Official Transcript of Proceedings

NUCLEAR REGULATORY COMMISSION

Title: Advisory Committee on Reactor Safeguards
Future Plant Designs Subcommittee

Docket Number: (n/a)

Location: Rockville, Maryland

Date: Tuesday, October 30, 2018

Work Order No.: NRC-3948 Pages 1-359

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

DISCLAIMER

UNITED STATES NUCLEAR REGULATORY COMMISSION'S

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

The contents of this transcript of the proceeding of the United States Nuclear Regulatory Commission Advisory Committee on Reactor Safeguards, as reported herein, is a record of the discussions recorded at the meeting.

This transcript has not been reviewed, corrected, and edited, and it may contain inaccuracies.

UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

\+ + + + +

ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

\+ + + + +

FUTURE PLANT DESIGNS SUBCOMMITTEE

\+ + + + +

TUESDAY

OCTOBER 30, 2018

\+ + + + +

ROCKVILLE, MARYLAND

\+ + + + +

The Subcommittee met at the Nuclear Regulatory Commission, Three White Flint North, Room 1C3 & 1C5, 11601 Landsdown Street, at 8:30 a.m., Michael L. Corradini, Acting Chairman, presiding.

COMMITTEE MEMBERS:

MICHAEL L. CORRADINI, Acting Chairman
RONALD G. BALLINGER, Member
DENNIS C. BLEY, Chairman*
CHARLES H. BROWN, JR., Member
VESNA B. DIMITRIJEVIC, Member
WALTER KIRCHNER, Member
JOSE MARCH-LEUBA, Member
JOY L. REMPE, Member
GORDON R. SKILLMAN, Member

DESIGNATED FEDERAL OFFICIAL:

GIRIJA SHUKLA

*Present via telephone

A-G-E-N-D-A

P R O C E E D I N G S

8:30 a.m.

ACTING CHAIRMAN CORRADINI: Okay, why don't we get started? Good morning. The meeting will come to order.

This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Future Plant Designs.

My name is Mike Corradini. I'm chairing this meeting for Dennis Bley who is chairman of the Future Plant Designs Subcommittee.

ACRS members in attendance are Charles Brown, Ron Ballinger, Jose March-Leuba, Dick Skillman, Walt Kirchner, Joy Rempe and Vesna Dimitrijevic.

Dennis Bley as I said is on the teleconference line and he'll let us know if he has questions through one of the members since we're on an open line that is muted.

Girija Shukla, the ACRS staff, is the designated federal official for today's meeting.

The purpose of today's meeting is to review the working drafts of the NRC staff and NEI guidance documents to implement a technology-inclusive risk-informed performance-based approach for approving non-light-water reactors also known as the licensing modernization project.

The subcommittee will gather information, analyze relevant issues and facts and formulate proposed positions and actions as appropriate for consideration by the full committee.

It is scheduled the full committee to address this matter in the December full committee meeting.

The ACRS was established by statute and is governed by the Federal Advisory Committee Act or FACA. That means that the committee can only speak through its published letter reports.

We hold meetings to gather information to support our deliberations. Interested parties who wish to provide comments can contact our offices requesting time after the Federal Register notice of the meeting is published.

That said, we also set aside time for extemporaneous comments from members of the public attending or listening to our meetings. Written comments are also welcome.

The ACRS section of the U.S. NRC's public website provides our charter, bylaws, letter reports and full transcripts of all our full and subcommittee meetings including all slides presented at the meetings.

Detailed proceedings for conduct of the ACRS meetings was previously published in the Federal Register on October 4, 2018. The meeting is open to public attendance and we have received no requests for time to make oral statements. However, time has been allotted in today's agenda in case of extemporaneous comments.

Today's meeting is being held in telephone bridge line allowing participation of the public over the phone. A transcript of today's meeting is also being kept.

Therefore we request that meeting participants on the bridge line when they are called upon to identify themselves when they speak and to speak with sufficient clarity and volume so they can be readily heard.

Participants in the meeting room shall also use the microphones located throughout the meeting room when addressing the subcommittee.

I'll note that we have a challenge in our new conference setting so we'll be looking for the presenters if they have experts they need to bring to the mike to come over to the other side and identify themselves.

At this time I'll ask the attendees to please silence all cell phones and other devices that make noises to minimize disruptions.

Also I remind the speakers in front of the table to turn on the microphone which is indicated by the illuminated green light when speaking and otherwise turn off the microphone when not speaking.

We'll proceed with the meeting and I'll call on John Segala, chief of the Advanced Reactor and Policy Branch of the Office of NRO to make our opening comments. John.

MR. SEGALA: Thank you, Dr. Corradini, and the other committee members. We're pleased to be here today to discuss the licensing modernization project.

The NRC staff sees this as a key aspect of licensing and risk-informing advanced reactors.

I wanted to step back for a moment and just provide some context of where we've been. Back in April 2017 industry submitted the first of four white papers on the licensing modernization project.

We reviewed those, provided feedback. They then consolidated those into an NEI document 18-04. We presented that to the ACRS committee in June of 2018. We also gave the committee some initial thinking on the development of a regulatory guide to potentially endorse the NEI document.

We took the feedback we received from ACRS. We developed a working draft of the regulatory guide and an associated commission paper. So today we're going to be presenting an overview of the NEI document, the commission paper and the draft guide.

We're looking for the committee to write us a letter on the commission paper. And again we look forward to the insights and the feedback that the ACRS provides us today. With that I can turn it over to Bill Reckley.

MR. RECKLEY: Thank you, John. So the order of the presentation today will be we'll provide a little background to answer one specific request from the ACRS. We're going to spend the first few minutes talking about the enhanced safety focused review approach which is -- Ian Jung will go into. But that's primarily for light water small modular reactors.

But we've referenced it in the licensing modernization project discussions as kind of a stepping stone to where we're ending up. So it fits in well with the background.

Then I'll talk about the overall non-light-water reactor program, just a summary because again we've been to the subcommittee a couple of times in the context of the program and then in the context of the advanced reactor design criteria and the functional containment performance criteria paper.

Then I'll give a summary or high-level overview of the technology-inclusive methodology. And then after the break the industry group, NEI, Southern Company and other participants in the industry effort will go over the licensing modernization and in particular the guidance that's now in the draft, the working draft of NEI 18-04.

And then we'll close the day this afternoon with a discussion of the specifics of the SECY paper which John mentioned. We'll be asking for a letter on that paper.

And the draft regulatory guide and the ACRS can decide on whether they want to weigh in on the draft guide or wait until public comments are received and we move to the next step to finalize the guide.

So with that I'll turn it over to Ian.

MR. JUNG: Good morning, Chairman and committee members. My name is Ian Jung. I recently took a position as a senior reliability and risk analyst within the same division as John and Bill are working.

I've been with the INC as a branch chief for chapter 7. Some of you have heard about design specific review standards for chapter 7 which is somewhat consistent with some of the framework we are talking about from instrumentation control systems. So I bring some background from a technical aspects of it.

The reason I'm here is to specifically talk about enhanced safety focused review approach. Some of the members may not have appreciation for some of the background.

So, Mr. Ray asked for specifically on this topic. So I want to spend a few minutes on overview of the enhanced safety focused review approach and its potential relationship with the LMP, licensing modernization project.

I think there's some relationship and I want to briefly touch upon that.

So, this particular approach is a staff's approach for NuScale specific review. The intent was to focus on safety. I'm going to go over that a little bit more.

This particular approach is about the tools and strategies for staff to use in defining scope and depth of the review which can have an impact on efficiency and effectiveness of the staff reviews.

This is a particular approach is a companion to NUREG-0800 SRP, standard review plan, introduction part 2. I believe the committee has been briefed on this particular topic on SRP update related to small modular reactor reviews.

And also I think staff has briefed the committee on design specific review standards and in particular chapter 7 was with the committee several times for mPower as well as NuScale design specific review standards where the whole SRP has been reformatted and restructured to be consistent with the fundamental design principles focus that Mr. Brown has working with us. We have a very positive letter on it.

The whole approach is intended to be used during both pre-application and during actual review process. And pre-application and collaboration with potential applicant is critical in success of this particular approach. Next slide.

So the overall objective of this enhanced safety focused review approach is to increase effectiveness and efficiency for staff reviews to meet the customer's needs. Also to meet the statutory NRC mission of the regional notional (phonetic) safety finding in an efficient manner.

This particular approach is also Commission directed. There are a couple of documents that I just -- I don't want to go over that but bottom line is that Commission told the staff to focus its review and resources on -- to risk-significant SSCs, structures, systems and components and other aspects of the design that contribute most to safety.

I think on this topic related to SRP introduction part 2 as well as the design specific review standard and this enhanced safety focused review approach there were presentations to the committee several times. In addition for chapter 7 I think we came to the committee multiple times to deal with the chapter 7 design specific review standards. Next slide.

So I just want to highlight there are multiple tools and activities that went on to help the staff with the NuScale review. And one of the review tools that we provided to the staff and had a multiple training and other sessions is this particular tool that providing sort of the table and logic that considers various elements of the -- various elements that could have an impact on the staff review's safety significance or risk significance.

This whole A1 A2, B1 B2 approach. A1, A2 refers to safety-related risk significant or not risk significant. B1, B2 corresponds to the non-safety portion of that.

Of course complying with the specific regulations, how to meet those. Novel nature of the design. NuScale had a multiple areas of novel design.

Also related to interaction between safety and non-safety as well as the safety interactions that could have dependencies that could have an impact on safety or risk.

Unique licensing approach. The NuScale had some areas where exemptions are made as well as in other areas. Of course the Regulatory Guide 1.174 has elements in safety margin and defense-in-depth.

Of course how to deal with the operational programs and additional risk insights to be considered.

Through these considerations without dealing some of the issues in a piecemeal I think the intent was to have the staff members consider these various elements in deciding the scope and the depth of the staff reviews. Next slide.

This is my final slide. So status and

future. This particular approach was applied during the pre-application and during the early reviews.

We had various aspects of it that not all place, all disciplines used this approach based on uniqueness of each discipline or the timing of the reviews.

We had successes. Chapter 7 is one that I keep referring to. But there are other areas that staff made a conscious decision on considering various elements in deciding the scope and depth of the reviews.

The staff is currently developing lessons learned. We expect to have a memo developed to share with the office and in other places.

We believe that this particular approach can be used in the future including advanced reactor reviews. We are coordinating with Bill's branch. I think there's more to come.

The nexus of that particular approach I'm just discussing with the future licensing modernization project is that -- most of today's discussion is on the framework approach and for industries to use and as an endorsement of it.

But I think there's going to be another piece related to what staff can review, what depth, what scope, efficient and effectiveness of the staff review. So I think standard review plan or this particular enhanced safety-focused review approach I think staff has been discussing how to go about doing that part of the piece.

But we are following this particular licensing modernization project very carefully as we deal with the staff portion of the review.

Overall I think the underlying concept of the enhanced safety-focused review and -- is consistent with the agency's risk-informed and performance-based approach. That's the end of my presentation. Any questions or comments?

ACTING CHAIRMAN CORRADINI: Questions by the committee?

MEMBER REMPE: So my understanding -- Harold's not here, but my understanding his concern was that some of the required content that has to be submitted would be reduced or would be eliminated from this Reg Guide 1.206 is why he asked us to discuss this at this meeting today. Which is reasonable.

But I guess he also was interested in how this would affect how ACRS interacts on such reviews. You can weigh in here, Mike, but with what we saw with NuScale I thought ACRS was pretty much kept onboard.

There were interactions with ACRS to make sure we were aware of where you were focusing on. Is that the intent? Like if you're going to say well, certain things don't have to be included as mandatory anymore in the submittals based on your interactions with the designer you would have some way of always coming to ACRS and interacting with us so we understood why certain components would not be required.

MR. JUNG: So I think the question is much broader than just enhanced safety-focused review approach. This particular approach is more of a staff's review approach based on what's expected, the information that is expected to be submitted through other vehicles.

Regulatory Guide 1.206 is one of those attempts. But I think we recognize that for advanced reactors in particular Regulatory Guide 1.206 update I don't think in my understanding is it does not really -- we didn't create Regulatory 1.206 to be completely up to date associated with the additional approach.

But I think I expect that, I mentioned about the standard review plan being updated for the future. I think that's a vehicle that I think the committee has the opportunity to discuss that.

ACTING CHAIRMAN CORRADINI: I guess I want to just stay on this slide for a minute to make sure I understand.

So to put it in the simplest terms, is the LMP that we're going to hear about throughout the day today a natural outgrowth of what you did for the enhanced safety-focused review for NuScale?

MR. RECKLEY: This is Bill. We certainly are taking the lessons learned from that and in previous discussions with both the industry and with the ACRS we talk about bringing the enhanced safety-focused review approach forward.

One primary difference to keep in mind is that for light waters which is Reg Guide 1.206 and also the SRP this is an overlay of that existing framework to say where additions and maybe subtractions should come in the staff's focus.

As we go forward with the non-lights we're going to take some of these concepts like the consideration of operational programs, the focus on safety and so forth, key concepts, but as opposed to overlaying it on that framework we're going to build a framework with those concepts embedded if you will.

We're not taking the SRP and scaling it

back for non-lights. We're tweaking it for non-lights. We're planning on building this framework which you can see the first step in what we're going to talk about today on how to build it basically from the ground up.

ACTING CHAIRMAN CORRADINI: Okay. So let me say it back to you so I've got it right. So you're looking at really assembling an SRP that is technology-inclusive.

MR. RECKLEY: Right. Which is why it ends up looking more like a methodology than a list. Most of the guidance for light water reactors are lists. There's specific items --

ACTING CHAIRMAN CORRADINI: That have to be looked at, that have to be reviewed.

MR. RECKLEY: Right. Whereas for what we're going to talk about today since it's technology-inclusive it's more of a methodology that any designer for any technology can use to construct an application and then as Ian said we'll have companion guidance for how we're going to do reviews.

But it won't look -- our current plans are it won't look so much like a list.

ACTING CHAIRMAN CORRADINI: To do things.

MR. RECKLEY: Right.

MS. CUBBAGE: I'm seeing Joy's looking a little confused still. This is Amy Cubbage, NRO.

So basically in a nutshell the NuScale application was generally developed based on the way applications have always been developed. And then ESFRA was a way for the staff to in certain areas with more or less emphasis.

This will develop a different type of application from the bottom up. LMP.

MEMBER REMPE: I think I understand. And again, I'm trying to interpret also what Harold conveyed to us. So basically you'll have a process and designer X will come in and they may only need 3 of the 10 components that were on the old list.

And somewhere the staff will interact with him and concur. And then Harold was concerned how will ACRS fit into this process. And at that point you'll interact with us and we'll say yes, we agree with you, or no, we don't agree with you, you need to include another component. Is that kind of -- are we talking the same thing?

ACTING CHAIRMAN CORRADINI: But let me just back up a step because I think Joy said it very well. I think Dennis had some other questions. Dennis.

CHAIRMAN BLEY: Yes.

ACTING CHAIRMAN CORRADINI: Did you want to ask your question?

CHAIRMAN BLEY: Yes, I had a comment and a question. The comment goes back to Joy speaking about what Harold was concerned about.

And Reg Guide 1.206 rev 1 states that the technical information that used to be in 1.206 at least the way I read it is going to show up in interim staff guidance or some other form in a while. And I guess the question on that is what's awhile. Is that going to be available about the same time as this reg guide or what are people supposed to do.

ACTING CHAIRMAN CORRADINI: There's some background noise on the line so whoever's out there is going to have to mute themselves. Bill, did you get it?

MR. RECKLEY: Yes. We are going to continue. We're mixing apples and oranges a little bit as we bring in the non-light discussions and Reg Guide 1.206 update which will continue to be for light water reactors. So just want to keep that. There's two things. They're related but there are separate activities.

There are activities underway to provide as Ian mentioned an update and further risk inform the SRP. Those things will take a little while. I don't think they are intended to be companions to the update to Reg Guide 1.206.

Ian, do you have any more or maybe John Monninger? No.

CHAIRMAN BLEY: I'm a little confused by that because in section B of 1.206 it actually points to the fact that this will be reflected in interim staff guidance by NUREG or some other management document to pick up that technical information that's disappearing from -- so we will leave that on the table if nobody there wants to talk to it.

MS. CUBBAGE: So you mean, is that in general or what was that in the context of ESFRA? I think in general, and please, John Monninger, correct me if I'm wrong, I think there is an attempt with the new version of Reg Guide 1.206 to put more of the guidance into the SRP in the future and less in Reg Guide 1.206. But John is coming to the mike.

CHAIRMAN BLEY: Okay.

MR. MONNINGER: Good morning. This is John Monninger from the staff. I'm the director, Division of Safety Systems, Risk Assessment and Advanced Reactors.

So I think it's a good discussion and with the staff in approaching the revisions of Reg Guide 1.206 and then the SRP they recognize that there was tremendous overlap between the two.

So the intent was to the extent possible could you pull out the technical details out of 1.206 and put the technical acceptance criteria within the SRP.

However, it will take a while to update the SRP so the staff is considering how best to do that and I think that's the concept of how the ISGs were brought into play. 1.206 was meant to be just the format and content of the applications and the real technical criteria the staff is trying to focus that within the SRP.

The problem is when we had technical criteria in two different documents when new insights, lessons learned, you know, it was difficult to keep the two documents consistent so the thought was to focus all the criteria within the SRP.

I'm not up to speed on the details of the schedule for the ISGs but during lunch we could run it down with the appropriate staff and chit chat in the afternoon session.

CHAIRMAN BLEY: I think that's great. I

know 1.206 isn't the focus for today, but since we mentioned a few things about it I may -- comment.

It seems to me this has gone the wrong way to providing more guidance than just how to put together the application for people who want to come and talk with the staff early and do the kind of things that have been evolving over the last year or two. Seems pretty thorough on that.

The other point is although it is for light water reactors right in the second paragraph the staff says they also consider this to apply to other types of power reactors. So I would agree with that.

It's kind of slipped off of just being an LWR document, right, even if it's introductory steps. That's about all from me on this, Mike.

ACTING CHAIRMAN CORRADINI: So let me try one more time to simplify for me. Maybe everybody else gets it. I'm still -- so it's fair to say there will be a 1.206 prime in some fashion for non-light water reactors and there will be a standard review plan prime.

Or will it be just -- because you use the word overlay but I sense it's more than an overlay. It's almost like a buildup from scratch. Which of those two is it? I'm still -- I'm not completely clear.

MR. RECKLEY: What we're going to do as we go forward you have NEI 18-04 and Draft Guide 1353 which is a first step.

We're going to then continue to work with the industry to see what other guidance is needed. If the feedback is more detail is needed on how to construct an application then we'll focus on that. If it is on how to do a particular area within NEI 18-04, maybe one of the analytical discussions that we're going to have later today and the developers think they need more guidance in that area then we'll focus on that.

ACTING CHAIRMAN CORRADINI: Okay. That helps. Thank you.

MEMBER KIRCHNER: Mike, may I ask a question? So Bill or John or whoever, I know we'll hear about this later today. I'm just a little concerned maybe about reconciling all these different approaches.

I'm looking right now on my computer at 10 CFR 50.34 and I'm wondering why you wouldn't start there in a technology-inclusive manner and proceed. Because you loop back to that later in your -- in the LMP.

So I'm just somewhat concerned about how all these different approaches get reconciled and which ones take precedence in terms of establishing some certainty.

You're looking for efficiency and effectiveness in the regulatory process, but I see complexity being built. But maybe I'm not appreciative of how you see this being streamlined when you're done. So maybe it's a discussion for later in the day but just put that marker down.

MS. CUBBAGE: Maybe I could just offer -- again, this is Amy Cubbage -- that we brought in the ask for discussion at the beginning just specifically to address Member Ray's question relative to the committee's review of Reg Guide 1.206.

And really other than the fact that there are some principles in common we're not applying ESFRA in the future for non-LWRs. That's something that was developed for the NuScale review, maybe used again if the opportunity arose, but we see the LMP as really the way we're going for the future for the non-LWRs to develop and bake in the process from the beginning to be risk-informed, performance-based and technology-inclusive.

It's difficult for going forward with a

non-LWR to start with the standard review plan that's largely light water reactor-centric and also isn't even applicable to the non-LWRs. So this process you see in the draft guide is really where we're headed for the non-LWRs and I don't want there to be left any confusion on the ESFRA.

MEMBER KIRCHNER: Then let me be specific because you have slides up there that suggest otherwise. What lessons learned have you so far derived from this process and what is being considered in coordination with LMP?

MR. JUNG: In terms of lessons learned there's a draft report in there so I don't want to go too far with that. I sort of briefly mentioned that.

Because of the timing and uniqueness of the discipline applying I think not everybody, not all the disciplines were able to execute that in a manner that was originally intended.

But I think the underlying concept of being able to -- the linkage that I was referring to, there's lessons learned that Bill was also mentioning. There's some elements that are applicable to -- it is a generic because if you look at the definition of risk-informed and performance-based regulation the staff's effort focusing on most safety significance of it. The underlying concepts are the same.

But I think as we apply some of these concepts for the future I see some valuable lessons that can be shared in terms of how we approach it. But specific elements of what documents to be submitted and how the specific regulations that under Part 50 specific, those individual regulations, how to deal with that as well as the staff guidance, I think the message is somewhat clear that staff needs to work on and work with industry to come up with something.

But I think the underlying safety issues and the elements, we have a great number of staff members who can use the current framework. I think the message from Amy and Bill is that perhaps there are new way of doing business in that regard.

MR. MONNINGER: If I could just add two comments on lessons learned. This is John Monninger from the staff.

So I think it's -- I think ESFRA was a very important worthwhile effort. I think we really had two big challenges.

One is the design of NuScale. It's a light water reactor design, compliance with the current requirements, compliance with the current SRPs. So we tried to come in with an approach that would then almost afterwards sort of dissect that. So that was very difficult to then apply in terms of the design, what to focus on, what should be submitted.

As a matter of fact it didn't even impact what was submitted on the NuScale design. So the NuScale design, the ESFRA approach had no impact on the actual submittal.

So we had all the existing SRPs, the entire application come in from NuScale and then to tell the staff to focus more heavily on these areas, not to focus as much on these areas.

It really represented some internal challenges with how we proceeded.

In addition to that the DSRSs that we developed really didn't benefit from a risk-informed approach in development of the DSRSs. Those had to a large extent begin prior to a lot of the ESFRA efforts.

The others I think in terms of just change management within the NRC staff. The real ESFRA efforts and focus probably occurred about a year, year and a half prior to the application coming in. So it was difficult in terms of our roll-out and our buy-in on that.

Here we're trying to build it in up front well in advance of the applications coming in. The effort is actually being led by and run by the projects, the licensing staff.

So the whole issue of -- to me it's two things. It's one in terms of the challenges with the NRC for change management and here we're trying to bake in the process from the ground up.

And the other is in terms of the applicant and the design and the material coming in. Have the material coming in and the approach consistent with how we intend to review it. So I think it's two things.

A lot of it is change management and execution within the staff and the other is in terms of the actual application of material and expectations on the applicant. They would be the two top lessons learned that I would throw out there.

CHAIRMAN BLEY: While John's still up there can I slip something in?

ACTING CHAIRMAN CORRADINI: Sure. We will need to move on.

CHAIRMAN BLEY: The safety-focused review approach is actually called out in Reg Guide 1.206 rev 1. I'm just a little curious, John. And this is not terribly relevant for safety, but your group spent an awful lot of time coming up with this phrase safety-focused review. And now suddenly it seems to be replaced by an incomprehensible acronym. I just wonder what led to that. And I'm off.

ACTING CHAIRMAN CORRADINI: Incomprehensible acronym. That's what he said.

MR. MONNINGER: This is John Monninger. If ESFRA is the incomprehensible acronym. So I think that really represents some internal challenges with change management.

Originally the team working on it talked about a risk-informed approach. There are some optics within the agency about risk-informed, risk-based, a reliance upon risk.

So really risk and safety, we view it as being one, hand in hand the same thing. However, there are some internal challenges there so we deliberately -- it's the same approach for risk-informed performance-based approach but in an attempt to address challenges internally with change management we used the incomprehensible acronym.

CHAIRMAN BLEY: Thank you.

ACTING CHAIRMAN CORRADINI: Okay, onward.

MR. RECKLEY: Okay. And as we go through you can judge to the degree that we've tried to incorporate some of those concepts into what we're doing now for non-light water reactors as we shift over to the primary focus of today.

We've been before the subcommittee a couple of times as I mentioned to talk about the overall program, our strategy, and our implementation and action plans.

One goal that we've had all along is wherever possible to be technology-inclusive. And that kind of drives a lot of the discussion today as to why we lean towards methodologies.

We had the same discussion when we were before you talking about the functional containment performance criteria, that it is more of a methodology. The performance criteria is not a leak rate from a structure, it's a methodology on how well a design using whatever combination of barriers is able to retain the radioactive material.

So just a quick summary. The implementation and action plans that we've had from the beginning is divided into six strategies, building the staff's knowledge, developing the tools like computer codes and the ACRS has had a recent meeting on that topic with DOE and the laboratories.

Strategy three is to develop a licensing framework. Strategy four is to work with the standards development organizations, ASME, ANS to develop consensus codes and standards.

Strategy five is the resolution of policy issues. And again the ACRS has been involved. The proposed rulemaking on emergency planning, SECY 18-103, that's going up to the Commission. The functional containment performance criteria, SECY 18-96 recently went up to the Commission.

Strategy six is communications. And then down at the bottom I have just a couple of points that the staff is trying to remain aware of potential first movers to see if we need to accelerate an activity or change our focus if a particular design or technology is moving ahead of the others.

And then a recent topic that's come up in the context of the Defense Authorization Act and elsewhere is micro reactors and the possible development and deployment of those technologies.

But the focus today is on the last block under the licensing framework, the licensing modernization project.

ACTING CHAIRMAN CORRADINI: Let me ask about the purple circle. This is still an option for the industry.

MR. RECKLEY: Yes.

ACTING CHAIRMAN CORRADINI: So, not to take us back. If they choose not to use the option they would essentially have to go on a case-by-case exemption under a light water reactor set framework.

MR. RECKLEY: Yes, or develop something totally on their own.

ACTING CHAIRMAN CORRADINI: Okay, that's what I thought. I wanted to make sure. Thank you.

CHAIRMAN BLEY: This is Dennis. Question for Bill. Actually a comment. When this all first started we really pushed for the staff to focus on strategies three and five and I think that's been done pretty well.

As you've pointed out all of these pieces are really tied together. Have you heard anything back from the Commission yet on the functional containment paper?

MR. RECKLEY: Not yet.

CHAIRMAN BLEY: Okay. Because without that I think all of this stuff starts to unravel.

MR. RECKLEY: Yes, we agree, and that's why we wanted to send it up first. And what we've explained to anyone who asks is if you have any fixed -- well, I'll get into that in the next slide actually. It's a good one to just lead into.

ACTING CHAIRMAN CORRADINI: But before you do. So let's just stay on the policy list because Dennis picked one. What is the status of the others? Or should we -- or is it that the functional containment is probably the leading policy issue that needs to be settled? I see a couple of others there that would concern me to be clear.

MR. RECKLEY: Right. So what we're currently working on, on the first one, siting near populated centers. We have guidance and the most restrictive part of the guidance is that we look at population density out to 20 miles. And the guidance is 500 people per square mile out to 20 miles.

For the deployment when we talk to DOE or the laboratories or others that's a particular challenge. And so we're looking to see if that is an appropriate factor for smaller reactors or reactors of different technologies.

We're currently working on that. We issued a preliminary white paper not with a proposal but just kind of to frame the issue. And we're currently working through our periodic stakeholder meetings to undertake that. And we have a contract with a laboratory to help us evaluate particular possible options.

In terms of insurance, the Price-Anderson Act, we the NRC, the agency owes a report to Congress in 2021. We plan to have a section on advanced reactors to say whether we think the current requirements are fine, whether we think they should be changed or whether we think more study would be warranted in terms of what insurance is required for non-light water reactors. So that's an early activity. We have it identified but we've really not done too much yet.

Consequence-based security. That SECY paper is identified there, 18-76. That's currently before the Commission where the staff proposed a rulemaking somewhat similar to the EP rulemaking to say we would do a performance or consequence-based approach to security and if certain performance measures could be met requirements such as the number of armed responders might be revised.

And then we're always looking to see if there are other policy issues or key technical issues that are identified that we would add to the list. There are others that we didn't list here. We just listed the primary ones that we're currently working on.

ACTING CHAIRMAN CORRADINI: Thank you.

MR. RECKLEY: So, one of the goals that the NRC staff has in any case is to try to look at this in an integrated fashion. And as Dr. Bley was mentioning these things are all interrelated. And that makes it difficult because for the light water reactors much of it was put in place in the fifties and sixties and then it was added and revised over the decades in various areas to say what are the events that need to be addressed, what are the controls or barriers to address those threats or events, and what potential measures might be taken to mitigate the consequences if there's a release.

So this bow tie diagram was used in the functional containment paper just to kind of lay out. It's got its limitations as an assessment tool perhaps, but it's a good representation of how to consider a number of factors as you're looking at the overall program.

So going back to that policy list you can see I've just -- I resist all along trying to put specific things on the blocks in the generic diagram in terms of what are the barriers or controls for different technologies.

But just as an example you can put up some and for example EP, emergency planning, the evacuation of people is usually considered the last step, the last mitigation measure that if you have to you reserve the right to move the people out of the way if you're unable to keep the radionuclides from being released.

So you see we have an activity in that regard. Insurance and liability and environmental reviews I mentioned as well as siting. That is a key factor not only in terms of things like external events maybe on the prevention side but it's also a measure that's used on the mitigation side. That's why you have population density criteria for example.

And then functional containment. The containment function goes beyond just the design basis events, traditional design basis events, and goes into the beyond design basis events if you do have in light water reactors a core damage accident or what we've defined for non-light water reactors the top level event being a plant damage state with the unplanned movement of radionuclides. You need to come up with terminology like that because some reactor designs have a planned movement of radionuclides in the form of molten salt going around the coolant system.

So, that is kind of what we were looking at and trying to make sure that as we go forward and look at any particular area that we are also looking at the integrated and how the whole picture fits together.

And so for example in the emergency planning proposed rulemaking it points back for non-light water reactors to the LMP in terms of where are you going to identify the events that you have to assume in order to assess whether the dose remains less than the protective action guides and perhaps you can justify a smaller emergency planning zone. And I'll get to that in a second.

So, whereas that goes beyond the immediate scope of licensing modernization there is a relationship there and the staff is trying to make sure that we remain cognizant of all of these different proposals and that they all fit together in the end to make an integrated approach.

As if that figure wasn't complicated and busy --

ACTING CHAIRMAN CORRADINI: I congratulate you on the denseness of whatever that is.

MR. RECKLEY: So, one of the challenges as you change technologies is the tendency, and we face this all the time, and I do it myself, everybody does it, to start where you're comfortable which is for example we talked earlier of NUREG-800 and so forth.

And say okay, we're going to apply it to something different now and how does it change. The more we've looked at that the more we conclude that you're better off to start with First Principles and borrow from NUREG-800 where it's applicable but don't become so wed to it that it actually hampers you going forward.

So what this slide which is included in the working draft of the SECY paper is trying to convey is the three fundamental safety functions with the highest level safety function being the retention of fission products or the retention of radioactive materials.

And that can be modeled through just basically a set of barriers or controls in saying how well can that barrier attenuate the radioactive materials or the release of radiation or another form of the equation what's the release fraction across each barrier as you go through the process.

And one of the things that you'll see is a different reliance on different barriers for the different technologies. And so we thought it was important to start with again high-level First

Principle kind of approach.

The formula there if you broke this down into a formula is the basic DOE five-factor formula on the retention of radionuclides or the source term for the release from a reactor or non-reactor facility.

So, the bottom half of the figure is the other two fundamental safety functions, the heat generation and the heat removal. And it's basically again just trying to represent that you can do that at a high level just by the heat generated from the decay heat or from the core or from whatever source that you're addressing.

And then the heat removal through the various paths ultimately out to the ultimate heat sink. So, for passive reactors it does generally look something as simple as this where it's just going from the core to the reactor coolant system or primary system or whatever you want to call the primary system through a building and then to a reactor cavity cooling system or something where it's released to the environment.

The failure on the bottom either in heat generation or heat removal such that you have a mismatch is in general what causes the degradation of the barriers in the top level approach. And so this is how these things kind of generally fit together.

I know it's an over-simplification but it was just an attempt on our part to try to focus the staff as we developed what is the content in an application and what the staff's going to look at during the review to focus on what's important.

You start with the fundamental safety functions as basically being a good place to start. And then as we build through this process as we're going to talk during the day using various analytical tools, probabilistic risk assessment, deterministic assessments and other tools, you're basically looking at how well does a design satisfy these fundamental safety functions.

MEMBER REMPE: If you only look at these or what's in this diagram why would you need to worry about having redundant shutdown systems because you could have a low power reactor that stays critical for a long period of time as long as you can remove heat. So you've gotten rid of the general design criteria needing to have redundant shutdown systems, right?

MR. RECKLEY: Well, as we go through the process you would have to show that whatever you're relying on provides you the needed confidence.

And so if it is small enough and simple

enough could one conceive that it be as you said, perhaps. But you would have to have the confidence that that heat path for example couldn't be interrupted, and if it could be interrupted then maybe you need either a diverse redundant and/or diverse function in order to serve that function.

And that would come out of all of the assessments we're going to talk about during the day.

But if you go down to could it be small enough or simple enough that you didn't need it, I wouldn't rule that out. But you'd have to see and the point would have to be proven that the reliability and the confidence that you have in that single thing would be enough.

So going back to the bow tie I tried to represent in general terms what we're going to be talking about today through licensing modernization. And it captures basically this part of the bow tie. The internal plant events, malfunctions, failures of plant equipment, external hazards, the plant systems and operational programs that are there to address those events, and in the beyond design basis category if the technology has a plant damaged state with an unplanned movement of radioactive materials what the plant might include to address that particular scenario.

It doesn't -- LMP doesn't feed over into the external responses, things like siting and emergency planning. It doesn't directly address environmental reports. And it doesn't directly address security, radiological sabotage type events.

Although in all of those areas you can draw some information from LMP.

So again looking at the LMP and how it fits into the regulatory structure. And this came out of our June meeting so I wanted to touch on this a little bit.

Within the licensing modernization activity there are specific regulations that are mentioned and credited for how this system -- this methodology would work.

Examples of that are quality assurance in the maintenance rule. As you go through the methodology it's going to define the desired reliability of equipment, for example. How do you ensure once you go from the design stage into operations that that reliability is maintained. You'll use something like the maintenance rule or something related to the maintenance rule in order to help provide that confidence.

As I mentioned the LMP interfaces although it's not specifically mentioned in the document or addressed specifically it is an interface with other regulatory requirements like siting, emergency planning and environmental reviews.

As I mentioned under emergency planning when you say for non-light water reactors how will you define the event by which you'll judge whether you're remaining under one rem to activate the PAGs, the protective action guidelines, that will come out of the events that are identified through the LMP.

There are requirements that are beyond LMP in which the LMP doesn't directly interface but which an applicant would have to address. Some of those are just routine effluents, Part 20.

If we do an equivalent to Appendix I for non-light water reactors Appendix I and 10 CFR Part 50 which address those routine effluents. Worker protections and other Part 20 kind of requirements.

As I mentioned security and aircraft impact assessments not directly affected. But designers should be looking at these requirements as they're looking at LMP to see that the overall design is meeting all of these requirements and from their perspective that they meet it in the most efficient way they can.

One easy probably example is aircraft impact. If they do LMP and look at all the natural events like perhaps wind is an easy example and decide that a building structure has to be X and they continue along on that assumption all the way until they get further in the design and then they'll say now we're going to do our aircraft impact assessment then they face the potential to say oh, that building should have been thicker, or some combinations of walls should have been different, or maybe we should have given more thought to putting it below grade.

So they need to be aware of all of these things as they're doing the design and I think this is the case. We all experience that they're well aware that they need to address all of these things. But I did want to just separate out. LMP doesn't answer every question, it doesn't answer every regulation, that there are others out there that they'll have to address.

MEMBER SKILLMAN: Hey Bill, before you change that slide. This is Dick Skillman. This list appears to me to be a list that was constructed or developed by designers.

And let me make a contrast. Over the last couple of decades we've watched the regulations change. Give you an example. In 1971-72 Appendix B to 10 CFR Part 50. Later on I think the gold standard was 50.65 the maintenance rule. I mean that was a fundamental change.

Industry resisted that like the dickens and it has turned out to be one of the most important changes in regulation at least from my years of experience.

But there have been other lessons learned that may not be represented here that come from the operating teams. As I said this appears to be a list developed basically by designers.

I'm wondering are there some key lessons learned from the operating side of industry and from the oversight of operations by the NRC that would add to this.

Actually, make it better.

MR. RECKLEY: I would assume that there are.

MEMBER SKILLMAN: I think so too.

MR. RECKLEY: Let me clarify that this wasn't intended to be all-inclusive.

MEMBER SKILLMAN: This is not a comprehensive list.

MR. RECKLEY: Yes. And it wasn't by designers, it was just by me.

But the primary reason I wanted to address it was to say that LMP doesn't answer every question.

MEMBER SKILLMAN: It's a good place to start. What I'm suggesting is that there is a I don't want to say list. There is a recognition by the operating individuals that yes, you have to design it properly, yes, you have to include design features and functional performance requirements to ensure that the machine does what it's supposed to and that the health and safety of the public are protected.

But beyond the if you will design features there are probably some other issues that need to be woven into quote "other requirements" to protect or further enhance the level of safety of new plants whether they're light water plants or they are non-light water plants.

MR. RECKLEY: I agree with you.

MEMBER SKILLMAN: Thank you.

MR. RECKLEY: And perhaps when we get into the defense-in-depth discussions and the integrated decision-making panel they can touch on that a little bit later this morning or this afternoon.

MEMBER REMPE: So, I actually am glad to

hear you say this and I noticed in the difference between whatever version we're looking at, N versus the ones we looked at last summer, they actually added a paragraph explicitly saying hey, just because you meet the top level regulatory criteria that we identified doesn't mean you're going to satisfy all the regulations.

That was a concern I had when I read the version last summer. So I'm glad to see both of you guys emphasizing that now.

MR. RECKLEY: We thank you. That was directly in response to the question.

CHAIRMAN BLEY: This is Dennis Bley. I'm going to follow up on Dick's comment and your response.

One place where we've really seen the kind of things Dick's talking about is on newly designed plants. The main control room board and operating procedures linked together through I'll say software but are linked together provide the operators with additional tools to understand things about their plant, or to a large extent based on events that have happened in the past. It kind of fits in that category.

MR. RECKLEY: Yes. Again, agreed. One of

the things that we do have to keep in mind I think is I don't want to overstate this too much, but at least the operating fleet is operating largely in a nineteen seventies world.

And so as we go through things like the man-machine interface that you're mentioning, Dr. Bley, the technology has developed a lot over those decades and I think it's --

PARTICIPANT: I'm just joking. I would never suggest such a thing.

ACTING CHAIRMAN CORRADINI: I think we have people online that have to mute.

MR. RECKLEY: That generated a response anyway. So I think it's fair to say that people designing plants today are looking at the available technology and areas like man-machine interface and so forth.

So going forward and getting again to try to lay out a little bit of the high level and then the industry folks are going to talk to you for a couple of hours about the details. And they're also going to go through largely at the suggestion from the June meeting some experience that has been gained through tabletops with different designs.

ACTING CHAIRMAN CORRADINI: Did we already do slides 13 and 14 and I just missed it? Just checking.

MR. RECKLEY: I'm a little repetitious. So you wouldn't have missed anything anyway.

The general approach within the regulatory guide and also the companion SECY paper building off of NEI 18-04 is to divide the framework into licensing basis events, and that gets looked at both from a probabilistic risk assessment viewpoint as well as deterministic viewpoint.

The safety classification and performance criteria, how do you define those for structure systems and components. Looking at what function does that SSC play, which ones would be identified as being safety-related and therefore subject to the higher hat in terms of quality assurance.

I think probably more importantly to some degree is how do you look at the non-safety-related equipment and determine what special treatment requirements, what are the reliability and capabilities you're crediting for that equipment and how do you assure it once you get into operations.

We have that now to some degree through things like regulatory treatment of non-safety systems, RTNSS. And if you go over to 50.69 you have it.

But this is again not an overlay in how can you change a design, or how can you change your operations for a reactor that's already been designed, but from the beginning how can you build in this logic.

Going back to the first discussion. In personal opinion, one of the better things about this overall approach again in my view is the marrying of the design and operations better than we traditionally did under Part 50. And there will be a talk later on about looking at the plant capability or the hardware and the companion performance and operational programs that go along with that.

And that is included also in the defense-in-depth assessment which is the last bullet up here looking again at the programmatic areas, at the hardware and then giving it a good scrub through an integrated decision-making process looking at it through multi-disciplinary going to Dick's point, the operations as well as design to see how it carries forward.

MEMBER REMPE: Before you leave that slide. The one thing when I read through this and I think about it, this integrated decision panel process which they do have additional guidance on in NEI 00-04.

Has the staff ever interacted with such a panel? Especially the way they've placed such emphasis on this panel it's going to be with the design from its inception through licensing. I'm just wondering what kind of issues might crop up with it versus how the regulator and the panel cite their opinions.

MR. RECKLEY: We've --

MEMBER REMPE: -- it will work.

MR. RECKLEY: We've had closely related experience I would say through both 50.69 type reviews and our reviews of PRAs and the peer review process.

But maybe I'll just ask the IOU for the industry presenters if they have any other examples where the staff has interacted.

I think there's been a couple of close but not exactly from the point of the design where we are now going forward on these non-light waters.

MEMBER REMPE: So in past experiences with 50.69 how did it work? Was it well documented? Did you like how this multi-experience whatever background panel came up and supported the design?

MR. RECKLEY: I might have to take an IOU on that unless Jason?

MR. REDD: Good morning, Jason Redd from Southern Nuclear.

I believe that we can make some comments on this -- make some comments on this topic in our session coming up soon. Thank you.

MEMBER REMPE: Thanks.

MR. RECKLEY: That would at least be from the industry side. I'll take an IOU maybe during lunch to see if I can get with NRR. I haven't been personally involved so I can't.

MEMBER REMPE: Even with the tabletops I don't think that you've had that interaction yet with the LMP process at all. So I'm real curious on how it's going to work.

MR. RECKLEY: So, one of the -- another area is the key considerations as the staff looked at this and developed the draft guide and the SECY paper, the enclosure 1 to the SECY paper and we mention it in passing in the draft guide goes through the evolution of this approach.

You can take it probably back further than this if you want but I tend to start with the development of the Advanced Reactor Policy Statement. There was an immediate test of the Advanced Reactor

Policy Statement through interactions funded by DOE and the staff looked at various designs including PRISM, modular high-temperature gas reactor and PIUS at the time as well as the CANDU 3.

Lessons learned from that in the identification issues was in SECY 93-092.

Around this same time the risk-informed performance-based focus with the PRA policy statement, the 1999 Commission white paper on risk-informed performance-based regulation was issued.

That obviously related to the things that were going on at the same time. Those efforts were applicable to both light water operating reactors as well as the development of the non-light water reactor technologies.

SECY-0347 was a follow-up where we came back to the Commission to propose resolution of some of those policy issues. That ends up being a key paper and I'll talk about it a little more this afternoon.

Just as an example of the marrying of the risk-informed approaches and the development of non-lights as well as other reactors you had the development and issuance of NUREG-1860 which is a feasibility study for a risk-informed approach.

Throughout all of that you can see that some similarity to the traditional light water reactor licensing structure is maintained, but one of the things as we go through today and as you look at the draft guide and the Commission paper is there are differences and some of those differences are hard to recognize on first blush because the terminology that's used uses some of the same terms but with a different definition.

And so just be a little careful as you go forward to say oh, I know how design basis events are analyzed. Design basis events are defined for light water reactors, they're defined for non-light water reactors using this methodology. It's a different definition.

Safety-related. The derivation of how something is safety-related is slightly different here than it is in Part 50, Part 1000 for light water reactors.

Anticipated operational occurrences. Same term, slightly -- and similar but slightly different definition in this case versus what you may be accustomed to in chapter 15 of the light water reactor.

So it's just a caution that whereas the

overall structure is similar there are key differences and some of those differences are hard to pick up on in part because the same terms are used with different definitions.

ACTING CHAIRMAN CORRADINI: So you'll remind us of this since we're forgetful.

MR. RECKLEY: One of the reasons to bring it up now is so when you bring up a question the answer might be careful, this is one of the areas where our definition is different than the Part 50 definition.

ACTING CHAIRMAN CORRADINI: So let me ask you, maybe you said it, I didn't hear you mention the next generation, the NGNP.

So I guess I'm empirical enough that I want an example. So what is it about what we're going to hear that's different than what was proposed for the NGNP?

MR. RECKLEY: It is most similar to NGNP and I should have listed it up there. It's on future slides. It is most similar to the approach of NGNP.

It's been refined a little bit based on interactions both with the staff and also as the effort was made to ensure it would be technology-inclusive it was tweaked some.

But it closely resembles NGNP. I see Karl Fleming, so Karl, if you want to weigh in.

MR. FLEMING: Karl Fleming, LMP project. During my presentation this morning and maybe early this afternoon I will highlight the similarities and differences with NGNP.

But Bill is correct, it's primarily the NGNP process with some refinements.

ACTING CHAIRMAN CORRADINI: So, if you can hold on a second. Then you'll tell us more, but at this point I personally found reading through this stuff difficult. Maybe it was because it's process and framework.

I really think if it's that similar an empirical example would really help. Maybe the industry gets it, but at least me trying to wade through the documents, I kept on asking myself gee, how is this different.

Because the frequency consequence curve is 1860, the NGNP frequency consequence curve was 1860 with attempts to place DBEs and LBEs on it.

So I think it would help for the less than completely involved individuals in this to marry those because I just think that would be a nice way of walking through this.

I really had a hard time in some sense trying to understand the process steps which you're going to go through.

MR. FLEMING: Good feedback.

MEMBER SKILLMAN: I'd like to weigh in on that just for a second. It seems out in the operating plant world we use a term called error likely situations. This is one. But it's right here in the staff.

And it just seems that it might be useful if we're using the same acronym at least mark the unique use of the acronym with a sign or something that communicates this is for the different application so that those who would read would say ah, get it, this is not identical, it's similar, caution.

But this really is an error likely situation for those who are trying to digest this information. Thank you.

MEMBER BALLINGER: Might we ask for a table that clearly lists the differences?

MR. RECKLEY: You can ask.

MEMBER BALLINGER: Can we make it a formal request?

MS. CUBBAGE: In the back of the NEI 18-04 document there is a table that lists a number of terms and in the right column if it says LMP that means it's a definition that came from LMP, and if it's the same definition as elsewhere it says where it came from.

MEMBER BALLINGER: I read that but I wasn't sure whether it was complete.

MR. RECKLEY: We will take a look and by the full committee we will prepare -- we'll prepare as best we can.

I just want to make sure, your request was on terminology or a comparison with NGNP?

MEMBER BALLINGER: Terminology.

MR. RECKLEY: Okay. Terminology is a little easier.

And as Amy pointed out one of the major things that was developed as we went through this was the glossary that's at the back of 18-04.

So again, keeping at kind of the high-level discussion as I mentioned the methodology consists of the three primary elements, the licensing basis event selection and analysis, the classification of equipment and the derivation of performance requirements in assessing defense-in-depth.

I'll say it probably a few times going through the day but the emphasis here is that this is an integrated approach and the staff is looking at these three elements within this methodology and they are like three legs to a stool. They're all complementary and they're all interdependent.

And so when we say that this is an approach that's okay for the selection of licensing basis events that goes to that's okay because of the way the defense-in-depth is also addressed within this methodology.

Likewise the safety classification and the assessment of the defense-in-depth. These things interplay with each other and we're saying that the three elements fit in this process and work together.

You would be challenged just to pick up one of these elements and say I'm going to pick my licensing basis events this way but I'm not going to do safety classification or a defense-in-depth assessment in the same way.

Then the next bullet on the slide. Another thing to keep in mind is when it comes to the actual regulatory decisions the criteria are basically the same in this methodology as are in the current rules.

The 50.34 25 rem number, that's used in this methodology. The safety goal, the NRC safety goal at the lower end of the curve, that's also within this methodology as one of the aggregate measures that's ultimately used to show the adequacy of a design.

The assessments are performed both using risk-informed and deterministic approaches and as was mentioned that includes the engineering judgment that would come from the integrated decision-making process.

And the methodology includes a specific element and step for looking at defense-in-depth and how that's provided using both hardware and programmatic controls, and how the programmatic controls are developed to support the defense-in-depth assessments, the uncertainties that might exist in a particular design and so forth.

And for me that becomes a very important point to keep in mind as you go forward because one of the questions that often arises for non-light water reactors is how do you address the availability of less operating data, of less operating experience.

And one key way that that's done is through this defense-in-depth assessment and really looking at both the plant capabilities or the hardware and what would be appropriate in terms of surveillances and monitoring and reliability targets and all the other things that you can set on the operating side in order to try to address some of those uncertainties.

MEMBER REMPE: So on the second bullet in your discussions with industry this does -- especially for -- well, design certification you have to assume some sort of characteristics about the site.

In the past, in the MHTGR example they reference that EPRI document that had like some hypothetical site that bounded 85 percent or some fraction of the site.

Did you try and push -- I mean, you're going to have a lot of different vendors coming in theoretically with a bunch of different designs. And if they would all just pick the same theoretical site wouldn't that make things easier and did you guys discuss that with NEI?

MR. RECKLEY: It might make it easier in some regards for us. The problem that arises is that these technologies to some degree have different potential uses, customers and locations that makes it kind of hard to say we're going to pick a generic envelope if you will.

Whereas some designs might be able to say off the bat we don't see Alaska as a potential siting others are being developed specifically for those kind of environments.

And so we are basically comfortable leaving it up to the designers to say you know the marketplace that you're trying to pursue. When it comes to picking an external envelope to try to bound where you want to put these it's really up to you to do.

MEMBER SKILLMAN: Excuse me, Dennis, this is Dick. Go ahead.

CHAIRMAN BLEY: Okay. Bill, you said something earlier that got me curious. You were going into the (telephonic interference) NEI 18-04 and something we put together.

In the guidance that you're going to get to this afternoon, it looks as if NRC plans to endorse NEI 18-04 with a few exceptions or clarifications. How -- when you look at NEI 18-04 is that kind of a consensus between the industry -- the NRC, or is it a separate product that you're evaluating later -- new reg guide?

MR. RECKLEY: It's a separate document, NEI 18-04 that the industry owns. And they'll be asking for our endorsement via the regulatory guide.

At the same time they didn't develop it in a vacuum and we've gone through -- you'll notice it's revision N. I think we've seen at the staff level during interactions three or four of those iterations and provided feedback of our own as well as what the industry has provided.

And as Amy just mentioned plus the white papers that preceded it, plus NGNP that preceded that. And so it's their product and they're free to put in what they want. At the same time we've provided feedback in order to if possible minimize the number of exceptions or even clarifications that we might need to add.

MS. CUBBAGE: And Dennis, this is Amy Cubbage. If you're specifically getting at the glossary in the back we specifically discussed that with industry at multiple public engagements and we provided input to them on that.

CHAIRMAN BLEY: Thanks. I was just trying to generalize.

MR. RECKLEY: And by the way, that's not any different than other guidance documents that are developed by the industry and then ultimately endorsed by the NRC.

MEMBER SKILLMAN: I'm going to hold up, thanks.

MR. RECKLEY: And again I'm going to just touch on these because there will be additional discussions of the actual methodology.

I just wanted to put a little staff context and maybe overview to prepare for the subsequent presentations by the developers of NEI 18-04.

A key aspect of this methodology as well as the NGNP and ANS 53.1 and basically the whole methodology that largely arises from the gas cooled reactor community and is being revised and updated here was the use of the frequency consequence diagram.

And one of the things that we would like to emphasize here is what's in the bullet which is an extract right from NEI 18-04 and it's an extract more or less right from the reg guide is that the target figure is a useful tool when you're doing the discussions assessment, when you're doing the safety system classifications, but don't look at it as an acceptance criteria where on one side of that line you're okay and on the other side of the line you're not okay.

The other caution --

ACTING CHAIRMAN CORRADINI: So can I -- with your first caution. But as we at least I thought we said in June if I start approaching the line things become concerning. That's the point of having some line.

MR. RECKLEY: That's right.

ACTING CHAIRMAN CORRADINI: Okay.

MR. RECKLEY: Yes, the closer you are to the line the more concern. And there is a point where it's unacceptable but we're trying not to use this curve that way.

As I mentioned earlier ultimately the regulatory decisions are made using basically the same metrics we use now which are the aggregate measure of the NRC safety goal policy statement, the specific assessments that are done against the criteria in 10 CFR 50.34, the dose reference values, the 25 rem number.

For those designs or projects that are pursuing a reduction in the emergency planning zone, that EPA PAG dose limit is marked on the figure. That might become a reference value that they need to address in the design.

But overall the figure is used in the context of identifying risk-significant licensing basis events. It is used in the defense-in-depth assessment and in the safety classification.

It's I think familiar to you, the anticipated operational occurrences, the DBEs. Again this is one of those cases where there's a definition difference.

DBEs are those event sequences between 10^{-2} and 10^{-4}. In light water reactors a DBE, that terminology is used as a broad category that is used within the definition of safety-related equipment and includes design basis external events, anticipated operational occurrences and design basis accidents or postulated accidents. I forget the exact terminology but they're the same thing. And special events.

And then to me what is actually key to this methodology is the inclusion of the beyond design basis events from the beginning and the assessment of those low likelihood events within the methodology. I'll let it go into this afternoon for a little more discussion of that, but again you can contrast that with the existing framework which through being conservative in the assessment of postulated accidents and anticipated operational occurrences was largely trying to address the fact that they didn't address some lower likelihood beyond design basis -- what we now call a beyond design basis event.

The last category on the curve there is

that DBAs, design basis accidents, are maintained as a category within the licensing basis events. They're done largely the same as is used now within chapter 15 of a typical safety analysis report crediting safety-related equipment and using analytical methods that are consistent with the guidance that the staff has issued for chapter 15 transient and accident analyses.

MEMBER REMPE: So a few weeks ago I was at a meeting and a designer put up a plot that showed the risk of the plant as a function of years based on their increased knowledge. And I would have actually liked to have seen a similar plot that also had the risk of their plant as a function of dollars invested in the design development because it was going up and down.

The reason I'm bringing that up now is that it might be good to provide some perspective about what was it Rickover's letter that said a paper reactor is very, very safe and then as you have more knowledge and more information that you find out that it has more issues that you have to address.

I just think that some perspective might be useful in your document of what the staff expects or some caveats to the design developers that are coming out with their concepts claiming they're so safe.

MR. RECKLEY: We try to do that through the pre-application discussions that we have with them as does EPRI and others that are involved in various exercises. So we try.

MEMBER MARCH-LEUBA: Okay, this figure, I don't want to call it -- is merely a mathematical problem. I guess the left side of my brain. And the issue is I may not be using the proper methodology, is segmentation of events.

If I take LOCAs and I decide to call it LOCAs that happen at midnight, LOCAs at 1 a.m., LOCAs at 2 a.m. suddenly the frequency of my LOCAs is 24 times more.

So when you plot only -- by making my events very, very specific I get a lot more events and I don't change the line. See what I'm talking about?

There has to be some guidance.

ACTING CHAIRMAN CORRADINI: I think what Jose is asking is what Dennis asked in June which is the bundling of these so they're appropriately bundled so that I don't by parsing enough they all get -- well, that's what I think you said.

MR. RECKLEY: This is a question that's come up. I guess I'll ask Dr. Fleming if he wants to.

MR. FLEMING: It's a very good comment. The LBE in this process is defined by constructing event sequence families. And it requires you to group together event sequences that have similar initiating event challenge to the plant safety functions and if there is a release mechanistic source term.

So you're required to group the sequences that are similar to avoid abuses like subdividing like that.

MEMBER MARCH-LEUBA: That has to be very specific in the guidance and should be on the standard review plan. That should be part of the review that they didn't cheat on the generation.

And also at the end of the day if I have a house that is downwind from this reactor I don't care what my risk is due to a LOCA I want an internal risk. And I don't know how you add up all these points to give me my risk in my house five miles downstream. This will give you a risk for each particular event. Again I want to know what is my risk.

MR. RECKLEY: Right. And there are aggregate measures where you take the whole risks. The summation of the sequences.

MEMBER MARCH-LEUBA: But you probably will have eliminated a whole bunch of events to do the aggregate. You will only aggregate the DBEs.

MR. RECKLEY: And the beyond design basis events.

MEMBER MARCH-LEUBA: You will aggregate everything?

MR. RECKLEY: Yes.

MR. FLEMING: Yes, if I might amplify. Because one of the applications is to select licensing events for different applications including coming up with our design basis accidents we needed a tool to look at the risk significance of individual LBEs separately.

However, we also have three cumulative risk metrics where we accumulate the risk from all the event sequences against the two QHOs from the NRC safety goals. And we also have a metric for the high-frequency low consequence events that's based on assuring that 10 CFR 20 is maintained.

So we have the aggregate measures and the separate measures.

MEMBER KIRCHNER: Well, let me ask a specific question. Which individual risk is the anchoring point down at the bottom right of the -- is this 750 rems which is the large release, or is this early fatality within one mile?

MR. RECKLEY: And this is the caution that we bring out both in the reg guide and elsewhere is one of the reasons again that this methodology we think works within the overall construct is that the bottom figures actually don't correlate to actual criteria.

For example, the bottom that you'll see is the effective dose over a month whereas the criteria for emergency planning will use a different number, a different time period.

The 750 rem roughly correlates maybe to the prompt fatality but we didn't want to argue --

MEMBER KIRCHNER: That's much greater than a prompt fatality.

MR. RECKLEY: But we didn't want to --

MEMBER KIRCHNER: It's not roughly correlating. LE50 is a much lower number.

MR. RECKLEY: Yes, it's a couple of hundred. So we knew that as we went in and for the purposes of the methodology. Again, this is why I keep coming back. As an integrated process to look at the methodology we're fine that that number does not actually correlate to the 50.50 prompt fatality number.

MEMBER KIRCHNER: Because you can't reconcile all those it is cleaner to show it as fixed points and a solid line. But like in 10 CFR 50.34 there is that footnote that cautions people that we're not intending -- let's see, it's there, the 50.34 dose limit.

The intention is not to approach that 25 rem exposure. So I just would feel personally, this is just one opinion, if there were some band on this that suggested you don't want to be approaching this line from what would be on the left side of decreasing risk significance. You don't want to be bumping up against this line with your quote unquote "advanced design."

The expectation is that you're not going to really come close to this or it's not an advanced design. By policy statement of the Commission.

So, the expectations are not to press that envelope. And I don't know visually how best to do that other than putting some kind of hatched area on the lower side of that that kind of suggests. And I know, I guess the designers will go and say oh, I see what they mean, it's now not 25 rem, it's 20.

But something that suggests that you're not expecting these designs to push this envelope.

MR. RECKLEY: Right. The presentations on 18-04 will specifically address one there is a hashed area that's two orders of magnitude lower than this line for looking at what you'd call a risk-significant event.

Then as I mentioned earlier most of these designs are going to go for the one rem at the fence objective. That would limit it as well.

But I think we'll get into it and if it's not addressed then I'll be back this afternoon. But it's a good comment. Yes. And we tried to address that specifically within the regulatory guide by saying don't look at these points as the acceptance criteria.

Dr. Corradini mentioned 1860 earlier. I'll offer a personal opinion. It was a great document but the stair step approach, many of us like the straight lines and that causes you to have some compromises here or there versus having so many different break points as 1860 had.

So, but I understand your point and as we get into it if it's not addressed as we go through it we can talk. That would be something we could tweak in the reg guide.

So I'm going to just quickly go through

the last couple of slides because again all of this is going to get repeated.

So the safety classification. This slide just has the definitions which we'll get to as we go through.

MEMBER MARCH-LEUBA: I have questions and maybe I need to ask this afternoon. First is language. I don't understand what you say on the first bullet. If I'm reading this correctly the designer selects which SSCs are safety-related or not. And he decides to -- those SSCs that are needed to meet the classification of DBEs must be safety-related. Correct?

MR. RECKLEY: DBAs.

MEMBER MARCH-LEUBA: DBEs. The first couple of sentences, to mitigate the consequences of DBEs --

MR. RECKLEY: Within the curve. Yes.

MEMBER MARCH-LEUBA: And then it says to mitigate only those DBAs which -- that only rely on SRs. There are other DBAs that can rely on long -- I'm talking about language.

MR. RECKLEY: Okay. If there's a confusion we can take that as a comment but the intent is that DBAs just much like they do now assume safety-related equipment.

MEMBER MARCH-LEUBA: All DBAs must have safety. That's not what that sentence says.

Now, the most important comment is the second bullet which I think you are trying to address my concern. I detect a circular logic here. Let me give you a simple example.

I have a very strong containment and I have an accident that melts the core but nothing comes out of containment. Therefore the frequency consequence is very small, it's way to the left to your line and it's not a safety -- a risk-significant event. Correct?

So then I decide that because it's not a risk-significant event I don't need a containment because I don't need to have it safety grade. This is circular logic there.

MR. RECKLEY: It's actually what's trying to be addressed here is that if you have something you've placed in the beyond design basis event category as a result of a low frequency and you're relying on a particular barrier to limit the consequence of that event that that is reason to make it safety-related because if you took away that barrier you would move up.

MEMBER MARCH-LEUBA: It will move up. So what are we gaining --

MR. RECKLEY: I might have explained that wrong.

MEMBER MARCH-LEUBA: No, no, you did it perfectly. What do you gain by doing it that way? You should have -- make that event a design basis event that you have to analyze and make the SSCs that you rely on safety grade. Where are you baking it, I don't understand.

ACTING CHAIRMAN CORRADINI: I think we can come back to this one. Karl can come back to it. You can take it up with Karl.

MEMBER MARCH-LEUBA: Okay.

MR. RECKLEY: So just the last two. I've addressed this largely, the defense-in-depth assessment and this is going to be talked about by the industry in the context of NEI 18-04. Again stressing that it includes PRA, deterministic assessments, it includes hardware and programmatic controls. And so in our view it's a good tool to apply to a design to make sure that you're addressing the uncertainties and other objectives that we have in this process.

Then lastly I did want to touch on that the reg guide that we're preparing is on content of applications. That is the rule that this reg guide is being used for. So we felt it necessary to add a little discussion, more than what's in 18-04 as to how this guidance is used in the development of the scope and level of detail of information that we expect to be in applications.

And so I'll get into this this afternoon in a little more detail, but primarily if you look at the fuel, the primary systems and the other primary barriers if you go back to for example that first principle slide what is retaining your radionuclides those kind of barriers would largely need to be described much as they are now because that's where you're going to get how do you get a release. You get a release because you're failing the fuel, you're failing the matrix, you're failing a primary system.

So that kind of information would largely be similar.

But then as it relates to other systems, ancillary systems we want to focus on what is the role of those systems in supporting again those fundamental safety functions. And from the beginning we know that many of these designs are going to rely less on those ancillary systems, things like ac power and to some degree forced cooling water or other active systems.

And so this process we would hope would build into the beginning that this is how you decide how much information you need to provide on those kind of systems.

Likewise whenever you're relying on programmatic controls that needs to be addressed in the application so that you're looking at the same time in concert to hardware and the programmatic controls to provide the needed assurance.

I think with that then I'll just set up that the next presentations will be 18-04 that you'll hear about for a couple of hours. And included in that discussion will be some recent example through tabletops that were done with various designs.

And then we'll come back, the staff will come back to specifically talk about the draft SECY and the draft reg guide because in the end the ACRS is here to make recommendations or observations on the staff's activities. Those are the two things that we plan to issue and so we will be asking at the December meeting for a letter at least on the SECY paper and at your discretion either on the draft guide or an acknowledgment that you'll get another shot at the guide after we address public comments and the Commission's decisions on the SECY paper.

So with that I apologize for being a little late.

ACTING CHAIRMAN CORRADINI: No, we're good. Final questions from the members.

MEMBER KIRCHNER: Yes. Bill, since you're trying to do this technology-inclusive I would suspect that first movers may not be non-LWRs but LWRs for many of the issues that you're addressing.

So in your tabletop exercises have you tried to walk through with an advanced LWR design -- I'm not saying NuScale, I'm thinking just an advanced design to just conceptually since as you said you're doing methodology and process. Just to see how it works.

MR. RECKLEY: We haven't. If someone were to come forward I guess we could entertain it.

The dilemma that you get in and I'll take NuScale as the most recent example. Since they started largely with the existing structure and how they did the design and the arguments it gets a little difficult to then apply this methodology that's intended to be used both during the design process and the license application process.

It was done for a large light water reactor but NUREG-1860 includes an appendix where they tried to do this exercise for a large light water reactor and they ran into some of the same problems. And by the way the same problems the staff and industry have faced for the last 30 years on trying to undo a methodology that was based so heavily on that large break LOCA and how it was incorporated both into the design and into the licensing structure.

So, the short answer is no, we haven't really entertained it. And the only way we could do it is if somebody came forward and asked for us to do it, a developer. For example, one of the other light water SMR developers.

MR. SEGALA: This is John Segala from the staff. But the focus of this, the NEI document and our draft guide is on non-light water reactors. So, when we say technology-inclusive we're referring to the different non-light water reactor designs that are out there versus light water reactors.

MR. RECKLEY: That was actually the whole intent of saying technology-inclusive versus the old term of technology neutral.

ACTING CHAIRMAN CORRADINI: Walt? Follow-up?

CHAIRMAN BLEY: This is Dennis. This bothers me a bit. And maybe Karl will talk about it at the next session.

I'm not sure what I see that is non-LWR specific about any of this material.

MR. RECKLEY: I don't think we're trying to say it could not be used. We're simply saying that the target audience that we're developing this for and the community that's been engaged with us is the non-light water community.

I don't think we would disagree, and Karl can weigh in later, that these notions would potentially apply to a light water SMR but that's not what we're trying to develop.

ACTING CHAIRMAN CORRADINI: Dennis, all right?

CHAIRMAN BLEY: Okay.

ACTING CHAIRMAN CORRADINI: Okay, why don't we take a break till quarter of.

(Whereupon, the above-entitled matter went off the record at 10:28 a.m. and resumed at 10:44 a.m.)

ACTING CHAIRMAN CORRADINI: Okay, why don't we try to come back together here and start our next session.

Which Michael is going to lead us off. Mr. Meier --

MR. AFZALI: Actually I'll start us off.

ACTING CHAIRMAN CORRADINI: Oh, I'm sorry, Amir. I apologize. I was looking over there by the computer. Go ahead.

MR. AFZALI: Good morning. It's a pleasure to be here again. We have based on our last conversation, June conversation, Dr. Bley asked us to come back and have a detailed conversation about the proposal we are making. And we have put a great team together to come and answer your questions.

We look forward to your insightful comments. We thought it would be appropriate for our utility representative to say a few words before starting the conversation.

To that end I've asked Dr. Meier, a regulatory affairs VP and Mr. Steve Nesbitt, I'm going to read his title, director of nuclear policy and support, to say a few words. So, Dr. Meier.

MR. MEIER: Good morning and thank you all for the opportunity to appear before the ACRS Future Plant Designs Subcommittee.

Southern Company has 46,000 megawatts of generated capacity and provides clean, safe, reliable and affordable energy to its -- throughout our service territory.

What's important to note, our CEO Tom Fanning announced to our generation fleet that we have a goal to be low to no carbon by the year 2050. And he has set some goals in between there.

In order to do this we're going to have to focus on technologies that will allow us to reduce these carbon emissions. With nuclear energy, and we have talked about this a lot in the company, is going to play a major role in that.

Regulatory modernization, however, is going to be necessary for us to remove any of these unnecessary challenges and reduce inefficiencies in order to make this happen.

NEI 18-04 proposals provide a robust systematic and a flexible foundation for modernizing the regulatory requirements for these advanced light water reactors.

Given all the variety we have on these non-light water reactor designs being developed by the advanced reactor community it's imperative that we have a good foundation as well as a follow-on regulations made available to the developer community.

We are encouraged and we are excited by the cooperation between the NRC, DOE and the industry to take concrete steps toward developing this foundational framework and we look forward to the ACRS suggestions to make the products even better as well as expediting endorsement by the NRC.

Finally, I would like to thank the NRC staff, DOE management, our developers and the industry partners for diligently and effectively getting us to where we are today.

Again, I want to thank you for your time.

MR. NESBIT: Good morning and thanks for the opportunity to appear before the ACRS Future Plant Designs Subcommittee.

So why are we here. At the risk of repeating the obvious the current nuclear power reactor regulatory framework dating from the nineteen seventies and even before has proven to be effective although not always efficient in providing adequate protection to public health and safety.

This project is about leveraging knowledge, experience and technological advances over the past 50 years to put in place a methodology that will work in the 21st century when applied to the range of innovative and diverse reactor designs many of which bear little resemblance to the light water reactors we've become so adept at operating today.

Duke Energy, the nation's second largest nuclear power plant operator, supports the licensing modernization project. The 2017 Duke Energy climate report to shareholders outlines a scenario in which our company would achieve a 72 percent reduction in CO_2 emissions by the year 2050 compared to 2010 levels.

In addition to phasing out coal-fired electricity generation this scenario envisions preserving generation from all 11 currently operating reactors, increasing energy efficiency, expanding renewable generation, expanding energy storage and deploying innovative technologies we refer to as zero emitting load following resources, or ZELFRs.

A ZELFR has essentially no carbon emissions, can generate power continuously and can adjust its output to match load.

To meet customer needs in this scenario Duke Energy analyses indicate 13 percent of our year 2050 generation will need to come from these ZELFR technologies that may not exist today.

Nuclear power generation has been a great asset for Duke Energy and its customers in North Carolina and South Carolina and we believe advanced reactors are good candidate ZELFR technologies.

There are of course challenges to the

deployment of advanced nuclear generation. One of those challenges is the need for a modern, flexible, adaptable regulatory framework.

For innovative and diverse nuclear power reactor designs we must have a methodology that continues to provide adequate protection of public health and safety and works in a timely and predictable manner.

NEI 18-04 is a key foundation for that regulatory framework about which you have heard already today and you're going to hear more.

I've been encouraged by the progress made to date on this endeavor and in particular on the constructive engagement I've seen among industry, national laboratories, the Nuclear Regulatory Commission staff and other stakeholders.

And our team looks forward to receiving your observations and insights.

MR. AFZALI: Mike, did you want to add anything? Okay. So you heard why we are here. We are excited to demonstrate to you the how part.

And we have a team of three who sit at the table and a team of contributors sitting in the audience to answer any detailed question you may have.

With that said we're going to leave and

bring the real team over to the table.

ACTING CHAIRMAN CORRADINI: The technical team versus the leadership team.

MR. TSCHLITZ: Good morning. My name is Mike Tschlitz. I'm the senior director of new plants, SMRs and advanced reactors at NEI. Thank you for the opportunity to come before the ACRS and give this presentation.

So, one of the objectives of my presentation here today albeit very short is to discuss the importance of this initiative and NEI 18-04 and to the overall vision for where the industry needs to head.

To paint that picture I'll point to the paper that's on the slide. It's entitled Ensuring the Future of U.S. Nuclear Energy: Creating a Streamlined and Predictable Licensing Pathway to Deployment. It was issued January 23rd this year and cosigned out by NIA, NEI and NIC. Sent to Chairman Svinicki.

And it laid out the near term regulatory reforms that the industry saw as being necessary for licensing advanced reactors.

And we'll go through all of these but the second bullet there talks about aligning the regulatory framework for advanced reactors with our inherent advanced safety and that's what in part we're trying to accomplish through NEI 18-04.

In this paper we also provided a vision for the future with a modernized NRC licensing process where the reviews of advanced reactors become more efficient and timely while continuing to protect public health and safety.

The methodology in NEI 18-04 will play a large role in enabling a technology-inclusive risk-informed and performance-based approach, a more safety-focused and predictable regulatory review process and ultimately the licensing and deployment of innovative and safe nuclear technologies.

MEMBER REMPE: Mike, I had a couple of questions about this slide.

First of all, this comment about the trend of increasing costs. And I looked at slide 28. And although it's good for exciting some folks on the Hill I'd suggest that maybe it's incomplete.

For example, I believe the APR 1400 if you had that cost might show a difference in trend. And in fact, in general when you already have an operating plant like the system 80 as well as the APR 1400 I think the staff has done things more efficiently. It's sometimes maybe design incompleteness that is leading to increased costs.

MR. TSCHLITZ: Sure. The information that we're using was based upon information that was reported to Congress in 2015 over the last 20 years for the reviews and it showed a four time increase in the cost of reviews.

That being said the staff deserves some credit. I mean, the NuScale review and the APR 1400 reviews are proceeding on schedule. The APR 1400 review as you know is basically an uprate of an existing design so it's kind of in a different category. So to say that's a completely new and different design that you can compare apples to apples for the cost would be a challenge.

But for NuScale, if you look at the cost of the design reviews for NuScale they're approaching and predicted to be about the same as ESBWR for a design with about one-third of the safety systems.

So you're wondering -- and a much lower overall risk profile. So, I think what we're finding is the staff is becoming more timely in its reviews as evidenced by APR 1400 and NuScale review, but the efficiency associated with that we're not seeing. So that's the basis.

MEMBER REMPE: Everyone could improve,

I'll agree with you, but I just was thinking that that chart is a little incomplete.

MR. TSCHLITZ: So if you go to the next slide.

MEMBER REMPE: Actually, I have another question too.

MR. TSCHLITZ: Okay.

MEMBER REMPE: This last bullet, providing additional flexibility for changes during construction. And I'm thinking about what happened with another certified design where some issues were identified and they had to change during construction. And it's expensive to change a certified design under Part 52. What are you thinking about doing here?

MR. TSCHLITZ: So if I can go to the next slide I'll refer to a paper here. So the paper in the lower right-hand corner of this slide, Assessment of Licensing Impacts -- I can't even read it myself.

MEMBER REMPE: On Construction.

MR. TSCHLITZ: On Construction. So it's a paper that we recently issued that looks at the experience with -- it started with the Vogtle and the Summer plants but ended up just looking at the Vogtle 3 and 4 constructions about all of the license amendments that had to be issued during construction.

And we did a review along with Southern. Southern was very instrumental in us being able to develop the data to support the conclusions in this report.

We found that a lot of the changes in the licensing had no safety impact. And they were basically causing additional costs because of the staff that's necessary to be maintained basically around the clock so you don't impact construction when you find an issue that requires some type of disposition that may require an amendment.

So the ongoing carrying costs and then the cost of writing amendments and having the NRC review them is not justified from a safety perspective. So there's these additional carrying costs for having the ability to make changes to the licensing basis on an ongoing basis throughout the construction period where the vast majority of the changes had no real connection to safety.

And so I would point out that that's a report that you can read and see all the details. We provide some specific examples in there. We look at tier 2 star information. We look at the level of detail that's provided for some of the civil structural part of the licensing basis.

We're basically suggesting that there be a reconciliation process during construction that allows a period of time where the construction continue in non-conformance with the licensing basis and allow a period of time for some development and submittal and the NRC review of a change while construction continues.

That goes at this. That was not going to be the subject of this talk today.

MEMBER REMPE: Sure, I just was curious so thank you. I'll look at the paper.

MR. TSCHLITZ: Okay. So on this slide as I noted in the January 23 paper we set priorities for what needs to get done in the near term.

The four documents shown on this slide were written over the past nine months and provide recommendations for making regulatory reviews more safety focused and efficient, providing guidance for developing a regulatory engagement plan that supports staged licensing, proposing a process for providing additional flexibility during construction under Part 52, and the topic we're here to discuss today, NEI 18-04 which provides a technology-inclusive risk-informed performance-based guidance for identifying licensing basis events, SSCs, and determining the adequacy of defense-in-depth.

MEMBER KIRCHNER: Can I ask you to go backwards?

MR. TSCHLITZ: Certainly.

MEMBER KIRCHNER: Since you highlighted it in yellow aligning the regulatory framework for advanced reactors with their inherent enhanced safety. I think I know where you're going with that but it would seem to me that the regulator requires the applicant to demonstrate the inherent enhanced safety. That's not a given going in even though on paper many of the designs look promising.

I'm just quibbling with your choice of words. If I were in your shoes I'd want to expedite my way through the safety review with a focus on safety and what's important to safety and risk.

This sounds like retooling the regulatory environment because we think these reactors have enhanced safety features yet to be demonstrated. It seems to me that's not your real objective. Your objective is to demonstrate that these reactors are indeed lower risk, they have more margin and therefore -- I'm just struggling with the words there because on paper it's incumbent on the applicant to make that demonstration that they really do provide an enhanced level of safety.

MR. TSCHLITZ: So, I agree with what you say. I think what we are trying to communicate there is -- I'll give you two examples.

Consequence-based emergency planning. If you make changes to the regulation that allow based upon the consequences associated with events to set the EPZ as appropriate that's aligning the regulatory framework with enhanced safety.

Consequence-based security measures. Aligning the security at the site with its enhanced security features. For advanced reactors that's changing the framework.

So those are the type of changes I think we were after. And this NEI 18-04 also fits in that category whereas you're looking at a different approach to determining licensing basis events that basically will focus on the most important parts or aspects of the design.

MEMBER KIRCHNER: Let me repeat my question to Bill from the last session. Is your document going to be amenable to an LWR based technology?

MR. FLEMING: Well, we never intended this to apply to an existing light water reactor. If an advanced non-light water reactor came forward with safety characteristics that were essentially the same as a light water reactor using -- relying on an inventory of coolant, metallic fuel, reactor vessel and so forth and a leak tight containment the process should accommodate such a design approach.

We didn't intend it to exclude any technology but we didn't intend it to be applied to light water reactors.

MEMBER KIRCHNER: Again, at risk of repeating myself the first movers may likely be LWR designs that will challenge some of the existing policies. And we have such an application for an early site permit before us to look at doing more of a risk-based and performance-based approach to the emergency planning zone as an example. Thank you.

MR. TSCHLITZ: So Jason, if you can go to my banner slide. So this slide reflects NEI's near term activities which have been focused on the topics on the four banners shown on this slide.

And the risk-informed performance-based technology-inclusive approach of NEI 18-04 has impacted the areas that I've highlighted in red circles that don't really show up that well on the slide here but I'll talk briefly about each one of those.

In the area of safety-focused reviews experience over the last two decades with the DC, COL, and ESP applications indicates that the NRC staff has to a large extent remained deterministic in its licensing reviews even though regulation and guidance allow the NRC staff flexibility to adjust its review on the basis of safety significance.

Costs of ongoing NRC reviews remain high leading to the conclusion that the advantages of safer designs appear to be of little benefit when trying to reduce regulatory review costs. Future NRC reviews should better utilize risk information in combination with the principles of defense-in-depth and maintenance of safety margins.

In the area of risk-informing advanced reactor licensing basis, information included in the licensing basis that doesn't have a connection to the safety basis in the NRC's determination of adequate protection imposes a burden on applicants who have to invest resources to develop the information and pay for the NRC to review unnecessary content.

In addition, there are ongoing costs associated with maintaining and evaluating changes to this information over the life of the plant.

Content that is not needed to demonstrate compliance with regulations and/or lacks a nexus to subsequent NRC oversight poses a regulatory burden with no benefit to safety. Inclusion of this information during initial certification or licensing is not necessary. These practices increase licensing review costs without a corresponding increase in safety.

NEI 18-04 provides the starting point for adjusting the content of applications and the focus of NRC's review based upon safety and risk significance.

Reversing the trend. In this area data submitted to Congress in 2015 shows the costs of NRC reviews have increased substantially over time.

As I mentioned briefly the NuScale example demonstrates that the projected licensing fees of advanced reactor designs are similar to other large light water reactors.

These design certification review costs have been normalized to 2017 dollars and have increased by a factor of approximately four over the last 20 years.

This shows that the advantages of safer designs have not resulted in reduction of regulatory review costs.

CHAIRMAN BLEY: Mike, this is Dennis Bley. Can you tell me anything about the success or failure of applicants who have challenged the staff that things they're looking at are not important to safety?

MR. TSCHLITZ: That's a good question. I'm probably not in the best position to answer that, but I can offer one example.

For the NuScale review, the chapter 9 auxiliary systems which have no impact on safety or mitigating beyond design basis events. I guess it was earlier on in the review and I'm sure this information has changed as the review has continued and shifted on to chapter 15.

But at one point in time 30 percent of the staff's RAIs were focused on chapter 9 issues. Chapter 9 as I said has no real nexus to safety.

So I think the vision would be in the future for those types of systems that don't have a direct connection to the safety case there would be a high-level description without a lot of detail in the application. And that should be sufficient for the staff's understanding of the design.

So at this point --

CHAIRMAN BLEY: That doesn't really get at what I was trying to ask. You showed increases in costs over quite a few years and during that time have the applicants tried to challenge NRC in these areas? Or do they just kind of go along with it?

MR. TSCHLITZ: Well, I don't know if I can offer a really good answer to that question because it involves a lot of different applicants over a long period of time.

I can say in general that there is a reluctance to challenge the NRC in some of these areas during the course of a review.

CHAIRMAN BLEY: I'm not sure that won't continue even with this new framework so something to think about.

MR. TSCHLITZ: I think the framework helps focus the discussion. So if you can show things more in black and white as you can on the frequency consequence curves as you'll see when you look at the results of the tabletops it helps focus the discussion I think on the issues.

So at this point in my presentation I'm going to make some introductions and invite some people who come to the meeting to support us to come to the mike and introduce themselves and explain their connection to the project.

So the first person is Jim Kinsey from

Idaho National Lab.

MR. KINSEY: Good morning. I just wanted to make a couple of remarks related to -- I know the NGNP project came up earlier in the day.

Back during that discussion we developed a process based on inputs from the three modular HTGR developers in the U.S. and also partnered with Entergy at the time to get some insights from an owner-operator organization.

And the risk-informed performance-based approach that we presented to this subcommittee back at that time was intended to work toward our marching orders of moving gas reactors forward, but it was always envisioned that it could be a technology-inclusive process.

So our involvement with LMP has been to bring some of that history to bear, provide insights from those previous reviews and as you'll see as we go through the day the current team is much larger, includes NEI, includes tabletops and evaluations from other technology types and includes other owner-operators. So it's provided some, as Bill mentioned earlier, some tweaks and refinements to that original process but it's still largely based on the foundation from that previous review. So we appreciate your insights today.

MEMBER REMPE: Jim, did the NGNP -- I can't remember. Did it have this integrated decision panel as part of that process?

MR. KINSEY: I don't know that it had that discussion in detail. I think that concept was out there, but I think one of the refinements that was the more significant one in the LMP approach is further defining the details of the defense-in-depth strategy and how you go about actually implementing and managing it. That's probably one of the more significant additions that we'll talk about. Other questions?

MR. TSCHLITZ: Thanks, Jim. The next person is Ed Wallace, consultant to Southern Company.

MR. WALLACE: Good morning. My name is Ed Wallace. I've been involved with advanced reactors since 2001 through the PBMR NGNP technology neutral framework and NuScale activities. And a member of the ANS Standards Board focused on risk-informed performance-based practices within the standards community.

Part of my purpose with the consultation to Southern is to bring that experience to bear in the evolution of this process which stems back 35 years or more to the MHTGR days.

My role has been to focus on the discussions aspect of it because of the comments that have already been made and the need to provide a practical way to perform that assessment in a consistent manner and consistent with the risk-informed performance-based information that's derived in the other activities that you're hearing about.

If you have any questions today I'll be glad to answer them. Thank you.

MR. TSCHLITZ: Thanks, Ed. The next person is on the phone line. Brandon Waites of Southern Company. And he's going to be speaking on behalf of X-Energy.

MR. WAITES: Yes, this is Brandon Waites. I'll just take a quick pulse to make sure everyone can hear me.

MR. TSCHLITZ: Brandon, just give us one moment to turn off area mikes so we don't get feedback. Thank you. Brandon, please go ahead.

MR. WAITES: Okay, thank you. I really appreciate the opportunity to speak today. My name's Brandon Waites. I'm new projects manager at Southern Company and I wanted to speak just real quickly on some activities we had regarding the LMP earlier this year.

Earlier this year the LMP team completed the first demonstration of the LMP process using a real world example with the X-Energy high temperature gas cooled reactor design.

And for this I'd like to take a quick minute to mention that the LMP team is grateful to X-Energy for their support and allowance and significant support of this demonstration.

Just to get quickly to the outcome of the demonstration we concluded in a report that is publicly available that the demonstration was successful and produced several actionable insights both in the area of -- for the LMP process itself and also insights into the X-Energy high temperature gas cooled reactor design.

ACTING CHAIRMAN CORRADINI: Brandon, can you give us a reference so the staff can get us a copy of that report? I'd be interested in seeing that.

MR. REDD: Michael, this is Jason Redd from Southern. We'll get you that reference momentarily. We've got it available. We'll provide it to a member of the ACRS staff before we leave today.

ACTING CHAIRMAN CORRADINI: Thank you.

Thank you very much.

MR. TSCHLITZ: Thanks, Brandon. The next person is Gary Miller from GE-Hitachi.

MR. MILLER: Good morning. I'm Gary Miller, manager of PRA at GE-Hitachi. We're responsible for all PRA aspects including design and licensing.

We used our PRA of the PRISM sodium fast reactor as a basis for supporting two of the LMP white papers on PRA and LBE selection and also we used it to demonstrate the methodology that we're going to talk about today. I'll be happy to answer any questions you might have.

MR. TSCHLITZ: Thanks, Gary. The next person is Steve Krahn from Vanderbilt University.

MR. KRAHN: Good morning. I'm Steve Krahn. I head up the nuclear environmental research group at Vanderbilt University where we do risk and hazard assessment on advanced nuclear technology. Specific to the subject of today's meeting we have been involved for the last four and a half years doing hazard and risk assessment of molten salt reactors and two of the outcomes of that research are part of the package that will be briefed this afternoon.

MR. TSCHLITZ: Thanks, Steve. The next

person is Dave Grabaskas from Argonne National Lab.

MR. GRABASKAS: I'm Dave Grabaskas. I'm a principal risk analyst at Argonne National Lab. I'm also the vice chair of the ASME ANS non-light water reactor PRA standard.

I was also the Argonne lead for the collaboration with GE to update the PRISM SFR PRA. In advance of issues we see with advanced reactor licensing our research has focused on passive system reliability, mechanistic source term and developing component reliability databases for advanced reactors.

And particularly applying them to the NEI framework but also its predecessors too with the NGNP and NUREG-1862. So I'd be happy to answer any questions you have in those areas.

MR. TSCHLITZ: Thanks, Dave. And the last person is Jim August from Southern Nuclear.

MR. AUGUST: Good morning. My name is Jim August. I'm with Southern Nuclear at Vogtle. I'm very excited to be here.

The reason I'm here is in my first post Navy commercial job I started off as a reliability engineer at Fort St. Vrain in 1981 and worked at Fort St. Vrain through about 10 years of operations and did a lot of work trying to resolve technical issues as well as licensing issues that surrounded that high temperature gas reactor prototype commercial plant.

As a result of those experiences when the ANS decided to reconstitute and redevelop their standard for safety design of high temperature gas reactors which are now termed modular helium cooled reactors I volunteered to join that committee.

From 2004-08 I was a member, 2008 I became the chair and we completed the standard ANS 53.1 which led to a lot of the work we're discussing here which was the safety design standard for modular helium cooled reactors.

My motivation for doing that work was largely the experience I gained at Fort St. Vrain which included a significant amount of frustration that related to us continually being judged in what I will call a light water reactor environment. I'm here to answer any questions that you might have.

MR. TSCHLITZ: So at this point I'll turn it over to Jason Redd.

MR. REDD: Thank you, Mike. Good morning. My name is Jason Redd from Southern Nuclear Operating Company. I'm pleased to be here with you all today, members of the committee.

The LMP methodology is ultimately focused on establishing a systematic, coherent framework for establishing a technology-inclusive risk-informed performance-based aspects of the licensing basis.

Given the wide variety of non-light water technologies that are proposed on the relatively near horizon a top down path of establishing technology-inclusive methods to establish compliance requirements such as the NEI 18-04 document, the advanced reactor design criteria which were released last year after collaboration between NRC staff and the Department of Energy leading to methods for establishing technology specific requirements such as the high temperature gas reactor and sodium fast reactor design criteria contained within the advanced reactor design criteria both leading to reactor design specific design and compliance basis, for example, the principle design criteria is an appropriate and effective pathway.

NEI 18-04 guides prospective applicants in answering the following questions. And we're going to come back to these questions again at the end of the presentation so certainly stay tuned through Karl.

What are the plan initiating events, the event sequences and accidents that are associated with that particular reactor design, how does the proposed design and its structured systems and components respond to initiating events and event sequences, what are the margins provided by the facility's response.

Again we've heard in the Commission's policy statements the margins are of significant interest both to the Commission and to the staff and to the designer and operator community as those margins relate to the prevention and mitigation of radiological releases within prescribed limits for the protection of the public health and safety.

And is the philosophy of defense-in-depth adequately reflected in the design and operation of this facility.

With these opening remarks I'll now turn it over to our technical lead --

MEMBER REMPE: Just a second, I have a question.

MR. REDD: Yes.

MEMBER REMPE: To make sure I understand because I did find when I looked through the document you're considering low power and shutdown events, you're considering external events. Hazards associated with the spent fuel pool. That should also be considered.

And then later on when you get to the tabletop discussions, did they have PRAs that considered all those types of phenomena?

MR. REDD: Let me answer the first part. Yes. The LMP process in NEI 18-04 is designed to address all of the radiological sources within the plant whether that's the reactor vessel -- the primary coolant system, spent fuel pool. Obviously some advanced reactor designs also have radionuclide inventory such as off gas holdup vessels and similar or storage tanks.

All of those sources of radionuclides that could pose a hazard to the public are included within the LMP process.

I'd like to invite Karl to answer the question about whether the demonstrations we've done so far have included those aspects.

MR. FLEMING: I'm not sure if we'll get to it this morning but certainly in the early afternoon I'm going to give you a breakdown of all the steps of our process and what was exercised and not exercised in each of the tabletops so far.

So in general most of the experiences focused on full power operation so the experience base is limited on some of these other sources. But I'll give you more details on that later.

MEMBER REMPE: Thank you.

CHAIRMAN BLEY: Karl, this is Dennis. Before you get started two things.

We did invite you guys back to hear more and more broadly and new material. So as you go forward if you can emphasize the new material and de-emphasize the repetitive stuff that would be great.

And number two, back in June we had draft Mary, M. Now we have draft November. Has there been any substantive changes that you can tell us about in the guidance since the last time we talked with you? And I'll go offline.

MR. FLEMING: In respond to your first question I'll do my best not to repeat things that you've seen before and try to emphasize the new material.

I'll invite Jason to comment on revision N versus M.

MR. REDD: Good morning. The changes from draft Mike to draft November were primarily the incorporation of comments from this committee in the June time frame.

The major changes have been an expansion of the discussion of certain aspects. There was increased discussion especially of how defense-in-depth is applied.

A lot of clarifications here and there in response to both staff feedback both industry feedback and the committee's June comments.

There was no change whatsoever in the underlying philosophy or the methodology. I would characterize these changes as editorial and explanatory.

MR. FLEMING: I'd just add one point to what Jason mentioned and that is that each of the revisions has reflected our evolution in being more precise about our terminology.

So the use of our terminology in avoidance of synonyms for key terms and cleanup of our glossary has continually been improving along the way.

Thank you very much, Jason. If I can start my talk here. The technical presentation that we have outlined has two parts to it. One of them, the first part is to just amplify on some methodology refinements that we made since the NGNP days and to point out some technical items that fill in some of the gaps from Bill Reckley's presentation.

And then the second half of our presentation is geared towards the lessons learned from our tabletop pilot applications.

On this first slide which outlines the

principal focus of this methodology the things that -- I just wanted to amplify on some of the things that Bill Reckley has already mentioned.

This is an integrated process for license event selection safety classification and defense-in-depth. And they're really interrelated in terms of the safety classification refers to functions that are performed by the SSCs on the licensing basis events.

The defense-in-depth refers back to both the SSC functions and the LBEs that are participating in preventing and mitigating accidents. And the defense-in-depth aspects have a lot to do with setting the performance requirements for our system structures and components that come out of safety classification.

The process leads to a systematic identification of the design basis accidents that will go in chapter 15 using a process that we believe is repeatable, reproducible and so far has produced nothing but sensible and consistent results.

Uncertainty is a very major focus of this activity. It's addressed within the state of the art of PRA in terms of estimating frequencies and doses with their associated uncertainties but it identifies sources of uncertainties that are captured and evaluated very carefully in the integrated decision processes associated with establishing defense-in-depth adequacy.

The evaluation of plant capabilities and programs for defense-in-depth is one of the areas that's extended beyond what was done in the NGNP process.

We think this process is risk-informed using Chairman Jackson's original idea behind that term in that it involves a balance of probabilistic and deterministic inputs. It's not risk-based by any shape of the imagination but our rationale for starting with a design-specific PRA that's integrated into the design process is it's a way to enumerate a systematic and exhaustive set of scenarios that we can draw from to build the license application.

One area that we have enhanced from the NGNP days, we've tried to emphasize more of the performance-based aspects of the approach. Performance-based includes using plant level metrics for measuring the risk significance of licensing basis events, but also in setting performance requirements for SSCs that are phrased in such a way that can be tracked and monitored throughout the plant operation and lifetime to get adequate assurance that a safety case is being upheld.

And the other aspect of this approach is that unlike the light water reactor model for prevention and mitigation which has been largely focused on preventing core damage and mitigating the consequences of core damage, these reactor designs that we're dealing with have many different end states, many different event sequences, different uses of barriers and layers of defense.

So finding a general way to talk about prevention and mitigation linked to balancing, preventing and mitigating the releases from radioactive material from the plant.

If we go on to the next slide. To clear up some of the discussion earlier on how we come up with our design basis accidents, we start with defining accident families in which we group event sequences according to the similarity of plant challenge initiating event, plant response and if there is a release mechanistic source term.

We group them and classify them by frequency into three regions. And from that we evaluate the -- we start with the design basis events and the design basis events region and we look at the design basis event as candidates for design basis accidents.

The idea is that we want to have a reasonably complete enumeration of design basis events that challenge the safety case.

When we get into this part of the analysis the LBEs that have no consequences are equally important if not more important than the ones that might have a risk significance. The risk significance is part of this but what we want to mine out of this is what are the features in the plant that are responsible for preventing releases from these accident sequences and then what do I have to preserve in my design basis to enforce that result.

ACTING CHAIRMAN CORRADINI: So can I -- if this is the wrong time to ask a question you can just hold me off.

So is there a standard process in risk assessment that one understands how to bundle these things? Because I know you've said it a number of times and we said it in June, but I don't -- I'm still trying to get a handle on a guidance here that it's perfectly clear what's a good judgment and what's an inappropriate judgment on the bundling. Whether it be based on source term or based on frequency. Or type of initiator. And I can't tell yet.

MR. FLEMING: Okay. We handle that

through the ANS ASME light water reactor, non-light water reactor PRA standard. There are technical requirements in that standard for defining event sequence families and this is fundamental to analyzing the contributors to risk in that framework.

So we actually have -- it's in that standard that was issued for trial use in 2013. David Grabaskas was alluding to one of the pilot studies done to exercise that.

ACTING CHAIRMAN CORRADINI: So if I have -- pardon if this is too simple, but if I have a station blackout event as we might have in a light water reactor but with a range of source terms that would all be bundled various station blackout events with various initiators, or would it be more akin to bundling them based on source term?

I'm trying to think in my mind that I've got an x-y plot where y is the frequency and x is the source term essentially for all intents and purposes. And I'm trying to understand how you bundle these things if I get a disagreement about how I bundle them based on initiator or source term.

MR. FLEMING: Well, first of all we want to bundle them based on source term. If there is a source term we don't want to have dissimilar source terms in the same event sequence family.

ACTING CHAIRMAN CORRADINI: That's the first principle.

MR. FLEMING: That's one. Then beyond that of all those that have the same mechanistic source term among those we want to identify those that have the same challenge to my safety functions. So what systems were working, what systems weren't working, what functions were fulfilled.

So we want to preserve the character of how the safety case was challenged by the event sq.

ACTING CHAIRMAN CORRADINI: So did I miss that, or is that written somewhere in 18-04?

MR. FLEMING: No, it's not written in 18-04. It's referred to in the PRA standard, the non-light water reactor PRA standard.

ACTING CHAIRMAN CORRADINI: Okay. And that's referred to in 18-04.

MR. FLEMING: Yes.

ACTING CHAIRMAN CORRADINI: Okay.

MEMBER KIRCHNER: Karl, can I interrupt and ask a question? So you're in the early stage of an advanced design. You can probably bound the source term obviously, whatever the core design is. But there are design characteristics, I guess I'm asking an uncertainty question in an indirect way. Without getting into specific designs. Let me see if I can phrase this generically. Technology-inclusive.

There are things like reactivity insertion accidents, or there are fuel failure modes that early on can have a large uncertainty associated with them until you've done the actual detailed design or you've done a fuel qualification program or et cetera. So how do you best include uncertainty early on so that you don't get down the road and find that systems that you thought weren't risk significant or weren't safety-related then you get into a backfit situation of revising your design well down the road which obviously would be a nightmare for any advanced concept trying to expedite its way through the system.

So how do you deal with that uncertainty early on when you're going through establishing your design basis and other events and then you're going through it, and then you're selecting your safety-related systems and such. Then do the DBA analysis. But put the DBA analysis aside.

I'm just curious how best in this process you avoid a major redesign, or a major backfit, or a major change in the quality level of systems and components as the design matures.

MR. FLEMING: Well, let's see. If you break the LMP process down into its full level of detail it's like an 18-step process. And many of those steps involve evaluations of what you have so far with feedback loops to go back to the beginning when you have to choose the design in order to get a satisfactory result.

In the PRA part of this process based on where you are in the design when you apply the PRA standard roughly half the requirements in the PRA standard have to do with uncertainties. Have to do with identifying sources of uncertainty, trying to account for them to the best you can and your estimates of the source term and the frequencies of occurrence.

The ones that you cannot handle that way beyond the state of the art to do that then you have to do sensitivity studies. But you have to document all of the sources of uncertainty in the overall process.

After the PRA has taken its best shot to deal with these in I'd say PRA space when we get into the defense-in-depth adequacy evaluation the defense-in-depth adequacy evaluation looks at these issues of uncertainty, takes a critical look at what was done in the PRA, what was assumed in the PRA, what sources of uncertainty were identified in the PRA and then identifies compensatory measures.

And the compensatory measures could range anywhere from changing the design to putting in programs, doing testing, experiments and those types of things.

So the process certainly does not shy away from this challenge of uncertainty. And I think the process accommodates it.

ACTING CHAIRMAN CORRADINI: So can I follow up Walt's question? So I'm still back to principles of using this because I'm still kind of muddled about this.

You said there are three possibilities if you go through your iteration loop. One was to change the design. One was to I'll call it sharpen my pencils and do better analysis. One was to use compensatory measures, some sort of programmatic --

MR. FLEMING: Or do testing.

ACTING CHAIRMAN CORRADINI: Or testing.

MR. FLEMING: Yes.

ACTING CHAIRMAN CORRADINI: Okay. So is the principle that if I can do something with low uncertainty and high confidence I would choose that over something with large uncertainty?

In other words I might change the design and now I have a hardware fix that solves it with a much smaller band of uncertainty. Is that preferred?

MR. FLEMING: Well, that would certainly be taken into account in whatever decision would be made. It's hard to prejudge.

ACTING CHAIRMAN CORRADINI: But it's not necessarily preferred.

MR. FLEMING: It's hard --

ACTING CHAIRMAN CORRADINI: I'm going somewhere with this, but I'm trying to understand it because it strikes me that unless I start off with a relatively sophisticated, or some level of sophistication in the design and the PRA I'm going to have a lot of uncertainty.

So the more I can change the design to minimize my uncertainty band the better off I am.

MR. FLEMING: Right, but there has to be sort of a cost-benefit part of that decision-making process to figure out what the most -- I'm reluctant to give a one size fits all answer.

ACTING CHAIRMAN CORRADINI: I understand.

MR. FLEMING: Given the different designs and different stages of design and so forth.

MEMBER SKILLMAN: Karl, let me ask a question here. I'm following your discussion with the material that was presented. You're explaining task 4.

The event sequences modeled and evaluated in the PRA are grouped into accident families each having a similar initiating event, challenge to the plant safety functions, plant response and mechanistic source term if there is a release.

MR. FLEMING: Yes.

MEMBER SKILLMAN: Now, here's my question. Can the family assignment affect the PRA's conclusion or frequency such that random selection will identify a sequence as an AOO one time and a DBE another time?

MR. FLEMING: I don't believe -- I believe if the words that you just read are followed properly that shouldn't result in any different classification randomly. I can't see how that would happen.

MEMBER SKILLMAN: So would it be accurate to assume that the family grouping is consistent whether it's done by PRA analyst A or B or D or Q?

MR. FLEMING: That's the reason why we develop standards. The whole idea of the standard is to create a reproducible process.

MEMBER SKILLMAN: Thank you, Karl.

MR. FLEMING: Getting back to the slide, after we define the DBEs in the DBE region the idea is to have a comprehensive set of challenges to my safety case.

And I go through a process and I ask myself what are the essential functions that I have to fulfill to keep these design basis events inside my frequency consequence target that if I didn't have these could easily flow outside the target.

And that's when I come up with what we call the required safety functions. These are the required safety functions.

Now they relate to the fundamental safety functions that Bill mentioned, but each reactor has the opportunity to come up with a specialized set of safety functions that fulfill the fundamental safety functions. So this is what we call the required safety functions.

This was the insight that was always in the process but needed better discussion that was fleshed out in the X-Energy pilot demonstration. It led to some substantial enhancements to that part of the process.

Then we look at, okay, what SSCs are available and not available during all the DBEs to perform those required safety functions. And that process leads to presenting the designer with a set of options that he can select among those that are available on the design basis events, he can select based on his overall strategies. Another integrated decision process, by the way.

He selects the safety-related SSCs that he wants to declare safety-related and then we construct -- from each DBE we construct a DBA where we remove any credit for the performance of any non-safety-related SSC and that leads to a set of DBAs.

And this process has now been done for three or four different plants and when we get to the end everybody thinks that yes, these make sense for this reactor.

ACTING CHAIRMAN CORRADINI: So can you give me an example of a list of required safety functions that are technology-inclusive?

MR. FLEMING: No. The point is --

ACTING CHAIRMAN CORRADINI: I'm struggling. I'm reading the words. I'm trying to understand. Because you said X-Energy this is something that was illuminated in the tabletop exercise was X-Energy. So I'm thinking there would be some required safety functions that are essentially --

I guess to put it a different way you're identifying safety functions that remove vulnerabilities.

MR. FLEMING: That's right. The required safety functions will be reactor-specific. So the fundamental safety functions that Bill talked about are generic to all reactors, remove core heat, control reactivity and contain fission products.

But then when you develop these for specific reactors, for example, in the high temperature gas cooled reactor family controlled chemical attack always comes up because that's necessary for the fuel integrity. They don't want to have oxidation processes go on.

We'll show you what the required safety functions were for GE PRISM this afternoon.

ACTING CHAIRMAN CORRADINI: Okay, that's fine. If we're going to get to it later that's fine. Thank you.

MEMBER MARCH-LEUBA: The staff presentation had a second bullet what safety functions are required to maintain the beyond design basis events to prevent them from going to design basis event in frequency. I don't see you addressing that. Do you understand my question?

They had two bullets on the selection of which structures are safety-related. And the second bullet said if you need a structure to make sure that your beyond design basis event does not increase in frequency and becomes a DBE. Those seem to be addressing that part.

MR. FLEMING: We do the safety classification, we may have a beyond design basis event that has a very high consequence above 25 rem. So part of the safety classification process is to prevent those BDBEs to go up into the DBE region. So that's another input to the safety classification.

This covers the safety classification that comes from mitigating the DBEs.

MEMBER MARCH-LEUBA: So you're proposing to do that only for those beyond design basis events that have high consequence?

MR. FLEMING: Yes. The goal is to make sure that if there's some degradation in performance of the safety-related SSC that you don't get outside the consequence target.

There's two ways to get outside. One is horizontally and the other is vertically. So that's the reason for that.

MEMBER MARCH-LEUBA: But you only do it for the high consequence events.

MR. FLEMING: For safety classification, yes. For safety classification. Now there's other aspects of the frequency consequence that come into the non-safety-related with special treatment which I'll get to in a second.

MEMBER MARCH-LEUBA: Well, we'll talk about this when you have the figure.

MR. FLEMING: Go to the next slide, please.

MEMBER SKILLMAN: Karl, let me ask a question before you go on. I'm back to my homework. Going to read a sentence to you.

Part of the LBE frequency dose evaluation is to ensure that LBEs involving releases from two or more reactor modules do not make a significant contribution to risk and to ensure that measures to manage the risks of multi-module accidents are taken to keep multi-module releases out of the list of DBAs.

MR. FLEMING: Those are design objectives. What you're referring to there are design objectives.

And since the beginning of this process which started in the MHTGR days and carried up through the NGNP part of this development it's always intended that this is a multi-module application.

So rather than worry about the lessons of

Fukushima after the fact to worry about what you're going to do about multi-module risk we wanted to get the multi-module treatment built in from the ground floor.

So what you were just reading is sort of a statement of a design objective. It's really the motivation for taking on multi-module event sequences is we want to take them on so the designer was aware of them so he can make decisions about sharing equipment.

There's benefits to sharing equipment because it provides more backup capability and redundancy, but there's down sides associated with maybe introducing the likelihood of a multi-module event.

So by embracing the multi-module considerations in the process we give the designer a tool to manage the risk of multi-module events as part of this design. So that's what that statement is.

ACTING CHAIRMAN CORRADINI: Thank you.

MR. FLEMING: On the safety classification as Bill mentioned we have three safety classes. The safety-related, the non-safety-related with special treatment and the non-safety-related with no special treatment. Those are the three classes that we have.

The integrated decision process associated with defense-in-depth has an impact on this because the second category, non-safety-related with special treatment, there's two ways to get in there.

One, it's a risk-significant SSC based on some risk significance criteria that are outlined up here, or the SSC performs in a function that's considered necessary for adequate defense-in-depth and that's the result of an integrated decision process that looks at the design, that looks at the redundancy, the diversity, the layers of defense and determines some SSC functions may be critical for adequate defense-in-depth. Those are the two ways to get into NSRST.

And that aspect of the classification process is analogous to some aspects in 50.69 although I don't want to say we're using 50.69 but that 50.69 also classifies safety significant SSCs as risk-significant or defense-in-depth adequacy.

ACTING CHAIRMAN CORRADINI: So when it's time maybe in the afternoon I'd be interested in an example about the risk-significant or performed functions necessary for defense-in-depth adequacy.

I had a hard time in the document understanding the logic so an example might help in that regard.

MR. FLEMING: Yes. We actually have examples this afternoon for GE PRISM we can show you.

One of the features of this approach is the use of what we refer to as absolute risk metrics for risk significance rather than relative metrics.

What I mean by that is in the traditional light water reactor risk-significant approach for operating reactors you measure the importance of a piece of equipment relative to your baseline result. And if you have a core damage frequency that's one or two orders of magnitude lower that's not reflected in the relative importance of the metric.

In the ESBWR application they adopted more of an absolute risk metric approach and we've adopted that here in the sense that we measure risk significance on how close you are to the frequency consequence target as far as licensing basis events are concerned and how far away you are from the cumulative risk targets that we have.

So the risk significance is tied to stationary numbers that don't change with your design. And that's a very, very important distinction between what we have for operating light water reactors and the LMP process.

The risk significance criteria by the way, the numerical risk significance criteria is something that was added since NGNP. NGNP did not come up with SSC risk significance criteria.

ACTING CHAIRMAN CORRADINI: So, can I say the second major bullet a different way, or the sub bullet in that.

What you're really saying is how close to the line can you get before something, it alarms you. And you're saying you have to get within --

MR. FLEMING: One percent, yes.

ACTING CHAIRMAN CORRADINI: Either in the frequency or in the dose.

MR. FLEMING: Well, 1 percent of the frequency as a function of dose. And I'll show you the chart. It's coming up. I'll show you the chart that shows that.

We also screen out doses that are so low that they're a small fraction of background which we talked about in June. Next slide, please.

So if we look at the universe of SSCs in the plant we have all the -- the rectangle represents all the SSCs in the plant.

The large oval there is what's modeled in the PRA. And the idea there is the PRA safety functions are supposed to capture all the SSCs that participate in either preventing or mitigating the release of radioactive material from any source, radionuclide source. So that's the logic for getting it into the PRA.

The safety significant SSCs are those that are risk-significant or they provide an adequacy of defense-in-depth. And therefore the risk-significant is a subset of that.

We also have our safety-related SSCs and they're almost always risk-significant but if there's a lot of redundancy in your ability to meet your required safety functions they're not necessarily risk-significant but they're always safety-significant. So we refer to that as the Segala-Cubbage diagram because it resulted from a long discussion we had with Amy and John about how these things relate.

MEMBER KIRCHNER: Since the point was made of excessive review and time and enhanced cost comes into play can you use this to make an argument that I only need, I'll make up a number, 10 chapters out of the standard application versus 18 or whatever we're up to in a typical application and the level of detail that's needed for say auxiliary systems.

If you can argue that they aren't safety-significant or they aren't risk-significant then can you propose a means to the staff that they should fall off the table in terms of the review?

MR. FLEMING: Right. Well, we haven't gone into great detail on this. The general understanding is that in the license application we would provide substantial information for the staff to review the safety-significant SSCs and their performance. And the ones that are not safety-significant would not be described in great detail. I mean, that would be the intent.

The motivation going back to the MHTGR, this process really started with the MHTGR application back in the nineteen eighties. And the motivation that General Atomic had to launch this approach is that they wanted to end up with a correct set of safety-related SSCs because that was viewed to be the thing that drove the cost of the facility.

They didn't want it to be larger or smaller than necessary, but they wanted to get the right set of SSCs. So that's obviously the motivation is to not spend a lot of time arguing and sending RAIs back and forth on non-safety significant SSCs.

And of course within the two categories of safety-related and non-safety-related special treatment the understanding is, the general expectation is that there would be a lot more focus on the safety-related SSCs given their importance and somewhat less level of detail on the non-safety-related with special treatment. That's the general understanding.

MR. REDD: I would of course add that Bill and Amy will be discussing this topic on application content further this afternoon. But I agree with what Karl said. The ultimate goal is to focus on those most safety-significant aspects that could affect public health and safety.

CHAIRMAN BLEY: This is Dennis --

MR. FLEMING: I think Dennis had a question.

ACTING CHAIRMAN CORRADINI: Yes.

CHAIRMAN BLEY: I want to make sure I understand your diagram. Things that are safety-significant are either risk-significant or they're needed for defense-in-depth. Is that correct?

MR. FLEMING: That's correct.

CHAIRMAN BLEY: And in your evaluation of defense-in-depth you're considering the uncertainty in the performance with barriers and other equipment.

MR. FLEMING: That's right.

CHAIRMAN BLEY: Okay. Go ahead.

MR. FLEMING: That's correct. Just a couple of comments about this diagram is that one of the areas that we went a little bit further compared to NGNP is that after we had the safety classification how do we come up with special treatment requirements for each of the categories.

The thing that's new here in the LMP process is that we start with both safety-related and non-safety-related special treatment, we start the process by setting performance requirements for reliability and capability.

Reliability because if you look at all the special treatment requirements you can sort of get into those two categories. Some of them give you greater assurance of reliability. Some of them give you greater assurance that they've got adequate margins when they perform that they'll get the job done to perform their function.

So we set the requirements for reliability and capability. Those requirements are set with input from the integrated decision process for evaluating defense-in-depth. They're looking at the uncertainties. They're looking at the whole package of things.

We set those requirements including numerical requirements for reliability and availability and performance requirements. And then the rest of the special treatment flows from that.

And for the non-safety-related with special treatment our thought is that in most cases all that should be required is putting into case a monitoring program to monitor the performance of those SSCs against those performance requirements.

If there's other special treatments or compensatory measures that are needed the IDP process would identify those whereas in the safety-related one there would be a more extensive set of special treatment requirements.

So that's an area where we've gone beyond what's actually in the NGNP documents.

ACTING CHAIRMAN CORRADINI: So Dennis actually clarified the one thing about what safety-significant SSC is. It's both defense-in-depth and risk-significant together.

MR. FLEMING: That's right.

ACTING CHAIRMAN CORRADINI: Where is safety -- oh, I see. Safety-related is the smaller of those.

MR. FLEMING: And getting to -- I won't go into the details on this. There's a table 5-2 for example in the guidance document that talks about the minimum requirements for plant capability defense-in-depth.

And one of the principles that's in that table is that for required safety functions and critical elements of your safety case you can't have over-reliance on a single design feature or a single element of your design or a single programmatic measure to assure that that's fulfilled.

Where that leads to is the need to have at least a couple of different ways to perform your required safety functions.

So all the safety-related SSCs are definitely necessary for defense-in-depth. And in most cases they're also risk-significant because if they don't perform their function you could easily have a point creep outside the frequency consequence target.

ACTING CHAIRMAN CORRADINI: Thank you.

MR. FLEMING: The final point I wanted to make on this is that this big rectangle, the change left over after you modeled everything in those ovals and everything, there's typically screening done because the PRA model doesn't include all the SSCs in the plant. So there's all kinds of screening assumptions made and screening sometimes based on low frequency or whatever.

The integrated decision-making process takes a look at that to say gee, is there some compensatory measure we've got to put in place to make sure that the assumptions to screen that component out of the PRA model is enforced.

So that's another example on how this is not a risk-based process. It's -- we get what we can out of the PRA process but then we supplement it with defense-in-depth.

MEMBER MARCH-LEUBA: Going back to your previous comment about not over reliance on a single thing. Is that single failure criteria light?

MR. FLEMING: It may be, I don't know. You may look at it as single failure heavy because the way it's typically manifested in the examples that we've gone through in the pilot studies is you end up having diverse -- in some cases you may have passive inherent feature to perform a safety function. And maybe the second item that's added to the defense-in-depth adequacy is an active system.

So it's more likely to result in diversity rather than redundancy. However, redundancy would be one of the tools that you would have to meet your reliability requirements. So after you set your reliability requirements redundancy may be necessary, it may not be, on a case-by-case basis.

MEMBER MARCH-LEUBA: So your guidance does not have single failure criteria, yes. It's a guidance.

MR. FLEMING: Not as an arbitrary requirement.

MR. REDD: How we would address that is again point out that through the PRA process you look at all forms and failure combinations including combinations that are extraordinarily unlikely so you get that same value of looking at a single limiting failure through a much more systematic and comprehensive evaluation through the PRA process. Karl, is that a fair statement?

MR. FLEMING: That's a fair statement.

ACTING CHAIRMAN CORRADINI: But to get to Jose's point, if it becomes a DBA I still would use a single failure criteria.

MR. REDD: No.

ACTING CHAIRMAN CORRADINI: No.

MR. REDD: No, we do not --

ACTING CHAIRMAN CORRADINI: Your point is -- then your point really is that the design when going through this exercise you'll see diversity or redundancy beyond safety-related equipment. That's when you said it was -- you called it single failure heavy.

MR. FLEMING: Heavy. Yes. In that respect, yes.

ACTING CHAIRMAN CORRADINI: So let me do a process question. We're at noon. A natural break point at least if I see it in the slides is after slide 15. Where would you want to break? That's what I guess I wanted to ask you.

MR. FLEMING: I think if you give me five minutes and then we'll get to a logical break point.

ACTING CHAIRMAN CORRADINI: Okay, thank you.

MR. FLEMING: At the June meeting Joy brought up a question about safety margins which we didn't have a chance to really give a good answer for so we prepared this slide specifically for you, Joy.

This is summarized in the guidance document. There's a half a page or so text that basically wraps around this.

But there's -- the approach to safety

margins in the LMP framework there's a plant-level safety margins and those are reflected in the margins between where the frequency consequence points plot against the frequency consequence target.

And as we got feedback from the staff in an earlier version of our paper by making this comparison of where our points plot relative to frequency consequence target it's one way to demonstrate enhanced safety margins consistent with the Commission's Advanced Reactor Policy Statement.

Then we also have SSC level safety margins and those are set in both the reliability targets that we set as well as the performance targets we set by selecting design codes in order to be able to perform the safety functions with adequate assurance.

So we have both the plant-level and SSC-level safety margins and we confirm the adequacy of these margins as an important element of the defense-in-depth process.

If we can go on to the next slide, please, unless there's a -- did that answer your question, Joy?

MEMBER REMPE: Maybe I missed it but does it talk about how the defense-in-depth process will do this? I know that there's programmatic and plant-level defense-in-depth and different things like that, but does it really -- is it going to be something where you kind of have to feel it out with another demo and have this integrated decision panel look at this to really understand how it's going to work?

MR. FLEMING: I think that will probably help. The integrated decision-making process -- well, the integrated decision-making process on defense-in-depth will measure these margins up in the plant level.

They'll say, okay, you put together a table. There's example tables in the guidance document that show how far away -- what are your order of magnitude margins in both the frequency and consequence scale for all your design basis -- I'm sorry, all your LBEs.

You do that process and that's an input to say based on a frequency consequence what kind of margin do you have in that. So they do that.

And then in the SSC safety margin area the IDP process is actually taking a lead role in setting what the reliability requirements are going to be and what the performance requirements are going to be for all the special treatment. So they have a big influence on what comes out of the special treatment box in the process.

MEMBER REMPE: When you said the IDP you mean the panel will help specify this, or do you mean just the process?

MR. FLEMING: The process.

MEMBER REMPE: The process. And the panel will review it.

MR. FLEMING: We like to emphasize the integrated decision process. There's a panel exercise here but it doesn't do all this work. There's a lot of integrated decision process that goes along the way.

That's one thing we tried to clarify in the last version of our guidance document is that it initially appeared as that all this important stuff was going to be done when we convened this panel at the end of the process and that was a misleading picture.

MEMBER REMPE: I guess I still had that concept. In the MHTGR and NGNP has this process been fully exercised yet?

MR. FLEMING: No. Well, in the MHTGR it was embedded, implied in their process but they didn't call it that. But if you go ask Fred Silady and others how they actually put together their design it actually -- it was a joint interaction between the design team, the PRA team, the analysis team. They all got together and made decisions.

MEMBER REMPE: -- part of that process and we used to have a transient plant design. But the way the NEI --

MR. FLEMING: So it was embedded in the MHTGR. But if you look at the documents IDP doesn't appear in the documents. They didn't make a big deal about it. It was just the natural way to do it.

MEMBER REMPE: In this NEI document it implies it's more formalized, and I don't recall it being that formalized back in the MHTGR days.

MR. FLEMING: Well, we tried to put more structure in this process.

MEMBER REMPE: Did the NGNP have this more structured process implemented?

MR. FLEMING: Well, in the NGNP we didn't really do much to apply this to a design.

MEMBER REMPE: It's not really been exercised is where I'm kind of going, and I think maybe it may need to be that way more.

MR. FLEMING: The one part that has been exercised and we'll tell you about this afternoon is in the GE PRISM tabletop they took a cut at looking at their non-safety-related with special treatment SSCs that are necessary for defense-in-depth.

Now, they didn't get into special treatments and performance requirements yet, but putting components into the NSRST box was -- we have an example of that for PRISM and we'll show you the results after lunch.

MEMBER REMPE: Thank you.

MR. FLEMING: I think given where we are it's probably a good time to stop for lunch.

ACTING CHAIRMAN CORRADINI: So we'll pick it up with the penultimate diagram.

(Whereupon, the above-entitled matter went off the record at 12:08 p.m. and resumed at 1:14 p.m.)

ACTING CHAIRMAN CORRADINI: Okay, why don't we begin. Karl, you stopped on slide 13. You wanted to move on to the most important.

MR. FLEMING: Before I make a key point on this slide I wanted to revise and extend my remarks on a couple of items that came up before lunch.

With the question of our experience in handling the scope of different hazards through the LMP process I forgot to mention in the MSRE work that's ongoing and Steve Krahn will talk to in a little bit they are looking at the offgas system in addition to the fuel cell system. So we are in fact getting some experience outside the normal core thing.

The second point I wanted to make refers back to discussion we had on uncertainty and it also refers to a request that Dennis made that we identify things that have changed in the guidance document.

We added a paragraph in the guidance document, I can guide you to the specifics if I can remember it. I can't, but we can get that to you.

But we wanted to make an emphasis on the point that the LMP process is designed to be flexible. It can be introduced early in the process and we offer -- we identify some advantages to doing that.

Or you can also apply it late in the process in more of a confirmatory mode. The GE PRISM example that we went through is maybe one example of a design that was designed using more traditional approaches and then the process came about later.

Kairos is planning to do a demonstration project on their fluoride high temperature salt reactor. And in their case they're going to risk-inform qualitatively their safety design approach with a view towards using LMP to confirm the selections that they made rather than to develop them.

So the reason I'm bringing this paragraph up is that when we talked about the question about uncertainties I wanted to point out that this question about uncertainties is not a property of the LMP process. It's not a property of even trying to do a PRA. It's the property of our state of knowledge about the machine we're trying to license.

And I just wanted to point out that we can see advantages to early introduction of this process we believe will help flesh out what the uncertainties are earlier in the process and hopefully minimize the chance that you end up with costly backfits. That's just a value judgment that I wanted to make.

On the current slide, the frequency consequence chart, this was actually alluded to in the earlier morning discussion. We've adopted a set of risk significance criteria for licensing basis events and we're setting those at 1 percent of the frequency all the way down the frequency consequence target.

If any part of your uncertainty bands on both the dose and the frequency get inside this zone then we consider it a risk-significant LBE and of course we look at that much more carefully than we would look at other LBEs that are not in that process.

So the discussion we had this morning and the concerns about the selection of the 750 rem number which anchors the lowest point in the BDBE region down there, this is something that was carried over from the NGNP process.

And I wanted to point out this is a surrogate. This is a dose surrogate, dose to be calculated at a fixed point at the plume center line.

This is a surrogate for verifying that you've met the QHOs. The QHOs for early fatalities is the average individual risk in a doughnut-shaped hole, a doughnut-shaped area from the site boundary to one mile beyond the site boundary for early health effects.

If the doses at the plume center line, at the EAB happen to be 750 rem the average doses in the doughnut hole are well below the threshold for early health effects.

So there was actually some work done to demonstrate -- this is actually a conservative selection, but it's just a surrogate for a more elaborate individual risk calculation away from the site boundary.

Because as the doses get one mile beyond the site boundary the dose versus distance profile will dilute the dose quite a bit. Just wanted to make that point.

MEMBER SKILLMAN: Karl, for those hatched areas where you express the caution in the 1 percent zone is there sufficient guidance to prevent there from being the kind of tortuous discussion that we might have with an item that's more than minor, if you will a gray definition of what it means to be only slightly more than risk-significant but not to the limit and therefore you burn up hundreds of hours barking and arguing over trivia.

Is the dotted line sufficiently identified or codified that the designers would know once you cross that line you need to consider more action?

MR. FLEMING: First of all, it's very important to emphasize that this is a statement of risk significance. If you look at any PRA result from a light water reactor you'll see the identification of risk-significant event sequences or accident sequences, risk-significant basic events and so forth.

This is the tool that we would use based on absolute metrics to say what is a significant risk as far as an LBE is concerned.

It just means it's significant. It doesn't mean it's not acceptable. However, when we get events that start to encroach into that zone they're going to get much more focused in the defense-in-depth evaluation.

So the defense-in-depth evaluation, the integrated decision process used there is going to look very carefully at the results coming out of the PRA, the limitations of the PRA, the screening criteria and so forth.

And when you're getting into these risk-significant LBEs they're going to drill down and understand what's behind that calculation. First of all, the definition of the LBE in terms of the event sequence families and also the estimation of the frequency and consequence.

So the trigger point is not a trigger point of unacceptability, it's more of a trigger point for focusing the resources of the defense-in-depth evaluation. Hope that answers your question.

MEMBER SKILLMAN: It does, but to me it raises the issue that we've all dealt with and that is once you set a line or a limit for better or for worse it becomes a discussion item. And depending on the strength of the personalities depends on how much more resource you're going to expand to determine how much further you're going to go.

MR. FLEMING: Right.

MEMBER SKILLMAN: So unless that

definition is very, very clear that it is a guide and not a drop dead consideration then what you have stated seems to make sense.

But having dealt with this kind of thing my whole life I know sure as shooting someone's going to say we crossed the line. It's obviously got to be in that bin, not that bin, so it needs more QA, it needs more of this, more of that, more analysis. And the only way you can undo that is to make sure that it's very clear that that line is not a drop dead go/no-go gauge.

It's a trigger for greater consideration, but it's not in itself a limit.

MR. FLEMING: That's right. It's very important to note that.

And also the fact that it's -- these are absolute definitions, i.e., there's a fixed frequency consequence curve and a fixed 1 percent line below that as opposed to looking at significance relative to the baseline result which is the way light water reactors do risk significance.

So, there's always something significant in a light water reactor PRA because it's just a relative metric. So we would expect in most of the case studies we've seen we haven't really seen very many examples at all of any LBEs show up in this region, but it's certainly possible.

MEMBER SKILLMAN: Thank you, Karl.

MR. FLEMING: If we can go on to the next slide. This last of the process slides. The defense-in-depth evaluation. We've already talked quite a bit about that so I didn't plan on doing a soup to nuts discussion on that.

In the guidance document we break down attributes of defense-in-depth for each of the three yellow cornerstones up here, the plant capability defense-in-depth, the programmatic defense-in-depth and the evaluation of risk-informed performance-based evaluation of adequacy.

And so those attributes are used by the integrated decision process and the panel to come up with a baseline defense-in-depth evaluation which is documented and then provides a basis for change management as the design goes through various stages of development, licensing and siting and so forth.

So I think we've talked about most of these. I didn't want to spend too much more time on this. This is I think one of the cornerstones of advancing the technology-inclusive approach that came out of the NGNP project.

There was a defense-in-depth white paper for NGNP that is consistent with this but I think we've taken -- in sort of a football analogy we think we've advanced the ball down the field on this topic.

MEMBER REMPE: So out of curiosity I was trying to think of this when I was reading the material. Is there an emphasis to make sure you have some plant capability as well as programmatic capability defense-in-depth. You should draw from both types of options. Plant capability is the device basically and you do have to have --

MR. FLEMING: Well, yes. They're sort of like different kind of animals. One way to look at plant capability defense-in-depth is defense-in-depth on paper. So if I build this plant according to the way it was designed and I implement the safety design approach and there's no changes and whatever, no uncertainties, then it's sort of like an as designed sort of defense-in-depth.

What the programmatic defense-in-depth, it does two things. Number one is that it puts in processes to make sure that if you build it according to the design it will be maintained and operated through the life of the plant maintained in that design envelope.

And also to address uncertainties in all the decisions that went into putting the features into the plant capability defense-in-depth including things like what do we have to do to assure the reliability and capability of the SSCs that are part of my defense-in-depth, the uncertainties that may have come out of the frequency consequence evaluation in evaluating LBEs.

So it's more of a preservation of defense-in-depth through all phases of building the plant and operating it, licensing it and managing uncertainties and deviations, temporal deviations in performance.

MEMBER REMPE: So your response implies to me you have to have --

MR. FLEMING: You have to have both.

MEMBER REMPE: Thanks.

MR. REDD: Let's ask Ed Wallace can you comment briefly on the balance about whether we have to have -- Dr. Rempe I think your question is do you have to have balance or does the guidance tell you to balance programmatic and --

MEMBER REMPE: I just was exploring it.

MR. WALLACE: A couple of thoughts here to add to Karl. One is when you look at this equation of sorts these are contributions to reasonable assurance and adequate protection.

And so adequate protection is more aligned with how does the plant perform and reasonable assurance is how confident are you about how does the plant perform.

And so the programmatic activities start to go to things like tech specs. As long as you stay in the operating box that the design was built for then there's a higher likelihood that you're not going to run into a problem.

As long as you monitor the systems to make sure they're not degrading in service then there's a higher likelihood -- that's a special treatment. Higher likelihood that you're not going to get surprised later in life.

So there's a series of things. You can include QA. Karl mentioned earlier and I think Dr. Corradini also made a point about early in the design your sources of uncertainty are extremely important when you look at what's going on. There's a lot of unverified assumptions in the design process that get worked through.

And one of the answers when you do this may be gee, this phenomena we don't know enough about and it's driving the uncertainty bands around the mean which might tickle if you will to the question that Dick asked the cross hatch zone. We'd say why is that happening.

And so the purpose of the defense-in-depth process is systematically to say we ought to be looking at that harder in a different structured manner and we ought to be looking at is it driven by plant capability, is there compensatory measures that you could take that would be more programmatic but not change the plant capability one of which is go run some more tests in your integrated non-nuclear test facility if you have one so that you can sharpen your pencil to use the term that was used earlier about that uncertainty and its significance to your overall plant performance.

So you end up with a set of things in both camps and the design process sort of weighs the best way to solve the problem and part of the defense-in-depth description is if it's already in concrete your design options are limited and so you may have a bias towards trying to solve the problem programmatically because tearing out concrete is not a good idea if you can avoid it.

MR. REDD: Thank you, Ed. Karl, which slide.

MR. FLEMING: Let's go to the next slide, please. Now the balance of our presentation is going to focus on lessons we're learning by applying this process to different technologies. And they're summarized here on one slide, everything that has been done or is planning to be done by the spring of 2019 to support the processes in the LMP.

And I put them in to sort of accident -- reactor type families. The high temperature gas cooled reactors, the liquid metal cooled reactors, the molten salt reactors and then we have some other reactor concepts that have different combinations of fuel coolant type arrangements.

ACTING CHAIRMAN CORRADINI: So these are like pilot applications of the LMP?

MR. FLEMING: Well, yes. Each of these contributes to some element of experience in applying the LMP process. I'm going to show you a matrix coming up that breaks it down into which reactors apply to which steps of the process to give you an idea of where we are today.

ACTING CHAIRMAN CORRADINI: But none of the four if you want pilots have exercised the whole process.

MR. FLEMING: That's correct.

ACTING CHAIRMAN CORRADINI: Is the intent that they will eventually?

MR. FLEMING: That's -- I doubt whether every aspect of the process will be demonstrated in the pilots. There's just too much resources.

ACTING CHAIRMAN CORRADINI: The reason I'm going there is to the extent that the industry works together and understands it together the better off it is downstream versus a fragmentary understanding.

So the thought that you're running -- I keep on using the word pilots. The fact that you're running four of these strikes me as interesting. It would be more interesting if they completed them because then any other particular vendor in a particular type can look back and see an empirical example of how --

MR. FLEMING: Right.

MR. REDD: And I want to add that as we've progressed through these demonstrations that the amount of detail we've been able to go into and the further through the process we've been able to go has been beneficial. Especially one site, the GE-Hitachi PRISM exercise given that they're by far the most complete design. We were able to exercise a good bit of the process there that we'll discuss further on.

MR. FLEMING: And when I get to the next slide, Michael, I think I can get a more complete answer to your question.

In the high temperature gas cooled reactor family this process was really first started with the MHTGR licensability submittal that was done back in the nineteen eighties.

That was done in conjunction with a preliminary safety information document, a PRA, an NRC staff and NRC staff contractor review. This is probably the most complete application of the process although some steps of the process were invented after MHTGR so they weren't able to do it all.

ANS 53.1 and Jim August mentioned that he was the chairman of that group that put together that standard, that built upon the methodology in between the Exelon PBMR interaction and the NGNP project is when ANS 53.1 came along.

And it basically documents a design process that follows the basic elements of the LMP framework.

We recently completed and Brian Waites reported this morning we completed a limited scope demonstration on the XE-100 pebble bed reactor and we have a public domain report that documents that. I'm going to show some example results that we got from that.

In the liquid metal -- in the sodium cooled fast reactor family GE PRISM similar to MHTGR submitted a licensability submittal, a preliminary safety information document, a PRA, NRC staff and contractor review and published NUREG-1368.

GE-Hitachi has also been actively involved in supporting with many other advanced reactor developers in developing a non-light water reactor PRA standard.

We issued a trial use standard in December of 2013 and it was intended to be piloted by a number of projects. There were quite a few different projects that piloted including the Chinese HTRPM that was used to license the pebble bed reactor being designed and just about ready to start up in China.

And one of the things that transpired was the Department of Energy granted a project to GE-Hitachi to modernize their PRA specifically to pilot the non-light water reactor PRA standard and give feedback to the standard process.

And that gave the opportunity to have a very modern PRA project that was done that supported a demonstration project, the tabletop project that we're going to talk about here in a few minutes.

In the molten salt reactor area there's an activity underway that Steve Krahn will tell you more about in a few minutes involving using the molten salt reactor experiment as a design and a plant that's already operated and had some service experience to work through the process to support the molten salt family reactors using the LMP process.

And they've already published a report where they've started to take a look at licensing basis events for the MSRE using the LMP process starting from basically a blank sheet of paper.

And they're also advancing the technology of using HAZOPs, process hazards analyses like HAZOPs and failure modes, effects analysis to build the knowledge base that you would need to start this process. And Steve will amplify on that in a few minutes.

We also have planned some demonstration projects, some pilot projects on the Kairos fluoride salt reactor and also the Westinghouse micro reactor, the eVinci heat pipe reactor. And both of those are planned demonstrations to be completed by the spring of 2019.

So now I'd like to go on to the next slide and start getting into what they actually did. So in this matrix we've identified this is progress to date. So this is actually what's been completed to date.

It doesn't credit what we plan to do for the ones that haven't been finished yet.

So this matrix shows it's broken down. There's about 18 different steps of the LMP process and we tried to capture here some of the key steps of the process including developing an internal events PRA, a seismic PRA, a PRA that covers both single and multi-module sequences enough to define the AOOs, DBEs and BDBEs using the accident families coming out of those studies, evaluate the LBEs against the frequency consequence target and the cumulative risk targets, identify the required safety functions that are necessary and sufficient to keep our design basis events inside the target, and have at least example selections of safety-related SSCs that would perform those functions.

We also have the process step of developing functional design criteria for the safety-related SSCs and safety-related design conditions. That's SSC-level design criteria. Those two steps have only been performed for the MHTGR.

This actually involves a completed design.

It's difficult to tabletop some of these steps.

And we also have looking into the defense-in-depth steps we've broken down two parts to that. That's evaluating the plant capability for defense-in-depth and we have some limited experience with the GE tabletop on that.

And also the rest of the defense-in-depth process including the programmatic defense-in-depth and the application of the integrated decision process. So this is the matrix that shows you where we are today.

CHAIRMAN BLEY: This is Dennis. Two things I wanted to ask you about. On all of these cases you were able to compare the LBEs with the FC curves which implies you were able to develop source terms for all of these scenarios. Are those described in something we can look at, how that was done?

MR. FLEMING: We'll get into the extent of source term development. The examples we have up here, the MHTGR and the GE PRISM are supported by mechanistic source term analyses to develop the doses. The XE-100 based on its stage of design we just provided estimates of those based on scaling from power level based on results of other studies.

And the molten salt reactor experiment

I'll let Steve tell us what they plan to do for source terms on that.

ACTING CHAIRMAN CORRADINI: So let me just make sure I understand what N/A means.

MR. FLEMING: N/A means it wasn't -- that step wasn't available when the MHTGR was done. The MHTGR was done in like 1988 and we hadn't invented these DID steps. We hadn't invented that.

ACTING CHAIRMAN CORRADINI: Excuse me. So NGNP is not a potential pilot. This is the 1986 MHTGR.

MR. FLEMING: The NGNP really didn't involve a pilot. There were several different designs but it wasn't really an actual demonstration like was done for the MHTGR.

CHAIRMAN BLEY: They hadn't actually settled on their design.

ACTING CHAIRMAN CORRADINI: Dennis, it's hard to understand you. Can you say it a little louder, please?

CHAIRMAN BLEY: I said NGNP didn't actually -- had not actually settled on a design.

MR. FLEMING: That's right.

ACTING CHAIRMAN CORRADINI: I think they didn't settle on their reactor core design, but I thought most of the equipment between the two designs were similar outside of the core geometry.

I think we have -- I'm looking at -- where did he go. I'm going to drag Jim up to the mike to make him properly characterize this.

MR. KINSEY: We had some preliminary information from the three players who were involved with pursuing designs but there was no selection and it didn't get -- those designs didn't progress far enough in their level of detail to be able to apply the process.

We used the GA MHTGR design as sort of our surrogate for all of those discussions during NGNP as our poster child.

ACTING CHAIRMAN CORRADINI: So the reason I asked the question --

CHAIRMAN BLEY: -- my memory.

ACTING CHAIRMAN CORRADINI: I'm sorry, Dennis, go ahead. I apologize.

CHAIRMAN BLEY: I said what Jim said agrees with my memory.

ACTING CHAIRMAN CORRADINI: Okay. But since Jim is there can I make sure I'm clear? In the MHTGR analysis they didn't do the ones that are N/A but in terms of functional -- I'm still back to what we've already written about and what we have taken a position on in terms of functional containment.

These are particularly of interest to me. So I'm kind of curious in terms of defense-in-depth adequacy is the only example this has been exercised is with the PRISM?

MR. FLEMING: So far, yes.

ACTING CHAIRMAN CORRADINI: Okay, thank you.

MR. FLEMING: That's where we are.

MEMBER DIMITRIJEVIC: Okay, so my question, you show us the graph with the -- the risk-significant, the safety-significant. That was only done on PRISM as much as I can see, right? Is it done? Because I'm not sure that these, like for example the necessary required safety function that's where we can identify systems which will get safety classification.

And then I can see the risk was done, the significance was done and if defense-in-depth was done then you have a safety significance there too, right?

MR. FLEMING: That's right.

MEMBER DIMITRIJEVIC: So will you show us example how many SSCs we have --

MR. FLEMING: For PRISM.

MEMBER DIMITRIJEVIC: You have that.

MR. FLEMING: For PRISM. We'll have that. It's on one of the slides.

MEMBER DIMITRIJEVIC: Okay, all right. Excellent.

MR. FLEMING: Okay. Shall we move on to the next slide? Some general points that we've learned collectively and many of these lessons are already reflected in draft November or whatever we call it of the guidance document.

So we now have experience with at least including some that are sort of still a work in process on the three major families of advanced non-light water reactors meaning the high temperature gas, the liquid metal and the molten salt reactors.

The feedback we've gotten from the developers and I'm going to ask them to give us this in their own words, but they found the demonstration to be useful. They like the approach and it seems to produce results that they think are reasonable. So that's the feedback we've gotten from them. And we'll get some more specifics on that from the developers in a little bit.

They really liked the idea of using absolute metrics for determining risk significance.

It really focuses the statement of what's risk-significant to what's really important.

If we had stuck with the relative significance we might be -- we might have an unnecessary burden.

And also I want to point out an important insight. This actually happened from the GE PRISM PRA modernization that was done to pilot the non-light water reactor standard.

When we first wrote the risk significance criteria in the non-light water reactor standard we used the light water reactor model. There was a lot of pressure by the Joint Committee on Nuclear Risk Management to keep everything consistent with light water reactors unless it had to be different.

So we used the risk significance criteria where we mapped the requirements for CDF-based risk significance to all the release categories.

And what GE PRISM found was it just created a mess because they had 40 release categories. So they had 40 sets of Fussell-Veselys and risk achievement worth and so forth.

So it was actually feedback from the GE PRISM PRA modernization project that had a great influence on how we do safety significance -- risk significance in the LMP. So that's already baked into the guidance document.

And we're now working on putting those absolute risk metrics for risk significance into the standard. We're working on the next generation of this standard now.

So that was a huge -- it has a huge impact.

MEMBER SKILLMAN: Karl, by changing from relative to absolute did the conclusions change?

MR. FLEMING: Oh, yes. The population of risk-significant SSCs was --

MEMBER SKILLMAN: Night and day.

MR. FLEMING: Yes, night and day. Absolutely. Huge, huge difference.

The other thing we learned and again we learned this, this was in the GE-Hitachi demonstration project. The Venn diagram I showed you that showed all the different safety-significant, risk-significant, safety-related SSCs.

We used to think that all the safety-related SSCs were risk-significant based on our definition and we put that down there. And it was actually the GE-Hitachi PRA people who had experience with the ESBWR and had done a similar approach where in their example they had 14 different ways to get water in the vessel and therefore whatever safety-related SSCs for vessel injection that they had in the ESBWR that was not risk-significant because they had 14 backups.

So they clarified that Venn diagram for us and got us a better understanding of the relationship between risk-significant, safety-related and safety-significant. So that was a good insight.

MEMBER KIRCHNER: Just quickly going back to your Venn diagram. How do you square that so to speak with the NRC's definitions for safety classification and performance criteria? Where you have three, safety-related, non-safety-related special treatment and non-safety-related with no special treatment.

MR. FLEMING: Yes. For those three categories -- well first of all, having those three categories was something that actually was imported from the NGNP process. The NGNP process also had those three safety classes.

But as far as the current reactor is concerned this is similar to the 50.69 process where you're dividing up and you're defining safety-significant sequences other than safety-related based on risk significance and defense-in-depth.

So we think there's some alignment there with the 50.69 just as far as the safety classification process.

MR. REDD: And just to emphasize we're not trying to implement the 50.69 process here. It's just a similar framework looking forward. That's one key takeaway we want to be very clear on.

MEMBER KIRCHNER: I'm just thinking in terms of clarification and simplicity are we going with three categories or four categories?

MR. FLEMING: We only have three.

MEMBER KIRCHNER: Maybe I'm just confused then.

MR. FLEMING: Oh yes. Okay, that's right. We do have four, that's right.

ACTING CHAIRMAN CORRADINI: I was going to say --

MR. FLEMING: That's right. There are four. Yes, I'm sorry, I misspoke. There are four. It's the ones outside. Thank you.

MEMBER KIRCHNER: Is there some qualitative understanding with the NRC about how these definitions are going to be used?

I mean, where I'm going is so you made the pitch in the beginning that the process requires the applications too much extraneous so to speak information and such.

It would seem to me your Venn diagram ought to be first order of basis for cutting out a lot of material that isn't important to risk, right?

I guess I'm missing something here.

MR. FLEMING: Should we go back to the Venn diagram?

MEMBER KIRCHNER: Doesn't this provide you a means for streamlining the application in terms of content and such if you can demonstrate that there are SSCs that are outside the envelope of contributing significantly to risk or whatever terminology you're going to use.

It seems to me that for consistency this would be the rationale or basis for then eliminating material or excess material from consideration in the license application.

MR. FLEMING: Well, I guess it's our general view that application of the LMP process vis-a-vis a conventional ad hoc process should lead to a more streamlined safety analysis report. But we haven't actually gone through chapter by chapter to actually demonstrate that yet.

MEMBER KIRCHNER: Thank you.

MEMBER REMPE: Could you go back to slide 17. In light of all the insights that you've gotten from doing what you've done why not -- are you confident you wouldn't get a lot more insights if you go through and finish the rest of these steps with the PRISM design?

Again, I'm still hung up on how this whole defense-in-depth and integrated decision panel is going to work. I know you've said we don't have the resources. Department of Energy has a lot of resources.

I'm just wondering is there something important you would glean if you went another step further and did some additional work in this area?

MR. FLEMING: I'm sure that we could glean more insights if we did more but really that question is really something that needs to be collectively asked to the developing community.

All of these developers are volunteering their services to come and apply this process because they're excited about using it and they're investing their resources to do it.

ACTING CHAIRMAN CORRADINI: But I think what Joy is asking is another way of what I was saying also which is the idea that you guys have gotten together and have again I use the word pilot these four different approaches, or four different classes and running through it. To the extent that you can more completely do it I think it would be better for the community.

It will clarify a whole lot of things it strikes me.

MEMBER REMPE: Yes, especially since you've spent extra time now to define defense-in-depth. That's what I'm thinking of and the integrated whatever, decision panel and all that.

I just think that there's some fuzziness in my mind from what I'm reading and maybe it's clear to you. But it seems like if you would step through those additional steps you might learn some important nuggets that ought to be considered. It's something to think about. That's kind of where I'm going.

MR. REDD: Certainly. We thank you for the feedback. And again we've got several more demonstration opportunities coming up.

MEMBER REMPE: But those designs are less mature and I think you're going to have to use one of the more mature designs to get that useful feedback. Unless somebody really jumps their design ahead in a hurry.

MR. REDD: Certainly. Thank you.

MR. FLEMING: Any experience we get we should be able to benefit from. I certainly wouldn't disagree with that at all.

If we can go on to that next slide. The next to last bullet --

MR. AFZALI: Sorry. Two of our exercises fundamentally the approach and the methodology hasn't changed. The insight we've gained, we're mostly focused on ease of application. So we have provided additional clarity but the fundamental approach hasn't changed.

So we totally agree with the concept of more applications to further improve the process and execution part of it. But fundamental part of our process we have a pretty much confidence that it works. It gives reasonable results. Just wanted to clarify that point.

And Karl, I would like you to make sure I'm not misstating our findings as a result of our pilots.

MR. FLEMING: Yes, that's a very important point. We're not finding the need to modify the methodology from these tabletops but we are providing

-- we're getting opportunities to provide better guidance on how to most efficiently implement it. That's what we're basically getting out of it.

MEMBER REMPE: Has the regulator been involved with these demonstrations at all? Or is it just the industry coming in and working with NEI?

MR. FLEMING: NRC staff sat in on one day of the GE PRISM demonstration. The GE PRISM demonstration went over a period of several months and there were lots of interactions and meetings between the LMP team and the GE-Hitachi team that was working on that.

But the final day of sort of like presenting the results the NRC staff participated in a one-day meeting.

MEMBER REMPE: Were some additional areas for clarification was needed identified because of that interactions with the regulator?

MR. FLEMING: I don't recall.

MR. REDD: Bill or John Segala if you all would like to provide any input.

MEMBER REMPE: No, okay. Thank you.

MR. FLEMING: The next to last point I wanted to emphasize is that one thing that's come out in our demonstrations is the importance of thinking through all steps of the process before making decisions. In other words if you're looking at your frequency consequence charts and you're starting to think about incorporating risk insights before you start thinking about making a change to anything because you don't like the results work your way all the way through the process so you know all the tools that are available to affect the results including what you're going to find out of defense-in-depth.

So this gets back to the fact that this is an integrated process and it's not designed to be taken piecemeal and applied partially from one aspect of it.

This really -- what Amir was jumping up to say was really the last bullet point on that is that what we're finding is we're finding ways to improve the guidance.

In fact, the GE and the X-Energy tabletops that were already completed already are reflected in changes in the guidance document. So we're getting better guidance out of it.

The next slide here is one slide we have on the XE-100. This is a pebble bed reactor, a very small pebble bed reactor. It's being designed by X-Energy.

And this is a good example of what this process would look like at a very early stage of design. The conceptual design of the XE-100 is recently started. It started earlier this year. So they're very, very early in their analysis.

And before the LMP project came along they decided to do a very, very high-level limited scope PRA just to help make some design decisions to support some tradeoff studies on how they were going to design their core heat removal systems and also to get some rough idea of what the licensing events were going to look like that they need to worry about in the conceptual design. And that was -- that PRA was done several years ago not necessarily tied to applying the LMP process in general.

And it was a high-level PRA. The event trees and event sequence diagrams from that PRA are actually in the PRA white paper that show examples of how you can develop the first building blocks of a high-level PRA at an early stage of design.

But they knew what their sources of radioactive material were, they had insights from prior PBMR type PRAs. And what we did in the tabletop exercise was help the XE-100 folks develop rough estimates of what the doses would be because their mechanistic source term analysis and their tools weren't ready yet to come up with their own estimates.

So we provided information from NGNP studies and PBMR studies and MHTGR work and based on power level scaling arguments they were able to come up with rough estimates.

They actually do have in the library of work they actually do have uncertainty estimates on these frequency consequences. But in the time available it was hard to get them plotted on the chart.

MEMBER MARCH-LEUBA: Karl, we have this example here. I'm a very visual guy. We can go how you select for this particular example the safety-related component. Let me see if I understand what you do.

You will take the two green points which are the AOOs and say those are going to be DBAs for me. And identify --

MR. FLEMING: Let me walk you through the process. We start with the events in the DBE region.

MEMBER MARCH-LEUBA: The other ones.

MR. FLEMING: Between 10^{-2} and 10^{-4} per plant year. Now, when we do that we capture events whose uncertainties straddle the boundary. So we make the set as large as we can.

And then we analyze each LBE one at a time and we ask ourselves what safety functions were being fulfilled that kept the doses as low as they are.

And by the way, also shown on here on the y axis are LBEs that have no dose whatsoever. There's no dose at all.

So we look at those and ask ourselves what are the required safety functions that are needed to keep those inside the frequency consequence chart.

And for this reactor the three they came up with was controlled core heat removal, controlled core heat generation or reactivity control and controlled chemical attack.

And those in turn will assure the containment of radionuclides.

MEMBER MARCH-LEUBA: And then for your chapter 15 you will run all those points with --

MR. FLEMING: Hold up, I'm not quite done yet. So after we've done that we look at all the DBEs that we started with and we identify which SSCs were available or not available to support each of those required safety functions.

So we go DBE by DBE. We look at every one singly and then we say can we select -- what are our options to select a single SSC that will perform each required safety function for all the DBEs, that cover all the DBEs that's available in all the DBEs.

And normally there's options. For the pebble bed reactor it turned out the options were the reactor cavity cooling system or the heat sinks, the passive heat sinks in the reactor building. Those were the two options.

By the way, very similar result is mapped out for the MHTGR in the LBE white paper. So then they decide okay, which of those options do they want to make safety-related.

And that's as far as we took that tabletop exercise but that's the process.

MEMBER MARCH-LEUBA: I didn't have any problem with that. I want to go beyond ten to the minus four. Now the beyond design basis event. You said earlier that the highest one gives you 20 millirems so you say if you want more than 2 and a half rem you would consider it.

The beyond design basis events you are not going to evaluate what safety-related functions make them safe?

MR. FLEMING: Well, by making the safety-related selections that we did make based on evaluating the DBE region it helped to reduce the frequency of some of the BDBEs.

MEMBER MARCH-LEUBA: For those points that you -- the purple points you put there on that figure, do they include all of the components, even the ones that are not safety-related?

MR. FLEMING: Yes, it includes all of them.

MEMBER MARCH-LEUBA: So how do you know that those -- if you have fail a non safety grade component, you fail it, that will move to 2,000. How do you know it doesn't?

MR. FLEMING: Well, we're going to pick that up when we do the risk significance evaluation.

MEMBER MARCH-LEUBA: See, the thing that makes sense to me is you go through your red and green points, decide what your systems are going to be safety-related, fix them, rerun the BDBEs and those components and none else. And then you know that you're okay. But that's not what you're planning to do.

ACTING CHAIRMAN CORRADINI: No, I think you're one step ahead of what he said. Once I identify -- I see it as a number of steps. The first thing you identify your safety systems, safety-related systems. The next step is you identify your risk-significant ones. Then with a defense-in-depth adequacy judgment which still I'm cloudy about you might have an even larger population than risk-significant.

MR. FLEMING: That's right.

ACTING CHAIRMAN CORRADINI: And then when you want to do a DBA analysis you basically assume everything that is not safety-related fails.

MEMBER MARCH-LEUBA: No, that's not --

MR. FLEMING: -- chapter 15.

MEMBER MARCH-LEUBA: No, chapter 15 you don't do BDBEs. You only do the DBEs.

(Simultaneous speaking.)

MEMBER MARCH-LEUBA: I'm asking him to do chapter 15 for all of them.

ACTING CHAIRMAN CORRADINI: Why would you do that? That doesn't make any sense.

MEMBER MARCH-LEUBA: Let's take a hypothetical. I have an event that melts my core, breaches the vessel, but containment is intact and nothing comes out. Is the containment a safety grade or not? If you run the calculation and assume that your containment failed that event kills a million people.

But if you run it this way you say I don't need a containment, it's not safety grade.

MEMBER REMPE: Well, doing the risk assessment sometimes things may fail, some things may not. But if you do a realistic analysis --

MEMBER MARCH-LEUBA: Your mike is not on.

MEMBER REMPE: But again if you do a realistic assessment for beyond design basis events sometimes things will fail, sometimes things won't but you consider that --

CHAIRMAN BLEY: Can't hear.

MEMBER REMPE: Sorry.

MR. FLEMING: When we determine our required safety functions we're going to assess okay, if I didn't do that function, like if I didn't have a containment would the doses go outside that line. And if they do then that's assurance why we have to --

MEMBER MARCH-LEUBA: In all those events I can assure you that the containment atmosphere remain inert meaning air didn't come inside the containment otherwise we will have a fire.

And that's because there was a component, a window that remained closed and didn't break. Should that window be safety grade?

MR. FLEMING: That should show up in the

required safety functions. If that window is so important it would be identified --

MEMBER MARCH-LEUBA: I can guarantee you it is. I can guarantee you it is. If you flood the containment with air and you have graphite that's a bad scenario, really bad scenario. And you're going to want to make that window safety grade. I can guarantee you that too.

MR. FLEMING: Well, without getting into the details the phenomena of graphite oxidation is tracked in the evaluation of the high temperature reactor LBE so graphite oxidation is tracked.

If you depressurize the helium pressure boundary in the reactor building you will displace the air from the building --

MEMBER MARCH-LEUBA: And then the window will close.

MR. FLEMING: And even if you have a vented structure you'll end up with basically a helium-rich --

MEMBER MARCH-LEUBA: Because the window closed and did not allow air to come in.

MR. FLEMING: But meanwhile, so assume I have a break in the helium pressure boundary if I've lost my coolant. If I cool I'm not going to have any graphite reaction at all. But if I have the heat up what's going to happen is that my thermal expansion, the helium inside the helium pressure boundary is going to expand and expel helium outside in the reactor building.

And later on when the core cools down it will start to bring in a helium-air mixture back into the system. And the graphite phenomena is analyzed as part of the deterministic calculation.

So anyway, we're getting into a specific. I think we can --

MEMBER MARCH-LEUBA: I didn't want to get into the specific but in my opinion all those purple points should be analyzed only with the safety grade components.

ACTING CHAIRMAN CORRADINI: I don't see that. I don't think that was the intent. The intent would be if the -- my interpretation of the process. I could have this wrong.

If the uncertainty of the purple -- that's the color. If the uncertainty of the purple points starts essentially encroaching upon 10^{-4} then I would have to include them. But if I'm sitting down two orders of magnitude lower I see no reason that I would make that assumption as part of the analysis.

MEMBER REMPE: And furthermore would you be doing that with the current fleet? We don't do that with severe accidents in the current fleet. You're asking us to take severe accidents and analyze them with only safety -- and it may be even more severe and the frequency would be much lower. So what's the point?

MR. FLEMING: Well, the LMP approach when you get to the beyond design basis region there are two points.

One is if you happen to have a high consequence BDBE you have to make sure that the reliability of the SSCs that keep it down there are adequate and that gets into a safety classification. It could be safety classified if it's not already there for some other reason.

And then the other open question is is it risk-significant or not. If it's risk-significant it could contribute to some of the NSRST.

MEMBER MARCH-LEUBA: But you're telling me it's not risk-significant because the non-safety component is working. Let's drop it. I understand. But do you understand. You assume the low safety grade device works.

MR. FLEMING: I don't assume it works. I

calculate the probability it works, the probability it fails. I look at the consequences when it works and the consequences when it fails.

Some LBEs have non-safety-related failing, some have them working. And when we get to the DBE region we're just going to extract out what we're going to call safety-related SSCs and we're going to then calculate the DBA analyses only crediting those SSCs.

We're trying to go through a process that gets back into some kind of alignment with the existing licensing process. And I forgot to mention one of the constraints of the LMP framework is to provide a set of licensing events, safety classes and defense-in-depth evaluation that would fit within the current regulatory structure. Because something more than that would require a rulemaking and would take much longer to implement. It wouldn't meet the objectives of the project.

MEMBER KIRCHNER: What were the assumptions. I know this is just a specific example, but how was the source term generated?

MR. FLEMING: Well, in the -- a lot of this work came from the MHTGR work that was done back in the nineteen eighties. But they had computer codes and mechanistic source term models that would first -- it would basically validate -- it would do the core thermal response for the different accident sequences for steam generator tube rupture events. There would be water ingress and graphite-water reactions to consider.

There's a whole mechanistic source term white paper developed for the gas cooled reactors that gets into the physical and chemical processes of those. So that's really what was behind the source terms for most of these.

XE-100 hadn't finished their design specific source term calculation so we basically scaled some information.

This was a demonstration project. It wasn't a real application. We just wanted to see if it worked and if the design team thought it was a useful way to proceed and the answer was yes.

MEMBER DIMITRIJEVIC: Karl, since you're familiar with pebble bed can you give me a couple of examples from each category. Those have sequences, right?

MR. FLEMING: The S, M and L are the small, medium and large breaks in the helium pressure boundary.

MEMBER DIMITRIJEVIC: Okay, so let's look in small breaks. That's these, right?

MR. FLEMING: Yes, it's less than 10 millimeters.

MEMBER DIMITRIJEVIC: So that small break we have in every category.

MR. FLEMING: Yes, that's right.

MEMBER DIMITRIJEVIC: So let's say -- let's look at this 01, what is that, just small break, nothing else?

MR. FLEMING: Nothing else happened. Circulating activity. This had circulating activity.

MEMBER DIMITRIJEVIC: And 02 which is in design basis region, what is that?

MR. FLEMING: It's probably a loss of forced cooling event combined with a --

MEMBER DIMITRIJEVIC: Small LOCA.

MR. FLEMING: With a small.

MEMBER DIMITRIJEVIC: And then when you have in the beyond design basis events.

MR. FLEMING: We have the large breaks which are the L's and then the steam generator scenarios --

MEMBER DIMITRIJEVIC: But let's say you have SD03 or something, right. That's a small LOCA with what now happen.

MR. FLEMING: I have to go back to the event trees.

MEMBER DIMITRIJEVIC: So I have a little problem that we call these events because they are definitely not events, they are sequences.

MR. FLEMING: They're sequences.

MEMBER DIMITRIJEVIC: -- small LOCA and a small LOCA is a design basis event. Here the small LOCA --

MR. FLEMING: It's an event sequences. They're event sequences. Yes, they're event sequences.

MEMBER DIMITRIJEVIC: So why do we call them events. That confused everybody who works on the deterministic side of the thing, you know, that this small LOCA here belong in every category.

MR. FLEMING: It would be more accurate to say event sequences. Yes, it would. All the LBEs are event sequences in our approach.

ACTING CHAIRMAN CORRADINI: To make sure that we're catching Vesna's point is they're all bundled.

MR. FLEMING: They're all grouped.

MEMBER DIMITRIJEVIC: They're grouped in

different groups.

MR. FLEMING: They're grouped in families.

MEMBER DIMITRIJEVIC: -- itself which is small LOCA. The event as well.

MR. FLEMING: And Vesna, there is a public domain report where you can actually get detailed answers to all the questions, what is this sequence, where is it in the event trees. It's all mapped out in the report, the public domain report.

MEMBER DIMITRIJEVIC: Right.

MR. FLEMING: I didn't memorize --

MEMBER DIMITRIJEVIC: No, no, no, I know. It's a bunch of the sequences. I just want to point out that --

MR. FLEMING: They're all event sequences.

MEMBER DIMITRIJEVIC: -- looking in combination of systems and events.

MR. FLEMING: Absolutely.

MEMBER DIMITRIJEVIC: Right. So they're calling this event, it's not an event anymore. It's an actual sequence --

MR. FLEMING: They're event sequences.

MEMBER DIMITRIJEVIC: It goes beyond -- it will go beyond containment for light water reactor here. I assume there is some building containment.

So it is a total different, our understanding how is treated is totally different because if you come to the chapter 15 that doesn't apply. And this will not apply --

MR. FLEMING: Fifteen is also sequences. It says large LOCA, loss of offsite power.

MEMBER DIMITRIJEVIC: But that's a different assumption they make for large LOCA. For small LOCA they would not have four different categories.

MR. FLEMING: Well, in the word definitions we have them. In the guidance document it's very clearly stated that all the LBEs are event sequences. So that's our intent.

MEMBER DIMITRIJEVIC: I just wanted to make sure --

MR. FLEMING: I'm sorry for the confusion.

MEMBER DIMITRIJEVIC: -- all understand that that's what we've got.

MEMBER REMPE: So to follow along on that they're really though, they're grouped. Like medium break LOCAs are something bigger than such -- something else. It's a group of sequences that are in that event category. Or whatever.

MR. FLEMING: The initiating event, in

this case there's basically four initiating events that shut off. They're small, medium and large breaks in the helium pressure boundary as initiating events and those are defined by ranges. Ten millimeter, up to 10 millimeter small, 10 to 65 millimeters, the size of a fuel pipe is medium, greater than that's a large. So that's the way we define it.

But then every LBE is a family of event sequences as Vesna points out that has the response of the plant all the way out to the source term.

MEMBER REMPE: Characterized by that sequence.

MR. FLEMING: That's right.

MEMBER REMPE: Also, why are there no ATWS?

MR. FLEMING: They're in there. They're in there. For the MHTGR ATWS has no adverse consequence. The reactor shuts down on negative temperature coefficient.

MEMBER REMPE: And the same is true for this XE-100.

MR. FLEMING: Yes. ATWS you don't have like a pressure spike and a challenge to your reactor coolant system. It doesn't in and of itself create any different dose. I mean, we track them, we model them, we calculate them.

MEMBER REMPE: It's just not showing up. Okay.

MR. FLEMING: And we put them in different families because we know there's interest to keep track of that. But they don't jump out on a frequency consequence chart at all. For high temperature reactors. And for a lot of these reactors.

MEMBER KIRCHNER: So Karl, just walk through if you would, please, what you do when you have things on the cusp or on the margin. Let's just pick one. Steam generator I assume that says steam generator tube rupture 18 sitting right there at 1 times 10^{-4}.

But it doesn't matter. I'm not asking the specifics of the design or anything. You have something that lies close to that line. What happens next?

MR. FLEMING: Well, okay. So we have rules for how we process each of the three regions, AOOs, DBEs and BDBEs.

And we also not shown here will address the uncertainties on the frequency and the dose. And when we have a straddle situation or something comes really close to the line we'll evaluate it on both sides of the line. In other words we're not going to get into one of these gee, if I can multiply by 0.98 where can I find a 0.98 factor and get below. We don't play those kinds of silly games if you will.

So we consider the uncertainties and if we're close to the boundary we'll evaluate the event as though it's either a DBE or a BDBE and apply the rules. So we're not sensitive to the line in the sand problem.

MEMBER KIRCHNER: Three decimal points.

MR. FLEMING: Right. May we go on?

MEMBER KIRCHNER: But the assumption here is with your mechanistic source term you're not assuming a significant failure in the case of the HTGR.

MR. FLEMING: Well, we're trying to model the actual phenomena that would dictate either the retention or release of radioactive material and how much.

I'm going to say a few words about the GE demonstration.

MEMBER KIRCHNER: Let me belabor this a little bit because it's an important point. This particular example benefits certainly from the amount of effort that was invested in the MHTGR which included a lot of experimental work. Do you sense that your colleagues understand the challenge that's in front of them for developing mechanistic source terms? Versus making an assumption in the LWR business is significant failure and proceed from there.

MR. FLEMING: I think that's a good question for some of our developers.

MR. REDD: I think that's an excellent question regarding mechanistic source term. But I think it also puts us on kind of a point Karl brought up earlier that the uncertainties are there regardless of whatever approach we take, but we haven't found -- at least from the work we've done we haven't found these uncertainties insurmountable or anything like that.

Yes, experiments might need to be done to help inform your decisions but if you cycle through the LMP process and you find that your uncertainties even if they are large but that you're still okay with that range of uncertainties then maybe you can demonstrate that you don't have to have such an extensive experimental program. You could actually use it as a justification for not doing some work to reduce uncertainties.

So it depends a little bit on the specific case but I think at least having the LMP structure there provides a way to prioritize uncertainties, especially in an area like mechanistic source term where there could be uncertainties all over the place. Some you might be able to live with and some you might not be able to.

MR. REDD: Was that responsive to your question, sir?

MEMBER KIRCHNER: Actually I was making a statement, a cautionary statement. Just as a designer in the past I would just submit that when the uncertainties are large you design robustness into the design.

I hope that the DID, the defense-in-depth process, that would be a result that would come out that you would go back.

And there are cliff effects for all these designs that it's not just uncertainty in the sense how uncertain I am about my calculations. There are real cliff effects for -- I won't enumerate them, but for each of the designs on your table that get you into -- could you get into a situation where you have significant release.

MR. FLEMING: Right. And just to confirm

it is something that's looked at very carefully as part of the defense-in-depth adequacy evaluation.

MEMBER DIMITRIJEVIC: I have one other concern. Let's say that we apply this to light water reactor existing fleet which we have most information. Let's not even talking advanced light water reactor.

Every point will correspond to the release category sequences, right?

MR. FLEMING: Well, also as I mentioned earlier we want to capture the no release sequences and understand why we don't have a release. That's fundamental to --

MEMBER DIMITRIJEVIC: All right.

MR. FLEMING: In the GE PRISM exercise they started out with a PRA that was focused on the traditional reason for doing a PRA finding the risk of severe accidents.

MEMBER DIMITRIJEVIC: I understand that.

MR. FLEMING: And they had to put more emphasis on the success states to do this process. But anyway.

MEMBER DIMITRIJEVIC: But I am more interested in release. So this will correspond to the risk category that is hundreds and hundreds of those sequences. If we separate them like this, right, based on initiator and where they belong we may satisfy this all the time. But when you sum them the large release may not satisfy.

MR. FLEMING: That's why we have the cumulative -- we keep showing this slide but this is only used to look at the risk significance of individual licensing event families.

We also have our cumulative risk targets for the QHOs --

MEMBER DIMITRIJEVIC: Those have some --

MR. FLEMING: Where we aggregate for three different metrics. One based on a Part 20 to look at high frequency low dose scenarios and the two QHO metrics. So we sum for those.

MEMBER DIMITRIJEVIC: So my -- one other comment because we discussed this this morning. This curve it's not practical to apply to existing or large light water reactor. I mean, you know. That's one insight. I don't see what would be point.

MR. FLEMING: The purpose of applying this to a light water reactor was to revisit what are the design basis accidents.

MEMBER DIMITRIJEVIC: Well, but you're talking design basis accident versus design basis sequences. So we are changing nature of the regulation. That's completely different issue. It's a qualitative -- quantitative jump, so --

MR. FLEMING: I'll say a few words about the GE demonstration. Gary Miller is here and also David if there's questions on some of these aspects. I'll sort of summarize this.

This is an example of an application after already developing a design back in the late nineteen eighties and then taking advantage of this modernization of the PRA project that was sponsored by DOE a few years ago. There's a public domain report on that by the way.

One of the features of the PRA that went into this is that they demonstrated the ability to meet our PRA standards requirements for putting together a component reliability database for a new kind of reactor. Also for demonstrating passive component reliability which is really -- it's primarily an uncertainty analysis in the phenomena that are responsible for the passive heat removal features and so forth, and also the mechanistic source term.

The PRA standard goes all the way out to consequence analysis, radiological consequence analysis and has separate requirements for mechanistic source term. So they demonstrated the ability to meet those requirements in their original PRA.

As I mentioned earlier the work they did on the PRA modernization really had a big influence on how we defined our risk significance criteria for the LMP process.

So more recently since the PRA was completed we did a demonstration that GE-Hitachi performed and this went on for a number of months of education process. We gave them a training program on the LMP process and they came back with questions and insights.

It culminated in not a public but a meeting that was attended by the NRC staff and some of the other advanced reactor developers just a few weeks ago.

As I understand it a public domain report will eventually be available on this exercise.

So, these are the steps that they performed. They processed event sequence families from their PRA into AOOs, DBEs and BDBEs. They did sensitivity studies to derive what the required safety functions were. And I'll let Gary speak to the specifics there.

They were able to come up with a

classification of not only safety-related but non-safety-related with special treatment SSCs based on a defense-in-depth adequacy evaluation of their plant capabilities.

They were able then to formulate what their DBAs would look like following this process. The NSRST SSCs benefitted from the plant capability defense-in-depth evaluation.

Gary, would you like to elaborate a little more?

MR. MILLER: As you said you described the process, the steps that we went through. This was limited in scope. It was internal events at power. And particularly as we went down the line in looking at defense-in-depth we looked solely at the heat removal function. So we did a good deep dive but it wasn't broad because scope, resources and things like that.

And as has been mentioned here before we found a lot of areas where the methodology made sense. We learned a lot. We added in describing how but not necessarily changing the methodology. I think it was pretty sound.

MR. FLEMING: This was the safety-related SSCs on the top part of this slide that they came up with for performing the required safety functions which basically was controlled core heat removal, controlled heat generation. By doing those functions for this reactor they assure the retention of radionuclides in the fuel.

And also a scope limitation was that they only looked at the source of radioactivity in the fuel. They didn't look at all the sources of radioactivity. They looked at some other sources but not all of them. Do you want to elaborate further?

MR. MILLER: You said it well, Karl.

MR. FLEMING: That's all right. I meant to tee up something for you that I forgot to. They found that none of their non-safety-related SSCs were risk-significant. So zero risk-significant SSCs. But applying the defense-in-depth adequacy criteria and particularly focusing on table 5-2 in the guidance document that talks about adequacy of plant capability defense-in-depth they came up with four additional items on here that would be examples of what could be added to NSRST SSCs.

MR. MILLER: We used the frequency consequence plot quite extensively to look at not only as you mentioned before borderline cases where we can do sensitivity studies and evaluate taking a component out of service one at a time, and then looking at the resulting plot to see if it was in the DBE region or in the cross hatched region.

And as Karl said when we took it one by one on each component none of them made it into the cross hatched region based on that criterion. However, because this is a very integrated process we went through the defense-in-depth process and asked those questions.

We did in fact come up with what you see there, the four areas of functions that did have some safety significance. So those were NSRST.

ACTING CHAIRMAN CORRADINI: So, help me -- so this to me is important. So you used the technique which I am still fuzzy about to use defense-in-depth. What did you exactly do? Can you go back to that slide? The four systems, the steam generator shell and tube design. I still don't -- can you help me what those four systems are and how they work?

MR. MILLER: Okay. If you follow the process and the detailed steps there's one step, I think it's layer two, but whatever layer it is it talks about what equipment do you need to maintain this within the DBE region. Not make it worse.

So you kind of look at one at a time what would happen.

If we took certain equipment out of service would it make it worse. In that case what we found was that in general our heat removal is adequately covered by the reactor vessel auxiliary cooling system, that RVACS.

When you look at defense-in-depth in the scope that the methodology mandates you determine that not only that but the backup function would be having to do with forced air cooling and along with that the natural circulation from your intermediate heat transfer system, and from there your steam generator tubes and shell.

ACTING CHAIRMAN CORRADINI: Okay. So let me say it back to you so I make sure I understand. So your point is RVACS is safety significant and therefore at a one at a time application the intermediate heat transfer system was not important and the shell and tube steam generator wasn't important. But if you took them as a combination they provided a defense-in-depth to the RVACS or vice versa.

MR. MILLER: Yes.

ACTING CHAIRMAN CORRADINI: Have I got it approximately right?

MR. MILLER: Yes.

ACTING CHAIRMAN CORRADINI: Okay. So then because of that they would appear as -- they would be treated as non-safety treatment of --

MR. MILLER: Non-safety-related with special treatment.

ACTING CHAIRMAN CORRADINI: I want to say RTNSS, but I'm not allowed to say RTNSS.

MR. FLEMING: Yes, non-safety-related with special treatment. NSRST.

ACTING CHAIRMAN CORRADINI: Okay, fine. Thank you. And then what is SWRPS?

MR. MILLER: That is sodium water reaction protection system.

ACTING CHAIRMAN CORRADINI: So you're looking for sodium leakage?

MR. MILLER: Yes. In the steam generator.

MR. FLEMING: From the intermediate.

ACTING CHAIRMAN CORRADINI: Are these double walled steam -- I'm sorry to get to details but it matters. Are these double walled steam generator tubes where you have the helium gap that you're monitoring the helium gap?

MR. MILLER: No, that was not -- the design was not a double wall.

ACTING CHAIRMAN CORRADINI: So what is that? Is it a pressure measurement? How do I detect it if I'm not tracking some sort of intermediate layer in the steam generator tube?

MR. MILLER: Go ahead.

MR. GRABASKAS: Typically it monitors for hydrogen production up in the top of the steam generator.

ACTING CHAIRMAN CORRADINI: Okay, fine. So it's a hydrogen sampling system. Okay, thank you.

MR. FLEMING: Would you back up a slide? I wanted to also mention that on the third bullet down here questions that often come up, how do you deal with passive component reliability. Another question that will come up is you don't have any experience, how are you going to develop a database. And then what about mechanistic source terms.

So I'm going to have David say a few words about that. We actually have some public domain papers out there on this. What it's trying to do here is meet the requirements in our non-light water reactor standard for these activities.

MR. GRABASKAS: It's interesting. I mentioned that we kind of foresee these as issues but it really goes back to the nineteen eighties and the

PSID of PRISM and the NRC review.

If you look in NUREG-1368 kind of three big issues the NRC called out with the PRISM PRA were a simplified optimistic look at passive system reliability, lack of a detailed treatment of source term and then also questions about the component reliability database.

So that was part of the reason why we had been focusing so much on that at Argonne, kind of developing methodologies. But then also with the new non-light water reactor PRA standard developing methodologies that also meet the requirements of the standard.

Because the standard can be really strict in some of these areas, for example with passive system reliability. It's a requirement in the standard that you need to mechanistically model the response of the passive systems but also using models that have been empirically validated through experimentation too.

So it's really quite a strong step in this PRISM PRA update and the LMP really gave us a good chance to demonstrate or actually run through the methodologies we had developed and we've refined them because of the lessons learned because of it.

Same with mechanistic source term too. We had come up with the methodologies but this was a good chance to actually apply them and go through the actual research and do the analyses.

MR. FLEMING: Thanks a lot.

CHAIRMAN BLEY: This is Dennis Bley. Two things. The first is beneath the slide of -- papers Karl referred to and you referred to and the other issue is on the passive component reliability at least to my thinking it's not so much component reliability on passive systems as it is potential degradation over time of the passive functions because some are fairly delicate balances. Did that paper go into a discussion of that area as well?

MR. GRABASKAS: Yes. You're absolutely right and I can provide a list of references. We have a whole bunch of public Argonne reports on mechanistic source terms but also the passive system reliability approach too.

And you're right, that's the real big tradeoff with passive systems is yes, you're running on inherent phenomena but then your driving force instead of being megawatt powered pumps is now just buoyance differences and things like that. So properly characterizing those differences has a big effect.

But yes, I'll provide a whole list of the open source references.

CHAIRMAN BLEY: Okay, and do that through our staff at ACRS. Thank you.

MEMBER REMPE: And the tools you used for the mechanistic source term were validated based on EBR -- it's a metal fuel reactor, right. So it's EBR2 data?

MR. GRABASKAS: A couple of different tools we used. Depending on what the tool did we validated different ways. But on EBR2 data experimentation. Unfortunately in the SFR world we also have some past accidents that we were able to pull data from too.

But there are other tools that we actually developed ourselves by demonstrating that the importance was low for the outside consequences we didn't have to validate to an extent that we might have to validate other codes too.

PARTICIPANT: It would be helpful if people that are asking questions would use the microphones.

MR. FLEMING: And to wrap up the GE PRISM part of this show this was some of Gary's thoughts about their feedback on the process.

MR. MILLER: Okay, to wrap it up we did find that it was very systematic and repeatable although it may have seemed like it was advertised up front. We did actually find that out.

It's pretty clear when a process step is complete as we went through the methodology. I say that sensitivity studies are easy to perform but to get there it was a lot of work. Setting up the logic, the file structure, quantifications and all that, it was quite a lot of work to get there. But once you do then you'd have a very easy way of doing a lot of sensitivity studies.

And this comes in handy in a lot of these steps later on as well as in tradeoff studies that you might have later on down the road.

And then the results are traceable to key risk and performance drivers. If you're familiar with event sequences and cut sets I think you know it's easy to go back and look at what are the drivers, what are the dominant failures and come back to the risk and performance drivers.

Another thing as a developer we appreciate -- it's more visual. It's more meaningful than talking about very low frequency numbers because as you know you lose interest right away. It's not relatable.

Where we can show an FC plot with a point or a group of points and then we can vary those based on sensitivity studies it's much more meaningful and it's much more relative. You do a sensitivity study, you look at how much it moved, it's very clear to the people.

And then iterative. Of course again as a developer I think in the early design phase with a conceptual design and a conceptual PRA there are a lot of uncertainties and assumptions and we document those. And we get to the point where something may be on the line or something may have a very high uncertainty distribution and that gives us a lot of options. We can look at design changes or programmatic changes there as well.

So we iterate that into the design and then we update the model of course.

And overall it just clarifies a path to regulatory engagement.

MR. FLEMING: Thanks a lot, Gary.

MEMBER MARCH-LEUBA: Just a question for clarification. If a component is non-safety grade according to this do you need to do seismic analysis of it? I'm asking specifically about the steam generator in PRISM. If it's non-safety grade you don't have to do the seismic for it because it can fail.

MR. FLEMING: As part of our process after we defined the required safety functions and our safety-related SSCs once you've selected your external hazard levels for your external events then there's a requirement, it's an implied requirement that you have to protect all of your safety-related SSCs so that they would be able to perform the required safety function in the event of an external event.

MEMBER MARCH-LEUBA: According to your methodology --

MR. FLEMING: And other non-safety-related components would have to be protected like the seismic two over one and those types of issues come into play. So there are ways for seismic requirements to creep into the non-safety-related area through that pathway.

MEMBER MARCH-LEUBA: Okay. I'm just surprised that when you apply the methodology it came out that your steam generator is not safety grade. It's not safety component. Steam generators are things that fail everywhere and that's the thing that separated your sodium from your water. I just cannot believe it came out no, we don't need it. I can't believe it.

MR. MILLER: It's an advanced reactor passive. There's a lot of thermal capacity in the sodium. In reactivity --

MEMBER MARCH-LEUBA: If it breaks you have a fire.

MR. FLEMING: Let's see. I think we should go on to the next and final part of our demonstration activity having to do with the molten salt reactor experiment. And Steve Krahn is with us to amplify on this.

There's a couple of different activities that have been done. There's a report indicated on the right, an Oak Ridge National Laboratory report and a chart in the center here which identifies some of the processes that they're going through.

The report on the right is an example of taking the technology they've been collecting and analyzing for the molten salt reactor experiment and building a PRA model using the guidance that's in the PRA white paper and then summarized more briefly in the guidance document.

The diagram in the middle identifies a process for performing process hazards analyses given the fact that these molten salt reactors resemble more of a process plant than a standard or a typical type of power generation reactor facility. And they're using a HAZOPs technology to build the knowledge base to build a PRA model and a deterministic safety analysis model for the MSRE.

Steve, would you like to amplify on that a bit?

MR. KRAHN: I'll also loop back and discuss the source term question which was asked earlier because obviously that's a primary concern. And also if you look at the dates on these reports we're looking at early work in process. So I would also state that up front.

The source term in the molten salt reactor experiment was similar to most molten salt reactors is split up into three large sections. The vast majority of the radioactive material is in the salt itself. There's also radioactive material in the offgas system because the offgas system is continuously hooked up to most of the -- is continuously hooked up to all of the primary plants that I've seen.

And then finally there is some means in place to either polish or chemically clean the salt. That is the third major source of radioactive material.

The characterization of those three radioactive material inventories is in the joint Vanderbilt-Oak Ridge technical report on the right which kind of started this effort about two years ago, a joint effort with Oak Ridge and Vanderbilt.

And one of the things that that showed was the hazard analysis for the molten salt reactor experiment was a very limited scope and very focused on what was going on just in the salt system. So one of the conclusions of the report was the need to do a broader hazard assessment that took into account all of the other potential radioactive material sources as well.

So that has been worked on in parallel with an Electric Power Research Institute project that is working to document the process to move from early stage safety analyses such as HAZOP analysis, such as failure modes and effects analysis through to probabilistic risk assessment. So that's where those two projects are being funded from.

If we go to the next slide I can walk through what we've learned to date and I'll expand a bit on this summary.

The MSR lack any significant PRA legacy.

So we're basically starting with a clean sheet of paper to look at what a PRA for a molten salt reactor would look like.

That's why we -- after completing the case study on the molten salt reactor experiment that was documented in the Oak Ridge technical report we have dropped back to do a comprehensive hazard assessment of the molten salt reactor experiment.

That effort is winding down now. We've completed HAZOP studies on four major systems. One of those has gone through peer review. The other three are going through peer review right now.

And the next stage -- one of the things that that showed us was that the HAZOP is amenable to providing the quote "comprehensive" hazard analysis that's desired by standards like the non-LWR PRA standard.

It also though supports early stage safety analysis providing insights back to the design team and allows preliminary modeling to be done for probabilistic risk assessment.

It also supports ready identification of potential risk important initiating events. And that's the parameter or the outgrowth of HAZOP that we're using to move forward to the next stage which is going to be quantifying event trees, at least one major event tree for each of these radioactive material inventories in the molten salt reactor experiment.

A couple of more lessons learned on this early stage safety analysis for the molten salt reactor experiment is it is valuable for providing near term design and operability information. One of the things we identified in the Oak Ridge technical report was where based on their simplistic -- simple, I don't want to say simplistic. Simple hazard analysis in the mid-nineteen sixties they had identified five operating modes for the reactor.

In our detailed review of their operations report it turns out that there were really closer to seven or eight operating modes that they used on a regular basis. That would have allowed a much more nuanced understanding of what their probabilistic risk assessment would look like.

And then we also identified -- one of the other things that the early HAZOP analysis does is, and I think some of the members have been pointing out this important factor, is it points out the need for additional analyses.

Early on it shows things that we don't

need and lets us evaluate whether or not they need an experimental program to be addressed or whether they can be addressed by deterministic analyses.

For example, one of the ones that we are in the middle of on the program with EPRI is looking at freeze valves. Every molten salt reactor design you look at uses freeze valves and they show up on schematic diagrams looking just like a standard gate or globe valve but they are in fact a pretty complex combination of an air system, an I&C system to maintain the temperature of that freeze valve and continue to maintain its isolation function or when demanded melt and allow the molten salt to leave the reactor.

That identification was done by going through the HAZOP study for the molten salt reactor experiment and with some support from Southern Company we're now in the process completing a failure modes and effects analysis for the important component that freeze valves are.

The next steps on this front are we're working with Karl and Amir to look at how we would characterize and move forward to do licensing basis event identification and safety-significant component identification and potentially if we don't run out of time before now and the middle of March trying to do some DID assessment as well. So that's where we are on molten salt reactor work. I'm happy to answer any questions.

ACTING CHAIRMAN CORRADINI: So you chose what's called the MSRE?

MR. KRAHN: Correct.

ACTING CHAIRMAN CORRADINI: Because there was enough information. What about some of the current conceptual designs?

MR. KRAHN: So it wasn't the only criteria we used to select the MSRE. The other major criteria is that not only was there enough design information, it was all publicly available and not covered by intellectual property. So it was a quick way to get things into the public domain.

MEMBER REMPE: But we were told I believe earlier you're going to have a Kairos evaluation coming soon.

MR. FLEMING: Yes. We're just in the beginning stages of putting together a Kairos demonstration and also a micro reactor eVinci that Westinghouse is developing. So those are on the books and we're launching off to get those completed by the spring of 2019.

MEMBER REMPE: The public information question. Are all of these demos publicly available documents, or at least available to ACRS? Earlier Mike had asked for one and you said yes, we'll get you that document.

MR. FLEMING: Well, the two that have been completed, the GE PRISM and the XE-100 will be -- well, XE-100 is available now and GE PRISM will be available in the near future. They're preparing it now.

MEMBER REMPE: Thank you. Go ahead.

CHAIRMAN BLEY: This is Dennis. I was a little surprised on the discussion of the MSRE that it focused on kind of starting from nuclear power plant PRAs and that this was so different. There have been very, very many chemical processing plant PRAs that it kind of follows the way you described it, so it would have the (telephonic interference) probabilistic hazards and how it -- and eventually to the PRA.

Did you look at what's been done on the chemical process industry in any depth?

MR. KRAHN: Yes, the HAZOP process which does the initial qualitative hazard identification work we took directly out of the chemical processing industry. It is the standard for doing the initial stages of hazard assessment and event sequence identification in chemical processing plants.

We will then move on to doing PRA using the LMP structure. But we definitely took all advantage that we could from chemical processing industry experience.

CHAIRMAN BLEY: Okay, that makes sense and it isn't a great departure when you think of it from that point of view. Thank you.

MR. FLEMING: Yes, to amplify on Steve's answer to Dennis's question being a consultant to their project we helped them put together a body of knowledge of prior work that would be relevant to supporting the project.

Among the many things that we looked at there was in fact a PRA done on the low activity waste facility at Hanford. It's part of their vitrification facility that was developed not only to look at radiological event sequences but also toxicological event sequences.

And that provided some inputs in the knowledge base report.

CHAIRMAN BLEY: Okay, thanks.

MR. FLEMING: Thank you very much, Steve. So coming -- this sort of concluding our technical presentation today we come back to these questions that are the LMP process was designed to address what are the initiating events, event sequences and so forth. How does the design and the SSC respond to the event sequences. What kind of margins do we have in the response. And how the defense-in-depth philosophy is implemented.

We give you a lot of examples of different applications at different levels of development so far. And if we have any more questions we'd be glad to answer them.

ACTING CHAIRMAN CORRADINI: Committee questions? Okay. At this point let's take a break because there was none shown in the agenda but we need a break. So we'll come back at 10 after 3.

(Whereupon, the above-entitled matter went off the record at 2:54 p.m. and resumed at 3:09 p.m.)

ACTING CHAIRMAN CORRADINI: Okay, why don't we get started. Everybody settle down so we can have Herr Reckley lead us through this portion.

MR. RECKLEY: Okay, so to close out we wanted to go through the draft Commission paper and the draft regulatory guide because as I mentioned this morning in the end this is what the staff is producing and it's what we would be asking the ACRS to comment on, realizing it's inseparable from NEI 18-04 because that's what we're proposing to endorse.

Before I get started though as personal soapbox I guess, they gave me the microphone these processes that have been described and as you're going to see the staff is comfortable with there's a couple of points to point out here I think.

One, just because you can define some flow charts and processes for what needs to be considered doesn't mean that we think that this is simple. The development of a mechanistic source term with the modeling of specific radionuclide groups across barriers, which ones -- if you're talking about molten salt which ones will stay in the salt, which ones will escape the salt. Then for the ones that escape how will they either be retained or escape from a particular barrier. That's a complex physical question.

We can model this out and say yes, the developers need to do A, B and C and we're comfortable saying that. At the same time we're not implying one, that it's been done in all cases, and two, that it's particularly easy in any case. So I just wanted to lay out that as we lay out these processes we didn't want to confuse the ability to define a process with the fact that the science still needs to be done, still needs to be proven.

Or at least the uncertainties in the science need to be accounted for. And that's what Karl was talking about in much of the assessments in some cases, how do you address the uncertainties that might exist for some of these designs.

So with that I'll get right into the two documents that the staff provided along with the working draft of NEI 18-04.

The first one was a Commission paper. The staff's view is that although much of this has been brought before the Commission before that time period is measured in decades. And you can see that we made great strides. One paper was followed by another paper albeit that paper was 10 years after the first one.

And so this will be really the first time that the process has been consolidated and applied or available in a relatively integrated approach that we want to bring before the Commission and say although we think almost everything in here you've accepted in previous papers from the nineties or the early two thousands this is the result of actually applying those decisions and what it looks like in a process.

And we thought the Commission would want to see that and have a shot at either saying yes, that's working the way that was envisioned or not.

So the paper as it's defined here is to seek the Commission approval. And it's divided into a standard format. In enclosure 1 it gives the background. I won't talk a lot about that one.

And then enclosure 2 which summarizes this approach really from NEI 18-04 and puts it in the context of where we think there are references to previous Commission decisions and where there might be in one or two cases a remaining unanswered question that this would provide the vehicle for the Commission to answer.

So going in to the background this is very similar to a slide I had earlier this morning. It does start with the Advanced Reactor Policy Statement.

Whereas we don't assume any particular design at this point can make it through the process. We're not pre-judging the ability of any design and how it would turn out we are assuming that the Advanced Reactor Policy Statement defines attributes of advanced reactors and we're assuming that there is an ability to design a reactor that has those attributes.

And what that assumption gives us is the ability to go forward without a particular design.

So that's supported by some of our previous interactions like the pre-application evaluations that were mentioned on PRISM on MHTGR. The SECY paper 93-092, the Commission made a few steps in the direction that we're currently in but there are also some differences in what was proposed in 1993 and what's being proposed now.

SECY-03-0047 was the closest and that probably makes sense. That was at the time when some other gas reactors were being proposed and we were interfacing with both developers, the Department of Energy and others.

And so in SECY-03-0047 they proposed some policy issues to the Commission or some resolution of policy issues that are directly applicable to today.

And again it's not surprising because as Karl mentioned this methodology has been evolving since the eighties starting with the MHTGR.

At the same time as I mentioned this morning the related initiatives on risk-informed performance-based regulation and those were largely incorporated into the proposals and the policy issues that were communicated to the Commission both during the development of the licensing strategy for NGNP and actually in SECY-03-0047.

So the three big bullets from SECY-03-0047 that I want to mention was that the staff asked specifically and the Commission stated in its staff requirements memorandum their approval of these three things which is that a greater emphasis can be placed on the use of risk information and the use of probabilistic risk assessments to identify events -- and here's the balancing of that -- provided there's sufficient understanding of plant and fuel performance and that deterministic engineering judgment is used to bound uncertainties. So that's a general consensus of a risk-informed performance-based approach using a mix of risk-informed insights and deterministic assessments including engineering judgment where necessary.

The second is that a probabilistic approach for safety classification SSCs is allowed.

And the last bullet there, that the single failure criterion can be replaced with a probabilistic reliability criterion.

So now the paper is organized into the three primary elements of the methodology, event selection and analysis, SSC classification and performance criteria, and defense-in-depth assessments.

And the key points in the paper are that we think this process is consistent with that recommendation and Commission approval from SECY-03-0047 to use a probabilistic approach to identify events and to back that up with deterministic and engineering judgment.

One thing that wasn't specifically addressed in previous papers and that is that as you'll notice on the frequency consequence target figure there is a lower frequency range and that is often interpreted -- we try to caution not to interpret this way as a hard PRA type cutoff.

But it is on the curve. The 5 times 10^{-7} value. And what we say in the paper is we think that those kind of values and considerations of when is a frequency low enough that it need not be considered is inherent in a risk-informed approach, but as we also state in the guide and in NEI 18-04 also states that's not a hard cutoff. You do need to look at uncertainties. You need to look at potential cliff edge effects as was mentioned. So you do need to look at the lower frequency events and make a conscious decision if you're going to say something is a residual risk that doesn't need to be addressed within the licensing basis events.

MEMBER SKILLMAN: Yes, Bill. For that fourth bullet. Is there a backstop? I could see a clever analyst making the case for no containment based on that fourth bullet.

MR. RECKLEY: The single failure criterion bullet?

MEMBER SKILLMAN: I could see analyses that indicate probability so low that one would then say what had been a single failure criterion really no longer applies because the -- I'm down to E^{-7}, E^{-8}.

A question is is there a backstop. Is there something that one would simply say deterministically I really don't care how low that number is, by golly we're going to have a strong box.

MR. RECKLEY: I would say the closest within the methodology to that is the fact that you don't rely on a single system or a single feature within the process.

And this was mentioned a little bit during the other parts of the assessment, that really you're looking at multiple failures and you're looking at it at frequency ranges that go below the traditional approach that was used for light water reactors.

So, I see Ed standing there. Did you want to?

MR. WALLACE: I wasn't going to let you dangle out there. The consideration here is looking also at layers of defense available in the design and having a single monolithic reactor with no moving parts that could take care of itself and start up and shut down and do all the things it had to do would be one layer and that's all you'd ever get to potentially which is crazy. It's not sensible.

So part of the strategy that's described in defense-in-depth looks beyond just the numbers that are showing up on the frequency consequence curve and saying what other layers of defense do I have starting with normal operations to keep the plant in good shape there, working through strategies of startup, shutdown, AOOs and so forth to really understand the robustness of the design.

And when you get to your design basis event category and you establish what your DBAs are you're still looking beyond them for other things that could (a) go wrong, part of the defense-in-depth strategy at the end is go back to the risk triplet and say what can go wrong, what's not in the PRA, all those other kinds of things and say am I satisfied that these questions that arise because of the uncertainties at that stage of the development have been adequately taken care of.

So what's below the 5 times 10^{-7} number they're still in the PRA but is there anything in there that really is showing a significant issue until you're looking at catastrophic --

MEMBER SKILLMAN: Thank you. That helps. Thanks.

MR. WALLACE: I'm sorry, Bill.

MEMBER MARCH-LEUBA: We went through this discussion during the functional containment. We all agreed that a big strong box is the best containment you could have. But I guess as long as the containment functions it doesn't need to be a big strong box. We had that discussion before.

MR. WALLACE: If I could add one thought to that comment. We're trying to design a process that would accommodate from test reactor size commercial reactors to full fleet big reactors with a common logic that you could follow as a designer and developer and licensing reviewer.

So the flexibility is in there to look at all these things and to use the risk insights you can garner from all of this information to say is this really a threat to the public or not and then take appropriate actions.

And it would be different at the small end of the spectrum. Your answer might be in the large end of the spectrum.

So the notion of functional containments versus physical single barrier containments and things like that, somewhere in the middle probably come into play when your hazard gets large enough and then you have to look at the other phenomena such as chemical retention and the fuel or other things that will affect the outcome.

MR. RECKLEY: As we look -- for any of these designs as we look at the mechanistic source terms across the barriers going back to that First Principles kind of approach and using the assessment of the release fraction or the attenuation factor against each barrier for each radionuclide group, for each event family is the way in the end will determine what is needed at the end of that process perhaps for a final structural barrier to the release. And then also whether that needs to be a safety-related structure or if it is only being there to protect against the beyond design basis events whether it would be a structure with special treatment but not necessarily safety-related.

The process would enable you to answer those questions we believe.

MEMBER SKILLMAN: Thank you, Bill.

MR. RECKLEY: Going to safety classification again within the paper and as the primary element of the process. This was specifically addressed in the previous SECY from the 2003 time frame and we think that it's consistent with that SRM, staff requirements memorandum from the Commission that allowed a probabilistic approach for the classification of SSCs. So it really was not too much of an issue there we didn't think from the Commission policy standpoint.

In assessing defense-in-depth again as we've talked about numerous times today the paper provides a framework, it looks at both probabilistic and deterministic approaches, has a role for the integrated decision-making process, it does include the verification that I think came up during the June meeting that we agree with and I don't think was ever really a technical issue but I think the guidance more clearly states now that you'll never rely solely on a particular plant design or operational feature.

The reason I bolded -- it's kind of hard to tell but the last bullet is bolded because this is something we want to bring up to the Commission specifically.

In the following Fukushima and also there was another initiative, the risk management regulatory framework there were papers provided to the Commission recommending that we define and come up with criteria for defense-in-depth.

The Commission's SRM came back and specifically said don't do that. And that was largely in the context of the operating fleet and the determination of whether doing that could be introduced basically as a change to how we were going to look at the operating fleet.

So we want to point out to the Commission that this process does have an assessment of defense-in-depth and is making a determination on the adequacy of defense-in-depth. And we point out we're not proposing that this be universal. We're not proposing that it be forced on anyone.

However, for those people using this process it does include a check on the adequacy of defense-in-depth and the Commission should be aware of it.

We don't think that's necessarily an

issue. In most of the discussions during the risk management regulatory framework and even during the recommendation 1 out of the Fukushima work there was usually a distinction of what we would force on the operating fleet and what would be a good idea going forward for example for advanced reactors.

It was generally acknowledged that a voluntary approach like this for advanced reactors was actually probably a good idea. It was just the Commission wasn't going to mandate it.

But in any case the reason again we wanted to point this out to the Commission. You said don't define adequate defense-in-depth. This process for these reactors using this methodology does include that step.

MEMBER REMPE: Before you leave this slide didn't you have an IOU that you promised me from this morning about the integrated decision panel and any sort of other interactions you'd had with such a panel in the past.

MR. RECKLEY: I did, but I didn't fulfill it.

MS. CUBBAGE: If Hanh is still here we did have a little bit of a side discussion about the integrated panel. He may be able to provide some insights.

MR. PHAN: Hanh Phan. I am the lead PRA analyst in NRO. Regarding the expert decision panels the staff expected the applicant will follow the guidance in NUMARC 93-01 that's the guidance for the Maintenance Rule 50.65, and for new reactors we expect the application would follow the guidance of the process they use for the reliability assurance programs in chapter 17.4.

MEMBER REMPE: Okay, so when I get my IOU -- or you're saying we have no experience. But what I'm wanting to know is how well did it work. Not what they should do --

MR. RECKLEY: And what I didn't do during lunch was to actually track down some people from -- that were involved either in that 50 -- unless Marty or Hanh if you've been involved in like a 50.69 review or some other review that included a similar panel.

MR. PHAN: Yes, but at this point from the NRO's or from the new reactor's perspective up to this point the staff had the opportunity to look at the meeting minutes from the expert panel conducted for other applications. We not directly participate in any of those meetings but we review the minutes and we have insights and information from those.

MS. CUBBAGE: And I think that's appropriate as our role as the regulator. We shouldn't be participating in those panels. Yes, it's on I hope. So I think it should be an auditable process. It should follow the guidance that's established. We wouldn't be participants.

MEMBER REMPE: I'm not asking you to participate. I want to know was it effective.

MR. RECKLEY: And I've got to get to the right people who were involved in that kind of a review that used a similar panel.

MEMBER REMPE: And again the reason I'm asking this is I think there may be some devils in the detail that haven't been fully fleshed out.

MR. RECKLEY: Yes. On informing the content of applications the draft guide does go into a little bit more detail than NEI 18-04 on how we think that these insights can inform both the scope and the level of detail. So there was some discussion of that during today.

We generally agree with the discussion. If I can say I got a sense of the meeting if you will that you should be able to use this process and if things are less important than the description can be boiled down to maybe some interface requirements or at least less detail on those systems.

An example that we have used throughout the development of this has been on the power production side. And for light water reactors the final safety analysis reports include a fair amount of discussion on the power conversion systems.

And that makes sense because the power conversion systems can involve failures that feed back to the primary system relatively quickly require the actuation of safety equipment.

If a reactor design, an advanced reactor design includes the particular attribute within the Advanced Reactor Policy Statement that the thermal response of a reactor should be much slower perhaps the sensitivity to the power production systems is much less and therefore the FSAR would not need to provide as much information on the power production systems, but just on the interface and whatever analysis is done to show that an upset doesn't feed back to the primary in quite as challenging a way as it does for light water reactors.

MEMBER MARCH-LEUBA: But this is something the staff proposes to do on their own in your letter. NEI 18-04 does not have it.

MR. RECKLEY: NEI 18-04 hints at it but

it's not as clear. One of the things that we're talking about now is what will follow this particular guide.

And to the degree -- and this is a little bit of what we're hearing, but I can't commit to it. But one of the things that we're hearing is that the developers would like a little more detail and a little more certainty that we would be comfortable with that kind of an approach.

And so this might be an area where we pick to either do it from the staff or what we would prefer is to work with an industry group to develop guidance that we could endorse similar to this process.

MEMBER MARCH-LEUBA: The easiest -- the least resistant path would be to hint in your letter that it would be acceptable and then bring me a ROC (phonetic). The next item that comes in bring me a ROC. Now, the guy that has to bring the ROC will be risking a lot.

MR. RECKLEY: And that's one of the reasons we're hearing that they would prefer to have a little more guidance in this area.

And it's one of the reasons that we tried to expand on it in the draft guide to at least say that we're amenable to it. But in the time that we had we weren't able to provide much more detail than actually what I'm giving here.

ACTING CHAIRMAN CORRADINI: So let me take this a bit further. So I asked the industry group about this idea of pilots and classes and completing the pilots so this provides a basis. What's your feeling about how that helps? Because in some sense that puts it back in industry's court but essentially they would develop enough of a pilot such that they would help out the other parts of the industry in terms of what's expected of them to actually go through this effort. Go through this exercise. It can be your personal opinion.

MR. RECKLEY: Well, it's going to be my personal opinion. The difficulty to some degree is that even within a technology group the designs can vary significantly.

And what my personal thought is that what would be useful to everyone is to keep it technology-inclusive as this guidance is in which case you come up with a methodology.

And what I just talked about, the designer would say -- the process would say what do you put in chapter 10, that's typically power conversion, you do an assessment. What's the feedback from the secondary to the primary and if you meet this then you don't need to describe.

However, if you do have feedback and some of the discussions were on chemicals so it may not be thermal feedback, it might be chemical feedback. If you have these kind of concerns then you do have to describe in more detail what's in that adjacent system because it has the potential to affect the primary side.

And it would lay out that kind of a process or methodology versus trying to define specifically what needs to be in for example chapter 10 for any design because all of those things become dependent on the technologies, on the power levels, on more factors than typically just one.

MR. TSCHLITZ: So I would just add that the industry recognizes that we need to do more as far as risk-informing the content of applications beyond what DG-1353 does and beyond what NEI 18-04 does.

There needs to be more guidance on this. It's one of the things that we're looking at working on in the near future to develop that extra guidance on what goes into the content of the application that the NRC could review and endorse as an acceptable approach.

ACTING CHAIRMAN CORRADINI: So, can I say that differently. So instead of them leaving it general you might put some examples out there as to what would be in and get their reaction as a group.

MR. TSCHLITZ: Yes. I would say even more that would be more of a guidance document to provide how to go about doing this rather than just simply examples.

ACTING CHAIRMAN CORRADINI: But I guess I'm still back with the examples strike me as important because within a class of systems there's going to be some commonality and certain things, chemical reactions you have to consider, the fact that I don't have solid fuel and I have moving fuel, these sorts of things are going to be similar enough that I would expect some sort of pilot would be beneficial for them to do and you to at least see to try to get a reaction to it.

MR. RECKLEY: I generally agree. It's just a caution that the designs can vary and that can lead you -- there was a question earlier on about the steam generator. Well, if your design uses double walled steam generators and the water is only a little bit away from the primary sodium loop that's one level of concern.

If you're a design that uses an intermediate loop and the water is one whole loop away from the primary side it's a different concern. Those are both fast reactors, sodium coolant but the designs are significantly different.

So I'm glad to hear Mike say that. We've heard it but now it's public.

This is another area, it's a little hard here again to take that that's highlighted on the slide. But this is another area that we don't think the Commission has -- we don't think there's an issue, but it's also not an issue that was brought up to our knowledge in the previous Commission papers and that we want them to acknowledge that we're going to use this approach not to scale the NRC review but to scale what's in the application.

The discussion this morning on the enhanced safety-focused review for example, that was things the staff does different. Once we get an application in, but the guidance on what goes in an application was basically the same. So NuScale gave us a full application and then we said how can we scale that back if you will. I'm shorthanding. How can we adjust the review given the risk insights.

I think as John Monninger pointed out or

Ian that gets complex because now you are giving a staff a chapter and saying we don't think you need to look at this in quite as much detail. That's an engineering practice that's hard to come across to give something to somebody and say but we don't really need you to look at it in quite as much detail as you typically have done in the past.

And so we think actually a better idea is to scale back what's in the application and what's given to the staff to review versus giving them the whole book and then telling them but you don't need to look at this in quite as much -- it's not human nature to actually do that.

But that's an area we're going to ask the Commission.

So again the recommendation is for the Commission to approve the use of this methodology that's described in 18-04 and as reflected in the draft guide.

You have a working draft of the guide so I'm just going to kind of quickly go through what's in there and the staff findings.

The staff has taken no exceptions to what's in NEI 18-04. We offer a number of things that we want to emphasize or perhaps clarify but at this time we're not proposing any exceptions. So this is again just the scope of the draft guide and it is applied to those rules that are associated with the content applications and they're listed there, 50.34, 52, 47 and so forth.

In regards to the licensing basis events again the staff position as it's stated in the working draft of the guide is that it's an acceptable method as described in 18-04.

We caution or emphasize that the FC target does not depict acceptance criteria for the actual regulatory limits. I think as Karl pointed out the anchors that are used are surrogates. They don't correlate to NRC regulations per se. So it's a useful tool but you have to look at it for what it is and not confuse it with actual acceptance limits.

The other point I already pointed out, the figure includes a cutoff of 5 times 10^{-7} for inclusion as a licensing basis event. The staff again just cautioning that's not a hard and fast cutoff. You need to look below it. You need to address some certainties. You need to look for cliff edge effects. You need to be very deliberative in what you're not including in the licensing basis events.

We touched on this or Karl touched on it.

The methodology does address external events. It has a definition of a design basis external hazard level. That is basically the same as the design basis earthquake, design basis flood, other external hazards for which safety-related equipment needs to be protected. It sets that kind of definitive limit. It needs to be protected at least up to this point.

ACTING CHAIRMAN CORRADINI: Can you help me here? If I'm in your -- I guess you've got a name for the diagram. If I'm in the Reckley-Cubbage diagram.

MR. RECKLEY: Segala.

ACTING CHAIRMAN CORRADINI: I'm sorry. Segala-Reckley-Cubbage diagram. Is it just safety-related equipment or is it risk-significant? I'm trying to understand what's covered under this.

MR. RECKLEY: Karl, be prepared. Because I will give you the way I think it works and then Karl can correct me if I'm wrong.

So for -- this is the alignment with the current arrangement. For safety-related equipment they'll need to be protected against the design basis external hazard level which is analogous to and determined using our existing methodology for defining those kind of external hazards.

In addition to that within the PRA it's looking at a fuller range of external events including down into the beyond design basis arena and to the degree that beyond design basis external hazard can influence the frequency of an event or a malfunction it's going to be also addressed in that category of events. So is that right, Karl?

MR. FLEMING: Yes, that's basically correct. We start with -- when we talk about the design basis external hazard levels we have a requirement, a deterministic requirement that says that you have to protect your safety-related SSCs in the performance of your required safety functions to achieve safe shutdown against any -- assuming the occurrence of any design basis external hazard level. And that's just for safety-related SSCs.

However, at some point in time and there's flexibility on when this might occur, at some point in time there will be external hazards included into the PRA and then that would then talk to the potential for creating maybe additional risk-significant SSCs or perhaps additional SSCs that because of the external hazard may have a defense-in-depth adequacy consideration.

So for those -- and therefore getting to the NSRST categories. And for all NSRST categories whatever hazard they may have come from we set reliability and capability requirements to basically start the process of the special treatments. And then the integrated decision process would consider is there anything beyond setting reliability and capability requirements which it may have to do with protecting against an external hazard or may not depending on the nature of the LBE that produced the risk significance or the defense-in-depth concern.

And the integrated decision panel would then decide what kind of special treatments beyond capability reliability requirements and a monitoring program to make sure that these are enforced through the life operation of the plant.

MR. RECKLEY: So, the other findings or clarifications. As we've already discussed the single failure criterion as it's applied traditionally to safety-related equipment within chapter 15 of light water reactors we think is not needed and it's consistent with the Commission's decision in SECY-03-0047.

We do offer again that the methodology in NEI 18-04 does in our view use PRA a little beyond what is currently done. We require PRAs to be done.

We require the results to be shown within chapter 19.

It's used to support things like determinations of regulatory treatment of non-safety systems. But in this particular case it's a little more integrated into the process.

And so we just offer the maybe obvious observation that to the degree that the ASME ANS standard is completed and to the degree that that standard is endorsed by the NRC that would make the process much easier.

And the staff does currently plan -- the NRC is engaged in that standard. Our understanding is that that standard will be provided to the NRC for endorsement when it's completed, and the NRC will review it for potential endorsement when it's completed.

So all of these things are planned to be looked at. We're just saying if it all works out as planned it would help tremendously in the process.

ACTING CHAIRMAN CORRADINI: Let me -- can I ask a little bit different question. Is this PRA standard for advanced reactors or advanced -- implying a certain level of completeness of the design?

CHAIRMAN BLEY: We can't hear you.

ACTING CHAIRMAN CORRADINI: Is the level

of completeness of the design implied in this PRA standard?

MR. RECKLEY: Since Karl's on the committee let me.

MR. FLEMING: I'd be happy to handle that. The standard does not enforce a given application. So the standard is available to support a variety of user applications.

So the user decides and perhaps with negotiation with the regulator what parts of the standard need to be applied to that application, what level of detail has to be supplied and so forth.

And then the standard has requirements to clarify whether certain requirements haven't been addressed or whether there's been assumptions made in lieu of actual inputs that would create the necessary model fidelity.

So the standard documents the basis for -- requires you to document the basis for the PRA and then whether or not that's sufficient is really a matter for the application process, i.e., negotiation with the regulator.

MR. RECKLEY: Because keep in mind from the staff's point of view we have the luxury of being at the tail end of the design process. For the actual application.

Interactions can occur throughout the design process but by the time they give us the application the assumption is the design is completed, the requirements for things like PRAs are completed.

I would suggest though if you're looking at how during the design process even before an application is submitted that the designers can be thinking in the context of the PRA what was mentioned earlier, the EPRI body of knowledge on going from process hazard assessments to PRA and how you kind of -- it's especially applicable to molten salts, but it's not only limited to molten salts. It talks about how you might start off doing PIRTs and again on particular systems failure modes and effects or HAZOPs. You'd use those tools that might be more readily available for a design that's still being developed and you mature into doing the PRA through iterations and in both the analysis and in the design as you go along.

But I found that EPRI body of knowledge document that was shown on the slides to be pretty insightful of how a designer might do it.

MR. FLEMING: If I might just add a couple of more comments on that topic. When the Board of

Nuclear Codes and Standards decided we needed some more standards for different kinds of reactors they set in place two working groups, one for advanced light water reactors and one for advanced non-light water reactors.

And those projects were going on in parallel. And we were guided by the JCNRM, the Joint Committee on Nuclear Risk Management to take a consistent approach to dealing with the same issues.

So this whole process of how do you write a standard for a PRA that's done in the maybe different stages of design was also faced with the advanced light water reactor working group. And it just turned out that our non-light water reactor standard got issued for trial use before the ALWR standard got out.

But there's an ALWR trial use standard that will be out pretty soon and it follows the same logic as far as how do you deal with PRA requirements for a design stage PRA.

A final comment is that we also have a PRA white paper that was drafted several years ago, or a couple of years ago I guess and one of our tasks in the LMP framework is to bring our white papers up to date and get them in alignment with what's currently in the guidance document, taking into account lessons from these pilot applications.

And that includes some of the standards Jas (phonetic) has talked about there.

MR. RECKLEY: Then moving on to the second element, the safety classification. Again, the staff position is that what's described in NEI 18-04 provides an acceptable method.

And the only clarification or point of emphasis here again is these things need to be looked at with all three elements as an integrated process. Just again offering a caution that we didn't want a designer to pick out an element like safety classification and think that that was a standalone process they could use.

Then lastly, defense-in-depth. Again the staff position, we're not taking any exceptions and saying that it's an acceptable method.

The only clarification here that we're offering and I'll be honest. These things were developed in parallel so I have to go back and make sure that NEI 18-04 as we've given it to you includes the same statement.

But the revision right before that had included a statement that talked about considering plant capability and programmatic defense-in-depth measures and change control processes that would go into the operating phase of a plant.

And we think that's a good idea, but this guidance document didn't really lay out much in terms of how that would carry into the operating phase. And we think that that is a good candidate for another guidance development in terms of how do you maintain this.

There was some discussion for example on all the programmatic measures that we would consider during licensing if you will to make sure that the SSCs were actually delivering as advertised. But how we roll that into the operating phase and how we include it in requirements like technical specifications or plant procedures or regulations or whatever form it takes we weren't ready to address at this point. So we're just leaving that open that this only addresses up to the licensing stage, not into operations.

Two more slides here. We mention in the draft guide the same thing I mentioned this morning. There are interfaces between this process and NEI 18-04 and other arenas.

One is emergency planning. And we're

trying to make sure that the Draft Guide 1350 on emergency planning and the Draft Guide 1353 on licensing basis events marry up because as I mentioned that's where the events will be identified that you then compare to the protective action guidelines in an application that includes a proposed reduction in emergency planning zones.

We've talked numerous times about mechanistic source term. Mechanistic source term is key to this. It didn't get a whole lot of discussion in NEI 18-04. It's an inherent assumption that you have the ability to assess the consequences or as previously stated the release fractions across all the barriers.

So we're just pointing out that link and that importance.

This is another area that we envision it's very possible that we'll have an additional guidance document on the development of mechanistic source term. And if for no other reason than the ACRS kind of suggested that that might be a good idea in the context of the emergency planning proposed rule.

So we don't really disagree with that and we're talking about it. And that is another good candidate for another guidance document that would be developed.

ACTING CHAIRMAN CORRADINI: It was pointed out in that session. Dennis was the chair of that session also and he can remind me if I have it wrong.

In Reg Guide -- now I'll get the reg guide wrong, 1.18 -- 1.83, 1.183. I can't remember the reg guide for essentially alternative source term. There was a set of seven or eight attributes that if the applicant wanted not to use what is in the reg guide but wanted to use something of their own making it ought to meet a series of attributes. And I thought at least that's a good starting point.

MR. RECKLEY: That is a good starting point. Under NGNP there was a white paper on mechanistic source term. For other designs there's also for fast reactors Argonne has produced a report on mechanistic source term.

So there is -- we actually are working with -- under our contract arrangements we're working with some national labs in a similar context to say can we develop a fairly generic way to describe the development of a mechanistic source term.

So it was a good observation and I think it's likely that we'll be here sometime down the road to talk about a draft guide on mechanistic source term.

I've already talked numerous times about informing the content applications. There is a short section in the draft guide that starts to talk about it as we've talked about before. Maybe it doesn't go far enough but it was at least a starting point to include in the draft guide that you can scale the format and the content and the level of detail in an application based on the insights you get from this methodology.

So going right to the bottom line here. Checking off that we were here today, October 30. Full committee the first week of December. I'm not sure it's the 6th, but whatever date gets set for that first week of December we'll come back to the full committee.

And again what we're asking for is feedback on the draft Commission paper and at your leisure or at your discretion feedback on the draft guide.

We then plan after the full committee to issue the draft guide by the end of the year is our current plan. Issue the SECY to the Commission in early 2019.

In mid-2019 depending on the feedback that we get from the solicitation of public comments on the draft guide and whatever feedback we get from the Commission on the SECY paper we would be in a position to finalize the guide and then start to engage the ACRS on the review of the final guide and issue the final guide we hope by the end of 2019.

ACTING CHAIRMAN CORRADINI: Thank you, Bill. Questions by the committee before we go to public comments? Okay. I think the line is open in our new high-tech room. So first let's go with there's comments from the members of the public that are in the room. Any additional comments by members of the public in the room? Okay.

So let's turn to the phone line, bridge line. Are there any comments from members of the public? Okay, hearing none. Oh, I'm sorry. Mr. Redd. Oh, you have a homework assignment. Let's make sure we have no public -- so there's no public comments from the bridge line.

Okay. Come up with your homework assignment.

MR. REDD: Jason Redd, Southern Nuclear. We talked several times today about the public report that has been issued on the X-Energy demonstration. I'd like to read that ADAMS session number into the record so it will be available in the future.

That is ADAMS number ML18228A779 dated August 1, 2018. Thank you.

ACTING CHAIRMAN CORRADINI: Thank you very much. I am pulling it up as we speak just to see if it really is there. I think what I got with that ML number is presentation September 13, 2018 public meeting on regulatory improvements. But not that the ADAMS system is disorganized.

MR. REDD: All right. That may be the overall package number.

ACTING CHAIRMAN CORRADINI: Oh, it's the whole package. Okay, excuse me.

MR. REDD: I will re-verify this again.

ACTING CHAIRMAN CORRADINI: I think that's the best thing to do.

MR. RECKLEY: We'll get it and the other Argonne reports and the things that were mentioned. We'll get to ACRS staff.

ACTING CHAIRMAN CORRADINI: Okay. Thank you very much. Dennis, I want to kind of turn to you since you're the actual chair. I'm just the in room chair. Do you have any final comments you want to make, Dennis?

CHAIRMAN BLEY: I was on mute. Thanks,

Mike, and thanks for chairing the meeting in my absence. I appreciate it.

I think we need to talk a little bit about the full committee meeting. Today's meeting had almost the whole committee, I think we're missing three people.

So right now we're scheduled for an hour and three quarters. And I think that's going to be okay.

Bill, I think pretty much a summary of what you presented today and I don't know if Karl Fleming can be there but there may be some detailed questions on the methodology and I think that would be really good if you had somebody to take that.

So we'll -- our staff and the NRC staff will work together to get an agenda set up for this meeting.

I think we're probably going to draft a letter on both the Commission paper and the new guidance document. I don't see why we wouldn't include them both.

And I'd like to thank everybody for a great meeting. A lot of good information. So I think that's where we're headed. If any members have any thoughts about the full committee meeting or the letter I'd love to hear them.

ACTING CHAIRMAN CORRADINI: Okay. We'll come back then to the staff and try to prepare for the full committee. Okay. With industry input of course.

Other than that I think we're done and we're adjourned. Thank you.

(Whereupon, the above-entitled matter went off the record at 4:09 p.m.)

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

ACRS Future Plant Designs Subcommittee

Draft Regulatory Guide (DG) 1353 and Related Commission Paper

"Technology-Inclusive, Risk-Informed, Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors,"

October 30, 2018 (AM)

Advanced Reactor Program

Outline

- Background
  - Enhanced Safety Focused Review Approach (ESFRA) for Light-Water Small Modular Reactors
  - Non-Light Water Reactor Program
- Context and overview for technology-inclusive methodology
- NEI 18-04 (Licensing Modernization Project)
- Draft SECY paper
- Draft Regulatory Guide 1353

Enhanced Safety Focused Review Approach (ESFRA)

- Staff approach used for NuScale application review to focus on safety
- Tools and strategies for defining the scope and depth of reviews
- Companion to NUREG-0800 (Standard Review Plan), Introduction – Part 2 as well as Design-Specific Review Standards
- Intended to be used during both pre-application and review stages

ESFRA Background

- Objective
  - Increased effectiveness and efficiency for staff reviews
- Directed by the Commission
  - SRM to COMGBJ-10-0004/COMGEA-10-0001
  - SRM to SECY-11-0024
- Review focus and resources…to risk-significant structures, systems, and components (SSCs) and other aspects of the design that contribute most to safety
- ACRS presentations in 2011, 2016, and 2017

ESFRA Review Tools

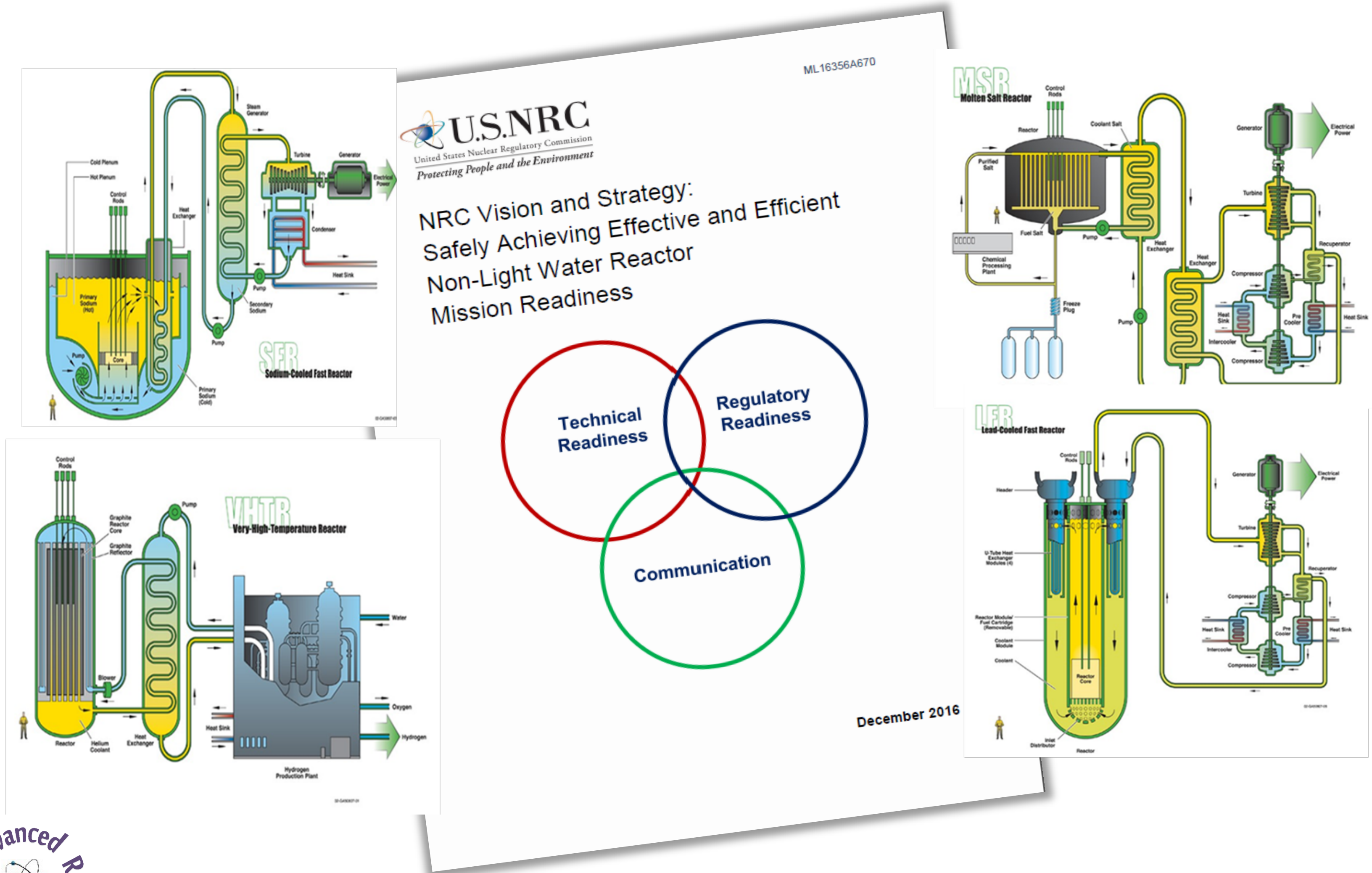
- Considerations
  - Safety Significance (e.g., A1/A2/B1/B2)
  - Regulatory Compliance
  - Novel Design
  - Shared SSCs/Nonsafety-Safety Interactions
  - Unique Licensing Approach
  - Safety Margin/Defense-in-depth
  - Operational Programs
  - Additional Risk Insights

ESFRA Status and Future

- Applied in multiple areas with varying degrees of success
- Developing lessons learned
- Can be used for future reviews including advanced reactors
  - Coordination with LMP
- The underlying concept is consistent with the agency's risk-informed, performance-based approach

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Advanced Reactor Program



Advanced Reactor Program

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Implementation Action Plans

Strategy 1 Knowledge, Skills and Capability
- ✓ ONRL Molten Salt Reactor Training
- Knowledge Management
- ✓ Competency Modeling
- Updated HTGR and Fast Reactor Training

Strategy 2 Computer Codes & Review Tools
- Identification & Assessment of Available Codes

Strategy 3 Flexible Review Processes
- ✓ Regulatory Roadmap
- ✓ Prototype Guidance
- ✓ Non-LWR Design Criteria
- Environmental Reviews
- Licensing Modernization Project

Strategy 4 Consensus Codes and Standards
- ASME BPVC Section III Division 5
- ANS Standards 20.1, 20.2 30.2, 54.1
- Non-LWR PRA Standard

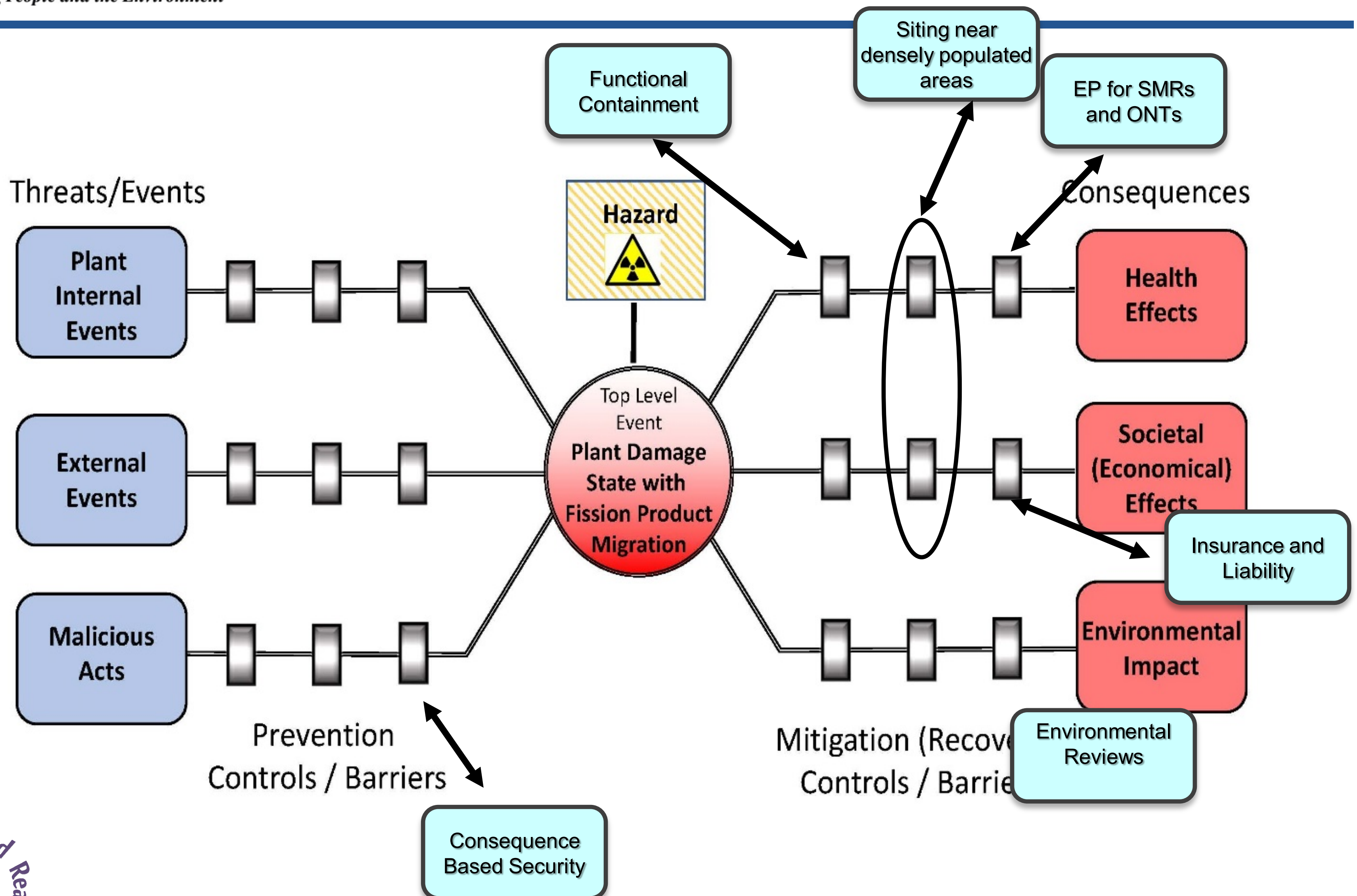
Strategy 5 Policy and Key Technical Issues
- Siting near densely populated areas
- Insurance and Liability
- Consequence Based Security (SECY-18-0076)
- EP for SMRs and ONTs (SECY-18-0103)
- Functional Containment (SECY-18-0096)

Strategy 6 Communication
- ✓ NRC DOE Workshops
- Periodic Stakeholder Meetings
- NRC DOE GAIN MOU
- International Coordination

- Potential First Movers
- Micro-Reactors

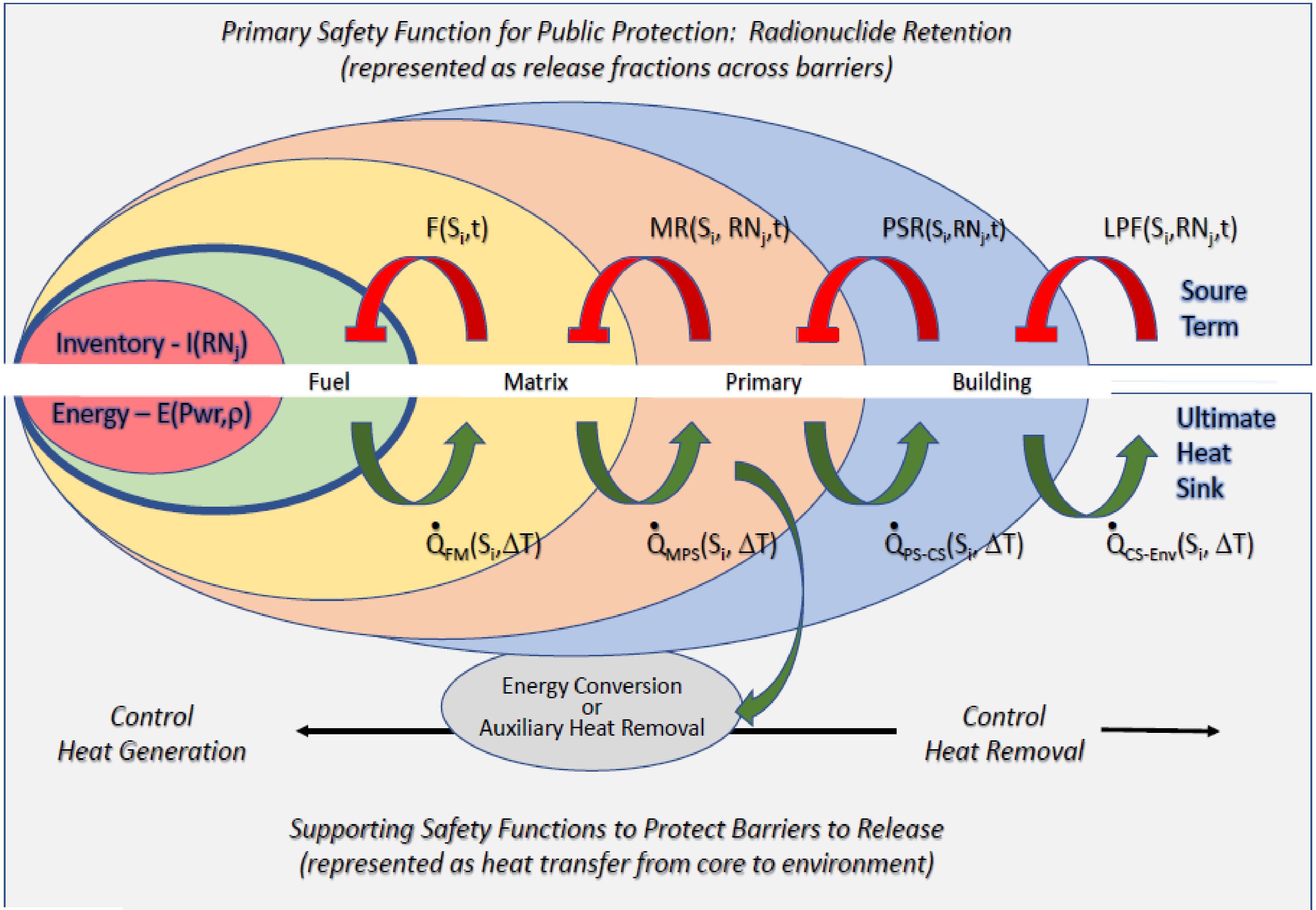
Advanced Reactor Program

Integrated Design/Review



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

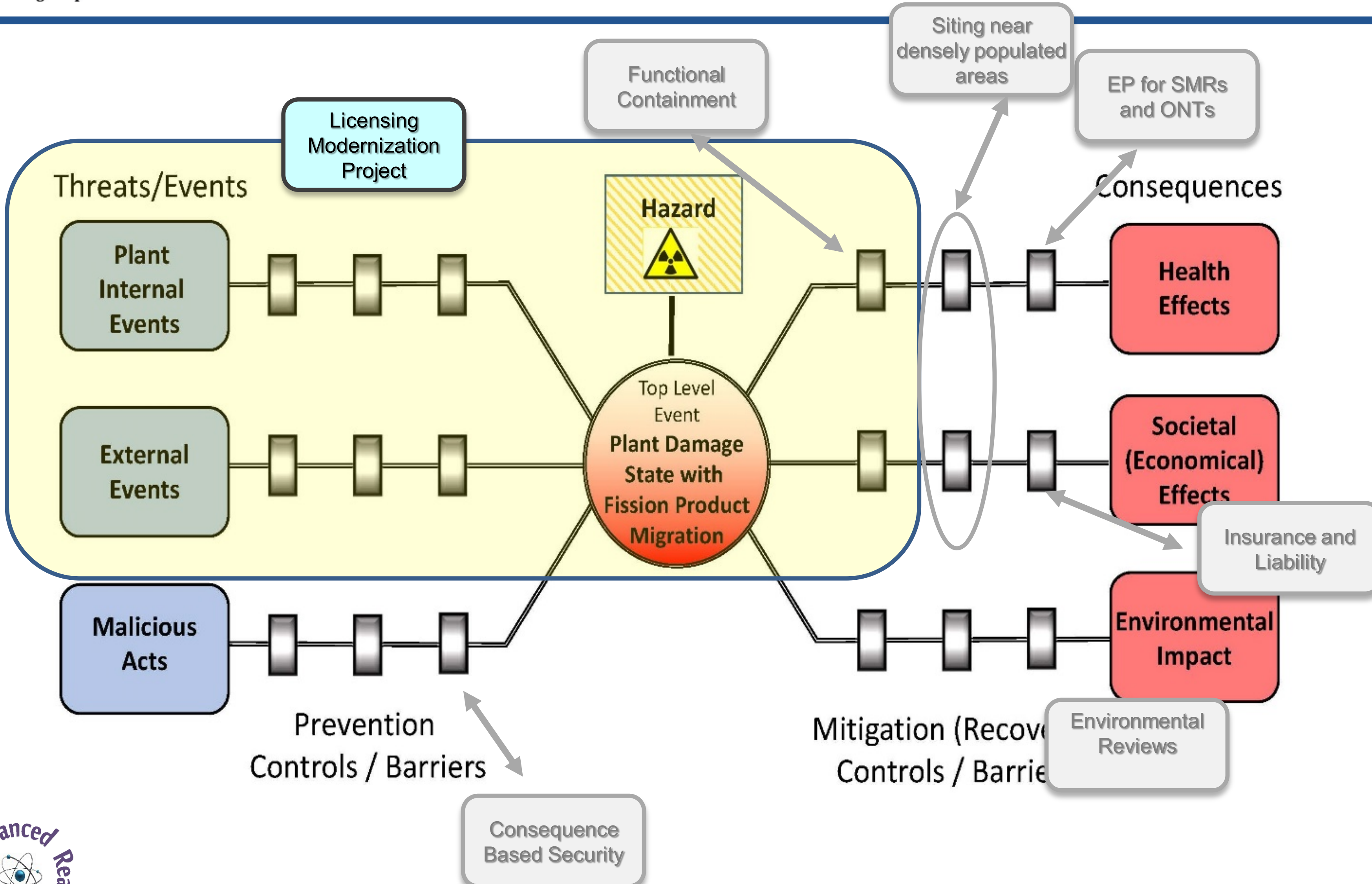
Revisit First Principles



$I(RN_j)$	Inventory
RN_j	Radionuclide Groups (j)
E	Heat Energy
Pwr	Power Level
ρ	Reactivity
F	Fuel Release Fraction
MR	Matrix Release Fraction
PSR	Primary System Release Fraction
LPF	Building Leak Path Factor
S_i	Event Sequences (i)
t	Time
$\dot{Q}$	Heat Transfer
FM	Fuel to Matrix
MPS	Matrix to Primary System
PS-CS	Primary System to Cooling System
CS-Env	Cooling System to Environment
ΔT	Temperature difference

Advanced Reactor Program

Integrated Design/Review



Other Requirements

- Associated requirements include:
  - Quality Assurance
  - Maintenance Rule
- Interfaces with requirements for:
  - Siting
  - Emergency Preparedness
  - Environmental Reviews
- Additional requirements for design/operation include:
  - Routine Effluents
  - Worker Protections
  - Security
  - Aircraft Impact Assessments

NEI 18-04, General Approach

- Licensing Basis Events
  - Probabilistic Risk Assessment
  - Deterministic
- SSC Classification
  - Function and Risk Considerations
  - Safety Related
  - Non-Safety Related with Special Treatment
- Defense-in-Depth Assessment
  - Structures, Systems and Components
  - Programmatic
  - Integrated Decision-making Process

Key Considerations

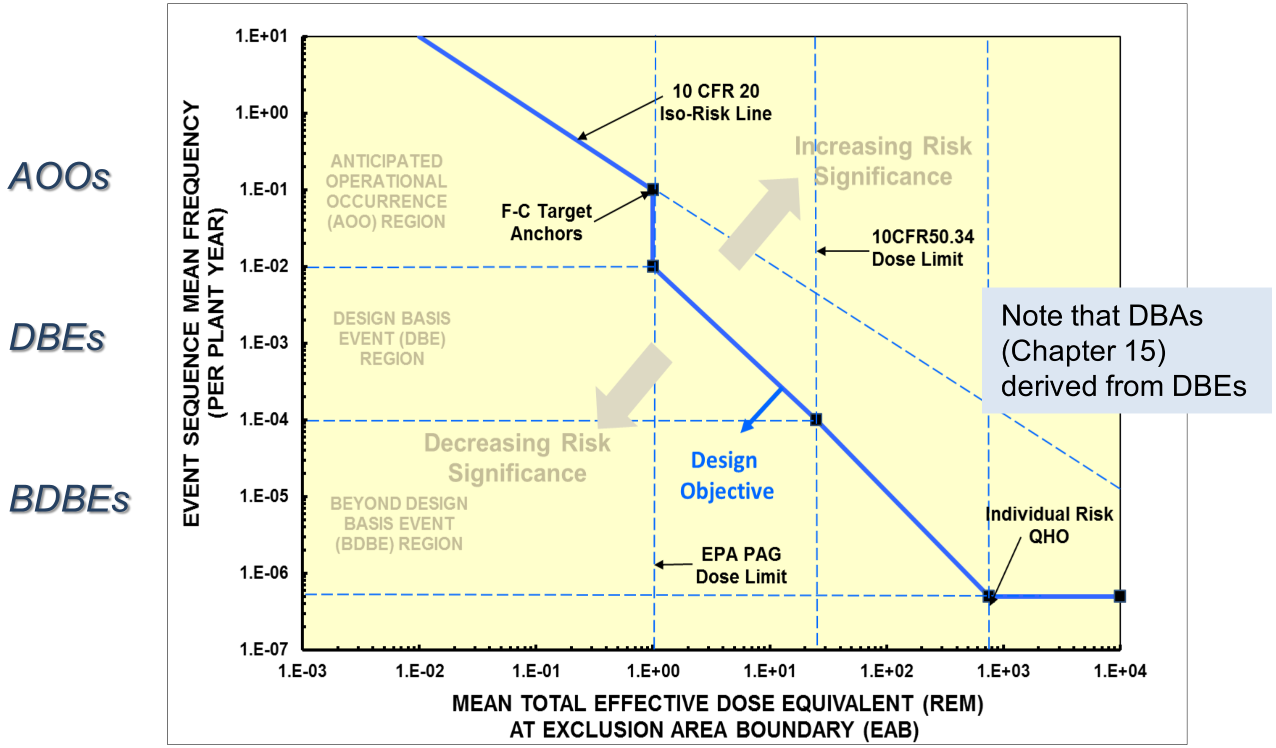
- Evolution of Approach
  - Advanced Reactor Policy Statement
  - SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements"
  - Risk-Informed, Performance-Based Regulation
  - SECY-03-0047, "Policy Issues Related to Licensing Non-Light-Water Reactor Designs"
  - NUREG-1860, "Feasibility Study for a Risk-Informed and Performance-Based Regulatory Structure for Future Plant Licensing"
  - Next Generation Nuclear Plant (NGNP)
- Similarities to traditional LWR structure, but also differences – including terminology challenges with different definitions for some phrases

Key Considerations *(continued)*

- Integrated methodology consisting of three primary elements
  - Licensing Basis Event Selection and Analyses
  - SSC safety classification and performance requirements
  - Assessing defense-in-depth adequacy
- Uses existing regulatory criteria, including guidelines for offsite dose and NRC safety goals
- Assessments performed using risk-informed and deterministic approaches, including Integrated Decision-making Process
- Includes methodology for assessing defense in depth provided by plant capabilities and programmatic controls

Event Selection & Analysis

The F-C Target values shown in the figure should not be considered as a demarcation of acceptable and unacceptable results. The F-C Target provides a general reference to assess events, SSCs, and programmatic controls in terms of sensitivities and available margins.

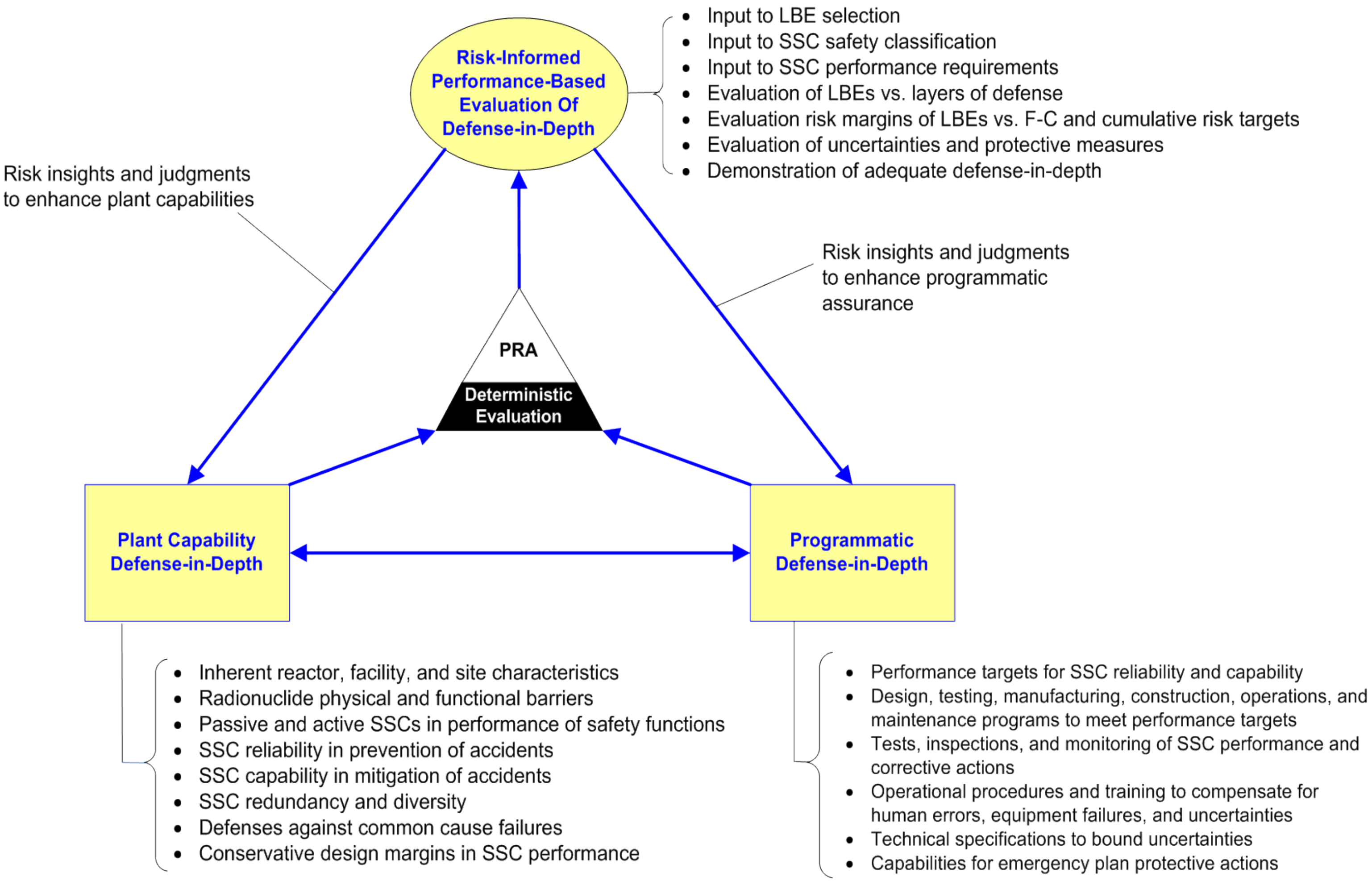


* F-C Target considered along with cumulative risk metrics, safety classification, and assessment of defense in depth

Safety Classification and Performance Criteria

- **Safety-Related (SR):**
  - SSCs selected by the designer from the SSCs that are available to perform the required safety functions to mitigate the consequences of DBEs to within the LBE F-C Target, and to mitigate DBAs that only rely on the SR SSCs to meet the dose limits of 10 CFR 50.34 using conservative assumptions
  - SSCs selected by the designer and relied on to perform required safety functions to prevent the frequency of BDBE with consequences greater than the 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C Target
- **Non-Safety-Related with Special Treatment (NSRST):**
  - Non-safety-related SSCs relied on to perform risk significant functions. Risk significant SSCs are those that perform functions that prevent or mitigate any LBE from exceeding the F-C Target, or make significant contributions to the cumulative risk metrics selected for evaluating the total risk from all analyzed LBEs.
  - Non-safety-related SSCs relied on to perform functions requiring special treatment for DID adequacy
- **Non-Safety-Related with No Special Treatment (NST):**
  - All other SSCs (with no special treatment required)

Assessing Defense in Depth



Informing the Content of Applications

- NEI 18-04 provides useful guidance for applicants to identify and provide the appropriate level of information needed to satisfy parts of the regulatory requirements in 10 CFR 50.34, 10 CFR 52.47, 10 CFR 52.79, 10 CFR 52.137, and 10 CFR 52.157.
- Combination of deterministic evaluations and probabilistic risk assessments
- Information needed on fuel, primary, and other barriers to define limitations, performance characteristics, and as input to mechanistic source term
- Information needed on SSCs and programmatic controls associated with key safety functions
- Scope and depth for other information (e.g., ancillary plant systems) to be determined based safety/risk significance (i.e., roles in preventing or mitigating licensing basis events)
- Level of detail can also reflect potential performance-based approaches (see Introduction, Part 2, to NUREG 0800)

Next Presentations

- NEI 18-04, “Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development,” (Draft Report Revision N) and Related Tabletop Exercises
- Requested ACRS Feedback
  - Draft SECY, “Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors”
  - Draft DG-1353, “Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors”

NEI

NEI 18-04 AND THE LICENSING MODERNIZATION PROJECT

Mike Tschiltz, Jason Redd, and Karl Fleming

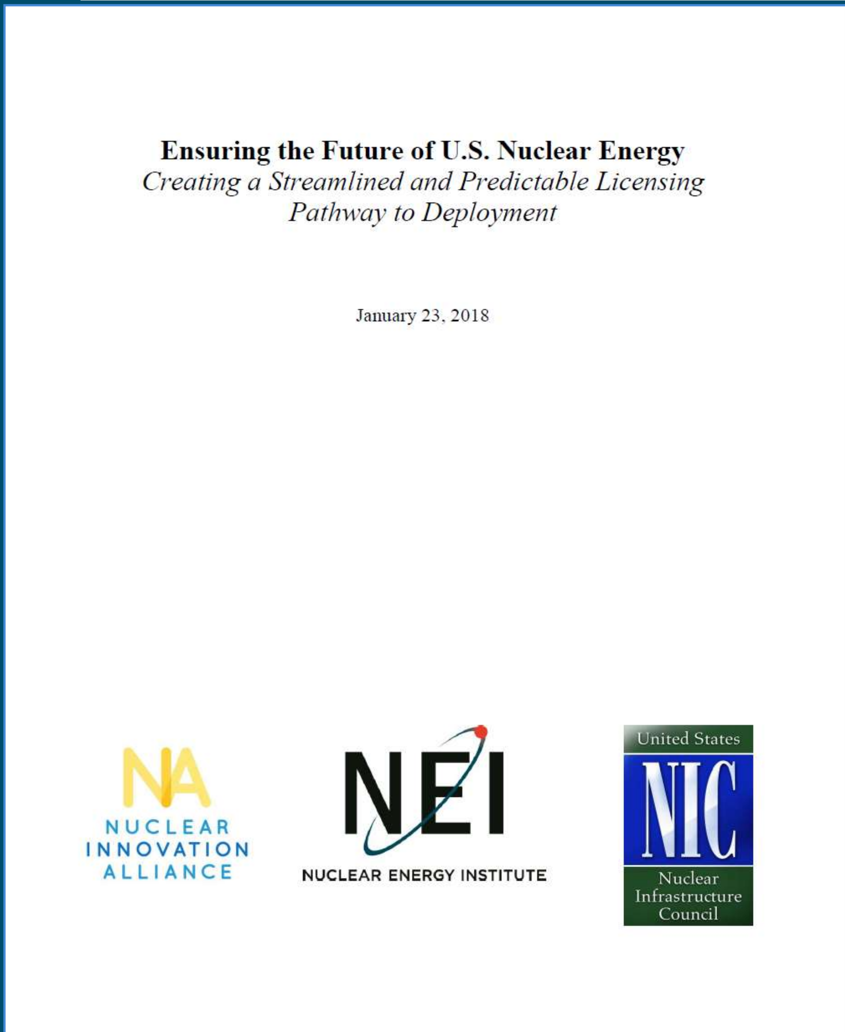
October 30, 2018

Mike Tschiltz

Senior Director New Plant, SMRs and Advanced Reactors

Nuclear Energy Institute

VISION FOR THE FUTURE - A STREAMLINED AND PREDICTABLE LICENSING PATHWAY TO DEPLOYMENT


Ensuring the Future of U.S. Nuclear Energy

Creating a Streamlined and Predictable Licensing Pathway to Deployment

January 23, 2018

NUCLEAR INNOVATION ALLIANCE

NEI NUCLEAR ENERGY INSTITUTE

United States NIC Nuclear Infrastructure Council

To ensure that advanced reactors are licensed and built in the U.S., near-term regulatory reforms are necessary.

These reforms should focus on achieving the following near-term objectives:

- *Reversing the trend of increasing regulatory costs and excessively long reviews;*
- ***Aligning the regulatory framework for advanced reactors with their inherent enhanced safety;***
- *Defining licensing options clearly, including options for staged applications and approval; and*
- *Providing additional flexibility for changes during construction.*

VISION FOR THE FUTURE – A STREAMLINED AND PREDICTABLE LICENSING PATHWAY TO DEVELOPMENT

VISION FOR THE FUTURE –
A STREAMLINED AND PREDICTABLE LICENSING PATHWAY TO DEVELOPMENT

NEI

Jason Redd

NEI 18-04 Guidance Document Lead

Southern Nuclear Development

NEI 18-04 guides prospective applicants in answering the following questions:

- What are the plant initiating events, event sequences, and accidents that are associated with the design?
- How does the proposed design and its structures, systems, and components (SSCs) respond to initiating events and event sequences?
- What are the margins provided by the facility's response, as it relates to prevention and mitigation of radiological releases within prescribed limits for the protection of public health and safety?
- Is the philosophy of Defense-in-Depth (DID) adequately reflected in the design and operation of the facility?

Karl Fleming

NEI 18-04 Senior Technical Lead

PRINCIPAL FOCUS OF LMP METHODOLOGY

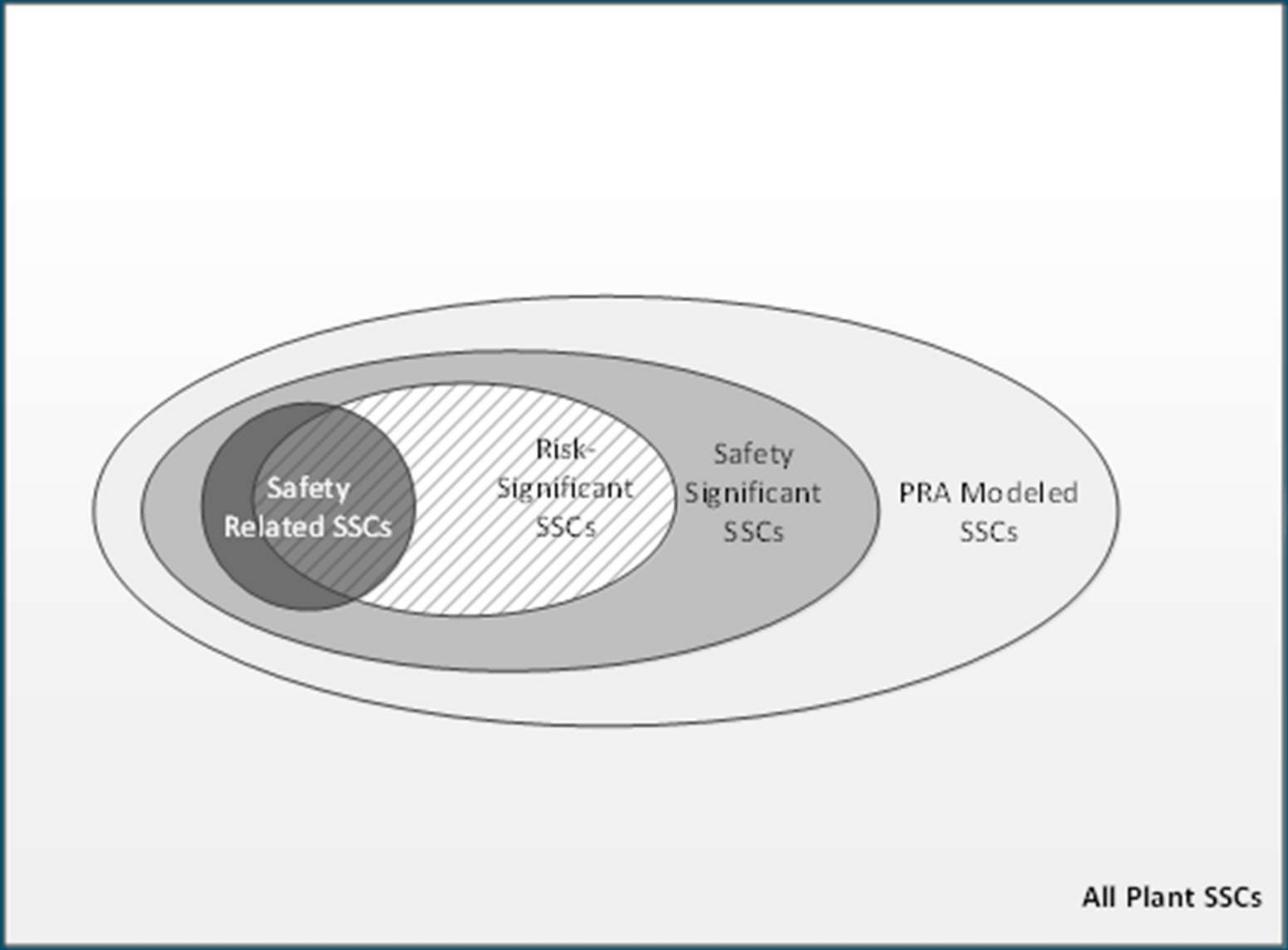
- Systematic, reproducible, robust ,and integrated processes for:
  - Identification of safety significant licensing basis events (LBEs) appropriate for each non-LWR design through an integrated decision process informed by a design specific PRA.
  - Safety classification of SSCs and selection of SSC performance requirements;
  - Establishing the risk and safety significance of LBEs and SSCs;
  - Demonstrating enhanced safety margins consistent with Advanced Reactor Policy;
  - Identification of key sources of uncertainty;
  - Evaluation of the adequacy of plant capabilities and programs for defense-in-depth.
- Appropriate balance of deterministic and probabilistic inputs to risk-informed decisions involved in design, operations, programs and licensing.
- Performance-based approach to setting plant and SSC performance requirements and monitoring performance against requirements.
- SSC performance requirements linked to balancing prevention and mitigation functions identified in LBEs.

SELECTION AND EVALUATION OF LBES BY DESIGN TEAM IS SYSTEMATIC AND REPRODUCEABLE

- Anticipated Operation Occurrences (AOOs), Design Basis Events (DBEs), and Beyond Design Basis Events (BDBEs) defined in terms of event sequence families with input from a reactor design-specific PRA that is integrated into the design process.
- AOOs, DBEs, and BDBEs are evaluated:
    - To ensure consistency with the reactor's safety design approach;
    - Individually for risk significance against a Frequency-Consequence (F-C) Target;
    - Collectively by comparing the total integrated risk against cumulative risk targets.
- DBEs and high consequence BDBEs are evaluated to define Required Safety Functions (RSFs) necessary to meet F-C Target.
- Designer selects Safety Related (SR) SSCs to perform RSFs among those available on all DBEs.
- DBAs are derived from DBEs by crediting only SR SSCs and evaluated conservatively for meeting Chapter 15 Design Basis Accident (DBA) requirements.

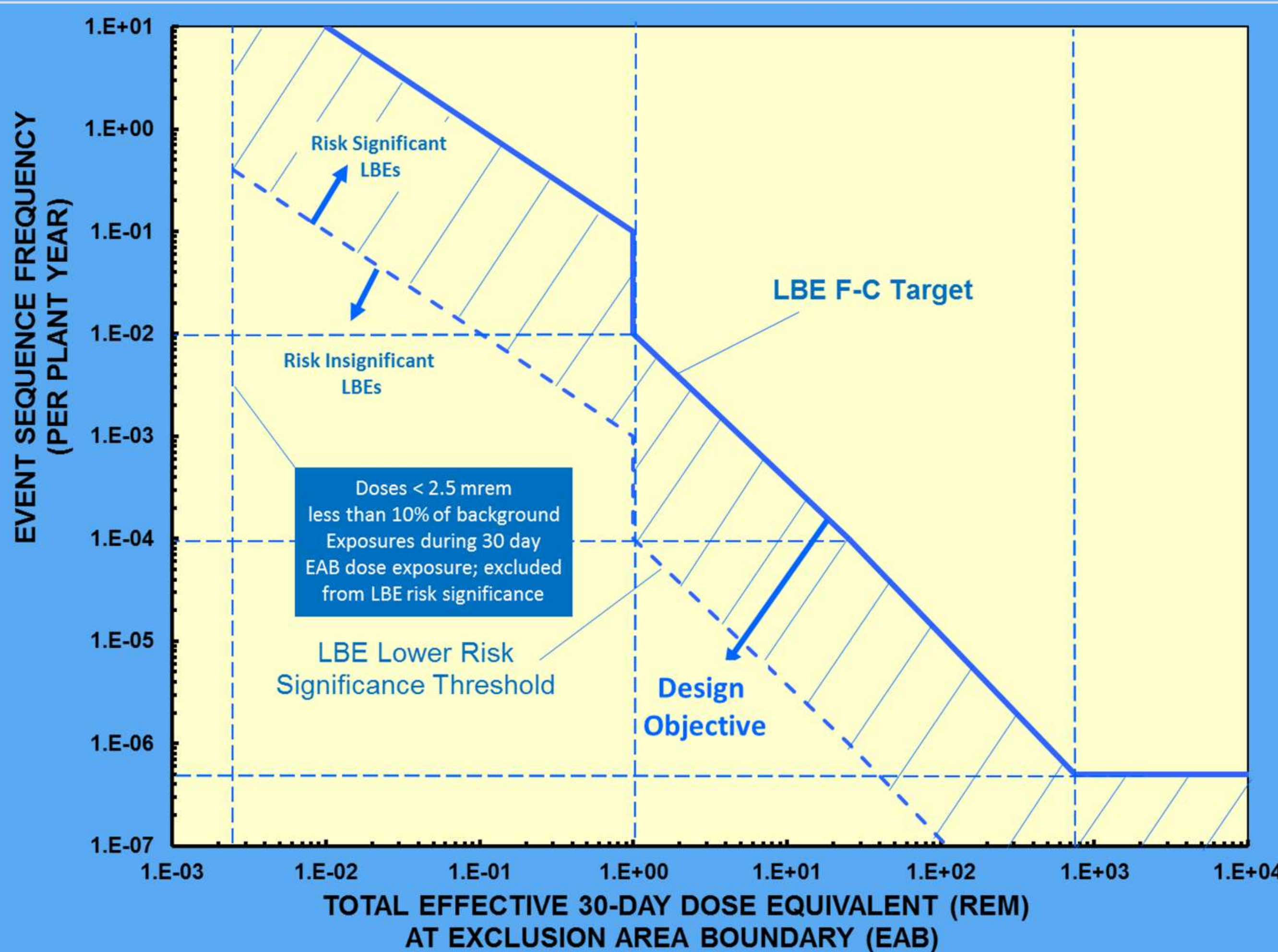
- SSC Safety Classes:
  - Safety Related (SR) – selected to perform Required Safety Functions;
  - Non-Safety Related with Special Treatment (NSRST) – non SR SSCs that are risk significant or perform functions necessary for DID adequacy;
  - Non-Safety Related with no Special Treatment (NST).
- Risk Significant SSCs based on absolute metrics
  - Perform functions necessary to keep LBEs inside F-C Target;
  - Contribute at least 1% to cumulative risk targets selected to meet Quantitative Health Objectives (QHOs) and 10 CFR 20 annual dose limits.
- Risk Significant LBEs
  - Doses exceed 2.5 mrem, and,
  - Frequency of the LBE dose within 1% of the F-C Target.

SSC CATEGORY RELATIONSHIPS



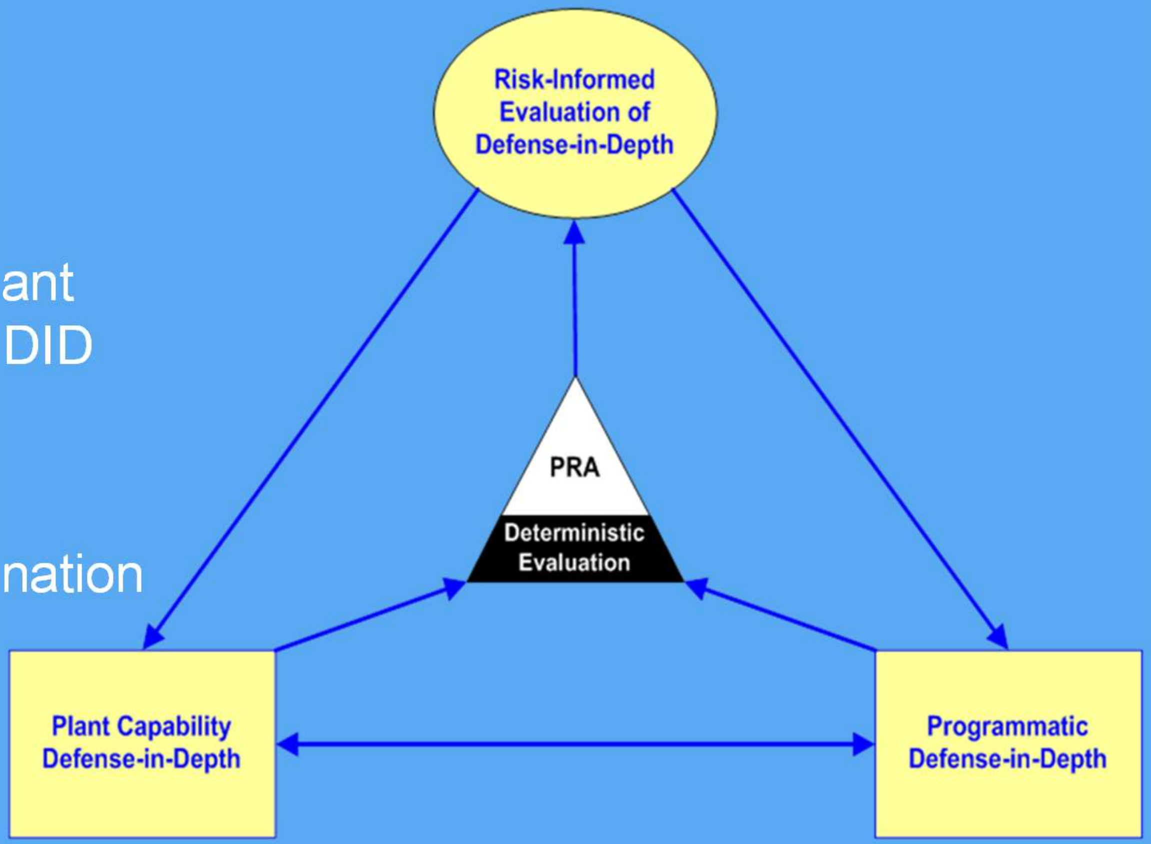
- Plant Level Safety Margins
  - Reflected in the margins between LBE frequencies and consequences and the F-C target;
  - One way to demonstrate enhanced margins consistent with NRC Advanced Reactor Policy.
- SSC Level Safety Margins
  - Margins in design codes selected to provide a robust capability to support the mitigation function of safety significant SSCs;
  - Margins in the performance requirements selected to ensure that SSC will perform their prevention functions with adequate reliability.
- Confirmation of adequate plant and SSC margins addressed as part of the DID adequacy evaluation.

LBE RISK-SIGNIFICANCE CRITERIA



Evaluation of DID involves…

- Attributes of DID
- Evaluation of attributes
- Guidelines for adequacy of Plant Capability and Programmatic DID
- Special considerations
- Integrated Decision Process
- Compensatory action determination
- DID Baseline documentation



DEMONSTRATING LMP APPLICABILITY TO NON-LWRS

- High Temperature Gas-Cooled Reactors
  - MHTGR-1980's PSID, PRA, NUREG-1338;
  - ANS 53.1 Design Standard for MHRs (PBMR, NGNP applications);
  - Xe100 LMP Demonstration (completed).
- Liquid Metal Cooled Fast Reactors
  - GEH PRISM -1980s, PSID, PRA, NUREG-1368;
  - DOE sponsored PRISM PRA Modernization;
  - GEH LMP Demonstration (completed).
- Molten Salt Reactors
  - Vanderbilt/ORNL MSRE Preliminary PRA, LBE definition, ORNL/TM-2018/788;
  - EPRI PHA-to-PRA Project using MSRE Case Study;
  - Vanderbilt MSRE LMP Demonstration (planned for 2019).
- Other Advanced non-LWRs
  - Kairos FHR LMP Demonstration (planned for 2019);
  - Westinghouse eVinci Micro reactor LMP Demonstration (planned for 2019).

CURRENT EXPERIENCE IN APPLYING LMP PROCESS TASKS (AS OF 10/30/2018)

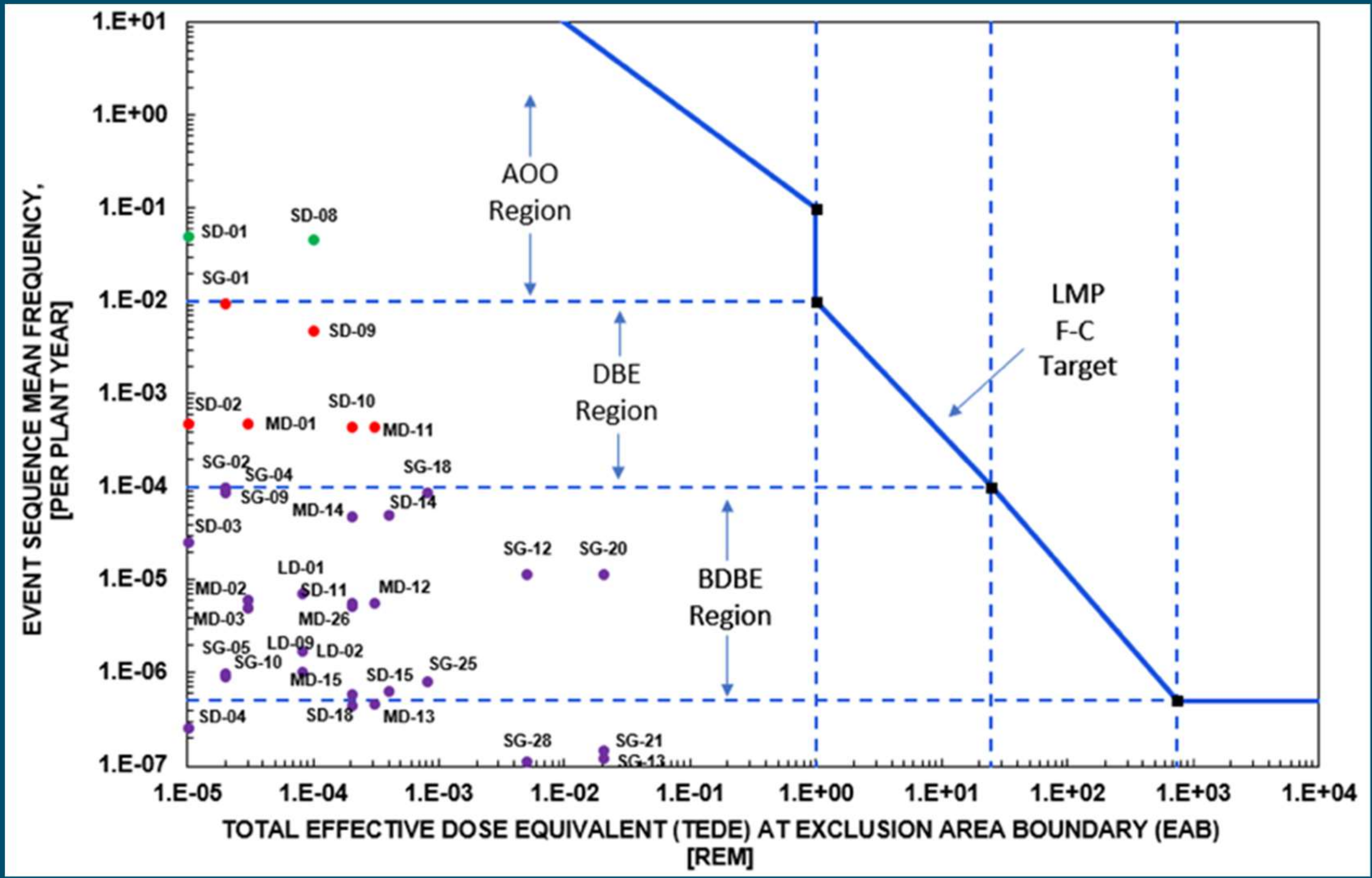
NEI 18-04 Tasks	MHTGR	XE-100	PRISM	MSRE
Internal Events PRA	√√	√	√√	√
Seismic PRA	√√			
Single and multi-module event sequences	√√	√	√	
Define/confirm AOOs, DBEs, BDBEs	√√	√	√	√
Evaluate LBEs vs F-C and Cum. Risk Targets	√√	√	√	√
Identify Required Safety Functions	√√	√	√	√
Select/Confirm SR SSCs and DBAs	√√	√	√	
Define/Confirm Required Functional Design Criteria	√√			
Define/Confirm Safety Related Design Conditions	√√			
Evaluate Plant Capability DID Adequacy	NA		√	
Identify Risk Significant LBEs and SSCs	NA		√	
Select/Confirm NSRST SSCs	NA		√	
Define Performance Requirements for Safety Significant SSCs	√			
Evaluate Programmatic DID Adequacy/Integrated Decision Process	NA			

√ designates limited scope application/demonstration
√√ designates full scope application
NA designates NEI 18-04 tasks not available when application performed

- LMP methodology demonstrated for the three major families of advanced non-LWRs: gas-cooled, liquid metal-cooled, and molten salt reactors.
- Developers involved in demonstrations found the methodology to be useful and to provide reasonable results consistent with safety design approach.
- Performance-based aspects enhanced by use of absolute, versus relative, metrics for LBE and SSC risk significance.
- Relationships and distinctions among safety-related, risk-significant, and safety-significant SSCs clarified.
- Importance of integrating the tasks of selecting and evaluating LBEs, safety classification and performance requirements of SSCs, and evaluation of DID adequacy into Risk-Informed, Performance-Based (RIPB) decisions demonstrated.
- Implementation feedback to be incorporated into LMP white papers.

XE-100 LMP DEMONSTRATION HIGHLIGHTS

- Example of LMP application at early state of design.
- Limited scope high level PRA developed during preconceptual design to guide conceptual design.
- Completed preliminary selection of LBEs and RSFs with examples identified for SR SSCs.



- Example of LMP application after previously completed conceptual design and NRC pre-application review.
- Recent DOE-sponsored PRA modernization to pilot ASME/ANS Non-LWR PRA standard.
- Included passive component reliability, component reliability database development, and mechanistic source term assessments.
- Inspired NEI 18-04 approach to LBE and SSC risk significance criteria based on absolute risk metrics.
- NEI 18-04 application included:
  - Identification / confirmation and evaluation of AOOs, DBEs, and BDBEs
  - Identification / confirmation and evaluation of RSFs
  - Classification of SR and NSRST SSCs
  - Preliminary selection / confirmation of DBAs
  - Evaluation of plant capabilities for defense-in-depth

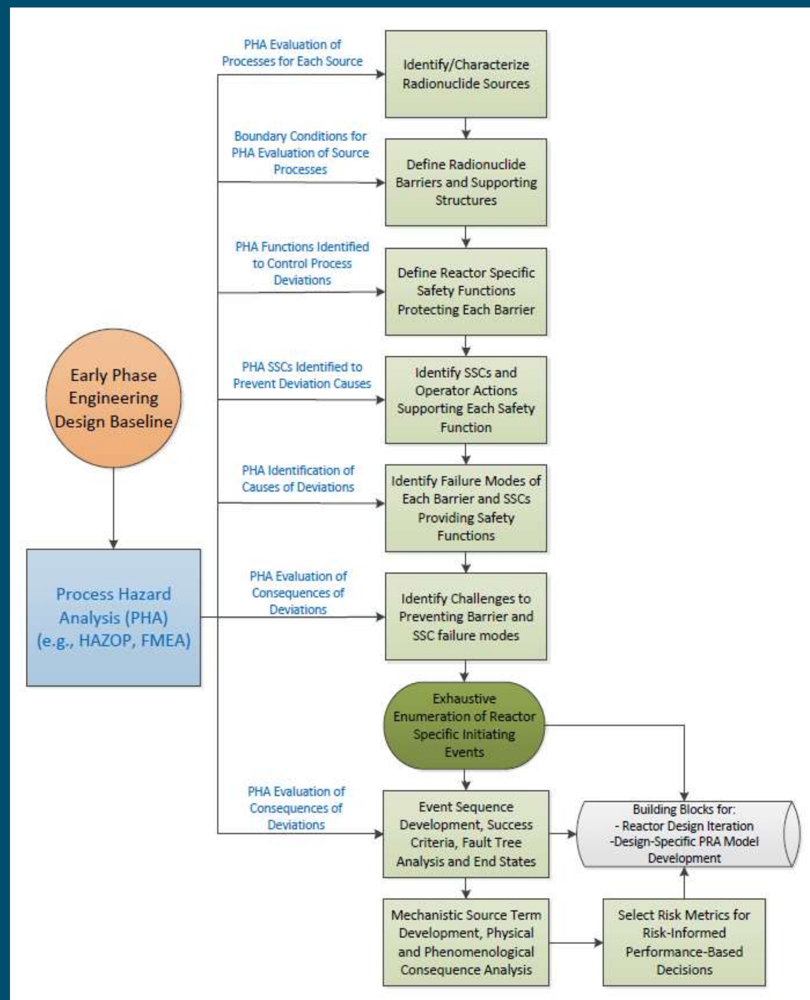
PRISM SAFETY-SIGNIFICANT SSCS

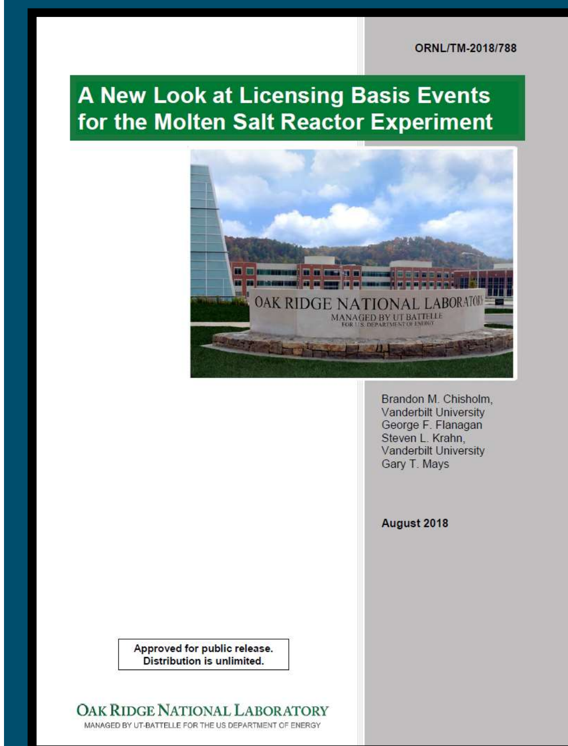
- The selected SR SSCs can be grouped into the following high level categories:
  - Digital I&C logic and load drivers (RPS, DPS, Q-DCIS);
  - Control rods and drives and associated operator actions;
  - EM pump supply breakers and associated operator actions;
  - 120 VAC equipment;
  - 125 VDC equipment;
  - Reactor vessel & internals;
  - RVACS;
  - Supporting structures.
- The following SSCs classified as NSRST for Plant Capability DID adequacy:
  - SG shell and tubes;
  - IHTS features supporting heat transport;
  - Forced air cooling mode of ACS and supporting 480 VAC electrical equipment;
  - SWRPS detection and mitigation SSCs.

GEH PRISM DEMONSTRATION OBSERVATIONS

- Systematic and Repeatable
  - It is clear when a process step is complete;
  - Sensitivity studies are easy to perform;
  - Results are traceable to key risk and performance drivers.
- Visual
  - Provides an point of reference for conveying PRA insights to Designers and Reviewers;
  - F-C plot illustrates results relative to risk targets;
  - More meaningful than displaying very low frequency numbers.
- Iterative
  - Complements the Design Phases;
  - Identifies vulnerabilities and trends early in the design;
  - Facilitates design optimization sensitivity studies;
  - Clarifies path to regulatory engagement.

PRELIMINARY MSRE PRA DEVELOPMENT





MSRE SUMMARY

- MSRs lack significant PRA legacy
- Comprehensive PHA (HAZOP) evaluations being performed to create body of knowledge for safety case and PRA development
  - Project benefits from EPRI PHA-PRA Project
- MSRE PRA is at early state of development
  - Event trees (with fault trees) were constructed for a total of three interesting initiating events;
  - 2 of 8 total event sequences had greater than “minimal” consequences;
  - IEs in auxiliary systems may be risk-significant for MSRs;
  - Systematic review of auxiliary systems revealed reliance on single feature.
- Next Steps
  - Definition of intermediate risk metrics;
  - LMP Demonstration.

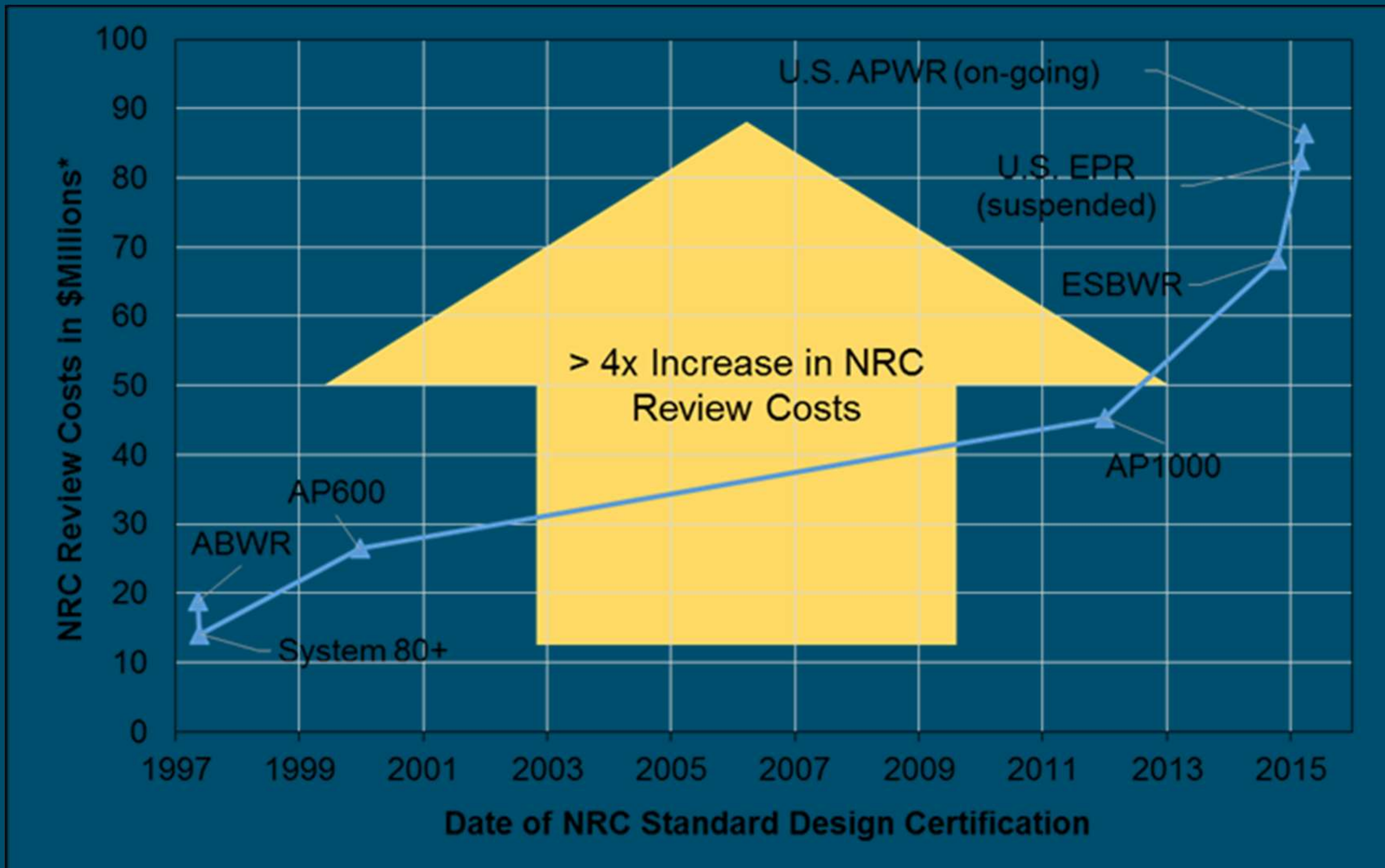
This presentation has provided a demonstration of the LMP approach to answering the following questions:

- What are the plant initiating events, event sequences, and accidents that are associated with the design?
- How does the proposed design and its SSCs respond to initiating events and event sequences?
- What are the margins provided by the facility's response, as it relates to prevention and mitigation of radiological releases within prescribed limits for the protection of public health and safety?
- Is the philosophy of DID adequately reflected in the design and operation of the facility?

Questions?

Backup Slides

NRC DESIGN CERTIFICATION REVIEW COSTS REPORTED TO CONGRESS IN 2015



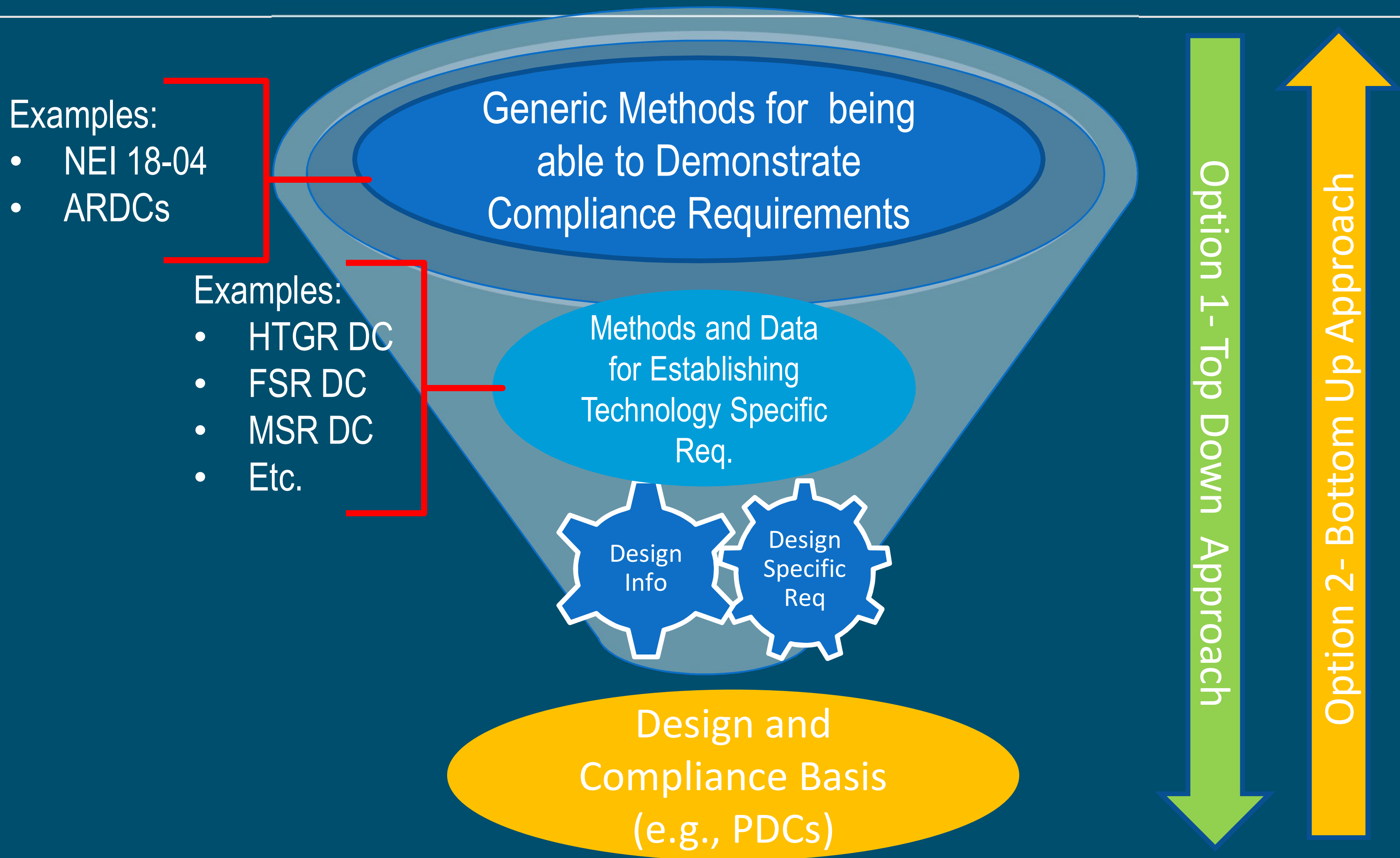
Costs have been normalized to 2017 dollars

- From the start of a reactor design project, the NEI 18-04 methodology systematically provides a clear plan to identify / confirm LBEs, classify SSC, and evaluate the adequacy of defense in depth.
- Knowledge gaps are recognized early and addressed in a deliberate, logical manner.
- Process is reproducible such that different design teams should reach similar conclusions for the same inputs.

- LMP methodology holistically considers the identification of LBEs, the classification of SSCs and associated special treatment, and the adequacy of defense-in-depth all together, rather than as independent, sequential actions.
- Incorporates data and insights from a wide variety of diverse sources to guide decision making.

- The LMP methodology can be consistently applied across different technologies.
- All technologies are evaluated against the same risk-informed, performance-based targets for safety.
- Technology-neutral, the process does not favor or penalize any particular method for satisfying regulatory outcome objectives and meeting the Commission’s safety goals.
- Innovative methods to satisfy safety performance objectives are encouraged.

TOP DOWN APPROACH IS NEEDED FOR OVERALL COHERENCY AND CONSISTENCY



- Demonstrations of the NEI 18-04 methodology have been performed successfully on different reactor technologies.
- Methodology accommodates designs at any stage of the design process by accommodating early design and risk information and incorporating feedback loops (which may be entered anytime) throughout as the design matures. Some designers may choose to use the methodology to <u>confirm</u> decisions made previously in the design process.
- NEI 18-04 is logical and within the typical technical capabilities of the designer at each stage of the design process.

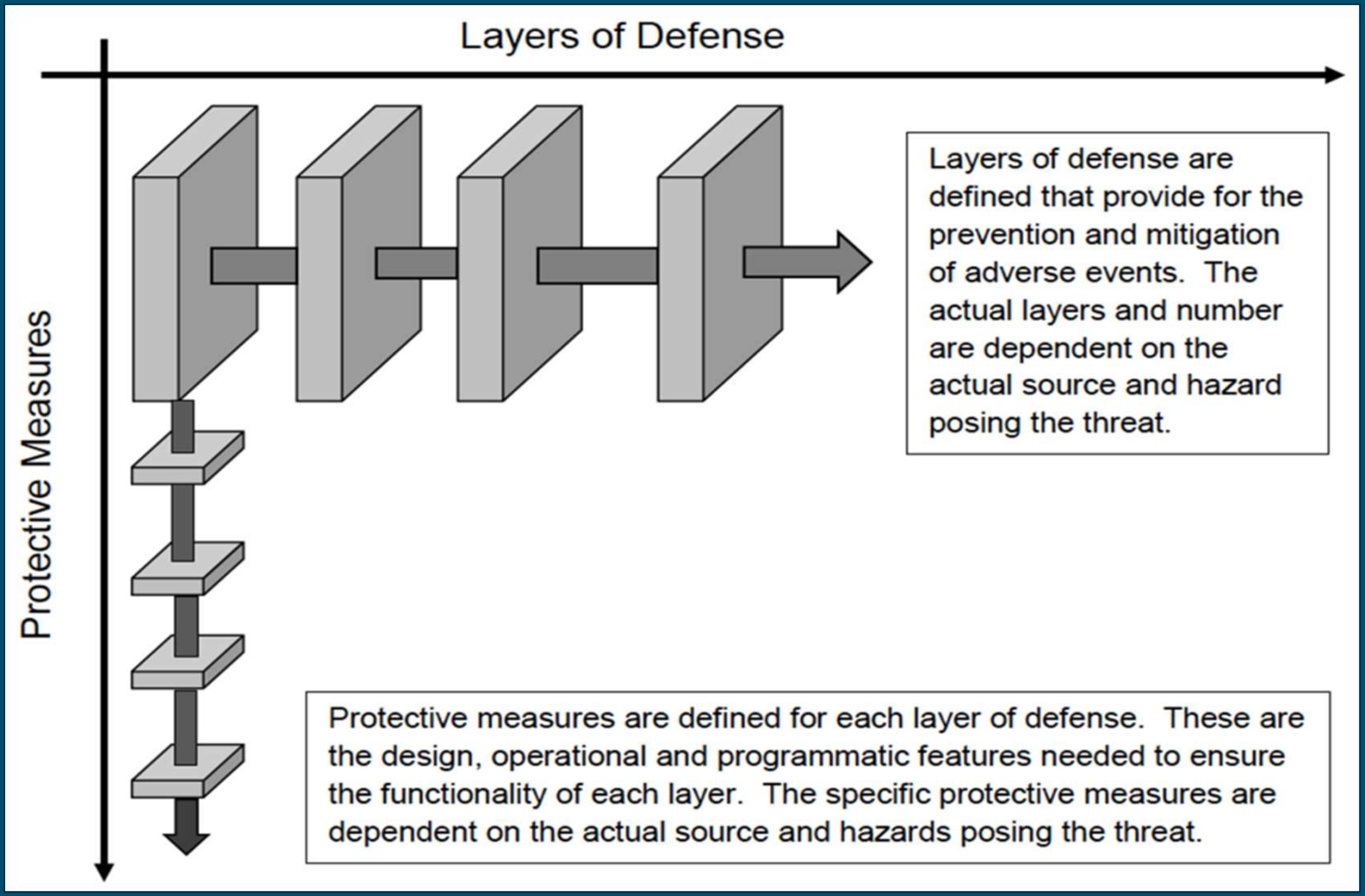
PRACTICAL

- NEI 18-04 elicits diverse sources to guide RIPB decision making, ensuring that viewpoints from throughout an organization are incorporated systematically.
- The process identifies and addresses gaps in knowledge and uncertainties that may otherwise go unnoticed.
- The systematic nature of the NEI 18-04 process is widely understandable, readily integrated with any engineering process, produces a more robust record of safety decision-making, and remains a useful framework throughout the life of the plant.

DID Backup Slides

"...an approach to designing and operating nuclear facilities that prevents and mitigates accidents that release radiation or hazardous materials. The key is creating multiple independent and redundant layers of defense to compensate for potential human and mechanical failures so that no single layer, no matter how robust, is exclusively relied upon. Defense in depth includes the use of access controls, physical barriers, redundant and diverse key safety functions, and emergency response measures."

NRC DEFENSE-IN-DEPTH CONCEPT

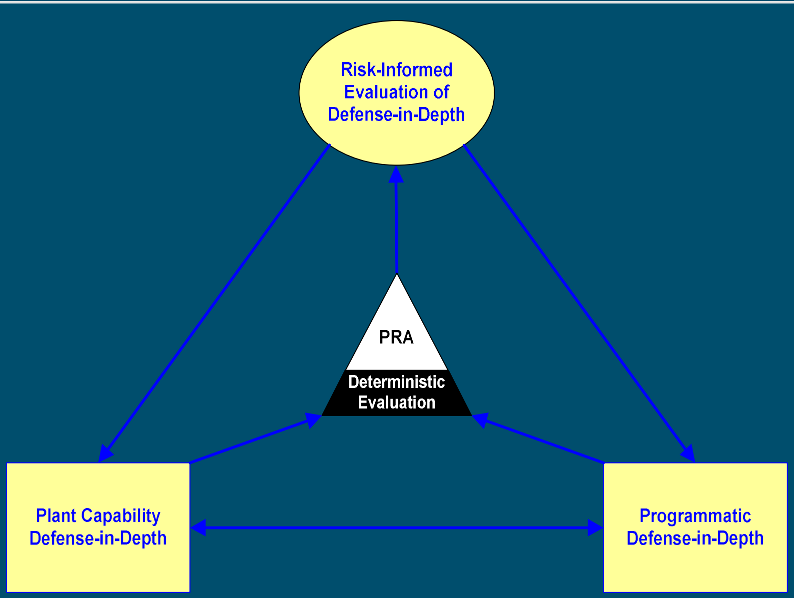


LMP DEFENSE IN DEPTH ADEQUACY BASIC STRUCTURE

Plant Capability DID

Plant Functional Capability DID—This capability is introduced through systems and features designed to prevent occurrence of undesired LBEs or mitigate the consequences of such events.

Plant Physical Capability DID—This capability is introduced through SSC robustness and physical barriers to limit the consequences of a hazard.



Programmatic DID

Programmatic DID is used to address uncertainties when evaluating plant capability DID and is used where programmatic protective strategies are defined. It is used to incorporate special treatment during design, manufacturing, constructing, operating, maintaining, testing, and inspecting of the plant and the associated processes to ensure there is reasonable assurance that the predicted performance can be achieved throughout the lifetime of the plant. The use of performance-based measures, where practical, to monitor plant parameters and equipment performance that have a direct connection to risk management and equipment and human reliability are considered essential.

PLANT CAPABILITY DEFENSE-IN-DEPTH ATTRIBUTES

Attribute	Evaluation Focus
Initiating Event and Event Sequence Completeness	PRA Documentation of Initiating Event Selection and Event Sequence Modeling
	Insights from reactor operating experience, system engineering evaluations, expert judgment
Layers of Defense	Multiple Layers of Defense
	Extent of Layer Functional Independence
	Functional Barriers
	Physical Barriers
Functional Reliability	Inherent Reactor Features that contribute to performing safety functions
	Passive and Active SSCs performing safety functions
	Redundant Functional Capabilities
	Diverse Functional Capabilities
Prevention and Mitigation Balance	SSCs performing prevention functions
	SSCs performing mitigation functions
	No Single Layer /Feature Exclusively Relied Upon

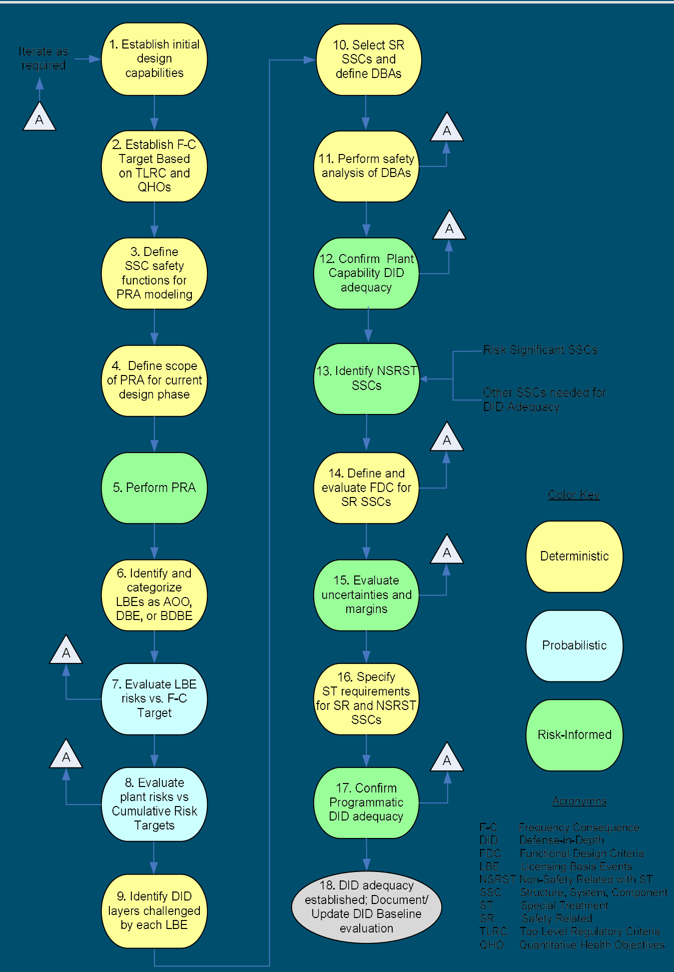
PROGRAMMATIC DID ATTRIBUTES

Attribute	Evaluation Focus
Quality / Reliability	Performance targets for SSC reliability and capability
	Design, manufacturing, construction, O&M features, or special treatment sufficient to meet performance targets
Compensation for Uncertainties	Compensation for human errors
	Compensation for mechanical errors
	Compensation for unknowns (performance variability)
	Compensation for unknowns (knowledge uncertainty)
Off-Site Response	Emergency response capability

Attribute	Evaluation Focus
Use of Risk Triplet Beyond PRA	What can go wrong?
	How likely is it?
	What are the consequences?
Knowledge Level	Plant Simulation and Modeling of LBEs
	State of Knowledge
	Margin to PB Targets and Limits
Uncertainty Management	Magnitude and Sources of Uncertainties
Action Refinement	Implementation Practicality and Effectiveness
	Cost/Risk/Benefit Considerations

INTEGRATED PROCESS FOR INCORPORATION AND EVALUATION OF DID

- Tasks are not necessarily sequential.
- Tasks can begin early in the conceptual design process and mature with the design evolution.
- All of the attributes included in the DID adequacy evaluation are completed when the design baseline for the license application is submitted.
- Programmatic confirmation of performance and sustained DID continues for life of the plant.



- Plant Capability DID
  - IDP Role in LBE Finalization
  - IDP Evaluation of LBEs against Layers of Defense
  - IDP Evaluation of LBEs for overreliance on single features
  - IDP Evaluation of LBEs for Margin Adequacy
  - IDP Evaluation of SSC Classification
  - IDP Evaluation of SSC performance capability requirements and Code and Standards applications
- Programmatic DID
  - IDP Evaluation of Quality and Reliability outcome objectives
  - IDP Evaluation of Sources of Uncertainty
  - IDP Evaluation of Residual Risk Management strategies

GUIDELINES FOR ESTABLISHING ADEQUACY OF PLANT CAPABILITY DEFENSE-IN-DEPTH (TABLE 5-2)

<table>
<tr><th rowspan="2">Layer[a]</th><th colspan="2">Layer Guideline</th><th colspan="2">Overall Guidelines</th></tr>
<tr><th>Quantitative</th><th>Qualitative</th><th>Quantitative</th><th>Qualitative</th></tr>
<tr><td>1) Prevent off-normal operation and AOOs</td><td colspan="2">Maintain frequency of plant transients within designed cycles; meet owner requirements for plant reliability and availability[b]</td><td rowspan="5">Meet F-C Target for all LBEs and cumulative risk metric targets with sufficient[d] margins</td><td rowspan="5">No single design or operational feature,[c] no matter how robust, is exclusively relied upon to satisfy the five layers of defense</td></tr>
<tr><td>2) Control abnormal operation, detect failures, and prevent DBEs</td><td>Maintain frequency of all DBEs $< 10^{-2}$/ plant-year</td><td>Minimize frequency of challenges to safety-related SSCs</td></tr>
<tr><td>3) Control DBEs within the analyzed design basis conditions and prevent BDBEs</td><td>Maintain frequency of all BDBEs $< 10^{-4}$/ plant-year</td><td>No single design or operational feature[c] relied upon to meet quantitative objective for all DBEs</td></tr>
<tr><td>4) Control severe plant conditions, mitigate consequences of BDBEs</td><td rowspan="2">Maintain individual risks from all LBEs $<$ QHOs with sufficient[d] margins</td><td rowspan="2">No single barrier[c] or plant feature relied upon to limit releases in achieving quantitative objectives for all BDBEs</td></tr>
<tr><td>5) Deploy adequate offsite protective actions and prevent adverse impact on public health and safety</td></tr>
</table>

Notes:

[a] The plant design and operational features and protective strategies employed to support each layer should be functionally independent

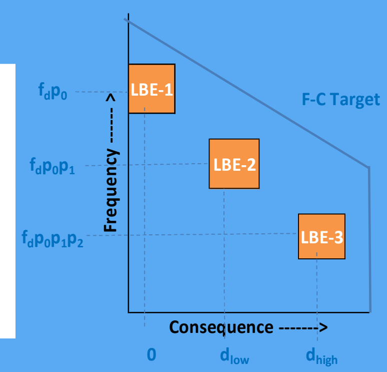
[b] Non-regulatory owner requirements for plant reliability and availability and design targets for transient cycles should limit the frequency of initiating events and transients and thereby contribute to the protective strategies for this layer of DID. Quantitative and qualitative targets for these parameters are design specific.

[c] This criterion implies no excessive reliance on programmatic activities or human actions and that at least two independent means are provided to meet this objective.

SSC LAYERS OF DEFENSE CAPABILITY AND RELIABILITY IN PREVENTION AND MITIGATION OF ACCIDENTS

Plant Distrubance	Plant features prevent Inititating event?	SSC_1 Prevents Fuel Damage?	SSC_2 Limits Release?	LBE	End State	Defense-in-Depth Layers Challenged [1]	Frequency	Dose
f_d	*Yes*			N/A	Disturbance controlled with no plant trip	Layer 1	f_d	0
	p_0 *No*	*Yes*		1	No fuel damage or release	Layer 2	f_dp_0	0
		p_1 *No*	*Yes*	2	Fuel damage w/ limited release	Layer 3	$f_dp_0p_1$	d_{low}
			p_2 *No*	3	Fuel Damage w/ un-mitigated release	Layers 4 and 5	$f_dp_0p_1p_2$	d_{high}

[1] See Figure 2-4 for definition of defense-in-depth layers



SSC	LBEs	Function	SSC Performance Attribute for Special Treatment
Plant	N/A	Prevent initiating event	Reliability of plant features preventing initiating event
SSC_1	1	Mitigate initiating event	Capability to prevent fuel damage
	2	Prevent fuel damage	Reliability of mitigation function
	3	Help prevent large release	Reliability of mitigation function
SSC_2	2	Mitigate fuel damage	Capability to limit release from fuel damage
	3	Prevent unmitigated release	Reliability of mitigation function

GUIDELINES FOR EVALUATION OF PROGRAMMATIC DID (1/2)

Attribute	Evaluation Focus	Implementation Strategies	Evaluation Considerations
Quality / Reliability	Design Testing Manufacturing Construction O&M	Conservatism with Bias to Prevention Equipment Codes and Standards Equipment Qualification Performance Testing	1. Is there appropriate bias to prevention of AOOs progressing to postulated accidents? 2. Has appropriate conservatism been applied in bounding deterministic safety analysis of more risk significant LBEs? 3. Is there reasonable agreement between the deterministic safety analysis of DBAs and the upper bound consequences of risk-informed DBA included in the LBE set? 4. Have the most limiting design conditions for SSCs in plant safety and risk analysis been used for selection of safety–related SSC design criteria? 5. Is the reliability of functions within systems relied on for safety overly dependent on a single inherent or passive feature for risk significant LBEs? 6. Is the reliability of active functions relied upon in risk significant LBEs achieved with appropriate redundancy or diversity within a layer of defense? 7. Have the identified safety-related SSCs been properly classified for special treatment consistent with their risk significance?
Compensation for Uncertainties	Compensation for Human Errors	Operational Command and Control Practices Training and Qualification Plant Simulators Independent Oversight and Inspection Programs Reactor Oversight Program	1. Have the insights from the Human Factors Engineering program been included in the PRA appropriately? 2. Have plant system control designs minimized the reliance on human performance as part of risk-significant LBE scenarios? 3. Have plant protection functions been automated with highly reliable systems for all DBAs? 4. Are there adequate indications of plant state and transient performance for operators to effectively monitor all risk-significant LBEs? 5. Are the risk-significant LBEs all properly modeled on the plant reference simulator and adequately confirmed by deterministic safety analysis? 6. Are all LBEs for all modes and states capable of being demonstrated on the plant reference simulator for training purposes?
	Compensation for Mechanical	Operational Technical Specifications Allowable Outage Times Part 21 Reporting	1. Are all risk-significant LBE limiting condition for operation reflected in plant Operating Technical Specifications? 2. Are Allowable Outage Times in Technical Specifications consistent with assumed functional reliability levels for risk-significant LBEs?

GUIDELINES FOR EVALUATION OF PROGRAMMATIC DID (2/2)

Attribute	Evaluation Focus	Implementation Strategies	Evaluation Considerations
	Compensation for Unknowns (Performance Variability)	Operational Technical Specifications In-Service Monitoring Programs	1. Are the Technical Specification for risk-significant SSCs consistent with achieving the necessary safety function outcomes for the risk significant LBEs? 2. Are the in-service monitoring programs aligned with the risk-significant SSC identified through the RIPB SSC Classification process?
	Compensation for Unknowns (Knowledge Uncertainty)	Site Selection PIRT/ Technical Readiness Levels Integral Systems Tests / Separate Effects Tests	1. Have the uncertainties identified in PIRT or similar evaluation processes been satisfactorily addressed with respect to their impact on plant capability and associated safety analyses? 2. Has physical testing been done to confirm risk significant SSC performance within the assumed bounds of the risk and safety assessments? 3. Have plant siting requirements been conservatively established based on the risk from severe accidents identified in the PRA? 4. Has the PRA been peer reviewed in accordance with applicable industry standards and regulatory guidance? 5. Are hazards not included in the PRA low risk to the public based on bounding deterministic analysis?
Off-Site Response	Emergency Response Capability	Layers of Response Strategies EPZ location EP Programs Public Notification Capability	1. Are functional response features appropriately considered in the design and emergency operational response capabilities for severe events as a means of providing additional DID for undefined event conditions? 2. Is the Emergency Planning Zone (EPZ) appropriate for the full set of DBEs and BDBEs identified in the LBE selection process? 3. Is the time sufficient to execute Emergency Planning (EP) protective actions for risk significant LBEs consistent with the event timelines in the LBEs?

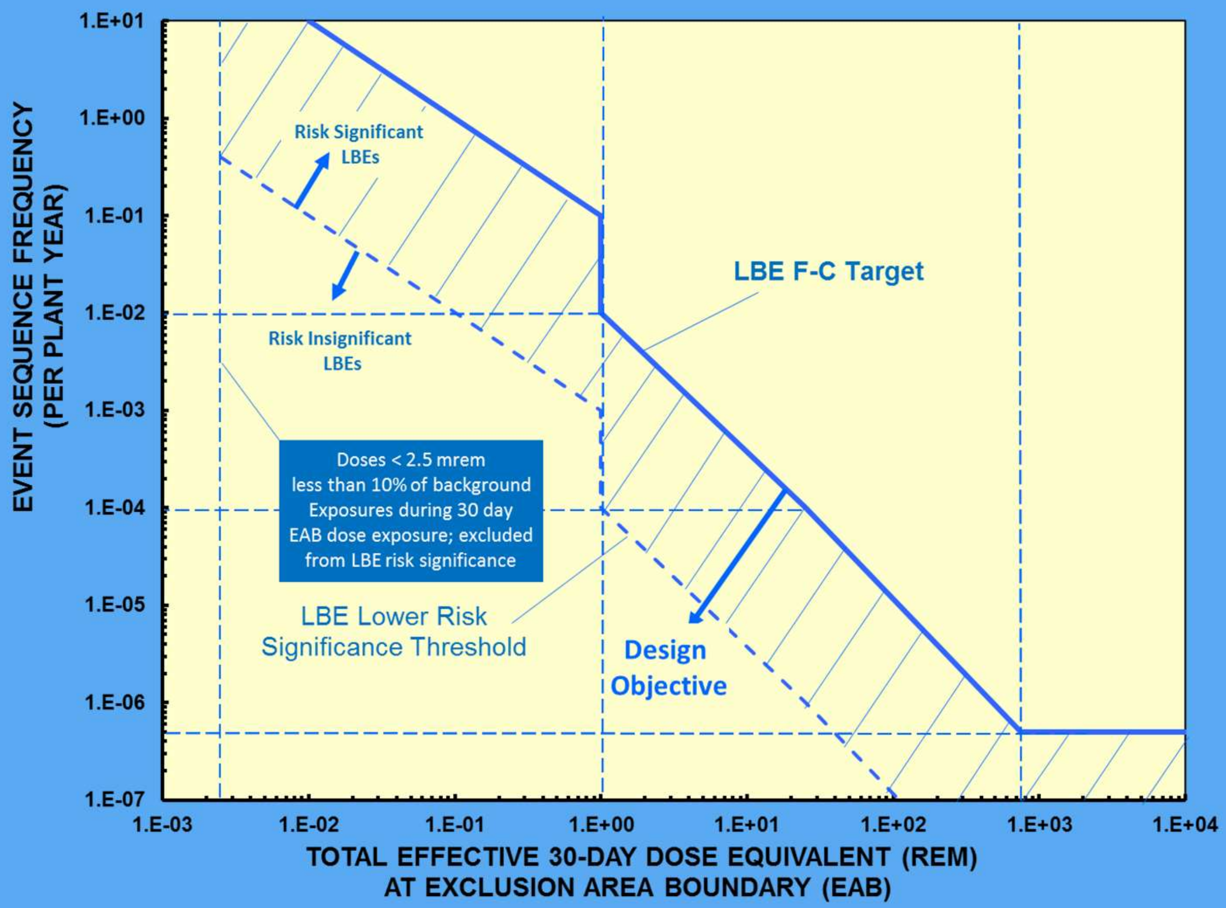
SPECIAL CONSIDERATIONS OVERVIEW

- Metrics
  - LBE Metrics;
  - SSC Metrics.
- Margins
  - Plant performance margins (LBEs);
  - SSC design performance conservatism.
- Uncertainties
  - Completeness;
  - Analyzed Uncertainties;
  - Residual Risks.
- Compensatory Action Decisions
  - Choices;
  - Impact on Risk;
  - Timing;
  - Practicality.

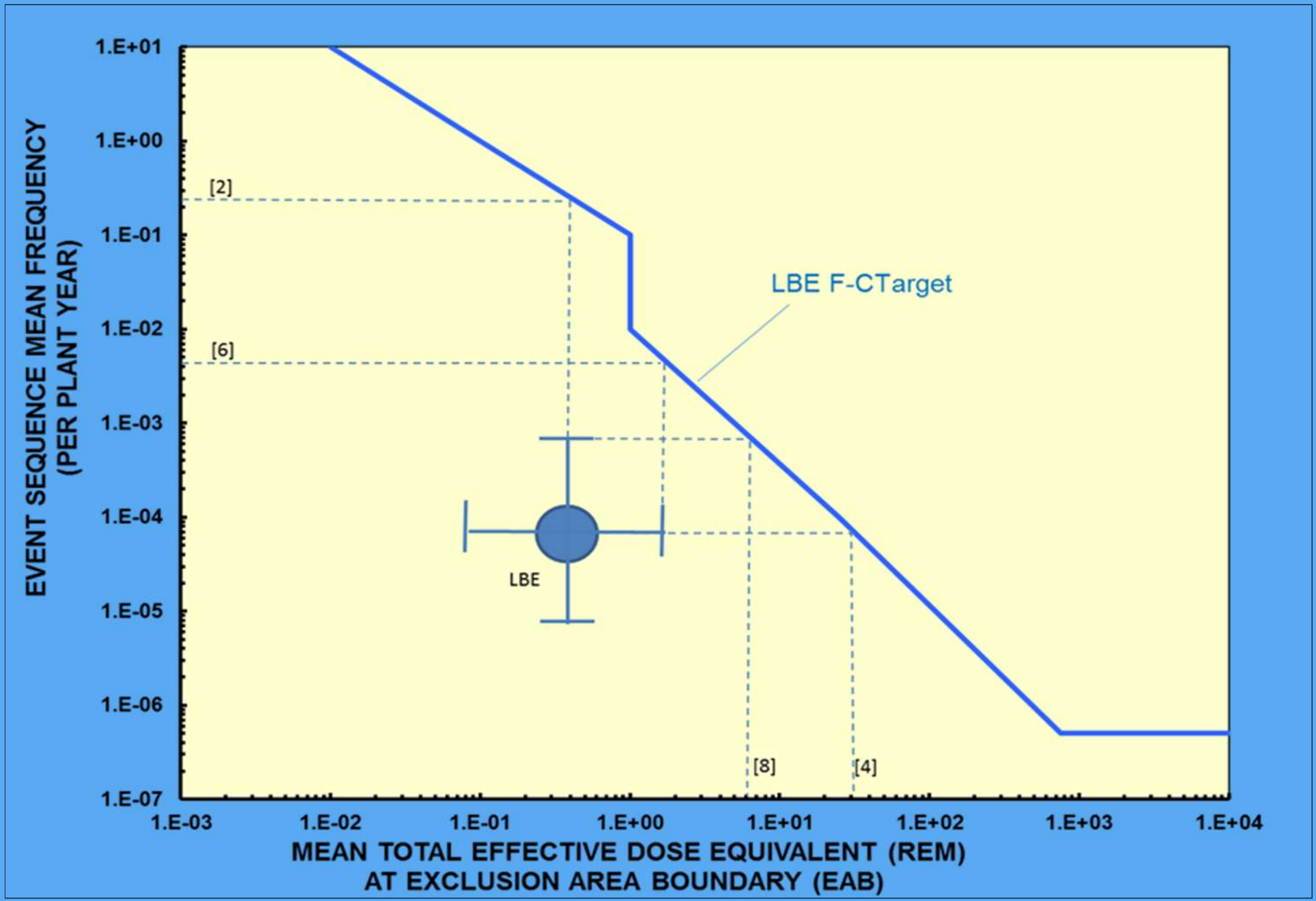
Plant Performance Margins

- Best Estimate
  - Doses below low dose threshold
  - Event sequence families below QHOs
- With Uncertainty Bands
  - AOOs that overlap DBE region
  - BDBEs that overlap DBE region
- DBA LBE Margins
  - Compared to 10CFR 50.34
  - Compared to 10 CFR 100
- SSC design performance conservatism
  - Use of Consensus Standards
  - Deterministic Margins around BE performance

LBE RISK-SIGNIFICANCE CRITERIA



EVALUATING MARGINS AGAINST F-C TARGET



EXAMPLE RISK MARGINS FOR MHTGR

LBE Category	Limiting LBE[a]			F-C Target			
	Name	Mean Freq. /plant-yr.	Mean Dose (Rem)	Freq. at LBE Dose/plant-yr. [b]	Mean Frequency Margin[c]	Dose at LBE Freq. (Rem) [d]	Dose Margin[e]
AOO	AOO-5	4.00E-02	2.50E-04	4.00E+02	1.00E+04	1.00E+00	4.00E+03
DBE	DBE-10	1.00E-02	2.00E-03	6.00E+01	6.00E+03	1.00E+00	5.00E+02
BDBE	BDBE-2	3.00E-06	4.00E-03	2.50E+01	8.30E+06	2.50E+02	6.00E+04

Notes:
[a] The Limiting LBE is the LBE with the highest risk significance in the LBE category
[b] Frequency value measured at the LBE mean Dose level from the F-C target, See [2] in **Error! Reference source not found.**
[c] Ratio of the frequency in note [b] to the LBE mean frequency, mean frequency margin
[d] Dose value measured at the LBE mean frequency from the F-C target, See [4] in **Error! Reference source not found.**
[e] Ratio of the Dose in Note [d] to the LBE mean dose, Mean Dose Margin

LBE Category	Limiting LBE[a]			F-C Target			
	LBE Name	95th Percentile Freq./plant-yr.	95th Percentile Dose (Rem)	Freq. at LBE Dose/plant-yr.[b]	95th Percentile Frequency Margin[c]	Dose at LBE Freq.(Rem)[d]	95th Percentile Dose Margin[e]
AOO	AOO-5	8.00E-02	1.10E-03	9.00E+01	1.13E+03	1.00E+00	9.09E+02
DBE	DBE-10	2.00E-02	6.00E-03	2.00E+01	1.00E+03	1.00E+00	1.67E+02
BDBE	BDBE-2	1.00E-05	1.50E-02	8.00E+00	8.00E+05	1.00E+02	6.67E+03

Notes:
[a] Limiting LBE is LBE with highest risk significance in LBE Category
[b] Frequency value measured at the LBE 95th percentile Dose level from the F-C target, See [6] in **Error! Reference source not found.**
[c] Ratio of the frequency in note [2] to the LBE 95th percentile frequency, 95th percentile Frequency Margin
[d] Dose value measured at the LBE 95th percentile frequency from the F-C target, See [8] in **Error! Reference source not found.**
[e] Ratio of the Dose in note [d] to the LBE 95th percentile dose, 95th percentile Dose Margin

- Completeness
  - PRA completeness for identified hazards
  - Sources of risk-significant uncertainties
  - Treatment of radiological and other hazards not included in PRA
- Analyzed
  - Data Availability
  - Model Maturity
  - Performance History
- Residual Risks
  - EPZ basis
  - EP response effectiveness
  - Tech Spec Completeness
  - AOT basis
  - Monitoring of Plant Long Term Performance
  - Etc.

COMPENSATORY ACTION DECISIONS

- Choices
  - Plant Capability
  - Programmatic
  - Mix
- Impact on Risk
  - Improve Plant Capability
    - LBE Outcome Changes
    - Layers of Defense increase or independence improvements
  - Improve Plant Performance Assurance
    - Programmatic actions
    - Reduction of Risk Significant Sources of Uncertainty
  - Reduce Residual Uncertainties
    - Siting and Emergency Planning performance
    - External Independent Oversight
- Timing - Life Cycle Considerations
- Practicality
  - “When is enough, enough?”

- LMP retains the NGNP SSC safety categories of SR, NSRST, and NST.
- All safety significant SSCs classified as SR or NSRST.
- Absolute risk metrics used for SSC and LBE risk significance.
- SR SSCs are not necessarily risk significant.
- NSRST SSCs include other risk significant SSCs and SSCs requiring some special treatment for DID adequacy.
- Specific special treatment for capabilities and reliabilities in the prevention and mitigation of event sequences.
- Special treatment defined / confirmed via integrated decision process using “forward fit” adaptation of 10 CFR 50.69 process.

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

ACRS Future Plant Designs Subcommittee

Draft Regulatory Guide (DG) 1353 and Related Commission Paper

"Technology-Inclusive, Risk-Informed, Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors,"

October 30, 2018 (PM)

Advanced Reactor Program

Draft SECY Paper

- Paper
  - The purpose of this paper is to seek Commission approval of the U.S. Nuclear Regulatory Commission (NRC) staff's recommendation to adopt a technology-inclusive, risk-informed, and performance-based methodology for informing the licensing basis and content of applications for licenses, certifications, and approvals for non-light-water-reactors (non-LWRs).
- Enclosure 1, "Background"
- Enclosure 2, "Technology-Inclusive, Risk-Informed, Performance-Based Approach"

Policy Background

- Advanced Reactor Policy Statement
- Pre-application evaluations (e.g., PRISM, MHTGR)
- SECY-93-092, "Issues Pertaining to the Advanced Reactor (PRISM, MHTGR, and PIUS) and CANDU 3 Designs and Their Relationship to Current Regulatory Requirements"
- SECY-03-0047, "Policy Issues Related to Licensing Non-Light Water Reactor Designs"
- Related initiatives to develop and implement risk-informed, performance-based regulation

Policy Background

SECY-03-0047, "Policy Issues Related to Licensing Non-Light Water Reactor Designs," and the related staff SRM dated June 26, 2003.

- Greater emphasis can be placed on the use of risk information by allowing the use of a probabilistic approach in the identification of events to be considered in the design, provided there is sufficient understanding of plant and fuel performance and deterministic engineering judgment is used to bound uncertainties;
- A probabilistic approach for the safety classification of structures, systems, and components is allowed; and
- The single-failure criterion can be replaced with a probabilistic (reliability) criterion.

Event Selection

- Consistent with SRM approving the use of a probabilistic approach to identify events provided there is sufficient understanding of plant and fuel performance and engineering judgment is used to address uncertainties
- Including a lower frequency range for licensing basis events, when combined with other considerations and engineering judgement, is an inherent part of a risk-informed approach and is consistent with the Commission’s SRM
- The F-C targets support defining needed SSC capabilities and reliabilities to support the design process and to inform the content of applications, considering uncertainties and multi-module issues
- Consistent with the Commission’s SRM approving replacement of the single-failure criterion with a probabilistic (reliability) criterion

Safety Classification & Performance Criteria

- The safety classification of SSCs and determination of performance criteria are directly related to and performed in an iterative process along with the identification and assessment of LBEs and the assessment of defense in depth
- Consistent with SRM allowing a probabilistic approach for the safety classification of SSCs
- Systematic approach to assessing and determining appropriate relationships between the needed capabilities and reliabilities for SSCs and the role of those SSCs in mitigating and preventing LBEs

Assessing Defense in Depth

- Framework that includes probabilistic and deterministic assessment techniques to establish defense in depth using a combination of plant capabilities and programmatic controls
- Assessments performed using several approaches to assess a reactor design and determine if additional measures are appropriate to address an over-reliance on specific features or to address uncertainties
- Includes verification that two or more independent plant design or operational features are provided to meet the guidelines for each licensing basis event
- Methodology includes use of an Integrated Decision-Making Process
- Staff is not proposing to more universally define DID criteria and seeks Commission acceptance of the NEI 18-04 approach for this specific case.

Informing Content of Applications

- NEI 18-04 provides useful guidance for reactor designers and the NRC staff for selecting and evaluating licensing basis events, identifying safety functions and classifying SSCs, selecting special treatment requirements, identifying appropriate programmatic controls, and assessing defense in depth
- Taken together, these activities support documenting the safety case and determining the appropriate scope and level of detail in applications for licenses, certifications, or approvals for non-LWRs

Recommendation

The staff recommends that the Commission approve the use of the technology-inclusive, risk-informed, and performance-based approach described in NEI 18-04 and DG-1353 for identifying LBEs, classifying SSCs, and assessing the adequacy of defense in depth. These key aspects of the proposed approach will also be used to inform the appropriate scope and level of detail for information to be included in applications to the NRC for licenses, certifications, and approvals for non-LWRs.

Working draft DG 1353 Scope

- Methodology supports identifying the appropriate scope and depth of information provided in applications for licenses, certifications, and approvals
  - 10 CFR 50.34, “Contents of applications; technical information,” describes the minimum information required for (a) preliminary safety analysis reports supporting applications for a construction permit, and (b) final safety analysis reports supporting applications for operating licenses.
  - 10 CFR 52.47, “Contents of applications; technical information,” describes the information to be included at an appropriate level in final safety analysis reports supporting applications for standard design certifications (DCs).
  - 10 CFR 52.79, “Contents of applications; technical information in final safety analysis report,” describes the information to be included at an appropriate level in final safety analysis reports supporting combined licenses (COLs).
  - 10 CFR 52.137, “Contents of applications; technical information,” describes the information to be included at an appropriate level in final safety analysis reports supporting standard design approvals (SDAs).
  - 10 CFR 52.157, “Contents of applications; technical information in final safety analysis report,” describes the information to be included at an appropriate level in final safety analysis reports supporting manufacturing licenses (MLs).

Working draft DG 1353 Findings

Licensing Basis Events

- **Staff Position:** NEI 18-04 provides an acceptable method for identifying and categorizing events with the following clarifications:

a) The staff emphasizes the cautions in NEI 18-04 that the F-C target figure does not depict acceptance criteria or actual regulatory limits. The anchor points used for the figure are surrogates for other measures that may be expressed in different units, time scales, or distances. The F-C target provides a reasonable approach to be used within a broader, integrated approach to determine risk significance and support SSC classification and confirm the adequacy of DID [defense in depth].

b) The F-C target and related discussions in NEI 18-04 include a frequency of 5x10-7 per plant-year to define the lower range of beyond design basis events. This demarcation of lowest event frequencies on the F-C target and category definitions should not be considered a hard and fast cutoff but should instead be considered in the context of other parts of the methodology described in NEI 18-04. These other considerations include the role of the integrated decision-making panel, DID assessments, accounting for uncertainties, and assessing for potential cliff-edge effects.

Working draft DG 1353 Findings

Licensing Basis Events

c) NEI 18-04 describes a set of DBEHLs that will determine the design basis seismic events and other external events that the safety related SSCs will be required to withstand. When the DBEHLs are determined using NRC-approved methodologies, this approach is generally consistent with current practices and provides acceptable protection of safety-related SSCs. When supported by available methods, the PRA model is expected to address the full spectrum of internal events and external hazards that pose challenges to the capabilities of the plant, including external hazard levels exceeding the DBEHLs. The inclusion of external events within the BDBE category supports the overall risk-informed approach in NEI 18-04 and the DID assessments described in subsequent sections. NEI 18-04 states: “When supported by available methods, data, design and site information, and supporting guides and standards, these DBEHLs will be informed by a probabilistic external hazards analysis and included in the PRA after the design features that are included to withstand these hazards are defined.” To the degree that applicants propose methods to identify DBEHLs that have not been previously reviewed and approved by the NRC, the staff would review the proposed methodologies on a case-by-case basis.

Working draft DG 1353 Findings

Licensing Basis Events

d) NEI 18-04 describes how the application of a single failure criterion is not deemed to be necessary for non-LWRs using the methodology because they will employ a diverse combination of inherent, passive, and active design features to perform the required safety functions across layers of defense and will be subjected to an evaluation of DID adequacy. The process described in NEI 18-04 includes assessing event sequences (including reliability and availability of SSCs and combinations of SSCs) over a wide range of frequencies and establishing risk and safety function reliability measures. … The approach described in NEI 18-04 is consistent with the Commission’s SRM approving the recommendation in SECY-03-0047 to replace the single-failure criterion with a probabilistic (reliability) criterion. …

e) The methodology in NEI 18-04 includes a potentially expanded role for PRA beyond that currently required by 10 CFR Part 52. The staff’s review of the PRA prepared by a designer could be facilitated by the NRC endorsement of consensus codes and standards (e.g., ASME/ANS RA-S-1.4, “Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants”) and the use of that approved standard by the designer.

Working draft DG 1353 Findings

Safety Classification & Performance Criteria

- **Staff Position:** NEI 18-04 provides an acceptable method for assessing and classifying SSCs as safety related, non-safety related with special treatment, or non-safety related with no special treatment. The staff offers the following clarification:

a) The SSC classifications and logic outlined in NEI 18-04 are part of an integrated methodology, which includes a defined relationship between licensing basis events, equipment classification, and assessments of DID. The classifications and related outcomes may not be applicable for alternative approaches that do not follow the other parts of the methodology described in NEI 18-04.

Working draft DG 1353 Findings

Evaluation of Defense-in-Depth Adequacy

- **Staff Position:** NEI 18-04 provides an acceptable method for assessing the adequacy of DID to be provided by plant capabilities and programmatic controls, with the following clarifications:

a) Section 5.9.6, "Considerations in Documenting Evaluation of Plant Capability and Programmatic DID," discusses change control processes following the issuance of a license, certification, or approval. The staff plans to address such change control processes in future guidance documents and therefore makes no findings on this section of NEI 18-04.

Working draft DG 1353 Findings

Other Considerations

- Emergency Preparedness
  - … For non-LWRs, the spectrum of events is expected to be the LBEs as described in NEI 18-04, adjusted as necessary to reflect the specific criteria in the emergency planning decisionmaking process (e.g., dose calculations over 96 hours from the release of radioactive materials in DG-1350 versus 30 days in NEI 18-04 for plotting on the F-C target).

- Mechanistic Source Term
  - …While not addressed in detail within NEI 18-04, the development of mechanistic source terms for designs and specific event families is another element of an integrated, risk-informed, performance-based approach to designing and licensing non-LWRs. Applicants are expected to provide in their applications or related reports a description of their mechanistic source terms, including the retention of radionuclides by barriers and the transport of radionuclides for all barriers and pathways to the environs. Where applicable, a facility may have multiple mechanistic source terms and specific event sequences to address various systems that contain significant inventories of radioactive material.

Working draft DG 1353 Findings

Informing Content of Applications

- NEI 18-04 provides useful guidance for applicants to identify and provide the appropriate level of information needed to satisfy parts of the regulatory requirements in 10 CFR 50.34, 10 CFR 52.47, 10 CFR 52.79, 10 CFR 52.137, and 10 CFR 52.157.
- Combination of deterministic evaluations and probabilistic risk assessments
- Information needed on fuel, primary, and other barriers to define limitations, performance characteristics, and as input to mechanistic source term
- Information needed on SSCs and programmatic controls associated with key safety functions
- Scope and depth for other information (e.g., ancillary plant systems) to be determined based safety/risk significance (i.e., roles in preventing or mitigating licensing basis events)
- Level of detail can also reflect potential performance-based approaches (see Introduction, Part 2, to NUREG 0800)

DG 1353 & Related SECY

- Target Schedule
  - *ACRS Subcommittee* — *June 19, 2018* ✓
  - *Draft NEI 18-04, DG-1353, SECY* — *Sept 28, 2018 (public, to ACRS)* ✓
  - ACRS Subcommittee — Oct 30, 2018 ✓
  - ACRS Full Committee — Dec 6, 2018
  - Issue DG-1353 — Dec 21, 2018
  - Issue SECY — early 2019
  - ACRS Interactions — mid 2019
  - Issue Final RG — TBD 2019