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P R O C E E D I N G S

MR. FARNHOLTZ: Okay. Welcome back from lunch. I hope everybody had a good one. My name is Tom Farnholtz. I'm a branch chief in the NRC Region 4 office in Texas, and I'm here to introduce our next session of speakers for the Session No. 3. Probabilistic Seismic Hazard Assessment is the name of this session. The speaker is Annie Kammerer is a senior seismologist and earthquake engineer in the Office of Nuclear Regulatory Research at the NRC office and headquarters in Maryland. She coordinates and manages the Seismic Research Program, overseeing research on topics such as a seismic hazardous assessment and seismic risk assessment for nuclear facilities.

And then Mark Petersen is the chief of the U.S. Nuclear Seismic Hazard Mapping Project of the U.S. Geological Survey in Golden, Colorado. He also serves as a national coordinator for the USGS Earthquake Hazard Program. One thing of note, you'll notice when Mark does his talk and his slides, you'll notice the slides are not in the package, and that's because we didn't get those in time to include those in the printing order. But they will be posted on the public website following the completion of this workshop. So four following along on the slides and can't find them that's the reason. Thank you. And Annie.

DR. KAMMERER: Thank You. I just wanted to clarify really quickly that Mark is the chief of the National Seismic Hazard mapping program, not the nuclear seismic --

MR. FARNHOLTZ: My apologies.

DR. KAMMERER: [laughs] Just for clarification purposes. Well, hello. Many of you I've seen before. Thank you very much for coming today. This is probably going to be very simple for many of you, especially given the fact that you've seen many elements of what I'm going to be talking about already, but my goal is really to make it simple enough that everybody leaves with an understanding of probabilistic seismic hazard assessment because it's something that we're going to see here related to the hazard assessment in the region over the next couple of years and so my goal is to really give everybody, especially the local participants in this workshop, an understanding of probabilistic seismic hazard assessment.

So we've seen, of course, that plate tectonics is the driving force of seismicity in this region. We've seen some really excellent presentations this morning related to that and that this region sits in a -- inner plate is its own -- which is a very complex share zone, so there's a lot going on, a lot of uncertainty. There's strike slip; there's thrust faulting. It's a very complex environment.

So some of the basic questions of seismic hazard assessment that we need to answer, there's really three fundamental questions. The first is how hard is the rock going to shake? What is our design or our review shaking going to be? How does the soil react? And I'm not going to talk about that in this talk. You saw Professor Moss discuss that earlier. And the basic question of earthquake engineering is, how to do the structures systems and components react to that shaking and how do we design appropriately to make sure that the plant is sufficiently safe?

The important elements that determine shaking earthquake at a specific place are, of course, the magnitude of the earthquake, the distance from the fault to the site -- and we saw some discussion of that earlier -- and the geology of the path from the point of rupture all the way to the sight. So how do we calculate how hard it's going to be, how hard the shaking is going to be? There's two basic approaches called deterministic seismic hazard assessment and probabilistic seismic hazard assessment, and so I'll go through the first and then the latter.

So deterministic assessments as we saw discussed earlier are worst-case scenario analysis that are based on known faults. We look at a single scenario, which we considered to be -- you heard the term “maximum credible earthquake” or “maximum vent on a particular fault.” And for this we need two types of information. We need information about the fault, which we've seen called “seismic source characterization,” and we need something called a “ground motion prediction equation.” And some of you might recognize these as formerly being called attenuation relationships. Attenuation relationships are now called ground motion prediction equations, and basically what these equations are are statistical relationships that say for a certain magnitude earthquake this far from your sight of interest, what is the likely shaking that's going to occur? It's basically what tells you for a certain scenario event what's going to happen at your particular sight of interest.

Now, as we heard, there's a lot of challenges in determining what the worst case really is. There's -- sometimes there's uncertainty as to how large a fault really is or what magnitude it's capable of. Sometimes there's uncertainty in its exact location or is it going to rupture in the future exactly where it is in the fast and what we'll see is there uncertainty related to the ground motion prediction equations and so that's another question. So, in deterministic assessments what one tries to do is to deal with those types of uncertainties through conservative assumptions. So, seismic source characterization, for this you require complete characterization of the faults that might produce that worst-case scenario.

Now, for probabilistic seismic hazard assessment, which I'll show in a minute, we need to characterize all possible sources that might impact the plant so we have to account for all the seismicity in the region, not just the particular scenario that we are considering. And as you saw in seismic source characterization, because of the complexity of the earth, particularly the complexity of the seismic zone such as we're in and the nature of natural variability, it's very, very important to use multiple sources of data to determine that characterization. We saw many different types of sources of data today, and all of those are critically important for creating a picture.

So the work that we saw earlier in the last session is very, very important for trying to characterize in certain in this region so just as a reminder, some of the types of data that we are looking at seismicity, which of course, is really one of our fundamental pieces of data because those are earthquakes. That's what we're considering. So we saw Dr. Hardebeck discussing how some of that's used. Topography, of course, we saw that in the landscape you see the effects of earthquake and that includes the multi-beam offshore work that's being done. Sub bottom profiling, which gets -- up there on the left, which goes to some information about where the faults may be. Geology, geomorphology, the magnetics gravity, we saw some geodetic data with GPS, all of those pieces of data are pictures into this very complex earth, and we have to take them all together in order to try and develop our source characterization.

So ground motion prediction equations, as I mentioned, these are basically statistically based relationships, here in the West, which take information from past events and develop a prediction of what we would see at a particular type. So these are recordings from the magnitude 6 Parkfield, California earthquake; we saw some information about this earlier. And one thing that you can see is that there's scatter in the data, so as you can imagine, not every time you are, say, 10 kilometers from a magnitude seven earthquake are you going to have the exact same shaking at your site. There’s natural variability in the earth; there's natural variability in the way that the fault ruptures. And so for that reason, there is what we call aleatory uncertainty or aleatory variability, natural variability in the process of the earth that we need to account for. So the line in the middle is the ground motion prediction equation that was developed by Boore [spelled phonetically] in '97.

So, one of the things that's important is to look at the range of that variability and our ground motion prediction equations. Now, I mentioned in deterministic analysis, we use what we consider conservative assumptions in our credible scenario. And so what we do and what we've probably seen, those of you who are familiar with some of the local information is we use an 85th percentile ground motion. And so if you were wondering on some of the plots that some of you have seen before, what that 80, 84th percentile means, it's basically that the upper bound of that blue band, which accounts for all of the uncertainty in the data. So these basically show the plus and minus one standard deviation along with the meeting ground motion. Now for, probabilistic seismic hazard assessment we look not at a single value but we actually integrate over all of those ground motions and it's a very important element in characterizing the uncertainty.

Okay, so moving to probabilistic seismic hazard assessment. For this we need to consider all sources that might impact a site and that includes both faults that we are aware of and back ground seismicity. You heard several times earlier that earthquakes occur that all not necessarily directly tied to a fault. We can't tie them to a specific known feature. In probabilistic seismic hazard assessments you have to account for both. So you take the recorded seismicity; you take the energy that's coming in out of a region. You saw Tim Dawson showed a plot of a scale saying all the energy going in has to be accounted for and all the energy going out and see that's how we make sure sin probabilistic seismic hazard assessment that we are incorporating all of that potential energy.

An important element of PSHA is that it considers the probability or likelihood of different events over time, which is different from deterministic assessments. And they also have to account for, what we call model uncertainty or epistemic uncertainty. There was -- in Tim Dawson's talk he was talking about how slip rates are not necessarily well-known so we have to account for the uncertainty in various parameters that go into the assessment. Now the NRC currently uses a probabilistic approach which considers the -- an annual probability, a ground motion, a 10 to the minus four, so that's basically a one in 10,000 ground motion for the assessment of new facilities.

So you've seen that something like this before a couple of times. This is a logic tree, and this is how we account for the uncertainty in our seismic source characterization and also the ground motion prediction equation models in a probabilistic assessment. And so as we address some of the questions that are coming out from the research that's happening at the USGS that we saw earlier in CGS [spelled phonetically], this is a way to account for the uncertainty that we are not quite sure if, for example, the exact location of a fault, or how long it is, or what its maximum magnitude is. This is the tool that we use to transparently show the uncertainty in the source characterization model that will be developed.

So just very quickly to talk about what it actually is, what are the components? I think I lost the mouse; there we go. Okay. So the first step, so just -- the PSHA consider the effects of all possible earthquake scenarios and the uncertainty in the different input parameters. It takes each scenario and says, okay, what is that scenario mean for my particular site? And these are not just maximum scenarios; these are also smaller events on the fault. For each scenario, okay, what will happen at my particular site and what is the likelihood of event of that actually happening? And all of these are combined together in a probabilistic framework.

So the first thing that we need to do is develop our seismotectonic model our seismic source characterization that it counts for all of the faults and all of the back ground seismicity and the uncertainty in all of those. Now, for each source we have to develop something called the recurrence model, which says that how often do earthquakes of different magnitudes occur? So we have the cumulative rate of earthquakes on that particular source verses magnitude. This tells us how likely any particular event is.

So taking all of those together to give us the whole suite of possible events and the likelihood that occur. We combine that with the ground motion prediction equations and the uncertainty in the ground motion prediction equations. Wrap that altogether and that gives us our ground motion hazard model. So what we're trying to do is very different from a deterministic analysis;

it's looking at all possible events.

Now, what comes out of this is something called a “uniform hazard response spectrum,” and it's called that because all of the points on this spectrum have uniform hazard. And some of you might have seen something that looks like this before but had no idea what it actually kind of meant other than it's a characterization of ground motion, so I'd like to go over it a little bit. And I want you to think back to your childhood of getting on a swing set. So kind of recall what it felt like: you get on and the swing is sitting there, and as you kick your legs, it moves and your swing goes higher and higher and higher. And if you recall, the way that that swing went back and forth it always had the same rhythm, and all that happened is you went higher and higher as you started moving faster and faster and faster. That was the national frequency or the national period of that particular swing, with of course, you being part of the system and if you recall when you got on something like a jungle gym like this the different swings had different natural frequency, and so some went really fast and some went really slow, but each particular swing had its own rhythm.

Well, picture the swing set and an earthquake goes through it. First, it's sitting there, just sitting there quietly, not doing anything, and an earthquake comes through, the swings begin to move, and they are all moving in their own way because they all have their own natural frequency or natural period. The earthquake passes and the swings all come back to a static position. Well, at some point in that earthquake that swing, each swing, was moving its maximum extent. Either it was accelerating more than at any other time or its displacement was higher or its velocity was faster. So if you take that maximum response and you plot it against its natural frequency, what you end up with is your response spectrum. So it's the response of a very simple system to that earthquake that's gone through.

So we use the same thing for different periods, different structures. One of the questions earlier that was asked was related to whether or not a small stout building verses a tall flexible building which one responds the most to share, and the answer is it depends on the frequency and the natural period of that particular structure. Well, this is really why, is because earthquakes are going to -- the frequency content of earthquakes are going to cause different simple systems to respond differently and also complex systems as well. So this response spectrum is how engineers receive information about how hard the ground shakes, and these are used for designer review. So these are -- this is the method of communication between the engineer and the seismologist. And so I would encourage those of you who can't remember what it feels like to sit on swing set to go find your inner child at some point over the next week and to try this little experiment, and if they only have one swing you should take one of the swing and throw it around the top and make it shorter so it will swing faster.

But so the uniform hazard response spectrum, with a little bit of modification is what's taken and turned into a safe shutdown earthquake, which we'll discuss a little bit later. So some of you seen this in terms of a response spectrum of different plans or comparisons and so that's what this actually means. Now, all of this is for a particular site, but the goal of something like the National Seismic Hazard Maps or the California Geologic Surveys portion of the California Hazard Map is to try and give a probabilistic hazard assessment for an enter large region which is a very challenging endeavor, and so next Mark Petersen is going to talk about how that's done for the enter U.S. and how the data is used for that purpose and into the national building codes.

[applause]

MR. PETERSEN: So, again, I work for the U.S. Geological Survey, and we are responsible for making hazard maps for the entire United States, and these are used for a number of different applications. For example, we work with the building code communities to put these into the international building codes that are basis for most of the buildings that -- probably the building that we are in today. We have roads and bridges that are governed by these national maps, the railways. We have the insurance rates, so the insurance rate industry is using these maps to try and understand. So we try to really give a fair and balanced approach to assessing hazard, and typically, in the past, the building code community, in particular has really wanted to go to this probabilistic seismic hazard format because they can understand better. Even though it's a very difficult process to get your hands on but they can understand what the different uncertainty, how those uncertainties all fold into the hazard so you are not just designing for something that's an average kind of ground motion but you are designing for something that really is appropriate for the importance of the structure that you are looking at.

So today I want to just give you a favor for what we do in the USGS to try and develop these maps, and I wanted to start by showing you the process that we go through in developing these maps. To do this we know that there are -- there's a lot of good science that's done all over the world, and in particular, in the United States there are a lot of universities and private industry that is doing important research to us so we hold workshops. We hold four regional workshops around the United States to gather information on each of the different areas and then we hold topical workshops to talk about the ground motion prediction equations like Annie just talked about. We have -- we work with the engineering communities so we talk with the user needs workshop where we discuss what kinds of parameters they are interested in understanding so that we can make these maps more useful to people. Do we have a pointer at all here?

FEMALE SPEAKER: No. You have to use the mouse.

MR. PETERSEN: Oh, okay. And in doing that we make draft map, and these draft maps all go out for public comment. So you can see there's a comment period here that went on for six months, and actually that says only two months but it was a lot longer, in 2007. We have an external review panel that reviews this. In cases where we don't -- where there's a lot of controversy I'm going to tell you about some ground motion prediction equations today that were a little bit controversial. We weren't sure if they real applied as well as we wanted so we wanted to get the -- we wanted to get the community together to try and assess whether the community felt that these ground motion prediction equations were appropriate for use in the National Seismic Hazard Maps. And then there's a lot of quality assurance that goes on, and we released the final maps back in January of 2008 and April 2008. And these now have been accepted into the NEHRP -- that should just be N-E-H-R-P -- 2009 version of the code the ASCE 7, 2010 and the IBC 2012 will then adopt these codes. So you can see it's a long process that we go through in order to get all this information together.

Now, for California, because California is such a complicated place, and also seismically --

[laughter]

-- we put a lot of effort into California, and we actually had a working group, a separate working group, that went forward with describing what are the different parameters that we should apply. So you can see the list of the different people that participated in it. We produced a Working Group on California Earthquake Probabilities that was also released about the same time as our National Seismic Hazard Maps in April of 2008. There was a separate review by both the National and the California Earthquake Prediction Evaluation Councils, so we try and put all the best minds on this to try and really give us the feedback so we can really have confidence that these maps are going to be used -- have the appropriate input in them for the use by the building codes and others.

For California we put a lot of effort into several different types of data. You can see down here at the bottom that we use a lot of geodetic data. We haven't always had that kind of data but we've been collecting geodetic data, GPS data, that will help us to analyze how fast the ground is straining. And so -- or how fast it's moving. And so we use that data now. We put together strain map and we put in a lot of effort into trying to understand how that strain relates to earthquakes. We also put a lot of effort into mapping faults. And you can see here is a picture of a nice easy fault that you can map, but we have a lot of faults, more than 200 faults that are including in our model that have significant slip rates. So we have measuring how fast the ground is sliding past, -- slides past each other, the different slides of the fault to try to understand how many earthquakes we think can occur. The faster the slips, the more likely -- the more frequency of earthquakes we would expect to have on that structure.

And we also -- I think there was some discussions in the last session about how we also need to determine different magnitudes and different sizes of earthquakes that can rupture on those faults. So we look a lot at different scenarios of how these things might rupture, and we do modeling of all the stresses to try and understand when a fault jumps to another strand and whether it jumps or not. And so, I think you have several discussions, probably -- Tim Dawson has done a lot of paleoseismology where they dig a trench and try and understand from that data about how many earthquakes they can actually see in the trench to give us an idea of the frequency of those earthquakes. And then we have all the seismicity data from California that go back about 200 years or so and there's a lot of effort that goes into trying to assess what are the appropriate magnitudes in that catalog. Back in the 1800s there weren't as many people in California, and it was more difficult to assess the size of earthquakes so we have to go in and try to understand how big those earthquakes were so we can get an idea of how big the future earthquakes might be. And finely we make a composite forecast of the rate of earthquakes, which again was released to the public. So this is some of the information that actually goes into the California model itself.

We also have spent a lot of effort recently putting together these strain maps. So on the left one over here, you can see the strain -- these are strain rate maps based on GPS measurements, many GPS measurements over the last 20 years or so, and you can see on the right panel some of the faults we have in our model that are color coded by the slip rates. You can see the San Andreas Fault coming up along through here and then the faults coming up along the coastal portion of central California. And you can see that same pattern is observed when you just look at strain rates or the deformation rates in the Earth. And so we are trying again to put these altogether to try and understand how the activity rates of earthquakes from this geologic and geodetic data. And finally, again, we put a lot of effort into these catalogs, and you can see that along the can he say of California there has been a lot of large magnitude earthquakes. These are all magnitude 6 plus earthquakes in yellow, and you can see that there has been a number of these over the last couple hundred years. And, again, we spend a lot of effort in that.

So in the end we produce what's called an earthquake forecast. We can't predict earthquakes. We've been trying for a long time to try and really say yes an earthquake is going to occur here at this place in the next 10 years, or in the next year, or next week, but we can't do that yet. But what we can do is we can look at all this information and try and assess how often these earthquakes occur and then what the shaking will be related to that, and when we did this exercise for the entire portion of California, the 30 year probabilities of having earthquakes for California of magnitude greater than 6.7 -- and we chose a 6.7 because that was the size of the Northridge Earthquake that caused a lot of damage down in the San Fernando Valley -- but the 30 year probability of having that is 99 percent. It's very likely if you go through almost any 30 year period in the past you would have seen a magnitude 6.7. We also do that for other sizes of earthquakes. There's a 94 percent chance that you'd have a magnitude greater than 7, a 46 percent chance that it would be greater than 7.5 and a four percent chance that you'd have a magnitude greater than 8. What's really in our model would be on the San Andreas Fault. This would be a major rupture, a 1906 rupture that affected San Francisco or in 1857 rupture that was particularly large. So these are the types of information -- and again, we have about three magnitude 5s per year across the state. So this is a very highly active region. We know that.

And we also broke it down by regions. People wanted to know how does the northern part of California from this line up, compared to that in Southern California and you can see Northern California again when the whole state has a 99 percent probability of having a magnitude of 6.7 or greater earthquake. Northern California has 93 percent and Southern California 97 percent. So again, this is -- this just gives us the statistics that we need to try and understand it. And when you look historically, a magnitude 6.7 typically occurs about every five years in California; 7 every 11 years, 7 and a half every 48 years. And a magnitude 8 we probably haven't even recorded one yet but it's 650 years or so.

So the other portion of the model that we need to take into account when we are designing or making hazard maps is we need to understand once the earthquake occurs how strong will the shaking be from that earthquake? And so we’ve worked a lot with different organizations, PEER, for example, the Pacific Earthquake Engineering Research Center is one who we've worked with to try and develop these ground motion models for -- that we are using in our maps. And you can go now to the PEER, which is aft UC Berkley. It's a major center, it's sponsored by PG&E as well as many others, but it's a place where you can go get information on all the different earthquakes that we have records for. And so this is a wonderful database that was put together to try and standardize the way we model ground shaking. When we do that -- when we make previous models, we had a certain amount of data but when they went through and collected all the data that they could find in these regions, that's shown in blue. So the previous data is shown in red; the new data is shown in blue. You can see that as they put these data together they were able to collect an additional large amount of data which makes us have more confidence in your ground shaking and also gives us better estimates of uncertainty as Annie talked about.

So they collected a worldwide, 172 worldwide earthquakes, 1,400 recording stations. There's a lot of data that goes into developing these models. When they did that, they realized that the ground motions were coming out slightly lower than they had previously thought. So the older equations are all shown in blue. This is for a one second spectral [spelled phonetically] acceleration value for magnitude 7.5 on a firm rock site condition and so the blue curves are what we previously used and the red curves are the new NGAs what they call those curves, NGA equations. And you can see that for one second for the large earthquakes they are typically lower.

And so, this again, just to show the process, a lot of people were wondering, is this a real effect? And so we made these modelers test all these to try to look at the residuals, to try and tell us, do these apply to worldwide earthquakes or do they apply to California earthquakes? Is California different than the world? There's lots of questions that we had, and we went through this process to try and really drill down and understand these equations, and in the end the science community really felt that these new equations were based on better data new updated models and that this was a better way of assess the ground motion hazard.

So these are the maps that we produce. Annie showed these. We use a -- excuse me -- we use a two percent probability of exceedance in 50 years, and Annie didn't get into that. Annie says that the NRC is a 10 to the minus four. We use four times 10 to the minus four in the building code industry, so it's a little bit -- the nuclear industry is a little bit more conservative. They actually are a little higher ground motions than we would because this is what the building code industry felt like was a reasonable model for developing building codes. So two times 10 -- four times 10 to the minus four, or two percent probability of exceedance in 50 years. And these are maps -- we have published versions on our website, and I'll talk about our website in a minute.

I'd mentioned to you that for one second spectral acceleration that the ground shaking models were lower and that didn't bring down the ground motions by about 20 to 30 percent across much of coastal California. And so you can see in this map the ratio of the 2008 maps to the 2002 maps, and the blue colors are about 65 to 75 percent of the previous values. So they have come down.

This is a picture that -- or a slide that shows for different regions across Southern California and northern California and other places in the United States how the ground motion or the ratios of the ground motion -- for example; in Los Angeles the ground motions are 93 percent of what they used to be. All the red percentages are lower by more than 10 percent. Now, in the building code industry they actually did some things. They decided to use the maximum component of ground motion so in the end the ground motions didn't actually come down by 20 percent they pretty much stayed where they were. So they are about 20 percent higher than these values. But the actual ground motions did come down as a result of those ground motions prediction equations that I showed you previously from PEER.

I wanted to show you on our website we have a wonderful tool that allows you to go break down the hazard for a particular site so I ran this hazard model just went to our website but in the latitude and longitude of San Luis Obispo, and this is what comes out. What it tells you is on this axis you see the distance from the earthquake. On this axis you see the magnitude of the earthquake. Excuse me. And these are all the earthquakes that are contributing to the hazard in San Luis Obispo, so you can see -- oh, thank you -- you can see that the major contributors to the hazard are -- in San Luis Obispo are the Rinconada, the Hascre [spelled phonetically], the Los Osos, the same ones you've been talking about, also the San Luis Range. Those all contribute about 65 percent of the hazard. Now, we also have a back ground component that -- where we use the earthquakes, the previously recorded earthquakes to say where previous earthquakes have occurred in the past is where we think they might occur in the future, where larger earthquakes may occur in the future. So that accounts for about 32 percent of the hazard the background seismicity and the eight faults the San Andreas faults, in this case contributes about 4 percent of the hazard to San Obispo site. And you can do this at any site you want on our website. It's all interactive and you can go there and put in your latitude and longitude and get anything.

We also have for the 2002 version of our maps we haven't quite gotten that for 2008, you can do a geographic deaggregation which actually will show you the faults, it shows you the contribution, the contribution for each of these different faults in this case looks like the Los Osos is very important to San Luis Obispo because it's so close, because it's so close. The Hasgret [sic] Fault and the San Andreas Fault out here plus all the back ground seismicity is shown here as smaller bars because it doesn't contribute quite as much. So this is all available, again, these are things you can look at when you go to our website.

The other thing we've been trying to do is we try and look at different ways of testing our hazard maps because we don't want to put out something that isn't robust, that isn't something that we can stand behind. So one way that we test it, is the USGS is over the last several years created what's called “Did You Feel It?” maps. So after an earthquake, maybe some of you have done this in the past, where you feel an earthquake, you go to the USGS website, and you can mark in there exactly what kind of the intensity it was, what shaking you felt, and what you observed at that site, and we get thousands and thousands of responses from people when we do this. And we compile all those. All that data is available.

And this isn't showing up very well, but what I wanted to show you was just that when you take one of our older hazard maps here which is like 10 percent 50-year ground motion map, and you look at five years, so this is for 50 years, and we have five years of recorded data, what you want to see is you want to see it start looking a little bit like your map. And it is looking like that. In many places when you take a big region like this, you can see the highs up here in Washington, and these are all earthquakes that occurred after that map on the bottom was made. So you can see that the area up here in Washington has been active, and we show that in our map the area down here in Southern California this area over near Landers is active, and we have that. When you go back east, you can see these different yellow points here and they all correspond to these spots that we have in there. Really what that's saying is basically that where the earthquakes have occurred previously is where they are going to occur, but that's part of our model. We just wanted to test that model, and so we look at this Did You Feel It? data, we look at shake map data, and we try and really understand how and if there are ways that we can test these grounds motions.

Now, Annie wanted me to really quickly mention some of the criteria for building codes, and we do make the building codes maps, too, and it's a combination of deterministic and probabilistic ground motions that are used to make up the building codes. So I'm showing you here deterministic map which, again, just is if you have an earthquake what do you think the ground motions might be, either the 86th percentile or the 50th percentile, and so we make those maps and then they are put together -- the engineers feel like they can't design for ground motions that are too high for buildings. And so they want to truncate them, and so there are different ways that we truncate these things, and so these are all specified by the engineering community. And we take the advice of the engineering community because we are not engineers. We don't try and tell them how to build buildings. We just tell them what we think are the best ground motions -- what are the estimates of the ground motions at their sites and they make maps like this that are, again, a combination of probabilistic and deterministic truncated at .6 G to some level.

So I won't go into detail there, but what I wanted to kind of conclude with were some of the products that we have on our website. And in particular, you can see our website is earthquake.usgs.gov/hazmaps. If you go to earthquake.USGS.gov, you'll be at our NEIC, which is where we post all the different earthquakes that have occurred. You can see the shake maps. You can see the Did You Feel It?, the pager which tells you kind of roughly how much damage you think in real time how much damage you might have from any particular event, and then if you go to has maps site then you'll see all these hazard products. And what we have basically are the U.S. National Seismic Hazard Maps and all the input information. We have analysis tools like the deaggregation that I showed you earlier, where you can go in there and select a site and understand exactly which faults are contributing most to the hazard at that site. You can go in there and see all the seismic design values so this is hit by tens of thousands of people hit this site every month because every time they design a building they have to go to this site and pull off the design values. We make urban hazard maps, which we're making for many areas across the country. We have deterministic scenarios. We have time-dependent ground hazard maps. We have a U.S. Quaternary Fault and Fold Database. Again, I'll show you a picture of that in a second, and then we have some tutorial information, Hazards 101. So you'll have a chance to be able to go in and learn more about what these hazards are.

We have probabilistic fault displacement hazard. We're working with the California geological survey to try and understand if you build right on a fault it might be different because you could have some huge displacements, and we have some ways of estimating what the likelihood of those faults would be. We make risk maps. So we estimate, for example, for the probability of having slight damage giving a certain building code, and we make different maps like this to try and assess for people what is the risk in the area. This area here is for Los Angeles and this is an area back in Missouri and Tennessee over here.

We have, again, our seismic hazard curve and uniform hazard response spectra. These are -- this is the website the Web tool that engineers like which building code they are interested in, the addition, data addition that they are interested in, put in their latitude and longitude, and they can pull out either hazard curves or design values that they can use in their design of a building. We have the Quaternary Fault Database, which has not only the faults that we use in the model but everything that we know of that has the quaternary offsets so we look at everything that -- those million-year-old faults and put them in this database so that people could go in there and really look. You could go there and put -- look in the area near San Luis Obispo and pull up all the different faults and some of them we haven't included in our model because we may not have good information about those, but all the different faults that has been mapped are included here. And so that's a good resource for you if you want to find information on the faults near a particular site.

And finally I want to conclude that we are just beginning the process again. We do this over and over, and we're about ready to start our next version of the hazard maps for 2013. We'll have California workshop in 2012. There's a new UCERF process, which is going on, which is the Uniform California Earthquake -- Uniform California Earthquake Rupture Forecast model will be -- is going on now. And what they are trying to look at are issues like how often does one fault jump on to or does an earthquake jump from one to another fault? That's a very important issue. It's cluster models, those kinds of issues. And we're going to have workshops and discussion about that. They are all open. So any of you are invited to attend those. We'll have more on the ground motion attenuation relations for the Western United States. PEER is now sponsoring a new version of the NJ [sic]. They are going to update it again. And so we're working with them to try and make sure that these updates come into these maps. There's a new user-needs workshop that will happen we'll have all the draft maps again, and these are, again, for the next version of the ASCE 7 and IBC versions.

So again, this is like a continual hell, you know, just keep making the updates of these maps. But we want to just make them better and better every time and we need the input of the science and the user-community to try and help us to get the best information available that we can put into these maps so that they are the most robust and best maps out there. So, thank you very much.

[applause]

MR. MAIER: Thank you, Drs. Kammerer and Petersen. We are way ahead of time now, so all sorts of questions on probabilistic hazards and probabilistic analysis. Remind you to please raise your hand and if you have a question for one of the two panel members based on the presentations that were just given, as you can see we're building towards an end point, moving closer and closer towards applying a lot of this to the plant nearby as well as here in the area. Okay. Butch, you ready?

MR. BURTON: All set.

MALE SPEAKER: All right. I also would encourage anybody who doesn't want to necessarily stand up and be videotaped, if you want to put your question on a 3x5 card, Butch and I have those. You can put your contact information and please write legibly again, and we'll get that to someone who can get an answer back to you. Questions? I see one here in the middle.

MALE SPEAKER: [unintelligible], just a clarification. So it seems that with the new data, the [unintelligible] for California, are you guys going down while on the other side of the U.S. the new data from the, since it suggests that the hazard is increasing is this consistent with more data on that side indicating something?

MR. PETERSEN: [inaudible] So the question is, as I understand it, is why is it that the ground motions seem to be coming down in the west where they might be going up in the east? Is that the question? You know, I don't, actually for the last version of the maps the ground motions came down in both the east and the west and so there -- but it's not a simple thing because some ground motions actually go up and some go down. There were lots of -- I simplify it when I say that they came down because they did, and I showed you the maps in the best but there are places where the ground motion were actually higher it just depends on the, a lot of different features of the faulting. For example, those new ground motion models take into account the dip of the fault and whether you were on the hanging wall side, or if you are above the fault, or whether you are on the side of the fault, and so all those features come into play. So I didn't point out but Santa Barbara, for example, went up compared to a lot of places, and it's because of the dips of those faults, some of the depths of the faults have changed.

In the east, the ground motions have been -- have changed a little bit but it's mostly because of one new ground motion equation that was added to the mix and what was determined was that for the east we needed to learn more about those ground motion models, and so there's a whole effort -- NRC is actually sponsoring a lot of it. It's call the NGA East. So it's following in the footsteps of the first NGA and trying to use that, the best elements of that process, to try and develop new models for the east. We don’t really know where those are going to end up. But I can just say that there's a lot of more uncertainty in the ground motions in the east than there are in the west because we haven't recorded any of the large earthquakes, so it's difficult to assess that. Here we have a better estimate of what ground motions can occur in an interpolate kind of environment where you are right near a big crustal earthquake. Other questions? We'll go to Sherry [spelled phonetically] first.

FEMALE SPEAKER: Hi. I'm not sure I'm going to get this out right, but anyway, the probabilistic assessments, which is what all this was, is based on data, and there was so much data there I couldn't understand much of anything but --

MR. MAIER: You weren't alone.

FEMALE SPEAKER: -- oh, I'm sure. I know. But the data -- most of the complex data seems to come from recent observations because it's such a new science on earthquake and all and you can find out distant past stuff by paleoseismology or whatever the word is, but that's not that detailed. I mean, you find something in a trench under the ocean you are not going to get all the detail that you get from an earthquake that's happening now. So, but on the other hand -- so you've got that, a lot of data from recent stuff, not data from more than a few decades, not much.

But also you have the population growing and you have building happening. So you got to do something. They have to come up with regulations. And they sound positive and good and hard-core, but they can't really be all that hard-core because it's still such a new and growing science. So the thing that bothers me is that it sounds like everything’s under control and understanding things when it can't really be because as you say you've not even recorded a very large earthquake, you know, well, you weren't here to record 1906, and I don't know how big that earthquake was because a lot of the problem there was the fire. So what's my question? I guess I just wanted to comment that it sounds more wonderful than it really is. Okay, maybe you can answer.

MR. PETERSEN: Okay. I mean, I agree that this science has a lot of uncertainty in it. I tried to express that, like you pointed out, in the east we hadn't recorded a big earthquake. And so it's difficult for us to predict what a big earthquake will look like. That's true, what you are saying. I think what we've tried to do is look at -- there are two parts to this. I mean, there are the ground motion part of it and there's the source part, and we haven't recorded big earthquakes on those faults near San Luis Obispo, big earthquakes other than the 1927 Lompoc earthquake was, again, on the Hosgri Fault, I think or somewhere near that. No, no. Okay wherever that was. There's a lot of discussion about that but the Lompoc earthquake was one that did occur in this region.

So that's -- but we have a lot of earthquakes in the same type of environment so that gives us a lot of confidence that future earthquakes will look kind of like that so when we look at places like Haiti, and we've seen that big earthquake that occurred there, we can understand those ground motions from these ground motions equations that has been developed. When big earthquakes occur in Chile, we can kind of look at it and say how much do they differ, and sometimes they do differ, and that's why we're continually updating them. If we knew everything, we wouldn't be in the process of updating these every six years. So I don’t want to make the impression that we know everything about earthquakes. I think you know that that's not true. What we do is we use all the information that's available to us, and that's on the ground motions.

On the source side we also -- we have certain faults that have been mapped and we use those -- people go down and do the best job they can of studying those. We also account for earthquakes that we don't know about. For example, I didn't talk too much about our background seismicity model, but we assume that where earthquakes are occurring or where future earthquakes are going to occur, which seems to be a model which is very likely to occur. I mean, people have tried to do statistical studies of that and find that like 75 percent of the time in the east at least, that they seem to occur in regions where they have occurred in the past. Now, there's some places where we don't know, I think that's true, nut we've tried to use everything we can from the geodesy from the GPS data to the geology that has been record, plus we've accounted for earthquakes that we don't know about just by looking at where the seismicity is -- where the small earthquakes are occurring.

So I hope that answers kind of your question. I think you are bringing up that this is a very uncertain kind of thing trying to predict earthquakes where we haven't seen them. I think we are using all the information we can to try and get at that question and resolve that issue.

FEMALE SPEAKER: I certainly appreciate that. But the trouble with probabilistic studies is that when people give examples of it, like in the very beginning today, you know, you’re speeding and what's the chance that some policeman is going to see you speeding, well, the consequences of your being caught by this earthquake near a nuclear power plant, you know, is not a speeding ticket, but it's radiation covering Southern California.

MR. MAIER: I think we'll get into that in some of the more --

FEMALE SPEAKER: I know you'll get into that tomorrow but it's something that can't be forgotten and with all of the studies that you're doing you are getting closer and closer but you are still a distance away and it wouldn't matter so much if it were just ordinary day life, you know, people living in huts or people living in careful buildings, but when you have something where the consequences are just astronomically huge compared to ordinary stuff -- okay.

MR. MAIER: Thank you --

DR. KAMMERER: Let me just address that really quickly --

MR. MAIER: Okay.

DR. KAMMERER: -- and not keep saying we are going to talk about it tomorrow, let's talk a little bit about it right now. So there was a mention of the building codes and things like that, and I think one of the things that you've seen everyone say, I think, uncertainty has probably been over and over and over in every talk, and I think that that's one of the benefits of the probabilistic approach that we use now, and I'm going to have another talk again in the afternoon, is that the incorporation of uncertainty, really trying to understand what we don't understand, and to try to make sure that we incorporate that in design with that you on the ultimate risk. Because there was a discussion before that it's not only getting to the hazard, you know, we saw the comparison with the Bam [spelled phonetically] earthquake where you have tons of thousands killed, and it was really about the design in the buildings that were there for that same hazard.

So it is both. And you are absolutely right, so I'll talk about probabilistic risk assessment this afternoon covering another talk but that's something that we always have to keep an eye on. And that's one of the benefits, I think, of the way we approach things now, is looking at that uncertainty as well, because, I mean, you are right, you know, we'll continue to learn more and more and more over time, but let's make sure that we at least try and wrap our heads around what we don't know and account for that as well. So I think that's very insightful, your comments.

MR. BURTON: Okay. We've got one over here. Many thanks to this young lady.

MS. THATCHER: My name's Janet Thatcher. I have a question about the Parkfield data. Is there anything that you can say as a summary of what you might have learned from the data from the recent Parkfield earthquake?

MR. PETERSEN: So Parkfield, again, the USGS made a forecast of an earthquake at Parkfield, and we saw the earthquake that occurred back the ’20s and then again I think in ’66 or something like that, so we saw that it had a typical 30-something year. I don’t have all the details, but recurrence, an average recurrence, and it seemed like there were a lot of similarities between those two earthquakes. And so we felt like that was a reasonable way to say that in another -- 30 year, 30 -- there was one period that was shorter than the others, and so we thought we felt like we could make a forecast about how likely that earthquake was and do something about it, and it actually didn’t occur when we thought. It occurred later. It has occurred by now, but it didn’t occur in the period that we thought. So one thing I think we've learned is that we probably underestimated the uncertainty in that process. We thought we were looking at the uncertainties at a reasonable way, and we weren't. So I think if anything, we'd probably say that we should have increased our uncertainties and how likely that was.

We still have a lot to learn about, again, that was an earthquake prediction evaluation. We really wanted to try and see if we could predict earthquakes. And that's still the “golden ticket.” If we can get -- if we can really learn to predict earthquakes it would be a lot easier for everybody, but we haven't gotten to that stage yet. So we just need to really try and concentrate on trying to understand how likely -- and for these kinds of models that we're looking at, we're going to see the Parkfield go off hundreds of times in the next thousand years, or 10,000 years. You’re just -- because if it's going off every 30 to 50 years it's not going to make that much difference as far as the rate of earthquakes because we get a lot of earthquakes in Parkfield, and we will continue to get earthquakes in Parkfield.

So for these types of maps, I think we will have a high ground motion near Parkfield no matter what because it just goes off so often. But I think we cannot predict earthquakes yet. And that’s the other message that I think we have to realize.

MR. MAIER: We have a question here.

MR. BARD: Jeff Bard [spelled phonetically], Upland Research Science Action [spelled phonetically]. I hope that when you’re working you don’t truncate your studies at the U.S.-Mexican border. I’m sure you probably don’t. And the people who live near the San Onofre reactor were probably very grateful for that.

My background is more in epidemiology and public health, so some of this terminology is new to me. I do expect to encounter the next generation of Dr. John Gaffman [spelled phonetically] or Dr. Carl Johnson [spelled phonetically] out there. The question is, are they going to be credible? Let’s focus on these quaternary consensus fault databases and secondarily on the deaggregation

Web pages, because as you hinted, those are going to be critical in developing some questions tomorrow and going forward. So the clarifications that I request are actually pretty simple.

First, I'm going to ask you to expound a little bit more about what I'm calling the QCF, the quaternary consensus fault database. And secondarily, please explain to us how the data in that is incorporated in the deaggregation Web page. So to more specifically characterize the question, does the QFC database include all suspected faults for which there is some data, or does it merely include those faults upon which there clearly is a scientific consensus? And that may be clear to some, but in epidemiology I haven't encountered that. So please clarify whether this is an exclusive or an inclusive consensus.

And secondarily, then, please explain whether the QFC database is actually fully reflected in the deaggregation presentation at this stage. And if it's not, do you think it would be a good idea if going forward they go ahead and create different versions of the deaggregation page? Because that will actually answer the question that was raised earlier about whether Diablo can be said to be on a fault, because the answer is, it's a probabilistic answer and it's really an aggregation of several real or suspected faults. So I hope the question's clear. If not, please -- [break in audio] -- and I'll clarify it.

MR. PETERSEN: So let me try and tell you what I know about that. We make -- we have this quaternary fault database, and we work with all of the geological surveys in the United States to try and get the best information that they have on each of these different -- all the different maps that have been made and all of the information on how these faults were named, what the ages of the offsets were. There are lots of different parameters in that database. And this database is the basis for our seismic hazard maps. But we do not include all of our faults from the quaternary fault database in our hazard maps because for some of these we don't know whether -- we don't know much about their activity rates. Our hazard maps are for -- were primarily developed for building codes. And nobody wants to have someone just put in a fault that is very poorly understood into something like a hazard map that would cause someone to -- when there's not enough information on it -- when it's someone's speculating. Someone could put in anything they wanted to in this. So we work with the geological surveys to try and get the best information in this database, and we've put in all the information where there are trenches, where trenching has occurred. And then from that, we developed what is the consensus fault database which are parameters that are actually applied in our hazard maps.

So what I'm trying to say is we don't include every single fault that's ever been mapped in our database because there are lots of faults that are most likely not active, that are in that quaternary fault database that are not included in our maps; and we don't know anything about them. If there was more information on that we would certainly consider that. But we have a standard, a publishing standard that someone really has to have published this in some way before we include it in our hazard maps. Does that make sense?

MR. MAIER: Does that give you the first question, Jeff?

MR. BARD: I'm still a little confused as -- if the maps and the deaggregation, if that's all the same data or if there's different versions of the aggregation, because it seems apparent we need a need for another set of deaggregation presentations for those faults which are less clearly established in the scientific consensus.

MR. PETERSEN: Okay, so the deaggregation is really taking apart the hazard and saying, which different faults are contributing to the hazard at that site -- which magnitudes, which distances are contributing to the hazard? And what I'm saying is that we take the quaternary fault database as the subset of all the different faults that we're considering, and then we bring that down to the number of faults that really have consensus of the activity rates for those faults. And then that's what we put in the hazard maps. That's what we make the aggregations for.

So we don't really de-aggregate because if you just see a fault, it's difficult to say how active that fault is. When you can go in there and you can see a slip rate that that fault has actually slid a certain amount in displacement in a certain amount of time, then you can estimate that there's an activity rate associated with that. But if you don't have that information, if all you see is just a fault on the ground, how do you tell how active that fault is? How do you determine whether that -- I mean, it's something that a geologist has access to all these faults. So when they do reports for buildings, for example, they might look at a lot of different faults in the area and they might even make some hypothetical guesses at what those faults, the activity rates of those faults. But we don't really have any scientific basis to assign an activity rate to that fault. All we have is a location.

So it would be difficult. In order to really put that into a hazard map, we'd have to determine how -- does this occur once in a million years? Does this occur -- because we're looking at a 2,500 year, one in 2,500 year recurrence. So mostly, what we care about is for these maps, is looking at the faults that rupture, you know, in 10,000 years or less, but we don't really know about -- the other --

again, these are the -- quaternary fault database is the basis for our hazard maps, but it goes through another step in order to really come up with consensus values for those faults that are included.

DR. KAMMERER: I guess I would go back. So, as I mentioned, [unintelligible] probabilistic seismic hazard assessments. What you do is you look at all of the possible scenarios that could contribute to the hazard at your site. So you look at all of the faults that you have in your model, and the parameters, and each possible event on that. And you say, "Okay for that particular event, what's its likelihood and what does it mean at my site?" And you take all of that hazard from all of these possible events and you integrate it all, you pull it all together and that gives you your values. Well for each of those scenarios, that magnitude and distance, there's some hazard associated with that that gets added. What you do is every single scenario, you drop it into one of the bins of magnitude and distance as you're doing it.

So really, all the deaggregation is, is taking all those possible scenarios that fed into your overall hazard and putting them in whatever magnitude and distance bin they came from. And then at the end, you say, "Okay, well here's the overall hazard I've gotten from integrating all of these scenarios together, and this is what the different components are."

MR. MAIER: Any follow up, Jeff?

MR. BARD: Well, I mean, since you asked, we could go on a long time. Very clearly, these were just designed for regular building codes. They were not specifically designed for nuclear power plants. And I think we need to get some funding to you guys through our representatives so that you can actually go ahead and develop a set of deaggregation presentations for the general public and the scientific community, which are based on different assumptions; because somewhere out there, there are going to be these mavericks who may turn out to be right about something. And we need to, you know, look at this thing every which way. So thank you for your answer and I'll certainly look -- [break in audio] -- let other people know if you guys seem to need money for this. Thank you.

MR. MAIER: Dr. Kammerer, anything else on that or are we done?

DR. KAMMERER: I suspect the USGS would appreciate the support of additional funding for the hazard maps.

MR. PETERSEN: And again, what the funding would really go into if you're going to do that exercise is to go look at all those faults. And I assume that that's been done for this region, that people have looked at all those different faults. But I don't know. It's happening now? Okay, so that's what -- what you need is to have a geologist to go out on the ground and look at each of those faults and determine how active that fault is.

MR. BURTON: Okay, any questions on this side of the house?

MR. MAIER: I've got one from Barbara.

MR. BURTON: Okay.

FEMALE SPEAKER: Earlier, Victoria Langenheim mentioned that through the seismic imagining might be helpful, but if it were also included supplemental coring or sediment studies -- is USGS planning anything like that for the [unintelligible] or shoreline, off shore? Or say the Los Osos onshore? Any trenches or sediment cores that you might be planning?

MR. PETERSEN: I don't know of any analyses that are taking place in those regions. You know, really, there are different communities that do this trenching. Some are the private industry goes out and does some of these trenches. The USGS has a number of different geologists that go out and the like that do these kinds of studies. But it's difficult because they're just so many places around the United States and there aren't very many of them to actually do that. So, right now I don't know of any particular trenching studies that are being planned for those faults. Do you know of any, Annie?

MR. BURTON: Any other questions?

MR. MAIER: We'll go to June first.

FEMALE SPEAKER: I want to get a clearer picture of your probability. You said that the 6.7 Northridge quake, there's a probability of 99 percent. And then 7.5 is 46 percent, which is almost half. Is that for the whole State of California, or can you --?

MR. PETERSEN: Yes, that's for the whole state of California.

FEMALE SPEAKER: So basically, there's even a four percent chance that we will have an eight like some of the huge earthquakes around the world. It's a possibility.

MR. PETERSEN: That's what our model shows that we would expect that -- typically the different size of earthquakes are like 7.9, I think, for the 1906 and 7.8 for the 1857 ruptures. And then there's uncertainty in those sizes. So it gets above eight in some cases. So it's a lower probability.

FEMALE SPEAKER: So it's just a little under half, though, for a 7.5 or above?

MR. PETERSEN: Right.

FEMALE SPEAKER: Right, okay. And in the other one, I wanted a little bit more clarification about where you said, "Sixty-five percent of the earthquakes or the 13 around here that we keep talking about and that 32 percent is the background seismicity." Can you go a little deeper into that and what ramifications that has potentially for the nuclear power plant?

MR. PETERSEN: Well, you know, again, this is a very -- seismic hazard can be kind of complicated. And what I did was I did a deaggregation for the hazard at San Luis Obispo. And what that tells us is how are each of those individual faults contributing to the hazard? But it has to be at a two percent probability of exceedance in 50 years, or at four times 10 to the minus four. It would be different if you used a different level. Like the NRC said they were using 10 to the minus four -- one times 10 to the minus four. So you could go onto our website and do one times 10 to the minus four and do a deaggregation. It might differ a little bit. But for the building codes, those are the earthquakes that contribute most at that particular level.

And again, the faults are contributing about, I think -- what did I say? -- about 60 percent to that hazard at two percent probability of exceedance in 50 years. And the background model which accounts for other earthquakes that we haven't seen that -- just using the model that where previous smaller earthquakes have occurred, or where the future big earthquakes will occur, that was about 30 percent or so. And a big San Andreas rupture is far enough away from San Luis Obispo, but it contributes, but not as much as those others. It would contribute if the ground motions happen to be exceedingly large in a particular earthquake on the San Andreas Fault.

MR. BURTON: Okay, good.

MS. MOFFATT: I'm Carolyn Moffatt from Port San Luis Harbor District. Probabilistic assessments consider the probability or likelihood of different events over time. I'm wondering what span of time you use and if that's applied consistently?

DR. KAMMERER: Yeah, what probabilistic hazard assessment looks at is level of ground shaking -- we had an annual probability of a certain ground shaking happening at any point in time. So what we look at is the one times 10 to the minus four as a starting point. We go from one times 10 to the minus four and one times 10 to the minus six. That means during a particular year, an annual probability, it had -- there's only a one in 10,000, a one in 100,000, or one in a million chance that that ground motion would be exceeded. It's an annual probability is how the assessment's done. And it can be translated into different likelihoods over, say, they use a 50 year because that's a typical building lifespan. And so that's why the building codes are focused on two percent in 50 years or, you know, five percent or 10 percent in 50 years. But we look at it a little bit differently as an annual probability of a certain ground motion being exceeded. So basically, we're looking at one in 10,000 as a starting point and then we work up from there.

And one thing I would actually just mention because you actually heard about the four times 10 to the minus four -- one of the things that we talked about it that there's the hazard and there's the design. And that gets you to your risk calculation. The design part of a typical building and a nuclear plant are very, very different; whereas, in the building code they look at four times 10 to the minus four as a life safety criteria. So the building doesn't have to be functional afterwards, but people shouldn't be killed in it. In a nuclear plant, that's the linear design. So there should be no onset of inelastic deformation. So there's the hazard, which is what we're talking about, and then there's also the design requirements that are associated with the hazard.

MS. MOFFATT: Okay, thank you.

MR. BURTON: Any other questions? Okay, we're running a little bit ahead of schedule, and I am trying to decide whether or not we need to hold to the 3:15 start time for session four, or start that a little bit earlier. So let me ask a couple of questions. First, everyone in the audience, do you know of anyone who is not here who was planning to be here for the 3:15? We've got a couple of people, which lends that we may not be able to start earlier. For the folks who raised their hand, it is going to be an issue if we try to start earlier? Okay, so it sounds like we probably should not try to start earlier and stick to the 3:15. Everybody all right? Which means we'll just have a longer break? Okay. Let's do that then.

[break]

Session 4: Nuclear Power Plants and Seismic Hazard

MR. BURTON: My name is Tony Brown. I'm the NRC resident inspector here at Diablo Canyon. I'd like to welcome everyone to this session, Session No. 4: "Nuclear Power Plants and Seismic Hazard." I'd like to introduce the two speakers for this session: Annie Kammerer [spelled phonetically], who's just introduced in the previous session -- she's a senior seismologist at NRC headquarters in Maryland -- and Torrey Yee. Torrey is a civil and structural engineer for Southern California Edison at the San Onofre Nuclear Generating Station. Torrey performs seismic evaluations and qualifications of structures and equipment and supervises the civil engineering group at [unintelligible]. With that, Torrey --

MR. YEE: Hey, good afternoon. As you can see, my topic here will be seismic design of nuclear plants. I'll present the objective, the seismic classification; I'll describe how we classify structures, systems and components. I'll go over the design process, and we'll talk about seismic monitoring, and also the seismic qualification of equipment.

So the objective is to discuss how nuclear plants are designed to protect against seismic hazard, or basically, how we design for seismic events. In terms of seismic classification, there are two primary categories to classify structures, systems and components, and you'll see there's an acronym SSC talked about in the nuclear industry. Safety related, needed to remain functional in order to maintain the safety of the reactor and prevent the release of radioactive materials outside. Those would be what we call safety related. Non-safety related is the capability and performance has no effect on safe reactor shutdown or potential offside release of radioactive material. So those are the two main categories of classifying structure, systems and components.

Now along with that then, safety related structure, systems and components are designated as seismic category I. That means they're designed to withstand the effects of an earthquake without loss of capability to perform their safety function. And that main safety function is to prevent the release of radioactive material. Examples of safety-related components, I mentioned the nuclear fuel assembly, the reactor vessel in the coolant system, and then the containment structure. I mentioned the containment structure only because it's the one that is the one that most people think of when they talk about the nuclear plant. And that is designed to prevent the release of radioactive material.

In terms of non-safety related structures, systems and components, these are what I'll term as non-seismic category I. The reason why I say they're non-seismic category I only in that when you look at the industry various plants do have different seismic categories, such as two and three or something else; and therefore, just generically I'll just call that non-seismic I. And these things are designed for the building code, the national building code that people have discussed earlier. And its purpose is to protect the life and safety of people. It has nothing to do with radiological safety. And typical of these are schools, houses, office building, warehouses, et cetera. Examples of nuclear plant that would fall under this non-safety related category would be our turban generator, which its main purpose is to generate electric power, maintenance shops, and office buildings.

Now, I'll talk about the seismic design process. Our seismic design process complies with the NRC regulation, and it's found under 10 CFR, Part 100, Appendix A. One of the first things we do in our citing of a plant is to look at the soil conditions, and they're evaluated to be stable, acceptable to support the plant structures. What I mean there is, is that we make sure that we don't have liquefaction on the site; we make sure that there's no faults directly under our structures; we also make sure that they're not in a landslide area. The other thing we do in the seismic design process then is that we obtain the maximum site ground motions when doing our design. And in doing so, we classify -- we have two categories, or I'll say two levels of earthquake. And the first one is what we call the safe shut down earthquake, and that is the maximum credible earthquake that the site would see if a seismic event occurred.

And then the other level is a lower-level earthquake which we call the operating basis earthquake. And this is usually at 50 percent level of the safe shutdown earthquake or it could be even lower than that. Structures are dynamically analyzed then and for these ground motions to obtain the earthquake forces for design. And that's basically where the engineer does a mathematical model and does their analysis and usually by computer to see how a building would respond to the ground motion.

Now earthquake loads -- when we do that analysis we do that we get earthquake loads. And then our SSCs, again, our structure systems and components -- they're designed for earthquake forces in combinations with other loads such as dead weight. These would be your normal loads such as the weight of the concrete, the steel equipment. That would mean the building. We also have operating loads which, again, would be the equipment operating loads such as normal pressure and temperature. And then we have accident loads where we sometimes postulate scenarios such as a pipe rupture or, a pipe break, or tornado missiles. And these are other things that we do design a nuclear plant for. These -- then resulting structural response actions are -- response motions are then used to qualify equipment and components, meaning after we do our analysis with these earthquake loads, we look at the building responses and obtain the motions that we would see at each floor of the building so that we could then design the anchorage and consider the function of equipment within the building.

Then, structures and equipment are designed using national codes and standards with inherent safety margins. These include NRC regulations and guides and then you'll see the list of other codes and standards that are applicable when we do a design. The American Society of Mechanical Engineers, that's basically a code that applies to our piping as well as our containment; the American Institute of Steel Construction, that's the design of steel; the American Concrete Institute, that's the reinforced concrete design; Institute of Electrical and Electronic Engineers, that governs our electrical and control equipment; and then American Society for Testing Materials, this basically defines the strength of materials and how we purchase that.

Seismic capability is robust. The first bullet, basically, proven design features. Over the years as we've experienced earthquakes from -- I'll start from 1971, the San Fernando earthquakes -- we learned a lot about how buildings should be designed, especially for reinforced concrete. And we then learned from some of the damage that was seen that we would have to make sure that the reinforcement that we have in the concrete is designed properly so that the building would respond in a, what we call a "ducto manner" [spelled phonetically]. What that means basically is that the building could basically still operate, or still stand up, without breaking apart, or what we call "brittle failure." That means then that the building could deform and not cause a failure or collapse of the building. We also have redundancy of equipment in the systems. In terms of our design, we always have two independent systems for our various safety-related systems. Again, this would mean that if we have to cool the reactor, we have basically two methods or two independent systems that would allow us to do that.

Another thing that we have in terms of robustness is design load combinations. They include accident loads. As I mentioned, we designed for pipe rupture. The theory is that we should be designing to prevent the pipe rupture and that's what we do, but still we still consider what if the pipe were to break and what loads that could do. And we look at that in combination with our earthquake loads. Safety margins and seismic capacity to prevent the loss of function or failure -- again, there's safety margins, meaning we design things not to necessarily the breaking point, but to a level that is prescribed by our codes that would basically show that the structure could maintain its function, meaning it won't fall or fall apart.

Conservatisms -- as there was talk about earlier, earthquake ground motions. We have conservatisms in how that ground motion is defined. There was, you know, mention regarding the probabilistic and a deterministic. Well, when we do our design we kind of covered the whole envelope in terms of what is the maximum motion, and adding into that, a broadened spectrum. There was a design ground spectrum that you saw. To cover the frequency of an earthquake, we broaden it; we make it wider to cover what events we think would occur. Analytical methods, this includes damping values that we would use, where we don't use -- again, the worst or the best damping curve. Rather we use what is a conservative damping. We also combine, basically, the maximum earthquake that could occur in three directions. In general, you don't see an earthquake that would have your maximum motion in horizontal --in two horizontal directions and a vertical direction all occurring at the same time. Yet we take that worse case of assuming the worst motion in all three directions and take that into account in our design.

Acceptance criteria -- again, I mentioned that we design things to a conservative acceptance criteria. They're not designed again to a breaking point. But there's margin between where the structure components would survive in terms of an earthquake, or how they would perform during an earthquake event. Steel and concrete are designed for ducto behavior. Again, that means allowing movement without breaking. Seismic qualification [unintelligible] levels are higher than the calculated seismic motions at the insulation location. Again, as I talked about, we predict or we estimate the motion at the various building levels. And then for the complex pieces of equipment that we cannot analyze, we do actual testing. And that testing usually requires that we test at a level 10 percent higher than what the building response is at each floor. And then this is all to basically provide assurances of withstanding the seismic event.

Seismic qualification of equipment -- this again is to demonstrate equipment well functioned during and after an earthquake. This includes testing and analysis. Part of that testing is to put the component or a piece of equipment actually on a shake table where we shake it to simulate the earthquake. The assimilates in certain conditions, meaning that we put the proper electrical signal, or we put the proper pressure and the loads that component or piece of equipment would see during normal operation. And these are again included in the testing. And then also when we have things that are too big to actually put on a shake table, we do mathematical modeling to simulate their operating capability.

Other seismic-related activities -- once we finish with the design, then you have to build the plant. And so as part of our quality assurance we make sure materials are verified to meet or exceed the minimum strength requirements. Again, those strength requirements are specified by the various codes, and we do testing again. For example, concrete, we make sure we meet our minimum strength requirements. There's also inspections after and during construction to again ensure that things are built to the way the engineers designed them. Then there's also testing involved to again make sure that things operate and function the way we design them.

Finally, we have to plan as operating, there's surveillances. We are constantly doing surveillances, meaning we still go back and test various systems and equipment to make sure that it's operating properly. As far as containment, when they're what we call "post tension" type construction, we go back and make sure that the post tensioning cables are still within the calculated estimate for how much strength they have.

And finally, maintenance -- that's a requirement for us to, again, maintain our structures, systems, and components so that they are not degraded. Just like you would for a car -- make sure that your oil is changed. Well we ensure things are kept in operating condition so that they can function during and after an earthquake.

And finally, post earthquake response requires evaluation inspections depending on the level and the site recorded motion. When an earthquake occurs near a nuclear plant, we have procedures that require us to take certain actions depending on the level of the earthquake. And then that could be up to and including the shutdown of the plant.

In terms of seismic monitoring, we have seismic ciligraphs [spelled phonetically]. These are located in various buildings in the plant, and they're also one in what we call the free field. That would be away from buildings, and it's to basically record what an earthquake would be at the site without being influenced by structures. This then records the ground and building motions during the earthquake. They are used then again to determine whether or not the operating basic earthquake is exceeded. If it is exceeded then the plant has to shut down. If it isn't exceeded, then again depending on the amount or the level of the earthquake, the plant does go out and do inspections and so on.

Plants in high seismic zones will automatically be shut down when the [unintelligible] is exceeded. In the United States, basically Diablo Canyon and San Onofre, we have reactive trips that if our operating basis earthquake is exceeded, then the plant will automatically shut down. Again the operating basis earthquake is some level, either 50 percent or less than the safe shut down earthquake.

This is a picture basically of one of the -- of a seismic trip instrument. It's located at the base of the containment. It's about the size of a big shoe box, and if you go in the break room I happen to have one of the instruments that were taken out of the plant because it was no longer working. We had to replace it. But I do have one that you can just see. But essentially what you can see here is there's three instruments here -- accelerometers -- and they each measure one direction -- two horizontal and one vertical direction. So they measure the ground motion that the containment would see. And if two of these instruments indicate that the operating basis earthquake is exceeded, then the plant will automatically shut down. It sends a signal to a reactor protection system, piece of equipment that then starts the automatic shut down of the plant.

Here is just to show you the amount of reinforcement that goes inside the containment. Right here in the center here is where the reactor vessel is placed. These walls here are around the reactor vessel is six feet thick. This is just a blow up view. You can kind of see the size of the reinforcement relative to the size of man.

In this picture here, on the left here, you see the pipe support. This is for a main-steam line. This pipe is 40 inch in diameter. And as I mentioned previously, this is just to demonstrate that the pipe is not only designed to -- or the pipe support is designed to keep the pipe intact, but also because of the postulated pipe break that we have to assume, we also have what we call a pipe whip restraint. And what this thing does then is to, if the pipe were to break, in a very unlikely event, the pipe would not whip around and hit anything else in the structure. And this is just a close-up view, again, of the pipe whip restraint. These rods here, you see, are approximately two inch, two and a half inch in diameter. And then we have anchor boats that tie up this whole assembly to the concrete walls.

Again, here's another situation with a smaller pipe. This is about a 12-inch pipe, and then we have a little pipe restraint here on the side. And then you can see the other pipe supports that are located here and going to bounce. We have pipe's numbers. What this does is -- pipe numbers allow the pipe to thermally move, but you have to get through an earthquake event occurs. The pipe's numbers lock up and then support the pipes. So that again, is to keep it integral.

This is again, to just show you an example of a pipe support that you might see in a nuclear plant. The pipe here is 28 inch in diameter. So you can see the size of the supports that are used to hold the pipe. And this is a 10-inch pipe, again with the support surrounding the pipe.

In terms of tanks, it's very important that they're anchored and stiffened at the base to prevent buckling. And so you can see that there's plates surrounding the base of the tank and then there's anchor boats to hold it to the foundation. And then finally, to show you the detail that we have in a nuclear plant -- this air tank here, on the left here, is basically about a quarter the size of the water tank that you see on the right. And there's half inch thick plates, straps to weld it to a steel plate that is anchored to a concrete wall. And then at the base here there's a little table with a solid plate ring to support the bottom of the tank. Whereas, for your home, you would have basically a strap near the top and near the bottom that basically about a 1/16 of an inch or less. And that's just to show you the comparison of what we do when we design something for [unintelligible] plant.

So in conclusion, we must meet NRC seismic requirements, meaning we have to follow the regulations in terms of how we design the plant. Maximum site vibratory ground motions are used for seismic design. You know, there was talk about the probabilistic, but most of the existing plants have used the deterministic, and they were designed for the maximum site vibration. Seismic design process has conservatism which leads to large seismic margins and robust seismic capability. As you can see, along the way in our seismic design process, there's various margins that essentially accumulated as we reach the final product.

Finally, seismic monitoring instruments will cause the shutdown of the plant if the operating basis earthquake is exceeded. And this is true both for, as I mentioned, just having seismic instruments and then for the high seismic zones the two plants that actually will automatically shut down.

[applause]

DR. KAMMERER: Well, hello again. So during this session, I'll be talking about nuclear power plant licensing basis for seismic hazards. And although I'm standing before you, I really have to give all the credit for this talk to Dr. Cliff Munson, who's in the Office of New Reactors. He put together the presentation and was supposed to be here today, but unfortunately couldn't be with us. So I'm hoping to be an acceptable stand-in for Dr. Munson. So all credit really goes to him for the presentation.

So as an overview, we're going be talking about the NRC regulations, some information on citing safety reviews, information on operating reactors, risk assessment, what's happening with new reactors, and then a summary. So as you know, the NRC is -- really the job is of a regulator of nuclear safety. And so it's the NRC's responsibility to establish standards and regulations, to issue licenses for nuclear facilities and users of nuclear materials, to inspect facilities and users of nuclear materials to ensure compliance with regulations. These are areas in which we focus. Of course, the NRC operates under the Code of Federal Regulations. And it's towards the code that all of our efforts are geared. 10 CFR and several different parts are the portions which are related to the seismic review. So in the past, 10 CFR part 50 was used, and it's a two-step licensing process for construction permits and operating licenses. More recently, 10 CFR part 52 has been used, which is a new licensing process for combined license, design certification of the plants themselves, and early site permits. And both of those also incorporate the 10 CFR Part 100, which I believe you just saw some information on, which is reactor site criteria related to citing seismology and geology. And of course you can read these parts of the code of federal regulation for yourselves. In support of the code itself, of course the U.S. issues regulatory guidance and new regs, which also provide additional technical information on how we expect the 10 CFR to be met.

So nuclear power plant structures system and components important to safety are required to be able to withstand earthquakes, national phenomena, and such as the seismic shaking, and other events. And that's something that we've been talking about all day, of course. One key element of that is what's called the safe shut down earthquake ground motion. And this is the vibratory ground motion which safety-related structures, systems and components must be designed. It's outlined in the Code of Federal Regulations and it's something to which we work. As I mentioned before, the safe shut down earthquake for current reactors typically use a deterministic analysis. And more recently then, SSC is determined by that uniform hazard response factor that I showed with an annual probability exceedance of 10 to the minus four with some additional enhancements. And we also look at the 10 to the minus five and 10 to the minus six ground motions and the way that changes.

So 10 CFR Part 100 requires that the SSC, that safe shut down earthquake, be determined through detailed characterization of the regional and local geology, seismology, geotechnical engineering, and of course, incorporated in this also is the geophysics, the geodesy, the GPS monitoring that we're seeing is also being incorporated -- really anything that helps us to get to that seismologic understanding. We also look at potential for surface deformation.

So, of course, in geology, some of the things we look at are geologic structures at a site and surrounding the site. Those are looked at in detail. There was a question earlier related to the Alquist Priolo Zone that was shown in the presentation, whether or not Diablo Canyon sits in one of those. The way that the NRC guidance is presented, the current NRC guidance actually requires very in depth study of that type at the sites and in different zones around the sites. That's undertaken for NPPs. And any structure that might cause a hazard, the site is identified and studied. And those are some of my colleagues in the New Reactors Office hard at work.

Of course, with seismology we have the earthquake catalogue and seismic source characterization. That includes looking at the earthquake history, the area surrounded the site. It's documented. We look at instrumental, historical, and geologic records, and that's combined with the other geologic and geophysical data sources. And I'd like to mention, there was some discussion of historic seismicity and paleoseismicity earlier in some of the talks. And that's an area of significant research in the Central and Eastern U.S. in addition to in California. And we're learning an awful lot about seismicity in the Central and Eastern U.S. through things like paleoliquifaction, and paleoseismicity studies. It's very, very interesting area of research that's going on.

So this is yet another plot showing ground motion prediction equations or attenuation relationships. And again, what it's looking at is for certain magnitude and distances what the shaking levels at the particular site are. And again, because there is natural alliatory variability, natural variability in the ground motions, we look at that assessment as well and incorporate that into our analyses.

So we saw this morning Professor Moss talking about geotechnical information, soil and rock properties in the site, on the site, that incorporates borings or rock sampling coring, geophysical measurements, standard penetration testing, cone penetration testing, a wide variety of site investigations, and of course, the associated laboratory testing, which is used for classification of the soils, understanding the engineering properties, and working towards our understanding of geological materials as a foundation material.

So, currently operating nuclear power plants generally establish the SSC using a deterministic approach. And as you heard earlier, that generally looked at the maximum historical regional or local earthquakes -- either actual or predicted from the source characterization activities. The magnitude and distance maximum earthquakes were used to determine peak ground accelerations at nuclear power plant sites. And generally in the past, that PGA was anchored to a spectrum shape called the Red Guide 160 Spectrum [spelled phonetically]. It was developed in 1973 from 14 strong motion recordings. And this is the basis for a lot of plants in the U.S. in addition to internationally. This has been used extensively around the world for the design of NPPs.

Of course, since the licensing of these plants in the 1960s and ’70s, earthquakes continued to occur and the NRC continued to look at the available information and to review the safety of plants. This particular figure shows the USGS Catalogue of Felt/Damaging Earthquakes from 1568 to 2004. And while many are focused in the west, as you can see, they are throughout the United States. And the red dotes are the NPPs in the U.S.

So as was mentioned, the risk that comes from NPPs is not only the hazard, but it has to be tied to the protection, the robustness of the plant, the design of the plant to assure appropriate level design that gives adequate protection to prevent loss or damage. And that leads to an analysis of risk, the likelihood that that particular hazard will cause loss or damage. And I think this plot -- there was a question earlier about the Kashiwazaki-Kariwa nuclear plant. And I think this slide is really the heart of explaining what happened in Kashiwazaki and the lessons for the U.S. So it’s probably appropriate after this talk that we go back to that question and address it.

So in the way that the NRC looks at hazard, it’s not ever -- it never stands alone. It’s looked at within a performance based framework, a riskinformed framework to get to the ultimate performance of the plant. So in 1985, the NRC Commission issued a policy statement after looking at potential for severe accidents, and they concluded that the existing plants at that time posed no undue risk to the public health and safety. However, they recognized that valuable insights were gained from probabilistic risk assessment and PRAs, probabilistic risk assessments, have been a key element of understanding nuclear plant safety ever since. So in the late ’80s and ’90s, each licensee was requested to conduct individual plant examinations for internal events and also external events, what we call the IPEEE. And many of those used PRA.

So I wanted to take just a moment and talk about the components of what a seismic PRA actually is. So this slide sort of is a cartoon that’s showing the various elements that we consider. Now up here at the top, we have our seismic hazard analysis. And so this is the load that we consider, the shaking levels with their different likelihoods of occurrence and frequencies of exceedance that goes into our PRA. But in addition, we have the elements related to design and the systems and the robustness.

So one of the elements that goes in is the fragility of individual components. So for any particular component, as you heard, there’s a shake table testing that occurs, there’s’ analyses that occur; and the equipment is qualified such that it remains safe and functional, operational during the SSC. But what we want to do is we want to look at those extreme events, the beyond design basis events as well. And look at the frequency of failure of individual components as a function of the shaking. Of course, you shake something hard enough and ultimately you can get it to fail. So that’s shown for a particular component in this plot. It’s basically a frequency of failure for a given level of shaking.

Now, of course, when you look at a risk of a nuclear plant -- something that happened -- it's never the result of just one component. There's a whole series of bad things that have to happen. The plants are designed with a lot of robustness and margin and defense and depth. And so the next thing that happens is a systems analysis, which is this box here, which represents that chain of events that has to happen, all of the failure of different components during that earthquake. Often there's human failure in a number of these.

And so what a systems analysis does is looks at all of the different possible ways, the different possible chains of events that could occur and lead to some sort of damage, or unacceptable performance at the plant, and takes that fragility for each of those components and combines it all together to say, "Okay, for a certain level of shaking then, what is the probability given the sensitivity of all of these different components, that all of this happens and we end up with that condition at the end?" So it's looking at all of these possible fault trees. And so it comes up with a whole list of them for any particular level of shaking. So you take that, all of those possible situations, and you have to convolve it with the seismic hazards. So what is the likelihood of different levels of shaking, and then what is the likelihood of some negative consequence given that level of shaking? That's the convolution here, and that gets you to, in this case, the main frequency of core damage, some parameter or some description of a negative event. So that's seismic PRA. And so that's how we get to an analysis of risk.

So in the IPEEE study that was done in the '90s, it was implemented to evaluate beyond design basis events such as earthquake, fire, and flooding. And for earthquakes, each licensee performed either a seismic PRA like I just described where they went though and found all of those possible sequences that would lead to core damage or the performed a seismic margin analysis depending on the particulars of the plant. The licensees evaluated structure and component fragilities to determine the margin beyond the safe shut down earthquake. A very important element of the seismic PRA is a walk down where you actually go through the plant and look at the actual physical condition of the plant. And so vulnerable equipment was also identified by walk downs.

So that was done in the ’90s. But at the NRC, the reassessment of existing plants goes on all the time. And when new seismic -- excuse me, when new hazard significant information becomes available, the possible impact to safety of existing plants is reviewed. And we’ve discussed that here in San Luis Obispo many times. Safety significant information is acted upon by NRC staff regardless of licensing activities. So it’s a continual process. It’s not necessarily tied to relicensing. Of course, the IPEEE was undertaken in the ’90s. But currently, the generic issue program is performing an assessment of new information for the Central and Eastern U.S. And that’s a program which undertakes that type of work, and it’s ongoing now.

Because of the move towards probabilistic risk assessment, and the fact that a fundamental input to that is the probabilistic hazard assessment, and also because of the benefits of PSHA in terms of characterization of uncertainty. During the 1980s, PSHA began replacing deterministic approach at the NRC. At about that time the seismic hazard models were developed for the Central and Eastern U.S. by Livermore and Apprie [spelled phonetically]. And currently, the NRC, DOE, Apprie with support for the USGS, assistance to the

PSGS, are doing new regional hazard model for the entire Central and Eastern U.S. And in addition, the U.S. Geological Survey began developing national seismic hazard maps, which you saw earlier which are on the basis of the building code.

So the current approach, 10 CFR 100.23 replaced Appendix A for NPP licensing in January 1997. This portion of the code specifies the use of probabilistic approach in order to quantify a certain decent seismic hazard. And Regulatory Guide 1.208, which was published in March of 2007, provides detail of guidance on development of site specific ground motion using probabilistic risk fixed approaches. And I should mention that the NRC's also developing additional guidance on how PSHA are undertaken.

So currently, as you're probably all aware, the NRC's reviewing new reactors designs and several new site applications. I'm not even sure how many are in-house at this point in time. So it's a big area for us. And this plot shows the new reactor sites which are currently being reviewed in house.

So in summary, NPPs are required to be able to withstand the effects of natural phenomena such as earthquakes. 10 CFR Part 100 requires that the safe shut down earthquake is determined through detailed characterization of seismic hazards. Seismic PRAs are used to verify the currently operating reactors have adequate safety margins. And NRC's regulations require licensees to reevaluate compliance with current licensing basis and new potentially safety significant, or risk or hazard significant issued are identified. Thank you.

[applause]

MR. BURTON: Torrey and Annie, thank you very much. Excellent presentations. We're going to go into our question and answer period. Again, if you have a question, raise your hand. Bill or I will bring the mic to you --

MR. MAIER: Butch, I would like to provide one annoying reminder.

MR. BURTON: Okay, please do.

MR. MAIER: I'd like to remind folks if they're going ask questions that it would be best to ask questions from a generic sense. Mr. Yee is from Southern California, Edison. Dr. Kammerer is from the NRC. Tomorrow is all Diablo, all day long. Sounds like an ad for a radio station or something. But we will have a PGE expert on each of the three panels, and that would be the time to say, "Does Diablo do this?" But this is a time when Kashiwazaki-Kariwa is fair game, right? And any sort of the processes. So that being said --

MR. BURTON: All right, sounds good. And again, for those of you who have Diablo questions but won't be here tomorrow, please make sure you write them down with your contact information, and we'll make sure we get an answer to you. So with that, questions? Ah, my side.

MR. HUNT: Yeah, I noticed that you have -- oh, I'm sorry. My name is Gail Hunt [spelled phonetically]. I'm a geologist. You have a design spectra that's based on 14 celigraph records before 1973. That seems like pretty old data. I was wondering if the new data is still conservative and if the envelope still fits after all the data got in the last 40 years is added to be looked at.

DR. KAMMERER: Well, that Reg Guide 160 is definitely a classic at this point. It was developed based on the information at the time. And that relates to the licensing of the existing plants -- many of the existing plants. Of course, that's no longer used here in the U.S. Now we use a site-specific. It was used to provide the shape of the response spectrum and it was generally tied to the PGA at a particular location. So currently the reviews that have been done, the reassessments that have been done, we've looked at the site-specific information in comparison with site specific-information.

MR. HUNT: I understand that, but it's still -- I was just wondering, is that a still conservative? I mean, if you plotted all the new data, would that still hold up for the existing plants? In other words, if you plotted the new data from 1973 on and added it, would your enveloping spectra still be adequate for the design of the existing plants?

DR. KAMMERER: Well, you would write -- that was a very generic spectrum. Now, you wouldn't -- for every earthquake that's occurred since 1973, some of them have exceeded the -- it's the curve. Generally, they would fall under the -- the issue is the PGA would move. The shape is very broad. The shape is nice and tall and broad, so generally the answer is yes. But we just do it such a completely different way now. So when we do a comparison now or a review of the existing plants, we use site-specific information.

MR. HUNT: Okay, so you don't use that curve anymore?

DR. KAMMERER: No, sir. No, sir.

MR. HUNT: All right.

MR. MAIER: I'll ask June to repeat the question she had earlier today. You want a new one. Annie's all ready to answer your question.

FEMALE SPEAKER: I'll ask Annie the question if I can also ask this one of Mr. Yee. Okay, the first one I'll cut down. The Japanese plant shut down by an earthquake in 2007 was designed to withstand short, intense tremors that the builders had studied, and designed the plant based on those studies. Not the broad horizontal swaying that occurred with the 2007 earthquake. There were numerous problems which I enumerated this morning. Some of them -- there were 63 problems -- I didn't name all of them. Given that the Japanese regulators were incorrect in their calculations about earthquake movement and design of the plant, and we were also notified in the last session that even Parkview -- they underestimated the unknown for that, then can the NRC rely totally on the seismic studies being performed for Diablo to by accurate?

MR. MAIER: I guess, once again, maybe can they rely on design studies for any plant to be accurate? Is that a better way of asking it for --

FEMALE SPEAKER: Aren't there always --

MR. MAIER: -- for this panel.

FEMAL SPEAKER: -- [inaudible] unknowns that you cannot judge?

DR. KAMMERER: Well, Kashiwazaki-Kariwa is a very, very interesting and well-studied case, as you can imagine. It was really the first time that a plant exceeded its design basis and by a significant margin. And so as again, I get back to that slide and why I think it's very relevant is the risk of nuclear power plants come from two factors. They come from the hazard at the site and the design of the facility that leads to the ultimate societal risk. And you mentioned that there was some release into the Sea of Japan. It was actually a very, very small amount.

So we've been studying this even now for three years. And by the way, two of the reactors have now restarted. And one thing I think that's come out now that there's been a significant amount of work is the safety-related systems performed as design. There was no risk to the public during that event. It performed very well. Without a doubt, they underestimated the seismic hazard. And I think that really speaks to your point. You know, the design basis for the earthquake was exceeded by two and a half times of the event they actually saw.

Now, I guess I would mention that when they perform the hazard at that site, they didn't do the offshore studies, such as are being done now. They weren't required. There was evidence that there was a fault there. It was not actively pursued by the utility, and it wasn't pushed by the regulator. And I think that's quite different from the situation we're seeing now where we're seeing fairly aggressive studies happening in the region to try and get to that. When we look at the fault that existed and that ruptured, and you use those ground motion prediction equations that I talked about several times that say, "Okay, for this magnitude and distance, the ground motions were predictable." And so I think one of the things that we've seen happen is actually a movement towards the approach that's used in the U.S. in terms of somewhat aggressive studies, rather aggressive studies, particularly in offshore environment and recognition of uncertainty.

One of the changes in the Japanese NPP regulations -- they changed the way that they actually assess hazard. And in their new regulations, they look at beyond design basis. Previously, they said the SSC will never be exceeded period. And now in their new regulations, there actually is a requirement that they consider that beyond design basis event and make sure there's not cliff edge effects.

And another thing that we've seen is a strong movement towards seismic PRA. I just, two weeks ago, was at an International Atomic Energy Agency meeting, IAEA meeting in Vienna, and what we saw the Japanese -- the technical support to the Japanese regulator presenting was unimaginable four years ago. I think that there's been a huge movement in opening of the approaches that are being used. And it's very positive, and I see a lot of very good cooperation happening in the future. And so I think one really important thing is this once again shows us we must consider uncertainties. And the reason that those plants performed very well even though the design basis was so well exceeded was because of the margins that occurred.

Another interesting element of the Kashiwazaki experience is that right now one of the things that was presented two weeks ago was the results of something called the charisma benchmark. And what this is, the utility TEPCO provided a significant amount of information regarding the performance of the plant, elements of the plant, and allowed participants in this benchmark to use their own analysis tools -- their soil structure interaction modeling tools -- to take the basic information and blindly predict what they would have seen at the plant. And what we saw is that we actually -- our tools perform actually very well at being able to predict any kind of damage or the response of the plant. And so that's something that's very interesting. It's ongoing, and it's called the "charisma benchmark," and it's being performed through IAEA. And that's also providing a lot of very interesting information. Now one of the things that was in there was the sloshing of the pools. That's one of the things that are analyzed, that and also the tanks, the piping structure were all part of that analysis. And so that's providing us information on understanding how well out assessment tools are predicting these types of things.

And so then the other question is, given how the hazard analysis was not -- it was lacking, let's say, and the fact that, you know, we didn't see the Parkfield earthquake every 30 years, how much confidence can we have in the design and the information that's coming out? Well, again, as I said, there's a significant amount of research that's happening here that didn't happen at that particular plant. And I think the key, once again, is really trying to wrap our heads around the uncertainty as well and making sure that we're considering all of that uncertainty and to not be surprised. And we don't expect it to be perfect, as you saw today. We're not going know everything perfectly. You never can with the Earth. Because even if you fully understood what happened in the past, there is a level of variability, and so the future is not -- you'll never know it perfectly. The important thing is to account for the uncertainty and to make sure that you incorporating that as we do the reviews and the design reviews and the seismic PRAs and that element. And I think that we have to understand that we're not going be perfect.

MR. MAIER: I'm glad you finished your presentation early. And per agreement, we'll let Dr. Kammerer's question, and June, I'll let you ask a question of Mr. Yee.

FEMALE SPEAKER: Okay, but I'd like to follow up on that one because you said, "It's not perfect." And certainly Katrina was not perfect either. And the reactors -- only two reactors are up, and it's three years after the earthquake. So there are still problems with that. And it also took PG&E Seismic Program 20 years to find the shoreline faults. So we've got several things there.

The question I have for Mr. Yee, though, is: when you use the shake tables in your simulations, do you use any corroded or aging equipment so you can analyze the effects on them? Because certainly, Diablo Canyon, we've seen all the corroded pipes and so forth that are below the surface. And I'm just wondering, do you use all new equipment when you do the shaking, or do you actually analyze the aging corroded pipes that exist in 20-year-old plants?

MR. MAIER: Good question.

MR. YEE: In the design of piping, when they do stress analysis, they actually consider a corrosion factor. So they include that already in their design. And so if they go out and check their piping and it's corroded beyond that point, then of course, it's not conforming any more. But during the design process, we do factor a corrosion factor especially in terms of piping. Now in terms of equipment, when we do shake table testing, we don't shake it just once, we shake it multiple times. So it essentially sees at least five or six earthquakes as part of that testing. So that kind of what we call seismic aging of the piece of equipment. And then there's also another program we call environmental qualification, which again would take into account the aging aspects of equipment and how they perform over their life.

MR. BURTON: I have one over here.

MR. O'CONNER: Mike O'Conner [spelled phonetically], I'm a local. And Mr. Yee, the question about the shake table again. Is that done by an independent laboratory? And also, how big is the table? You know, what size equipment can be shook?

MR. YEE: Most plants -- I am going to speak -- San Onofre's unique and we do have our own shake table test, I mean, shake table. And that was out of necessity because of buying components. But for the most part, in general, all plants go to independent test labs to do the testing. And the size generally in the past, it's been -- electrical panels are probably the biggest thing that was actually tested, and those are usually in like about seven-and-a-half-feet tall, and maybe up to about four feet wide. And those are what gets tested on our table. Nowadays, there certainly are a large shake table tests, one that comes to mind is one at University of California, San Diego, which can actually test buildings components full size.

MR. BURTON: Other questions?

MR. MAIER: Got one over here. From Jeff --

MR. BARD: Actually, I would like to defer if this gentleman does have -- [break in audio] -- otherwise, I'll proceed. Regarding the -- [break in audio] -- instruments, I certainly hope there's not only one. I think we all know in the Gulf of Mexico there was a device that failed. So if the seismic trip instrument fails, I hope that the general practice is to have a secondary backup.

MR. MAIER: Is that your question?

MR. BARD: No, actually, what happens if that fails? Is there a provision for manual shut down, and who would make that decision and how would they decide if the machine failed? And the other question is, what if you don't exceed the OBE, but there's a rupture somewhere? No one's going know there's a rupture. So it seems to me the OBE should be much less than 50 percent. And finally, is shut down really the solution? I mean, if you have pools that even can slosh into the ocean, I don't see how you can say that the public was not endangered. I mean, what if somebody was surfing out there? I mean, so this is a group of connected questions.

MR. MAIER: Okay, first one was redundancy of the seismic trip?

MR. BARD: Yes, is there a redundancy or not? And what if there's a rupture?

MR. YEE: Okay, well, you asked how many instruments we have. And I'm going to just speak about San Onofre at this point, because I'm not familiar with Diablo Canyon's system. That black box you saw, basically we have four instruments at the base of the containment, and they're located basically at 90 degrees. So there's four equally spaced instruments. And we have what we call a two-out-of-four logic. And the reason for that is sometimes if somebody's down there doing maintenance -- if somebody kicks it, we don't want just one instrument to cause the plant to shut down. So it requires two out of the four to basically trip the panel automatically.

Now, you indicate, "Well, what if the instruments don't work?" By procedure, our operators still are required to check the level of the earthquake and then proceed. And their procedure is to do what's necessary, and that could be up to and including shutting down the plant. So they have to follow their procedure. We have to calculate, basically within four hours, what the level of the earthquake is and then proceed to shut down if the operating basis earthquake is exceeded.

MR. MAIER: And then the question of less than OBE -- less than operating basis earthquake -- plant does not automatically shut down, but there is a problem in a piping system somewhere.

MR. YEE: And then they would be responding based on whatever that system failure was. And if that included having to shut down the plant, then that's what they would do.

MR. MAIER: And the last question was --

MR. BARD: The other was, why does it have to exceed OBE in two directions? What if one direction is say 75 percent, far in excess of OBE, but in the other direction it's only at 49 percent of OBE? It doesn't sound like a logical design at all.

MR. YEE: It only has to exceed it in one direction.

MR. BARD: Thank you. He answered the question. I'm not quite sure he -- [break in audio] -- but he did answer the question.

MR. MAIER: The security concern -- what was that last one?

MR. BARD: Well, the safety concern -- I'm not satisfied that the safety concerns are fully addressed. But the question was answered.

MR. MAIER: Say that as a question, please.

MR. BARD: It was really a thank you, and I'm deferring to other people who may be waiting.

MR. MAIER: I appreciate that, Jeff. Thank you.

MR. BURTON: I got one.

MR. WEISMAN: Hi David Weisman. This is both a new reactors even though the fellow, Munson, is not here to talk about it -- is that his name? And because Kashiwazaki was at the same time, so let's see if we can combine this. Slide 15, Ms. Kammerer, probabilistic risk assessment, and Slide 17, same question. Since 1985, this has been something that's been asked for. And this would apply to San Onofre, too. Subsequent then to the 1985 statement -- [break in audio] -- existing policy statement recognizes valuable insights from PRAs. Have SCE and PG&E done PRAs then subsequent to that statement?

MR. YEE: I can say that San Onofre, we have done our PRA for what she called the IPEEE. So that was done.

MR. WEISMAN: When was that done?

MR. YEE: 1995.

MR. WEISMAN: 1995. And for Pacific Gas and Electric?

MR. MAIER: All Diablo, all day.

[laughter]

MR. WEISMAN: All right, same slide -- her presentation, currently. Next would be, when you speak of an SSC and it speaks of a safe shut down earthquake -- and we referenced Kashiwazaki's as safely shutting down -- question I have is, are the standards of building a reactor to meet an SSC, which assumes it shuts down safely, also assuming that the reactor is built with a robustness that once the earthquake has passed, the ground has stopped moving, the immediate danger is done, the structure should therefore also be able to generate electricity the next day. So you would say that the requirement of the SSC is simply it shuts down safely?

DR. KAMMERER: I think about how -- oh, here we go. Once an SSC is exceeded, a significant amount of work needs to happen before that plant would be allowed to operate again. That's why I think the years that it's taken to restart the plant to Kashiwazaki is not necessarily showing that there's huge problems. More that so much effort went into the review of that plant, testing, non-destructive testing. Of course, the regulatory environment there is very, very different. But if an SSC is exceeded, the level of effort to look at every part of that plant is such that it would not be operating the next day.

MR. WEISMAN: Okay, from a standpoint that if depending on it for my reliability, and generation, and shareholder perspective, the NRC standard of assuring safety in health is not [unintelligible] ensure commercial electric production or reliability of grid integrity as a result of a SSC event.

DR. KAMMERER: The NRC looks at safety.

MR. WEISMAN: All right, well then along those lines and since you mentioned new -- I got a lot of papers here -- new reactors and both Kashiwazaki. In 2008, NRC has document New Reg 1650, Addendum 3, Question 19-1 is raised. For the lessons learned from Kashiwazaki nuclear plant, does the NRC have requirements to assess the anti-seismic ability of operating plants in the United States? And the answer is, "New reactor designs are expected to demonstrate an as-built plant has a level seismic margin of 1.67 times the design basis. Even a 1.67 times the design basis event at high confidence in low probability failure," Page 127. The question, would Diablo Canyon meet that standard? Does it offer a design basis of 1.67 times the seismic margin?

DR. KAMMERER: We're going be talking about Diablo Canyon tomorrow.

MR. WEISMAN: No, no, but this is in relation to Kashiwazaki. That was the --

DR. KAMMERER: No, you just -- that wasn't in relationship to Kashiwazaki.

MR. WEISMAN: It's the same paragraph. It's the answer in the NRC's own document to the question that was asked about Kashiwazaki. And I'm just saying if that's the answers that -- what is the lesson learned? That a plant must be built to 1.7 times the design basis confidence.

DR. KAMMERER: Well, that's not lessons learned from Kashiwazaki. That requirement comes from NRC's own work previously. The requirement for 1.67 is an NRC regulation. It's unrelated to Kashiwazaki. The work that was done in Kashiwazaki to look at the margin and understand what happened in that plant is a different type of work that was happening. Now the Apprie documents in U.S. sort of approach has played significantly into that. But I don't -- the question relates to Diablo Canyon.

MR. WEISMAN: All right, well if that's how it's gonna be then I'll save the ACRS testimony from 2008, again, regarding new reactor standards. But because they mentioned Diablo Canyon deep into the document, I guess I'll have to wait for that. So let's go back to Japan then, besides Kashiwazaki, has any investigation --

MR. BURTON: David?

MR. WEISMAN: -- has any other investigation been done of over year long outages caused by the earthquakes at the plants in Onagawa and Hamaoka? I'm sorry, did you not catch that? In addition to Kashiwazaki, has any evidence -- has any research been done on the year-long outages that were caused by earthquakes at Hamaoka and Onogawa?

DR. KAMMERER: Yeah, a significant amount of research has actually been done in Japan. In fact, when the Kashiwazaki earthquake happened, Japan was already in the process and, in fact, already had changed its regulatory guidance related to seismic hazard as a result of earlier earthquakes at NPPs in Japan, in which seismic events occurred. And so a significant amount of work has happened in Japan looking at those events. In fact, there was already an extra-budgetary program that was started at the International Atomic Energy Agency to look at seismic reevaluation of existing plants. And because the Japanese wanted to make the most of those experiences, and to pull in international expertise, they actually had initiated an extra-budgetary program research program at IAEA, even before Kashiwazaki occurred. So a significant amount of work has been done in Japan looking at the various events. And, in fact, they completely changed their regulatory guidance, and were in process of starting the review before Kashiwazaki happened.

MR. MAIER: I've got a question over here from Jane.

MS. SWANSON: Yeah, Jane Swanson [spelled phonetically], I have questions about the spent fuel pools at Diablo Canyon -- in general, and the reason --

[laughter]

-- no, it works in general. I'm going on Mr. Yee's presentation and Diablo entered my mind because of highly dense storage of spent fuel there. So it's on my mind. But under the seismic classifications category one, safety-related, you know, you gave examples and I know they were just a few examples. I'm just hoping you're gonna tell me that the spent fuel pools are considered safety equipment in category one.

MR. YEE: Yes, spent fuel is considered seismic category I.

MS. SWANSON: Okay, that makes me feel better. And then, if you would like to say a word about in general, how those spent fuel pools are tested regarding their ability to withstand a major earthquake, I'd be interested in that.

MR. MAIER: Thank you, Jane.

MR. YEE: Spent fuel pools are designed basically like the structure -- we consider the forces from the spent fuel rocks. And we also consider the hydrodynamic and hydrostatic forces from the water in the pool. So they are -- basically, most pools are reinforced concrete walls and so that the forces from the earthquake and again, normal accident loads. In the case of spent fuel pools, we also consider the high temperatures that could occur due to loss of cooling. And all that's then factored into the structural design of the concrete wall that's around the spent fuel.

MR. BURTON: Other questions?

MS. BECKER: Rochelle Becker, Alliance for Nuclear Responsibility. I was wondering if either one of you know how many studies that included lessons learned from the KK earthquake you're aware of? Have the NRC done any? Has [unintelligible] done any? Has SCE done any? I just want the number of lessons learned, either from the KK quake or other Japanese quakes, that people in California could have learned from.

MR. BURTON: Can I piggyback on that? Can you talk in general about how we use international information, how we share it, and what we do with it? You know, we're focusing a lot on the reactors in Japan. But there are reactors all over the world. How do -- in general, how do we share that information? And when we find some information that's significant, what we do with it?

DR. KAMMERER: Okay, well, there's a number of studies that have happened. In the NRC -- unfortunately the studies are non-public because we were provided proprietary and sensitive information. But it's a little hard to separate them out into a number of lessons learned because sometimes, you know, they're more all encompassing. Sometimes, you know, depends on how you break down the specific lessons. So, I mean, definitely it's something we've been looking at in depth for a very long time.

In terms of how -- and you're right, there have been additional NPPs which have, you know, gone through different external events, not only seismic hazard but also things like tsunami. Currently, most of the international -- of course, the NRC tracks this information, but much of the international experience is actually currently held in a new international seismic safety center at IAEA. It was just initiated with Japanese support in July of last year. And, in fact, has really gotten into full swing with the end of some extra-budgetary research projects which are ended and now going to this new international seismic safety center. And it was developed in response to the Kashiwazaki earthquake, and also in response to the Indian Ocean Tsunami as a clearing house of information and research, because one really didn't exist. We sort of -- the international community came together when there were lessons learned to be had and disbanded. So the International Seismic Safety Center is now a permanent sort of clearing house for information for cooperative research. It's a really, a very positive -- one of the positive outcomes of the Kashiwazaki experience. And so as part of that, the IEAE has developed the International Experience Database which everyone puts their data into and which then is shared.

As part of that, there have also been 10 topical areas, which have been identified as areas of mutual interest among the international nuclear community; and a lot of those folks around seismic hazard. Working area number one is seismic hazard analysis and looking at uncertainties, looking at different elements of that. Working area three is seismic PRA. And so that's really now the focus of how external events -- it's called the Seismic Safety Center, but it's really all external events -- moving forward are going to have a more robust framework. And so that's going to be sort of the focus moving forward with annually a meeting to identify areas of active research and share information as well as a number of workshops that are gonna be happening over time throughout -- depending on when research information comes out.

And in fact, there are gonna be a major workshop which is happening in Kashiwazaki in November to open a new research center in the Niigata Institute of Technology, which JNES -- which is the technical arm supporting the Japanese regulator has sponsored. And so significant amount of research in terms of seismic hazard in Japan will be happening at that research center. So there's an international forum which is gonna be happening in November.

MR. BURTON: One second, one second. Make sure everybody can hear you.

DR. KAMMERER: Well, you can go to the workshop in Niigata.

MS. SWANSON: No, no, IAEA website where you're storing all this information, you just told me that the NRC's is confidential. Is the IAEA's confidential, too?

DR. KAMMERER: I'm not sure. I would assume so. Well, at least you would have to be contributing data.

MR. BURTON: I think we -- do you want to speak to that? We may have an answer for you here.

MR. MARKLEY: I'm Mike Markley from NRC headquarters. The IAEA information itself is proprietary, and it's handled that way. That's the reason that the information is shared with us in that manner. Now, we do a lot of sharing back with them, but I will say with regard to the Japanese event, the industry's also issued a fairly comprehensive SER on that. So, I mean, the industry's communicating and doing things as well. It's not just the NRC that's involved in all of this. There's a lot of players in the process. But the initial IAEA reports on this are considered proprietary from all countries when they're submitted. Now, if they're released later with the permission of those countries, because that's the reason it's shared that way, then they have to release it.

MR. MAIER: Butch, is there still a generic question about it? Or did you want to, you know, ask about the generic process? I hope it's a question because you're gonna be on a panel tomorrow, and this is double dipping if you're gonna say something.

MALE SPEAKER: No, I just wanted to make sure that you understand the NRC has a very robust process of looking at operating experience. There are 24, 25 different groups to which this kinds of information is circulated as soon as something important happens. And the leaders of these groups recommend what action needs to be taken, and it is followed up through all the nuclear power plants if it is appropriate. And I don't want to get into any kind of details, but just wanted to make sure you understood that operating experience is supposed to have been considered through an independent office of operating experience. It is now subsumed into Office of Nuclear Reactor Regulation, and the events of significant nature are immediately looked at.

MR. MAIER: Thank you. We've got Judith if there's nobody on your side. We've got Judith over here if there's nobody on your side.

MR. BURTON: Doesn't look like it.

MR. MAIER: Okay, Judith.

FEMALE SPEAKER: Just one for Mr. Yee. About SONGS, I think the first reactor there was retired, and it's still on site isn't it? Or did they get it away? They had a lot of trouble loading it or something, as I remember.

MR. YEE: Yes, the unit one reactor vessel is still on site.

MR. MAIER: Is it seismic?

FEMALE SPEAKER: The big red canisters or tanks -- there must be about 30, or maybe 25 to 30 of them on site there, and I've always wondered as I passed by train if that's the storage for the spent fuel. What's in those red -- big red canister-type tanks?

MR. YEE: Yes, we do store spent fuel -- dry storage, is that what you're --

FEMALE SPEAKER: Dry.

MR. YEE: Dry storage of the spent fuel.

FEMALE SPEAKER: Thank you.

MR. BURTON: Any other questions? I thought I had seen a hand over on Bill's side before, no? I guess I was mistaken. Okay, if there are no more questions, we're gonna go into our closing, and I'm going to ask Roy Caniano to close us out.

MR. CANIANO: Well, first of all, I want to thank everybody here today for their participation in the workshop we had; in particular, each of the panel members, both of our facilitators, and the moderators for each of the panels. When you take a look at all of the panels that we had today, we had four of them, a lot of information was provided, and we actually finished on time. So I appreciate the efforts on everyone.

When reflecting on my opening remarks from this morning, I said one of our goals today was really to provide information and educate. I can tell you I learned more today about seismology than I did -- I know more now than I did before this morning walking in here, and just talking to some of the audience here, I think that's the same reaction they have as well. So I appreciate everyone's participation, high level of professionalism. We established some ground rules this morning, and everyone complied with the ground rules. And I think that facilitated the success to this meeting today.

This morning there was a statement made. It was associated with the timing of the workshop. And I do want to apologize if there's any inconvenience that we're putting on anyone tomorrow for those folks that are not able to attend the workshop for tomorrow. I know we've mentioned a couple of times that we are videoing this. And again, there's cards that are available. I urge each of you, if you have questions for the panel members tomorrow that you're thinking of now, please provide them to any of the facilitators tonight before you leave. I know it's not the same as being here in person. But again, I think it is an opportunity to take a look at the video in a week or two.

So with that again, I thank everyone for their participation today. And we will see everybody in the morning at about 8:00. Bill, I think you have some logistics.

MR. MAIER: Of course, I'd like to thank everybody except for the facilitators. They were a real pain.

[laughter]

But I was asked to make an announcement -- actually, a couple of announcements. If you have one of these plastic badges and you're not planning to come back tomorrow, or are unable to come back tomorrow, we've got a little box out on the tables as you go out, if you'd like to drop it there. We will recycle these. If you are coming back tomorrow, feel free to take your badge with you and then we can collect it at the end of the day tomorrow.

Also, if you're not coming back tomorrow due to whatever reason, if you would please take the time -- and since we're finishing up a little bit early, take the time to fill out one of those public meeting feedback forms and get it to any of the NRC folks or you can leave it up here -- I guess on the front table if you don't, you know, know who to give it to. If you thought it was a horrible first day experience, we want to know. If you thought it was a great first day experience, Roy wants to take the credit for it.

Also, if anybody has any questions that are based on the topics that we had today that you were not able to ask, or you felt uncomfortable standing up to ask, we haven't gotten any cards that have questions and contact information on it. If you would please put your contact information, e-mail, phone number, legibly on the card with your question, we'll try to get an answer to you. And with that, we will start at 8:00 tomorrow.

MR. CANIANO: For the panel members, if you could stick around just for five, 10 minutes and maybe convene in the room next door. Appreciate it, thanks.

[Whereupon, the proceedings were concluded]