. But there is no real easily definable metric that I can measure --

MEMBER APOSTOLAKIS: No.

DR. AKE: -- and say oh clearly I've met the bar of representing the community.

MEMBER APOSTOLAKIS: It was never in the tool --

DR. AKE: You know, I mean it's a deep philosophical debate usually conducted over a glass of wine in the evening.

MEMBER APOSTOLAKIS: But if you think about it--

DR. AKE: But it's not really something that you can really ascertain --

MEMBER APOSTOLAKIS: When a federal agency makes decisions using a distribution that is derived from an expert opinion dissertation, there is always the understanding that this is the revision of the

community; otherwise they wouldn't make a decision. So this is just making something that was understood and more explicit, but I wouldn't really read more into it.

And also, the value of it is that when the experts deliberate by stating this, maybe they would think a little bit differently than if they -- or if it had not been stated.

DR. AKE: I think that's probably one of the key things, another slide that actually states that explicitly. I think that's one of the key things.

MEMBER APOSTOLAKIS: Okay.

DR. AKE: But the first step in this process was to go back and look at all the major previous studies that had been conducted, and this is a laundry list of what I would consider to be large major studies that had been finalized with a couple of exceptions one could add in here. Obviously the EPRI and Livermore.

The major studies that were conducted for Diablo Canyon which were in hindsight probably on the order of something we would refer to as a SSHAC Level-3, a big project up in Washington State. Those were all conducted prior to the finalization of the

original SSHAC document. And then subsequent to that I guess technically there are three for Yucca Mountain. Originally Yucca Mountain PSHA, the probabilistic volcanic hazard analysis for Yucca Mountain, as well as the PVHA update for Yucca Mountain. And then a ground motion study that EPRI conducted in the early '90s following the SSHAC framework. And then the so called PEGASOS study conducted for nuclear sites in Switzerland.

All of those were Level-4 accepted EPRI ground motion studies.

And at the time we kicked off this study in terms of ongoing studies there was one that was going on for British Columbia Hydroelectric, which is a Level-3 study for 41 sites in the province up there. And its both for seismic source characterization and ground motions.

And then at about the same time we started on this study the central and eastern U.S. SSC study that Larry's going to talk about tomorrow with you kicked off as well. And there is also one that has just started for South Africa for nuclear facilities in South Africa.

And the last two bullets we're obviously trying to the best maximum extent possible trying to

implement the experience we've gained from the previous studies in this particular project here.

The project kicked off in late 2007. We conducted three workshops between January and June of 2008. I think we had a total of 57 or 58 participants in the workshop. Some people could only attend one or two. We had about 40 participants in each workshop. Almost everybody there had lived those major studies that we talked about on the previous couple of slides.

And so there was a lot of really interesting debate about how one goes about doing these projects during the course of the workshops.

So based on the workshops, the first couple of workshops and the accumulated experience of the folks in the room we defined at least a few particular bullets about what works; what are the lessons learned. And I think the key one is the fact that the experts can be evaluators. If given proper mindset and they get their little laminated card that says this is what you're supposed to be doing everyday, that they can be very good impartial evaluators of a suite of models

And I think with that clearly defined role in mind, that's partly why we haven't had the problem of really outlier experts so much at this point. I

think that's the reason we haven't seen that in these major studies.

One of the other things was data development. We felt it was extremely useful and had worked well to have a consistent data set placed in the hands of the evaluators as early as possible and identifying if feasible what new focused data collection could be done.

CHAIRMAN POWERS: You say you haven't had the problem of an outlier --

DR. AKE: Well, one expert team is so radically different than the others that you just say this is not the solar system. There's clearly broad ranges, and I think Yucca Mountain ground motions is a good example that. You get a big difference amongst some of the experts and some of the assessments.

CHAIRMAN POWERS: It seems to me that you've put up a long list of primarily Level-4 studies.

DR. AKE: Yes.

CHAIRMAN POWERS: And I would have expected there to be an outlier in that list. Okay. Just strictly based on statistics.

MEMBER APOSTOLAKIS: I suspect what happens is that in the old days like this -- he

developed his model like most of develop models. Probably sitting in his office with his graduate students and so on. And then he publishes it.

I think that what happens the moment people start criticizing you become defensive and really go out of the way to defend it.

DR. AKE: Yes.

MEMBER APOSTOLAKIS: They probably have people who have different views on certain things in those exercises. But the fact that they participated in a workshop maybe they convinced others so the final result was broader, the division was broader, or they were convinced to mitigate a little bit there. But they're standing out as outlier anymore. They are part of the total. They have influenced the final distribution.

So I think there is a difference just because they participated and they defended their views and they understood other people's views without publishing something separately, in which case now they may be an outlier and then they defend it. But their distributions may have been very much broader because of the presence of these ---

DR. HINZE: I would like to support that. I probably am the only one in the room who has sat

through this as an expert evaluator in the EPRI program. And, you know, I had published a lot of papers where I stuck my neck out and I had made my mark in the sand, if you will. But when you have the four people get together and have breakfast, lunch and dinner on many occasions and get to know each. And then you put them in the room. We would sit around and we would discuss this. And I'd say, well okay, maybe there's only a ten percent probability. Because you're within a small group, not a workshop, not a big workshop, but within a small group that you know very well and that you can really communicate with. And I think that that's the real benefit of the Level-4, which comes from this cohesiveness with this understanding, with this cooperation between the group. And you reach a point where you're willing to back off and take a more objective view of it.

MEMBER ABDEL-KHALIK: It sounds that the expert team is generally much, much smaller than the pool of experts.

DR. AKE: Absolutely.

MEMBER ABDEL-KHALIK: And therefore, has this process ever been sort of done twice where you get a --

DR. AKE: Yes.

MEMBER ABDEL-KHALIK: -- experts that goes through and does that and then you compare the finer results?

DR. HINZE: Yes. The PVHA and the PVHAU.

MEMBER ABDEL-KHALIK: You mean a separate team?

DR. HINZE: A separate team. It's a totally separate team now for the same issue.

DR. AKE: But the reason would be simply cost. I mean, you open the bidding --

MEMBER ABDEL-KHALIK: But if you really interested in finding out whether this process captures the entire range of opinion or converses on the correct opinion. So if you have two completely separate teams from the large pool of experts that go through the same sort of sifting and winnowing process that you're talking about and they ultimately reach similar or nearly similar conclusions, then that would be proof that this process actually works.

MR. LEE: Is there a risk of homogenization by having everyone defend everyone else's positions or being able to --

MEMBER APOSTOLAKIS: That's always. I mean, anytime you deal with judgment no matter what you do, there is a criticism --

DR. HINZE: It's harder to homogenize it--

CHAIRMAN POWERS: No, I don't think you are. I think it's exactly what Bill was talking about that you get to know people and they refuse -- they no longer take outlying dispositions. And here's what bothers me. The whole --

MEMBER APOSTOLAKIS: I think there's a difference between an outlier and somebody having a significantly different view. Because I submit that in these groups there may be people who have this differing perspective, different prospective from the other three, but this process of talking about it and producing a distribution at the end which is fairly broad because of that, then you don't use the word "outlier" anymore like you would do it in the days where I publish my paper, I have my model and now I'm not going to defend it. And I'm differing from everybody else. But I still may have influenced the distribution.

But again coming back to your point, Mike, there is always a risk. I mean no matter what you do with judgments if you have them individually, eliciting information and so on, then you don't have the benefit of interaction and understanding each other. If you do it as a group, there may be one guy

that has such a personality that dominates everybody else. So you know you have to find -- EPRI has tried cases where they've had several groups that don't talk to each in principle, so now you have this independence but also you have a group effect. Now the more of that you do costs, you know, skyrockets.

And the other thing is I'm not sure, Said, that the pool of experts is so large.

MEMBER ABDEL-KHALIK: It depends on the issue--

MEMBER APOSTOLAKIS: I mean, I think there is a group of five, six, seven people who really drive the community, right? One of them, unfortunately, passed away a year or so ago. But the truth of the matter was that if you something that says Kennedy and Cornell, this is probably the next best thing, right. And there are a few other names that do that.

So I don't think -- it's not thermohydraulics where you have a lot of experts.

CHAIRMAN POWERS: Millions of them.

DR. KAMMERER: I just want to make I think one point to follow that up if I can? Is that, again, regardless of what level and how it's done the goal is to capture the center, body and range of the informed technical community. And in a Level-4 what you're

doing is you have a lot of small teams, but each one of those teams is still trying to achieve that goal; the center, body and range in the informed technical community.

I would argue that it's challenging to represent this body if you haven't really had the interaction to understand where they are and what this body would be.

And so for me I think it's really challenging for each of these teams to meet that goal if they don't speak to each other and understand what all of the views are.

DR. HINZE: You're gaining confidence in each other, you know that's part of it.

MEMBER APOSTOLAKIS: Another way of challenging the results is what happened in Switzerland, I think. There were some very strong objections to the results.

DR. AKE: Yes, that's the last word on what doesn't work slide.

MEMBER APOSTOLAKIS: So the message does not include the Swiss?

CHAIRMAN POWERS: They're outlier.

DR. AKE: There was something that was bothering you, Dr. Powers. Is there anything else

that you wanted?

CHAIRMAN POWERS: I got a lot of things that bother me.

I will simply make an anecdotal comment that the British government has had a long history of setting up expert panels. The first one I know of was set up by Henry VIII. And I suspect that there were ones before that. To make judgments about what the future is going to look like. That probably the most famous one was the one that they set up on the possibility of heavier than air flight.

And people that have gone back and looked at those find that if you bet on the minority opinions that were expressed, you're more often right than if you bet on the majority opinions. That outlier tend to be --

MEMBER APOSTOLAKIS: That's why we observe them in the distribution --

CHAIRMAN POWERS: And make sure you do.

DR. AKE: I think your point is very well taken. And I think it ends up at the end of the day, and that is one of the things about integrating all the way through to hazard and you see this over and over again, even though they might have relative low weights and they're not de minimis weights, that

certain opinions because of the fact that things in hazards space scale so strongly and we saw this at Yucca Mountain in the final hazard numbers at Yucca Mountain, it was one element of uncertainty in one expert's model that really has a significant effect on the final --

CHAIRMAN POWERS: And just because you take the tails of the distribution?

DR. AKE: Right.

CHAIRMAN POWERS: That's right.

DR. AKE: And if there is enough of an outlier there and you pick it up in the equation.

MEMBER APOSTOLAKIS: Not forget how decisions are made. It's that the decision making phase where these that Dr. Powers raised come up. We had a very good example here in this room a couple of years ago.

The expert elicitation 95th percentile of the 95th percentile says that the transition size for a pipe diameter to break in a guillotine was eight inches. And the Director of the NRR says 14. Why? I want to cover myself.

So we do have this margin that we put. So the decision maker is not naive, the decision maker knows where these numbers come from and the

distributions. And if he's a really responsible decision maker, then he says 14 or 12. A lot of people are unhappy.

So there is a whole process there. And there are many, many examples like the ones -- I remember now that I read somewhere that a lot of newspaper people and columnists at the time thought that "Gone With the Wind" was hopeless. It's going to be a flop. Well, it was on television yesterday, right? The movie, I mean. Don't look at me that way.

CHAIRMAN POWERS: Yes. I think that your point that because we do, we end up looking at the tail, that we really don't wash out minority opinions. That the problem really lies -- or the danger really lies in how you select experts, the first item in your list.

DR. AKE: I think that's one of the key things. And also the appropriate training that ingrains into their mind. Your job here is not to represent your own personal views. Your job is to use your own personal background to evaluate the breadth of models in the community and represent those in our community distribution.

And, George, I can only say one thing. Having lived through being one of the experts at Yucca

Mountain, there's nothing like the interactions in these facilitated workshops where they lock you in a room with all the other experts, not just your team but all the others, and you're all assigned. And Kevin was actually really good. He made up little different colored hats. And today, Annie, you're the proponent and you wore the black hat and this is the model you're going to explain to the group and defend. And you guys, you all get red hats. You're the evaluators. Your job is to take shots at this until you completely understand the model.

MEMBER APOSTOLAKIS: And that's not necessarily her model?

DR. AKE: No. In fact, it would most likely not be her model.

MEMBER APOSTOLAKIS: That's a key.

DR. AKE: And so that whole facilitated -- I'm going to come back to that in just a second. But that whole idea of these facilitated workshops and interactions I think is the key to this.

Briefly what doesn't work, this is only as good as the understanding of the SSHAC and intent. In other words, the rules of the game need to be clearly articulated to the participants going in.

One of the key things, part of the reason

we went to the effort of trying to implement this study was it's not clear what the need for, and ways to go to updating these majority studies. And that's one thing I'm going to finish the last two or three slides with.

Obviously, the reality is the probability of effectively efficiently capturing the community views is still a function of the study level. If you spend more, you probably get a better shot at capturing that.

And then one of the things that everyone who participated complained about a little bit at these major studies is lack of schedule continuity from the TI/TFI and the experts. Tends to be a very intermittent process. Lots of activity for two months and then nothing happens for six months. And then you're supposed to pick it up and get back up to speed again. That's a real problem in terms of efficiently conducting the study.

This gets to the point here: The takeaway on this one is the bold at the bottom.

What we're doing here is formal expert assessment. It's not expert elicitation. The people who really know about expert elicitation will tell you flat out what goes on here is not formal expert

elicitation where you tend to ask narrow questions about specific things of your experts, generally without interaction amongst the experts. And so you get independent points estimates of some quantity.

What we're doing here is a more structured process with interaction. And the key sentence in that first bullet is "Subject matter experts participate in an interactive process of data evaluation, learning, model building and quantification of uncertainty." Key things there are: Interactive process and learning. This is where which gives the expert elicitation community the heebie- jeebies. Every single expert who has participated in one of these says "I learned a lot during the course of this study." That's sort of antithetic to what you suspect your experts, you bring them in, because they already know everything. But that's clearly not the case. Everyone is not expert in everything. So that's one of the key things that it's a little bit different.

And so we claim now is that this formal expert assessment and not expert elicitation.

MR. LEE: Can I ask a question?

DR. AKE: Sure.

MR. LEE: Go back to heebie-jeebies. I

made reference to the heebie-jeebies, expert assessment versus expert elicitation. If you go back looking at some of the history regarding the use of expert judgment vis-à-vis expert elicitation, you know you had the RAND Corporation and Stanford developing decision analysis methods for reasons that I think most everyone here is aware of. Have there been any studies to evaluate how the SSHAC methodologies of decision science tool works? I know that there's been a lot of, as you pointed out, use of the methodology within the earth science community. But has anyone ever given that some thought to see?

DR. AKE: I know we had -- that was one of the couple talks on the first day of the first workshop by Karen Janney and a couple of others whose specialty is --

MR. LEE: Decision science?

DR. AKE: -- decision in science.

MR. LEE: Okay. All right.

DR. AKE: And that was the conclusion, is that we really should not claim this as expert elicitation.

MR. LEE: No. I'm not saying -- my question more generically is is this a new --

DR. AKE: Well, I think she is looking at

that as something.

MR. LEE: Okay.

DR. AKE: But I don't know that she has published it, and if she has I am not aware of it.

MEMBER APOSTOLAKIS: Who is she?

DR. AKE: She used to work with Geomatrix for a long time with Kevin.

The evaluator models are for a Level-3, you end up with a single evaluator model and Level-4 we end up multiple evaluator models.

I'm going to spend just a moment or two on logic trees, and I'll move fast through this.

The logic trees are really, what I'll refer to them here, the numeric interface between the evaluator models and the hazard calculations itself. This is how we structure the epistemic uncertainty.

And this is going to lead me into one of the recommendations of the study and I want to use this example from Yucca Mountain as a way to point that out.

This is an example of logic tree, simplified, very simplified logic tree from Yucca Mountain where on the left we have the seismic source characterization teams, six different teams. Each of those teams developed a seismic source

characterization model for the Yucca Mountain site-specific study.

And on the next slide you see a geologic map. The potential repository is in the light purple there. And all the dark lines are active or potentially active faults in the immediate vicinity of Yucca Mountain. These are north trending faults, most of them dip to the west. Just off the slide to the west is a major east dipping fault that somewhere in the seismic crust all of these faults interact, come together in some sense.

And each of the different teams had very complicated models about how these faults, these small intermittent faults, did they dip together, did they go on one rupture. You know, what sort of probabilities of activity. Very complicated sorts of models that they put together.

So what's in the center here in terms of the team model is not really representative. Each one of those teams just for the local fault sources there had hundreds and hundreds of branches. And each one of those different unique team models then was put together with the ground motion experts on the right hand side here from the seven ones. Each different nod was exercised for each of the seven different

ground motion experts. And each one of the experts had a model for medium ground motion as well as the aleatory variability in that ground motion, as well as uncertainty in the median and uncertainty in the uncertainty. Uncertainty in the aleatory variability.

The point of all this is is at the end of the day you end up with logic trees that have hundreds and hundreds of thousands of nods, in this case if not a million nods. And so that was one of the key takeaways from I think the second workshop. Is that we needed to sort of concoct a scheme by which we begin to trim the logic trees.

At the end to say we've truly captured the range of the informed technical community, you probably need the entire tree. But for actual use that we thought that you're going to have to begin to do the process of trimming the logic tree. What we refer to as the trimming of the dead wood. Those branches that have very low aggregate probability throughout the multiplication that don't influence the hazard. And one of the key recommendations is that that needs to be trimmed with input from the experts that derived the models as well as the hazard analysts and the TI and TFI.

And this gets to a point that Jeff was

talking about earlier with the ability to easily do sensitivity analyses. We need to have these simplified models available to us to be able to do the sensitivity studies. Because these million nod models are very, very difficult to actually execute the hazard calculations with.

And this is really what I think George talked about a few moments ago. How do we ensure that we've captured the views of the informed technical community? Well, it's a philosophical question. We're really not sure we can ever guarantee we've done it. But the things we've outlined here in terms of the bullets are those things that we recommend that need to be done to give us the highest probably that we achieved our goal.

And the first is aggressive participatory peer review. The peer reviewers need to be evaluating not only the technical aspects of the study but also the process and procedure aspects as well.

And of course, the training of experts in the role of evaluator, as we've talked about.

And the last two are I think the things we just spent the last ten minutes talking about, you know, bringing in members of the technical community who are not part of the peer review panel or the

evaluator team to actually be proponents of their own models in some cases has been a very useful thing as well.

And a couple of other lessons learned. Selection of study level. The conclusion of the group was that Level-1 studies really shouldn't be used for critical facilities. We really needed to base the assessments for critical facilities on regional studies conducted at Level-3 or Level-4. That's not to say that once we have a high quality regional study that was conducted at a Level-3 or 4, that targeted updates or evaluations to those studies couldn't be done at, say, a Level-2. But that the basic requirement for the original studies would probably be at the Level-3 or 4.

And, you know, that is ultimately whoever is funding the project, that's their decision about what to do. But the recommendation after discussion was that having the regulator at least well informed about what the study was going to be or not be is something that you couldn't get away from.

And, again, the idea of feedback. This is one of the takeaways from both Yucca Mountain and PEGASOS, is that more feedback is better and that early feedback is good. As you begin to develop the

models and you start to do sort of the basic development of the logic tree structures, looking at sensitivity studies as you go along allows you to more properly apportion your resources as you finish the study in terms of what's hazard significant.

And this is just an example from the Swiss study. This is the kind of different types of feedback that the experts are now getting as they do their assessments. This is one that just for the Beznau site in Switzerland and this for each of the four left hand groups across the bottom, they are the four science teams that were in charge of seismic source characterization. And this just represents the contribution of particular elements within their model to the overall sensitivity.

I might point out that let's say for this particular team you can see the assignment of M_{max} for this source has a relatively small contribution to the total uncertainty in the hazard assessment, in this case for one hertz at relatively high amplitudes, ground motion amplitudes to be a proxy for relatively low annual exceedance frequencies. Whereas, if you look over at this team for this particular source, a bigger range of uncertainty associated with M_{max} with a different source zone. But if you compare that to the

overall uncertainty in this particular case, this is aggregated over all the ground motion models, the uncertainty in the median ground motion model in this case, you can see it's much greater than the uncertainty in these other elements. And they're using these types of feedback assessments to try and help them determine where they want to place their resources as they go into the update of the PEGASOS study which is now ongoing. This is just a similar type of one for PVHA at Yucca Mountain.

And this is really the same sort of ownership issues really that were outlined in the original SSHAC study of where we have ended up in conclusion of this particular study as well. That for the high level studies the ownership is really by the experts shared with the TFI. And for Level-3 the ownership is by the TI team or TI and TI team.

And then the last bullet I think is the takeaway lesson learned from the Swiss study. Is that the sponsors to be capable of both specifying the scope, understanding the scope, and understanding and interpreting the technical results. They have to be intellectually co-owners of this, not just the people with the money. And the feeling was that that's what led to the problems in the Swiss study at the end.

Not that there were problems with the study. It was problems between the funding agency and those who conducted the study.

The last couple of slides I'm going to try to go over very quickly here. And these have to do with recommendations for updating of PSHAs. And this was a very long two days worth of discussions on this particular topic.

We're not as mature, I don't think, in where are recommendations are at this point in time. And, again, these recommendations are the recommendations, they are not necessarily NRC staff recommendations. These are the recommendations that are contained within the documents that are a draft to us from the USGS, the document of discussions of these workshops.

We considered three different applications that we would need to potentially deal with for doing updates.

The first is the broad regional models, like Jeff described.

The second would be site-specific updates for new facilities. Let's say I have a existing regional model and I want to put a plant at a particular place. I'm going to try and use the

existing regional model to the maximum extent practical. How do I go about ascertaining what kind of updates I need to do for that?

And then the last would be site-specific models for existing facilities.

And the way we had ended up having to do this, and I apologize, it's a bit complicated. Is we ended up devising new terminology: Never a good thing to do.

The first being "revision," which we refer to as the development of a complete regional models and that could be in terms of seismic sources or ground motions, or both.

And the second would be "refinement," which would be those things we'd have to do for a site-specific modification for the example I just mentioned a moment ago. If I have an existing regional model, but I need to go in and look at more detailed evaluations within a 100 kilometers of my site, for example.

And the last is a "partial update." That would be if I have an existing regional model but new information becomes available, what are the basis for making the decisions about updates. And that decision process you can't get away from having to talk about--

no matter what you do it's always going to be couched in phrases like if a significant change is -- if inclusion of some new model result in a significant change. And ultimately after quite a bit of discussion of what the conclusion was, that in terms of recommending changes this significance is going to be project-specific. In a sense, it's going to be something we talked about a little earlier. It depends a little on what your project is interested in. Is what I'm interested in in terms of the ground motions at a given probabilistic level, in other words changing this model does it make my ground motions for 10 to the minus 4 go up significantly, you know, 2 percent, 5 percent, 10 percent, whatever. Or is it in terms of the hazard level for a particular ground motion? In other words, it matters whether or not you're interested in the X axis or the Y axis as a hazard curve.

And typically for projects that use risk we're more interested in terms of the hazard, the Y axis for a given ground motion level, and we tend to tolerate larger changes in that than we do the ground motion. And that's a function of the slope of the hazard curves. But those are things that we'll have more to say on when this document comes out.

DR. HINZE: Again, sensitivity studies?

DR. AKE: Yes. But essentially thought you run a sensitivity study and then you have to compare it to something else and say well how much did it change my result.

DR. HINZE: Right.

DR. AKE: And it matters whether you're talking about change in the ground motion for an annual exceedence level or changing the annual exceedence for a given ground motion.

And lastly, the primary couple of slides here have to do with regional models. This is what Jeff talked about. The community felt that for the central and eastern U.S. that we're going to be dealing with large regional models for the foreseeable future that are applicable to large regions and that could compute the hazard in any latitude and longitude within this large region. And that these should be conducted at the SSHAC Level-3 or 4. And the overall goal is to provide stability, and we think that doing a high quality study following these general guidelines does hopefully achieve that goal.

And what the models consist of is actually the logic tree that describe the alternative models, the supporting databases. And sometimes --I didn't

put down here unfortunately. These days we're referring to as the hazard input document or HID. This is something that rose out of the Swiss study, and I think everyone who has looked at that feels that that's definitely the way to go.

The old models like Yucca Mountain, like EPRI, like Livermore it's very difficult to look at the documentation for that and immediately translate that into something I can put in my hazard computer program and actually use. It's a formidable challenge. And the hazard input document is something that was developed really by the hazard analysts as a way to really distil this down into something we could use quickly.

MEMBER RAY: On that point, I know you're in a hurry and the Chairman wants to get done here, but I just have to insert a question, or maybe an observation.

I've been involved in siting here over the last couple of years. And you were talking about Yucca Mountain. It's quite granular as much as you can possibly get, I guess. But I see that there's much incentive in general. You're talking about large areas, whether it's east or west. To be very granular with regard to regions. And yet an applicant might

well have a very good site that has been painted with the brush of a big region because nobody bothered to parse the thing down in more detail. Is that a problem as you see it? I mean, these regions defined in a way that people are going to say oh well now I've got a subregion in here that I want to address for siting purposes that doesn't need to carry with it the attributes of this large region that you've cooked up.

DR. AKE: Well, one of our requirements is for someone goes in using a regional model like this, the requirement is to look at increasingly more detailed studies within 320 kilometers, 40 and one or ten or something.

MEMBER RAY: So you don't think the region carries with it any necessary conclusion or outcome as far as a particular site?

DR. AKE: Not necessarily, no. It provides a framework as a starting point. But then there is the requirement that any applicant has to look in more detail, successfully greater levels of details as you move in --

MEMBER RAY: You know, because it's expensive to actually --

DR. AKE: Right.

MEMBER RAY: -- parse these regions down

and God knows some God forsaken place that nobody thinks you're going to want to build a plant, but it turns out that you do.

DR. AKE: Right. Well, and the idea here is that there is efficiency and expediency with having this existing regional model so that you can expend your resources mostly within those inner rings where the probability of finding something that would actually change the hazard significantly is the greatest.

MEMBER RAY: I'll let you go on.

DR. AKE: So the regional model really doesn't include the hazard calculations or, you know, site-specific site response models is merely the basic framework.

And this goes back, the last slide here goes back to what Jeff was talking about that there was a lot of discussion about this community-based regional model and that the idea that that could be advantageous, I think that's carried over in the draft documents to us. And that, again, would have some sort of multi-sponsor framework. And one of the advantages to that is that it provides stability in terms of long term funding, although you know whether or not that could actually ever happen. The practical

implications of that are certainly one we'll see where we'd have a broad variety of different co-sponsors. And as Jeff in the last slide that Jeff showed, the organizational structure would be some sort of management committee that was derived or developed from the sponsors and then there would be a technical working group under that that met on a regular basis, yearly or biyearly I think is what we talked about.

And obviously one of the issues is whether or not you could get long term commitment from a diverse set of agencies like that to perform something, and what role the USGS would play is also. They have somewhat different needs for their products.

And there again, this ultimately in terms of the issues for updates, you know we have to go back and look at for refinements of the regional model, if we're going to put a plant somewhere, to look inside these smaller rings and look for additional local sources that may have been missed in the development of the regional model. And we have to evaluate the importance of those based on some significance tests like we talked about before.

MEMBER RAY: I'm actually thinking about it the other way, which is that there's areas within a

large region that are not as hazardous as the region itself.

DR. AKE: That is incumbent upon the applicant to make that case, that that is in fact what--

MEMBER RAY: Yes, that's right. But I mean there isn't any additional barrier to them doing that as a consequence of --

DR. AKE: I don't think so. Would you? I mean, they would have to make the case that there is something different about that site.

MR. MUNSON: I have to confess I haven't been following this conversation.

DR. KAMMERER: I mean, well one of the things that, for example, the technical integration team is looking at is when you look at these different models, all the tectonic models that you really tried to separate out your regions by the fact that everything within that region, is the same sort of -- has the same --

DR. AKE: Has the same tectonic characteristics.

DR. KAMMERER: Right. So if you had, say, a different maximum magnitude or you had significantly different rates or things like that, those would

actually separate out those source regions. Those are the types of things that you would use.

Now there is some areas, you know you saw the smoothing. So there might be some. But generally things are really different within a region, you would have a different region.

MEMBER RAY: Well, we'll let it go.

MR. CHOKSHI: But I think from the process point of view and there's no prohibition. People can come and make a case.

MEMBER RAY: Okay. I just don't see the effort being made to look with that degree of granularity nor is there any reason at this point in time.

DR. AKE: These large regional models the discussion if we go towards these -- and this really is one of the key things that we wanted to deal with in this project is what's a reasonable frequency for updates or revisions to these regional models. And we ended up discussing two different approaches here.

One would be what we refer to as the fixed life span and the other would be indeterminate life span.

Indeterminate life span is really, we've talked about a little bit, the decision to update or

not would be based on the availability of new data and the significance of that data. You know, relevant to a previous existing hazard estimate does it change? And, again, you're going to have to decide for a particular application -- and I don't mean an application to the NRC, but application of the hazard, is it hazard significant or ground motion significant?

One of the issues with that as it leads to perception of stability, but it clearly incentivizes updating. You know, you could end up with a very, very long shelf life at that point.

Fixed life span, conversely, clearly defines upon what schedule are we going to do updates. We think one of the advantages of that is it allows agencies involved to try and development a more stable planning of their budgets. Downside is you may be required to perform a revision when there really isn't a lot of information available.

Ultimately after a lot of debate the recommendation in the draft report at this point is that regional models should have a maximum life span of about nine years. And part of that is based on this philosophical approach that we would like to have a community model in many cases that we can integrate with things like the building code, the USGS National

Hazard maps. And a nine year life span on these would allow integration with those if it was a year or two of the six year cycles and three year cycles of those products.

And this point we're wrapping up getting the draft reports from the USGS. The first one, which is on the implementation guidelines, has been received. Ultimately that will come to us as a final product and the USGS has an open file report.

The second portion of that deal with the process of updating, and that is in progress. And so it will come to us as a white paper.

NRC staff with some contractor support is going to take those two documents and bring them together and produce a NUREG. And we hopefully will be able to do that in roughly the first quarter of 2010. It depends a little on when we get the final white paper on the recommendations.

If anyone's interested, we can provide a copy of the draft report. I think Tom didn't see a problem with that.

And I'll leave you that, which is Tom Hanks' version of what the Level-4 process actually looks like. And you can see all the various participants there outlined. If you're on the TFI

team, you get the really cool wizard's hat. And if you're a TI member, you would get a little laurel wreath with a Greek -- EPRI members, I noticed that with the exception Annie, they're all grayed beards. And the hazard analyst, who actually does all the heavy lifting, he gets the hard hat.

Anyway, I'm sorry I ran over.

CHAIRMAN POWERS: No, no. We started you off a little late. That's fine.

Any questions to the speaker here.

DR. HINZE: I was wondering, Jon, will your report have a recommendation about a decision between Level-3 and Level-4?

DR. AKE: The NUREG you mean?

DR. HINZE: Yes. Your plan, I don't see that in here. You thought that either Level-3 or Level-4, there's a lot of difference.

DR. AKE: At this point sitting in front of you I can't tell you for sure we would say. I think it would presumptuous for me to actually say at this point. I don't know.

DR. HINZE: Will the USGS second report touch on that subject?

DR. AKE: They will probably have a recommendation from -- I think the way it's written

right now is Level-3 or Level-4. Very good point, Bill, it's a long ways from Level-3 to Level-4.

DR. HINZE: I mean, that seems to me that answers only half the problem you know. When you answer the problem of when do you have to revisit the probabilistic study, you have to also say something about the level.

DR. AKE: I can only say from practical terms it's a big difference whether or not we say you should update every X number of years and the update consists of doing a Level-4 again or a Level-3. That's a major -- and I wouldn't feel comfortable sitting here and saying it.

DR. HINZE: I commiserate with you.

MEMBER ARMIJO: I have a question. In coming with the --

DR. HINZE: Can I just throw just one very last thing.

MEMBER ARMIJO: Oh, go ahead.

DR. HINZE: You might find it useful to look at the contentions that are coming in from the State of Nevada on the PSHA.

DR. AKE: I looked at those.

DR. HINZE: You've looked at them? Have you learned anything?

DR. AKE: No comment.

MEMBER ARMIJO: Coming with your nine year frequency in your recommendation, is your expectation that these regional models that will continue to change, the new information will continue to come in that it's really justified? Won't there be a time when you reach a point of diminishing returns where, you know, the earth is what it is and --

DR. AKE: Well, the earth is what it is. The problem is --

MEMBER ARMIJO: Is it your expectation this thing will just keep -- every nine years you'll have sufficient new data that would actually justify the time, expense to do, let's say, a Level-4?

DR. AKE: I have my own opinion that. I'll try and answer that. I'll maybe ask Cliff and Annie and Jeff what they think, because they also attended all the workshops as well. I should point out there was a fair number of NRC and other folks that attended these workshops.

At the end of nine years you might conclude that significant amounts of the existing regional model don't really need to be updated, that there might only be certain parts of the model that needed to be touched. So you'd be doing an update,

but you may not be touching --

MEMBER ARMIJO: A portion of the model? Okay.

DR. AKE: You may not be touching all elements of the model.

MEMBER ARMIJO: Okay.

DR. AKE: There may be relatively little-- let's say, you know 18 years from now there may be relatively little new data with respect to, say, paleoliquefaction in the central and eastern U.S. That would influence what you would do in terms of updating.

MEMBER ARMIJO: Yes, that was a point I was trying to get at. Okay.

DR. AKE: Do you guys agree with that or--

MR. MUNSON: Yes. Definitely it make sense since we're doing a Level-3 study right now, we're certainly not going to do a Level-4 update in nine years.

DR. AKE: Yes.

MR. MUNSON: So it doesn't make sense. So I think, yes, we would tweak parts of the model where we see differences.

DR. KAMMERER: Yes, I agree. I think the way that things are going now, certainly in the

foreseeable future nine years, I would anticipate that we would have new information. But, yes, I mean again we're doing a Level-3 now and I think we're going to see then how we feel at the end of that. But so far it's going very well.

And, again, when you redo the process you don't necessarily have to start from scratch. I think one of the very important elements of this is a lot of effort is going into documentation, data collection. And so in nine years we wouldn't be starting from the same point or starting from this time.

DR. HINZE: It's kind of interesting to think about what really has triggered the current reevaluation. I mean what has changed over 25 years. You know, I mean I've got my ideas and I think everyone else. But there are valid reasons for redoing it now, and that kind of gives a kind of an insight into when you should be redoing, I think.

DR. AKE: Thank you all very much for the opportunity for us to come and talk to you.

CHAIRMAN POWERS: Thank you.

At this point we can -- I'm going to call a 15 break and we can bring the transcription to a close. The Committee will come back and we will discuss a little bit about what we will do in

connection with the Research report and so on.

You got to go. Would you tell us what you think we ought to do in connection with the Research report before you go?

MEMBER APOSTOLAKIS: I liked everything I heard. I think praise is in order.

CHAIRMAN POWERS: You know that I'm constitutionally incapable of that.

MEMBER APOSTOLAKIS: I actually am really anxious to look at the GSI-199.

CHAIRMAN POWERS: Well, that is a separate issue.

MEMBER APOSTOLAKIS: I know it is a separate issue, but I am. But in the Research report you might point out that this is really a great piece of work and there's a lot of investment on the part of agency, and yet the NRC is not using it. Other groups within the NRC don't use this, and we have a good example with 5046 where they did their own thing.

And I think I had that other comment some time ago urging the Commission to direct the staff to have a uniform approach --

CHAIRMAN POWERS: You have, indeed.

MEMBER APOSTOLAKIS: And it went very far, as we all know.

CHAIRMAN POWERS: That's right. It had the usual impact of an academic recommendation.

MEMBER APOSTOLAKIS: But it seems to me that it's important to that. I mean, the 5046 is of equal importance and yet its done completely differently. So that's all.

But in the Research report, we might say something like that.

CHAIRMAN POWERS: We certainly can reiterate comments we made in the past.

Okay. Well thank you, George. And appreciate you attending and wish you well on your travels.

I'm going to take a break until 25 off. We're going to come back and get your input. We can bring the transcription to a close.

(Whereupon, at 3:23 p.m. the meeting was adjourned.)