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UNITED STATES NUCLEAR REGULATORY COMMISSION'S ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

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UNITED STATES OF AMERICA

NUCLEAR REGULATORY COMMISSION

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ADVISORY COMMITTEE ON REACTOR SAFEGUARDS

(ACRS)

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FUTURE PLANT DESIGNS SUBCOMMITTEE

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TUESDAY

JUNE 19, 2018

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ROCKVILLE, MARYLAND

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The Subcommittee met at the Nuclear Regulatory Commission, Two White Flint North, Room T2B1, 11545 Rockville Pike, at 8:30 a.m., Dennis Bley, Chairman, presiding.

COMMITTEE MEMBERS:

DENNIS C. BLEY, Chairman

RONALD G. BALLINGER, Member

CHARLES H. BROWN, Member

MARGARET CHU, Member

MICHAEL CORRADINI, Member*

JOSE MARCH-LEUBA, Member

HAROLD RAY, Member*

JOY L. REMPE, Member

PETER C. RICCARDELLA, Member*

GORDON R. SKILLMAN, Member

MATTHEW SUNSERI, Member

DESIGNATED FEDERAL OFFICIAL:

CHRISTIANA LUI

ALSO PRESENT:

AMIR AFZALI, Southern Nuclear Operating Company

GEORGE APOSTOLAKIS, LMP

AMY CUBBAGE, NRO

KARL FLEMING, LMP

BILL RECKLEY, NRO

JOHN SEGALA, NRO

*Present via telephone

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

P R O C E E D I N G S

(8:33 a.m.)

CHAIR BLEY: The meeting will come to order. Good morning.

MEMBER MARCH-LEUBA: Good morning.

CHAIR BLEY: This is a meeting of the Advisory Committee on Reactor Safeguards Subcommittee on Future Plant Designs. I'm Dennis Bley, Chairman of the Subcommittee.

The ACRS Members in attendance or shortly to be in attendance are Dr. Joy Rempe, Charlie Brown, I don't know about Walt, Jose March-Leuba, Dick Skillman, Margaret Chu, Matt Sunseri and Ron Ballinger.

ACRS Members Michael Corradini, Pete Riccardella and Harold Ray are attending remotely. That's what all of this shenanigan was about.

Christiana Lui of the ACRS staff is the Designated Federal Official for this meeting. The purpose of today's meeting is to hear an introduction to the guidance document entitled, Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors.

This is an information only meeting. So the Subcommittee will gather information at today's

meeting. The Subcommittee is scheduled to review the final version of the guidance document and associated documents at an October 2018 Subcommittee meeting.

Just an aside, when you get to it maybe you'll expand, one of your slides talks about an NEI guidance document which I guess follows on from this. But if you can let us know how that's hooked in it would be appreciated.

Full Committee is scheduled to address this matter at the December 2018 full Committee meeting. ACRS was established by statute and is governed by the Federal Advisory Committee Act, 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.

We have received no requests to make comments at today's meetings. That said, we also set aside time for extemporaneous comments from members of the public attending of listening to our meetings. Written comments are also welcome.

The ACRS section of the U.S. NRC public

website provides our charter, bylaws, letter reports and transcripts of all full and Subcommittee meetings including the slides presented at the meeting. Detailed proceedings for conduct at ACRS meetings was previously published for this meeting in the Federal Register October 4, 2017.

The meeting is open to public attendance. As mentioned, time has been allotted on the agenda near the end for comments. Today's meeting is being held with a telephone bridge line allowing participation of public over the phone.

Also as mentioned a separate teleconference line has been established to allow participation of three ACRS Members remotely. A transcript of today's meeting is being kept.

Therefore we request that the meeting participants on either the bridge line or the teleconference line identity themselves each and every time they speak and to speak with sufficient clarity and volume that they can be readily heard.

We request that those participants on the public bridge line keep their phones on mute until they are called on to speak during the public comment period. Participants in the meeting room should use the microphones throughout the meeting room.

At this time I ask everyone in the room to please silence all their electronic devices. I remind speakers at the front table to turn on your microphone when you speak and turn it off when you're not speaking just to keep the noise on the line down.

We will now proceed with the meeting. Before I introduce others, I just wanted to welcome old friends and colleagues back and everyone who is here to talk today and remind ourselves and some of you that the history of some of what we're going to hear, as far as I know, goes back at least to the late 1980s with the modular HTGR application and the NRC's review of that application in NUREG 1338.

In 2007, NUREG 1860 originally known as the Technology Neutral Framework was published. A lot of interaction with ACRS on that one and a letter from ACRS generally supporting. But a couple of negative comments on it.

In 2010, the DOE NGNP white papers were reviewed by the staff and submitted, including one on licensing basis events. There was a staff assessment of those white papers and we wrote a letter on that staff assessment, made some comments.

Pretty much the staff agreed with our comments. But then months later when the final

version of their review was published all mention of this process kind of disappeared, ostensibly because the staff was worried about getting ahead of the Commission on this issue.

But that's all part of our history. Then there was NUREG 2150 which one of our speakers today is responsible for, the proposed risk management regulatory framework in 2012.

In 2018, we had the staff white paper on functional containment which also included some of these ideas. And Reg Guide 1.232, ARDS, the Advanced Reactor Design Criteria published as guidance for developing principle design criteria was out.

And on those, that last one there was also quite a bit of ACRS interaction in the letter. And one side report I'm going to ask you folks about when we get to the defense-in-depth area was in 2016 there was a new kind of NUREG called Knowledge Management-0009 on the history and observations of defense-in-depth which I believe we wrote a letter on that.

And I'm not sure I saw that mentioned in the documents I've reviewed. Anyway, just to bring us up. We've had a long interaction. We've been looking forward to today especially through our discussions on the Advanced Reactor Design Criteria earlier this

year.

And almost the whole Committee is either here or on the phone today to follow this. So even though it's an off week it's drawn quite a bit of attention. At this time I would like to --

MEMBER REMPE: Before you do that, I've been getting emails from Mike and Pete that are timed at 8:35. They were complaining all they could hear was music. It would be good to --

CHAIR BLEY: Please check on it.

MS. LUI: It's being addressed right now.

MEMBER REMPE: Okay, thank you.

CHAIR BLEY: If we get more of those please pass it on to Chris so go ahead with that.

(Off record comments)

CHAIR BLEY: Thank you. At this time I would like to turn, do you have another comment?

MEMBER MARCH-LEUBA: She's not getting the emails. You're not connected are you?

CHAIR BLEY: We will now proceed with the meeting. I'm going to call on John Segala, Chief of the Advanced Reactor and Policy Branch Office of NRO to make introductory remarks, John.

MR. SEGALA: Okay, thank you. I think you had mentioned just now that we had previously briefed

the Subcommittee on the NRC's vision and strategy and our near term implementation action plan for advanced reactors last year.

And then we followed that up with presentations on our Reg Guide 1.232 on principle design criteria for advanced reactors and then functional containment. Industry has been working on this licensing modernization project developing an NEI document which they plan to request the NRC endorsement in a regulatory guide.

We are in the process of starting to develop that draft regulatory guide. And so we're looking forward to the Committee's feedback today that we can use to help direct and, you know, incorporate into the development of the draft guide.

CHAIR BLEY: So you envision this being something like 0209. You'll endorse either fully or partially --

MR. SEGALA: Yes.

CHAIR BLEY: -- this paper when it finally comes out. And that's the one we expect will be an NEI document.

MR. SEGALA: Yes.

CHAIR BLEY: Okay, thanks. And by October when you come back will your review be complete? Is

that the expectation?

MR. RECKLEY: This is Bill Reckley. At least well enough to support a draft guide.

CHAIR BLEY: Okay, thanks. And if you're finished I guess we'll turn it over to Amir Afzali, Afzali, sorry. I can't get all my consonants out.

MR. AFZALI: Good enough.

CHAIR BLEY: Amir.

MR. AFZALI: Good morning, Amir Afzali from Southern Company. I'm the project lead for licensing modernization project. It's a pleasure and we are very excited here to discuss our activities with you.

My job was to provide some type of a context on where we are and then pass on all the difficult challenges to George and Karl. But you guys did an excellent job of putting a context on why you are here and what we are doing at this phase.

So I'm going to potentially repeat some of the issues that was discussed already or explained already. Next page please. Do I do it or what? How does this work?

CHAIR BLEY: Before you pass it on let me, I've just seen this email stream they were talking about, if our Members on the line are there please say

something so we can hear if you can talk to us.

MEMBER RAY: This is Harold.

CHAIR BLEY: Thank you, Harold.

MEMBER RICCARDELLA: This is Pete.

CHAIR BLEY: Okay, and, Mike.

MEMBER CORRADINI: And Corradini is here.

CHAIR BLEY: Okay. We've got you all. So if you want to talk at any time feel free and we should be able to pick you up, thanks.

MEMBER CORRADINI: We'll go on mute on our side. We'll keep it to a minimum.

CHAIR BLEY: Thank you.

MEMBER RICCARDELLA: The same.

CHAIR BLEY: Karl or George --

MR. AFZALI: Shall I continue? Yes, again here I would do a little bit of introduction then we get some high level comments on our proposal, feasability of our proposal from Dr. George Apostolakis who is one of the Advisory Members of our project.

Our other two advisors are former Commissioner Dick Meserve and former Commissioner Jeff Merrifield. And then Karl will, who is leading a team of experts will discuss about the technical basis, our proposal and our technical basis for those proposals.

Next page please.

So the project fundamentally is trying to develop a foundation for an integrated licensing for advanced reactors. So again, this is not the entire licensing framework. It is the foundation for creating that licensing framework.

It's trying to integrate three most important aspects, fundamental and important aspects of licensing which is, which are licensing basis event selection, SSC classification and defense-in-depth evaluation adequacy determination.

So those are a fundamental part of starting your licensing process and finishing the licensing. So beginning and the end of your licensing process.

MEMBER REMPE: So, excuse me, but just to make sure it's clear in my brain. You're going to do this for folks that are trying to pursue a Part 50 or a 52. You're not trying to limit it to one or the other, right?

MR. AFZALI: That's correct. So if you look at the Part 52 or Part 50 the fundamental technical requirements are the same. The processes to go from A to Z is different.

But the fundamental technical requirements

are the same. So other than maybe Part 52 requires PRA and Part 50 at this point may not require it. That's debatable. But fundamentally that's a technical requirements.

MEMBER REMPE: But when we get to later discussions there's something you're going to need if you're going to tie it to dose if you go with a 52, something associated with some sort of site. Back in the MHTGR days there was EPRI document that we had used to try and tie it to dose.

And I didn't see this in the discussion I read. But we can get into that later I assume during Karl's presentation.

MR. AFZALI: That's true.

MEMBER SKILLMAN: Amir, I feel compelled to follow on Dr. Rempe's question. Was there a bias or a sense or preference that for the newer non-light water reactors Part 50 would be the better path versus Part 52?

MR. AFZALI: You're asking me a very difficult question because it's totally a business decision in my opinion. So it just, personal opinion is not LMP's opinion, it is not Southern Company's opinion it's just personal opinion.

I would say that a lot of the utilities as

a whole, the people who run it would prefer a Part 52 approach. The developers would prefer a Part 50 approach just an extremely general statement and personal opinion. So I don't --

MEMBER SKILLMAN: I appreciate your candor. Most of us have dealt with both sides of that and understand benefits and challenges associated with one side or the other.

But I would think there might in fact be a preference if you're going to have salt cold or lead cold or something that's not a light water reactor given what we've learned and how to do a Part 50 versus a Part 52. So it was just a curiosity question and thank you.

MR. AFZALI: Thank you. So the last bullet on that slide is very important. We're talking about multiple technology and multiple designs within each technology.

Okay. So we are not talking about one technology. We are talking about multiple technologies and multiple designs within each technology.

This systematic approach allows us to have technical requirements which are, which provide a balance to all these technologies as a systematic

range is repeatable and doesn't bias one design or one technology.

So it, other potential approaches may, if they're not systematic enough, may create differences making different designs simply because of the ad hoc nature. So we're trying to create a coherent path to efficient.

But the coherency is the important part of our objective.

CHAIR BLEY: Amir, before you go on. Two things. One is a question and one is more of a comment. And I guess I would ask the other presenters this.

Your second bullet talked about integrate new advances in risk-informed performance based methods. If there are new advances since 1860 and the DOE white papers maybe you can point those out as we go along. I would find that very interesting.

On this last one the coherent path, I recall during the trial application of 1860 they took it back to an existing PWR and one of the people who had been involved in that PWR, the PRA did a lot of that work.

But there was a lot of effort in keeping the analysis coherent when you start trying to apply

the criteria that will be talked about later deciding licensing basis events you can break up into smaller and smaller pieces which makes the frequency go down and down and down so you can meet any criteria.

So how do you keep this whole thing coherent and group it in such a way that it's a meaningful application? And I would be happy to wait for that until we get to the appropriate parts of the talk today.

MR. FLEMING: I will be happy to answer.

CHAIR BLEY: Okay. And I know Karl has done that before in other applications. So we would be very interested in hearing that.

MEMBER MARCH-LEUBA: I wanted to remind you that you need to turn the phone, the microphone on otherwise you won't be on the record. John Stetkar left me in charge of microphones.

MR. FLEMING: I will address your question, Dennis. Thank you.

MR. AFZALI: So, as I said at the beginning of this discussion we're going to provide the presentation that familiarizes you with our processes. The three processes we are going to be discussing are selection and evaluation of licensing basis events, SSC classification and defense-in-depth

adequacy determination.

You can see I have highlighted the first, we have highlighted the first and the third bullets on there. We believe a very robust conversation around those two topics are going to be fundamental in taking us to the next steps.

So although SSC classification is extremely important it is a combination of the first and the third bullet kind of and they are all integrated. So you cannot say which one is most important.

But I think the area where we need the most feedback on are the first and the second bullet, okay. Next slide. So just a summary of where we are right now.

We are trying to develop a set of procedures which are for the developers and for the NRC endorsement. So when we started it is the how's and the what's.

We believe the NRC staff are not in a position to endorse the how's because I think that would be prescriptive on our developers. But the what's are what we are trying to establish.

So our white papers include the how's and the what's. The guidance document only includes the

what's. So if you are a developer you need to read the white papers from the endorsement point of view as the guidance document.

That guidance document is going to be finally issued as an NEI document. I believe, correct me if I'm wrong, 18-04 is the number which is assigned to that particular document. And that would be endorsed through a Reg Guide as previously said by Bill and others.

So again, the staff review has been provided in the white papers. We have had at least two new things where we have discussed the requirements on the guidance document, the working sessions.

We have kind of modeled our activities similar to what was done for Fukushima response activities where there was a lot of public meetings discussing comments from each side and trying to get the document to the end point as quickly as we can.

And the final document, as I said, is a risk-informed performance guidance document.

CHAIR BLEY: Before you go on, I understand you want it to be a what document. But you're going to need some at least examples which will to some extent be showing possible how's to do this.

Are they going to be part of this guidance or do you envision that as a separate document?

MR. AFZALI: So we're going to, I'm going to defer that at a later date to people who understand that juggling the regulatory implications of NRC endorsing a document. Do they endorse a document it gets appendices or not for example or just a document?

CHAIR BLEY: It's been done both ways in the past.

MR. AFZALI: Yes, so I don't have a full answer to that question yet. But we will make both of them available for the developers and the NRC.

CHAIR BLEY: Are you expecting the examples to be in place by October or is that too optimistic?

MR. AFZALI: Too optimistic.

MEMBER CORRADINI: So this is Corradini. I'm kind of just jumping on with Dennis. I think an example is very important because I found it very hard to follow the what's and then go back to the four white papers to understand the how's without some sort of examples.

Maybe I'm just too much of a pragmatic or empirical engineer. But I do think that's very important. And I was going to ask a question. Is the

example that you're developing a non-LWR or are you going to go back to the 1860 approach and use an LWR which is more of a known quantity?

MR. AFZALI: I'll start and then you finish it. So we are doing, we have done examples. We are doing multiple tabletop exercises. We have completed one already.

With that said, I was just talking about how we are going to present that information and when not whether we are going to do it or not. So with that said, Karl, did you want to add something?

MR. FLEMING: Yes. I wanted to clarify that we started with the four white papers built on the NGNP white papers and bringing into account more recent information including ACRS comments and so forth.

And then we went to the guidance document to abstract down the things that we thought were appropriate for an NRC endorsement. The white papers do have examples.

In the PRA and the LBE paper we have examples from the MHTGR and the PRISM in terms of how one works from the probabilistically-derived licensing basis events and deriving, you know, design basis accidents.

We also have in the SSE paper in the appendix how the MHTGR came up with functional design criteria safety classification and so forth. The MHTGR applied the steps in the first three white papers with some things that were not available at that time with some exceptions.

But they, all the way out to safety classification in the LBEs. So those example are in the white papers and it's our intent that as we finalize the guidance document we will go back and make any adjustments to the white papers to make sure that the white papers are in synch with the guidance document.

And as Amir points out, we do plan to do some tabletop exercises to expand the capability, expand the inventory of examples and those are in the planning stages and we'll incorporate those as they're available into these documents.

MEMBER CORRADINI: Thank you.

MR. AFZALI: So I'm going to finish up with just one statement and then turn it to Dr. Apostolakis. And that statement is that I do realize that there are not many developers coming in and asking the NRC to review their application.

But and that sometimes creates this sense

of there are no applications, there is no sense of urgency. Currently there are many, many developers that invested a significant amount of their dollars and the government is doing the same in developing those designs.

Developing those designs without a, this is my opinion, developing those designs without a method that allows them to decide on these fundamental questions are going to potentially cause future challenges as they are putting the applications in front of the staff.

So if there's no sense of urgency perhaps from the application being in front of the NRC point of view there is a sense of urgency from developers developing a design which ultimately is going to be acceptable to our regulators.

With that said, I'm going to turn it over to Dr. Apostolakis.

CHAIR BLEY: Before you go ahead there is one other area you speak of and you'll get to it here later. One other use for this work and that's to come up with or support the development of principle design criteria.

We've had a year or so of going over where the NRC staff has been maneuvering here and at least

to me as we went through it I think their focus changed from one of having advanced reactor and HTGR and sodium cooled reactor design criteria that would be in a final design criteria to developing their Reg Guide to help people come up with their own design specific criteria.

So I had two things I'm interested in. The one I'm pretty sure you'll get to. The other one I hope you'll expand on. One is how you use this process to help support development of those principle design criteria.

And the other is if we have Advanced Reactor Design Criteria in the Reg Guide that people can look at to help them, how do we ensure that the principle design criteria are complete, that they don't just look for the ones that have already been identified in a more generic way when they're looking on their own specific plan?

If that's something you would rather wait until you get to it that's fine.

MR. RECKLEY: I'll address that.

MEMBER REMPE: As you address it is the vision that you would avoid any exemptions? I mean is that the vision and is that what you're trying to achieve with this process?

MR. AFZALI: The desirable outcome would be getting an application in front of the staff which does not require any exemptions. However, because we haven't actually exercised the activity it's very hard to say that's going to be the case or not.

So desired outcome, yes. Whether we believe that's a practical solution I would not be able to make a comment on that. With that, Dr. Apostolakis.

DR. APOSTOLAKIS: Excellent, okay. This is something I haven't done before, by the way being on this side of the table.

CHAIR BLEY: You know, there are a couple --

DR. APOSTOLAKIS: I know.

CHAIR BLEY: There are a couple of Members who had they known you were coming this month would have delayed their retirement I'm sure.

DR. APOSTOLAKIS: Okay. I'll just make a few fairly high level comments. I have been reviewing the documents and as Amir said I'm a Member of the Advisory Team. We'll come back to that.

The first issue I would like to address is the issue of PRA. PRA of course is the foundation or the cornerstone of the approach. And people may raise

questions, you know, how reliable is it and so on.

My third bullet is something that I really love. I've noticed over the years that because PRA was the new kid on the block people focused on its limitations, shortcomings and so on and there is an implicit assumption that the existing system is preferred.

And I will show you examples that show that the existing system is far from being perfect. And, you know, I've seen IAEA documents and so on. PRA here are the limitations.

And there is never a section on the limitations of the traditional system.

MEMBER MARCH-LEUBA: Let me be, Dr. Apostolakis, for you and stop you right there. If I understand what we are proposing you are going to do a deterministic analysis, the old analysis to determine, you find your LBEs.

And then you're going to weed them out with risk-informed --

DR. APOSTOLAKIS: No, that's not my understanding. We start with a PRA defining the licensing basis events.

MEMBER MARCH-LEUBA: How can you do a PRA if you don't know what your events are?

DR. APOSTOLAKIS: Coming next, next slide. So there is, next slide.

MEMBER MARCH-LEUBA: No, no, don't move it yet. Okay, I'll wait for the next slide. You need to show me why your statement makes sense.

DR. APOSTOLAKIS: Okay.

MEMBER MARCH-LEUBA: Because you made a mention that Charlie wasn't a skeptic. You have found another one.

DR. APOSTOLAKIS: And, okay. One interesting development is that there is also a standard from the ASME and ANS on the PRA for advanced non-LWRs and LWRs.

I think we're in a situation now that is very similar to what was happening in the early 1970s when the Atomic Energy Commission at that time decided to do a PRA what came to be known as the WASH-1400. Indeed there was no operating experience from, to support the study.

They collected failure data for components from all over the world. And of course they used extensively expert judgment especially for human errors.

The internal event analysis that WASH-1400 did has survived to this day. They did a remarkable

job 45 years or so, 43 years later. For internal events we're still using the same approach.

So one of the most influential and consequential PRAs was completed with minimal operating experience at the time. And the next slide we give examples and then we will come to you. Next slide.

MEMBER MARCH-LEUBA: I know that I have a clear exception to your statement here. I mean let's go back to the 1970s. Everyone knew, everybody knew that PRA analysis knew that if you survive a large break LOCA for sure you will survive a small break.

We don't even need to analyze it. And we are stuck analyzing small breaks after we have operation experience in TMI that the small breaks need to be analyzed.

DR. APOSTOLAKIS: No, I disagree. First of all not everybody knew. Everybody assumed that the large break LOCA was a bounding accident. It's not that they knew it.

The Reactor Safety Study showed, next, that a small LOCA was a major contributor to it.

MEMBER MARCH-LEUBA: Was that performed before or after TMI?

DR. APOSTOLAKIS: Before. That was the

whole point.

MEMBER MARCH-LEUBA: And no action was taken?

DR. APOSTOLAKIS: The Commission made a big mistake. Because of the controversy they directed the staff not to use the Reactor Safety Study in any regulatory activities which meant as Norm Rasmussen used to say everybody had 11 blue volumes in their office and nobody read them.

Then four years later TMI comes and somebody says, well, gee that looks like it's in the Reactor Safety Study and the study became again legal in the sense that the staff was allowed to use it. So it was a confirmation of what the Reactor Safety Study found.

It was four years, five years actually because in 1974 we had the draft report out. So it was the other way around. Transients also the study said are very important.

Human errors, it still puzzles me that the traditional system up until that time ignored human performance completely. It was the Reactor Safety Study that said no human errors are important.

I still remember when we were doing the Zion/Indian Point PRAs we were in a room in Southern

California and the human error ratio came up and the representative of the utility stood up. He was very agitated and said my operators are trained.

They will never do what you say. Nobody will say that today. That Zion/Indian Point PRAs came out four or five years later and showed that earthquakes and fires are among the dominant contributors to risk.

And then interestingly enough the Commission in '84 and '88 issued two rules for two reasons. One reason was that there was some operating experience showing that you could have an adverse event and a station blackout but also that PRAs have shown that these were important from the risk perspective.

So we had two rules. The reason why I'm saying that is because we can divide the last 40 years or so into two periods. The first years after the Reactor Safety Study and other PRAs like Zion and so on we saw a lot of regulatory activity, new rules, new orders.

One of the very first ones was the utilities should make sure that the auxiliary feedwater system is actuated automatically. In some plants it was manually actuated.

The Reactor Safety Study said that's not a good idea from the risk perspective. So there was a lot of regulatory activity. So then after the August statement of '95 we started seeing some relaxation of the regulations which creates the wrong impression to many people that PRAs are used to relax the regulations which is absolutely not true.

It's because of this separation in time that first when we took care of the regulations and then we started relaxing the regulations. The reactor oversight process provides objectivity through the assessment of the culture of the plant.

An example of the extension of the allowed outage times provides flexibility to the licensees. That was the very first risk-informed initially by the way approved by the Agency.

And in addition to extending the times it had a major psychological impact. The staff and the industry did not trust each other. So after they allowed, outage time was extended to 14 days I was here talking to the staff wait and see. Those guys on the other side will go to the fourteenth day before they fix anything.

Evidence from South Texas Project showed that within five days they had fixed the problems.

And that started building trust between staff and the industry that everybody was serious.

And of course when it comes to burden reduction and improving safety nothing can compete with risk-informed ISI which I understand all the plants now have implemented.

CHAIR BLEY: George, there is one of those examples. There's a lot more examples you could have cited. But there was one that I was personally involved in and interested in.

Back to the time of these early PRAs they showed that common cause failure of reactor trip breakers is a lot more likely than people thought because of the way they were forced to disable the shunt trip mechanism on the breakers which makes them much more vulnerable to poor maintenance caused failure.

And that was years before the Salem event finally led the staff to let them put the shunt trip back into the reactor trip breaker circuits.

MEMBER CORRADINI: So can I make a comment? I think I know where Jose is coming from. But I guess I would argue to Jose, I'm sure he'll respond, is that everybody in their mind does the equivalent of an ill-conceived or inadequate PRA by

even assuming a set of deterministic accidents that we must design against.

I think what I heard George is saying that the WASH-1400 regularized the process of engineering thinking so that you came up with insights that you would not have by making assumptions of what are the limits. That's what I hear from George's discussion.

MEMBER MARCH-LEUBA: But what I see in reality is that you come out with a list of accidents and then you weed them out based on PRA results.

MEMBER CORRADINI: But you don't necessarily, I guess I would disagree, Jose.

MEMBER MARCH-LEUBA: You don't?

MEMBER CORRADINI: I read the guidance and the starting point is you start off with a list of LBEs. But you don't weed them out. They may grow, they may shrink.

They may move relative to each other on terms on frequency and their dose. But you're always iterating on what you think can challenge the system.

MEMBER MARCH-LEUBA: Right, which is what they call developing a list of LBEs. What can possibly happen?

MEMBER CORRADINI: But I guess, let me just fight back. That's what you would call

developing a systemized approach of risk analysis.

MEMBER REMPE: And when I was working at GA we used to laugh about a transient plant design because they would add a system so you could weed out an event and have a lower frequency. And so we would constantly be iterating on what we were analyzing.

DR. APOSTOLAKIS: So the point is that if you don't want to do this because the PRA is incomplete I would argue the so-called deterministic approach is incomplete too. How are you going to do it?

You're going to get a bunch of guys in a room and say well I think this may happen. Okay, let's make it a design basis accident.

MEMBER MARCH-LEUBA: I would call it the Murphy Rule. If it can happen it will happen.

DR. APOSTOLAKIS: Sorry.

MEMBER MARCH-LEUBA: The Murphy Rule. If it can happen, it will happen.

DR. APOSTOLAKIS: Well I'm not so sure about that. That rule has not been approved by Congress.

MEMBER MARCH-LEUBA: It hasn't been approved by anybody. But it happens in life.

DR. APOSTOLAKIS: But a large LOCA has

never happened.

MEMBER MARCH-LEUBA: Right.

DR. APOSTOLAKIS: And it's still the cornerstone of regulations. It's very expensive. It affects many other things like the containment spray system and so on.

That was a lot of research from Lawrence Livermore National Laboratory showing that you will have a leak before a break. The rule is the same. It was the same as it was in the time of Athens and Rome.

That's a major problem of the design basis accidents. They don't evolve.

MEMBER MARCH-LEUBA: What is the safety implications of having a LOCA?

DR. APOSTOLAKIS: What comes to mind is the automatic actuation of the core spray system when there is no need for it. And it has been observed I understand three or four times.

And I know the Agency doesn't worry about that. But the cost, I mean these guys --

MEMBER MARCH-LEUBA: We're going back to this. You're thinking cost. You're not thinking safety. So maybe you are --

DR. APOSTOLAKIS: Your statement to be said to me that I don't care about safety. My whole

damn career was on safety. I'm sorry. I know a presenter to the ACRS is not supposed to react that way.

But, you know, don't tell me I don't care about safety. So the Commission's PRA policy statement in 1995 says a probabilistic approach to regulation enhances and extends the traditional approach by allowing the consideration of a broader set of potential challenges.

In this case the potential challenges are the LBEs. Okay, instead of going straight to the design basis accidents we start with a broad set of licensing basis events and then derive the DBAs from there, next.

MEMBER SKILLMAN: George.

DR. APOSTOLAKIS: Yes.

MEMBER SKILLMAN: Let me make, I think you're selling yourself short.

DR. APOSTOLAKIS: Okay.

MEMBER SKILLMAN: I am in agreement with what you're doing here. But I think what you haven't communicated and what needs to be communicated right up front is that this is driven by a recognition of what are quantitative health objectives and other very high level safety objectives.

And if those are held as the, if you will, the guiding limits or the guidelines that develop through a systematic approach how the plant should behave, whatever the plant design might be, then I think the argument that you're projecting really hangs together and it challenges Dr. March-Leuba's challenge.

What you haven't said is what this is, is a rigorous systematic approach to make sure that the key health objectives and the key safety objectives are thoroughly implemented.

DR. APOSTOLAKIS: Yes.

MEMBER SKILLMAN: To me that's the touchstone for this. That's what makes all of this work together. And as long as those safety limits or health objectives are clearly etched and agreed to then a lot of people in diverse places can say I'll argue about how we get there, but I agree where we need to get to.

And if we stay focused on that approach then reasonable men and women can say, yes, this is a thorough way for everybody to approach those objectives pretty much the same way. So I think --

DR. APOSTOLAKIS: That's a good way of presenting it, yes.

MEMBER SKILLMAN: I think that's the glue that really makes this come together.

DR. APOSTOLAKIS: Yes. The regulatory requirements QHOs that we meet those, yes. Thank you.

MEMBER MARCH-LEUBA: So I know Dennis thinks we're wasting time, but we're not. We need to have a discussion and an argument about this approach because otherwise what are we doing here.

I would agree with what he said, this method makes a lot of sense in theory. In practice I have never seen a PRA analysis that was complete or accurate --

DR. APOSTOLAKIS: Or?

MEMBER MARCH-LEUBA: Or accurate. If you look at the basic frequency data that we use for that PRA analysis it's awful. Let me give you an example and I'm not going to make it long but this is interesting.

I have four cars in my garage in Knoxville. There are three Toyotas and one Saab convertible. If you get the average of the three car maintenance record they are pretty good.

But applying the Toyota liability to my Saab is lunacy I can assure you. So whenever we put the simple data we get the average of the valves out

there and we give it a failure probability of so and so.

And now you're using a very specific, in these new plants a very specific, very complex valve that has never been used before and you're saying it's going to behave the same way as these other ones that have been running for 100 years.

So my basic problem is I agree 100 percent with what you guys are saying, this implementation. You need to have complete and accurate PRA and I've never seen any.

MEMBER CORRADINI: But, Jose, I don't understand why is your engineering judgment any more complete or accurate if that's what you're saying?

MEMBER MARCH-LEUBA: What I am saying is you should not be weeding, and you know the event I'm thinking about, the one I've been complaining about. You should not use incomplete PRAs, in my opinion, to weed out particular events.

DR. APOSTOLAKIS: This is not the objective of this. And don't forget what we say has to be approved by the staff. So the staff can use arguments like that if they wish if it is appropriate to say, no, here we think you should do that and there would be a debate.

So this is not a risk-based approach. It's risk-informed and there is a lot of traditional deterministic. This is a misnomer. Traditional methods that one can apply.

But I think the fundamental question is if you are demanding PRA to be accurate and what's the other one --

MEMBER MARCH-LEUBA: Complete.

DR. APOSTOLAKIS: Complete, I am arguing that the traditional system which is based on judgment is neither accurate nor complete. So you take the two together and you try to come up with something that is fairly complete.

That's the whole point. I don't want to start a discussion, well it's not up to me. But I think a discussion on the limitations of PRA without talking about the other system is misdirected.

MEMBER MARCH-LEUBA: Let's improve the system. I'm all for improving the other system. Let me put some other numbers on the table.

DR. APOSTOLAKIS: Yes.

MEMBER MARCH-LEUBA: You have told me the problem, melting fuel reactors on the same day breaching containment, leaking such an amount of hydrogen that would make Hindenburg be proud and then

blowing up the top of the reactor like tv would have been 10^{-18}. Yes, that's what it would say.

DR. APOSTOLAKIS: Well is a ridiculous number anyway.

MEMBER MARCH-LEUBA: 10^{-6} times three. That's what you would have said had I asked you ten years ago.

DR. APOSTOLAKIS: I don't know what I would have said. I don't know how to answer that.

MEMBER RAY: George, George, this is Harold. Would you speak to the quantification of uncertainty in the context that you're talking about? To me that's always been the biggest challenge.

DR. APOSTOLAKIS: Well I think Karl will address all this stuff.

MR. FLEMING: I just want to make a few comments. No competent PRA engineer would have come up with a 10 to the minus, you know, low number for what happened at Fukushima.

In fact there was evidence available even in the country of Japan that indicated the likelihood of a very, very large tsunami was in the 10^{-2}, 10^{-3} range. And given --

MEMBER MARCH-LEUBA: What was the published number for that much frequency?

MR. FLEMING: Given the fact that the switchgear and the diesel generators were located in the most prone area of the plant the core damage, you know, the conditional core damage probability by any competent engineer would have been close to one. So it wasn't 10^{-18} event.

MEMBER MARCH-LEUBA: And what was the published number?

DR. APOSTOLAKIS: And that was an abuse of PRA. And that's why we have a competent staff that would never let it fly. This is not what Amir and Karl and decide here. We have a regulatory staff.

MEMBER MARCH-LEUBA: This is my complaint. The objective you didn't like complete. I call it uncertainties of omission. What did you forget to take into account in your analysis?

DR. APOSTOLAKIS: Well and again, this is a limitation of the state of knowledge, not a limitation of PRA. If you are going to omit something you're going to omit it in the traditional system too because if you knew about it you would put it in the PRA.

MEMBER MARCH-LEUBA: I think I put my concerns on the record and I will continue to do so.

DR. APOSTOLAKIS: Okay. Now I was very

glad to see these especially the first line develop an Agency wide process and organizational tools to expand the system of the use of quantitative risk assessment. This is what we tried to do with NUREG 2150 four years ago.

What we're doing is consistent with the staff's recommendation.

CHAIR BLEY: By the way, we're on Slide Number 11 for people listening in.

DR. APOSTOLAKIS: Yes, Slide 11. The Chairman mentioned NUREG 1860 that the Committee reviewed it and so on. And it's interesting to recall that the Committee at that time agreed that the idea of licensing-basis events is a good one.

And then the second bullet that if you do that it reduces the risk that licensing-basis requirements will divert attention from events of real safety significance. Joy, you want, you raised your hand now?

MEMBER REMPE: No.

DR. APOSTOLAKIS: Okay, next.

MEMBER REMPE: It goes really high when I raise it and I just interrupt usually.

DR. APOSTOLAKIS: As Amir mentioned the former Chairman Meserve, Commission Merrifield I are

members of the Advisory Group and we wrote a letter in February to Mr. Kuczynski, the CEO of Southern Nuclear. And you have the letter.

These are excerpts. Now of course we said that we are not in a position to comment on the technological survey.

CHAIR BLEY: Will you say something more about that? I read your whole letter. I liked, you told a good story and then you get at the end and said we're not in a position to comment on the technical adequacy. What did you mean?

DR. APOSTOLAKIS: Well we are not. We are not because remember this is me, Merrifield and Meserve. And you go down to the technical details. It was not just possible.

By my reviewing the documents and I go into technical details. But the group could not do that.

MEMBER CORRADINI: So, George, I understood that to mean that you're in favor of the spirit of it but the details have yet to be analyzed completely?

DR. APOSTOLAKIS: This is the group's position, yes.

MEMBER CORRADINI: Okay.

DR. APOSTOLAKIS: Okay. And then we believe that this, that guidance can be developed based on these documents that can be endorsed by the NRC. And the last one I think.

And defense-in-depth, this Committee wrote a letter back in 1999 stating that one of the major drawbacks of defense-in-depth, of the principle is that we don't know, there is no guidance how much defense-in-depth is enough.

We also praised it that it has worked very well and the plants are safe and so on. But there are some shortcomings. So the methods that Mr. Fleming will present that we claim can be used to decide that the amount of defense-in-depth in a particular design is sufficient are attempting, these methods are attempting to answer that question, how much defense-in-depth is enough?

So again, you will see the group does not explicitly say this is it. It says we are approving it in principle.

But it's interesting in the middle of the second bullet like all risk-informed tools it could also result in the identification of areas where additional requirements are necessary. Okay. And I think I'm done, right.

MEMBER REMPE: So now I would like to interrupt. When I look at this document and it says hey, we want to reduce some of the uncertainty with the regulatory process and if we also, what it doesn't sometimes mention is the Commission at one point said the current fleet is safe enough.

So if you believe that and you do this whole process in some ways you're going to be identifying new requirements because you're looking at beyond design basis events and having some sort of dose limit they have to meet.

But you know, and I think this is where you're coming from, is that the designers if they want to have an economic plan are going and reduce some of the margin. And that document that we were asked to review has a lot of statements about adequate margin is preserved.

But I never saw any sort of hard number for what is adequate margin. And I think that if you want to reduce uncertainty in the regulatory process that's going to be a big area of contention on what's adequate margin.

And those discussions are going to be extensive when someone goes through them. So maybe the examples will help clarify what that is. But I

was kind of wondering what's adequate margin when I was looking at it.

And did your Advisory Group discuss that at all and that, that might be a pitfall with this process?

DR. APOSTOLAKIS: No, no.

CHAIR BLEY: I do have one discomfort with your first bullet up here, George. Significantly reduce risks associated with many of the advanced reactor designs.

Jose cited roughly numbers that came from PRAs that weren't plant specific with plant specific data and plant specific external events analysis. We don't have any plant specific PRAs with plant specific operating experience and plant specific external events analysis for any of the advanced reactor designs.

So the conclusion that the risks are significantly reduced with them is a little troubling for me and I wonder how you come to it. I get the concept why you're pushing this way.

DR. APOSTOLAKIS: Well, maybe that could have been phrased better, you're right. But there is a general feeling that the new advanced reactors employing passive safety systems and so on, as the

Commission has said, are expected to be safer.

CHAIR BLEY: They are expected to be. But we haven't really placed one at a site and looked at all the external evidence that could affect that.

DR. APOSTOLAKIS: That's correct. That statement should have been stated better.

MEMBER CORRADINI: So if I might follow up. So you don't think the limits of experience with Fermi 1 and Fort Saint Vrain gives us no insight, Dennis or George?

I'm trying to understand what is necessary to give us confidence in the statement changing it from expected to at least is shown by some analysis and limited experience.

CHAIR BLEY: Well for me, Mike, since you addressed it partly to me, it's really the external events side of it at a specific site. The local specific cooling water systems it should have.

And that's the main thing. And those plants you cited didn't really have full scope PRAs done. So we don't really have the risks.

They ran for their time, did okay, had, some of them had quite a few different kinds of problems but nothing that resulted in a big accident of any sort. But they didn't have that long a run

either.

So I don't gain a lot of confidence from that. But it's really putting them at a specific site and looking for all of the things that could happen there.

And for some of them that run on very low thermal hydraulic margins the effects of aging or fouling of different sorts haven't been included into the design cert PRAs that have been done. So that's another area that leaves me not, it's just not proved in any sense yet for me.

MEMBER CORRADINI: Okay. If I might, I guess I want to hear George's view on this. But the way I interpreted what you said, Dennis, is these are not technology specific issues.

These are almost technology neutral issues relative to siting, external hazards, ultimate heat sink needs. Am I understanding correctly?

CHAIR BLEY: The issues are general. The effects are very plant specific.

MEMBER CORRADINI: Right, okay. You're right. George, I'm curious what we can you learn from the past limited experience or is yet to be proven by some sort of demonstration?

DR. APOSTOLAKIS: No. Past experience for

sure will be included in the guidance and the, whatever other documents are produced. But I think it's also important to bear in mind this is a technology neutral approach.

Once you have a specific technology it will go down and develop regulatory guides or whatever else to have technology specific requirements. So I have no doubt and in fact already Karl in the white papers is using examples from MHTGR and so on.

So all this experience will be incorporated in whatever documents are produced. Anyway, my final, I'm sorry --

MR. FLEMING: I was going to say given I'm sort of a glass is half full type of personality, when I read George's first bullet what I interpreted that is that given the expectations for enhanced safety coming out of the Commission's policy statement if that's true then this, then you know there's a concern that you could end up with enhanced conservatism. That's what I read it to be.

DR. APOSTOLAKIS: I think it could have been stated.

CHAIR BLEY: I couldn't object to that. It was pointed out that I might be getting tense about the time and I was. But we're almost halfway through

the real slides you're using not counting the extra ones you have at the back and we're not quite halfway through the time you had. So I think we're on track.

There's a lot of detail we would love to dig into. And I think we should have probably scheduled this for a longer meeting but we didn't. Maybe the October meeting will be a full day or something because we'll have a lot of detail to go through then.

But somebody over here started to say something.

MEMBER BROWN: I just have held my tongue since George has announced I'm the resident skeptic for the most part. And I would just let you know that I am not the skeptic relative to the use of PRA to identify those scenarios that you need to protect against.

But it's a very, very useful even the iconic naval nuclear program embraced the PRA approach many, many, many years ago to and not at the quantitative side but at the qualitative side of identifying cut sets and other type things that would identify and help you with that.

My difficulty is when we apply this now to two things. I keep, my area is obviously I&C,

instrumentation and control. And the latest drive on that is to now create a risk-informed performance-based regulatory framework.

I'm still trying to figure out what a risk-informed framework is for designing and building I&C and what do you mean by performance-based. To me you build it and if it trips the plant when you want it to then you've got a performance-based system.

Putting that aside talking, somebody brought up the notion of enhanced safety. Not just say they are significantly reduced risks. As I've looked at each of the ones when we've been in these advanced reactor designs I still have not seen a really good layout of why is a sodium fast reactor necessarily enhanced safe.

I'm familiar with the earlier sodium plant that was built and operated as a submarine which was unfortunately thrown over the side and sunk before we applied it to any other ones. I'm just looking for how do we say they are enhanced safety?

Where is that list of enhanced things that make them better and we know we can design to ensure those enhancements are there? It's been very difficult for me to grasp that. That's all I have.

MR. AFZALI: I apologize. I just want to

make sure we are not representing any of the developers here. So I think that this is a very important conversation.

But I think to be fair to our developers and have a full conversation which is meaningful conversation we need a representative of the developer.

MEMBER BROWN: I don't disagree with that. I'm just, I'm looking forward. I'm trying to go forward and if we're going to go down this path and use it we just somehow we need to get over that bridge as well, that's all.

DR. APOSTOLAKIS: I think if you have a specific design and you implement this approach with LBEs one measure of these reactors being safer is the distance between the end point of the accident sequences and the regulatory requirement.

That's a margin, which by the way in 1860 as I recall when they applied it to a PWR it did not pass the criteria, the existing reactor. And you probably remember Dr. Powers for years saying that we don't know that the existing fleet meets the QHOs because we're not doing level three PRAs.

Now you're first comment again, there are certain things that are not in the PRA. Digital I&C,

safety culture, you can argue, you know, about the culture affects the data. But basically it's not in the PRA.

And that's why you need a risk-informed approach where you scratch your head and say now what can go wrong here. What is happening? And you, if it's a deterministic approach like I&C you do that.

If risk analysis can provide some insight you do that. So it's a combination. So I don't know what they're going to do with the risk informing I&C. I think it's a very tough job.

MEMBER BROWN: I would agree with that. But that's, if you look at the Commission direction they were tasked with development.

DR. APOSTOLAKIS: Actually they showed risk informed --

MEMBER BROWN: We're going to talk about that tomorrow.

DR. APOSTOLAKIS: -- security should be risk informed.

MEMBER BROWN: That's all I had.

DR. APOSTOLAKIS: Of the I&C. Security is really, well I'm not on the Commission anymore. It's terrible. It imposes such unnecessary burden on the licensees that, well the problem is we don't know how

to do it.

MR. AFZALI: Just before comments start, I'm glad I brought Dr. Apostolakis to talk about it.

DR. APOSTOLAKIS: I retain my calm especially when I address Jose.

MR. AFZALI: Before we go to the --

DR. APOSTOLAKIS: I'm sorry I blew up earlier, okay.

MEMBER MARCH-LEUBA: I'm used to it. Most people go 14 to 1.

DR. APOSTOLAKIS: Yes, but you told me I don't care about safety.

MEMBER MARCH-LEUBA: But, no, I did not say that. I said that the consequences of applying this will reduce safety. But to probably acceptable levels.

But this is a good discussion to have and it has to be had not by itself the nuclear industry. But it has to be done in a competitive, adversarial relationship so people bring up what's wrong.

And if we don't have those arguments and you have those discussions we will not come back with a good product.

DR. APOSTOLAKIS: That's true.

MR. AFZALI: I just want to add something

here that our objective is make sure that we achieve adequate safety. But adequate is nobody defined it, right.

So we are trying to at least get us closer to that conversation so we know what adequate is. The second thing is fundamentally I am surprised there are people who push very hard on operating experience. They ignore operating experience.

So what operating experience tells you over the years risk-informed performance-based have improved safety. Forget about the costs. I'm not talking about the costs.

I'm saying the operating experience that everybody rely on says risk informed performance-based improved.

MEMBER MARCH-LEUBA: It has in the past.

MR. AFZALI: And fundamentally ignoring that proposition, that experience it's kind of, doesn't seem really justified without any, I know you have a different opinion. I'm just --

MEMBER MARCH-LEUBA: No, I want to say that I have an equal opinion. I agree the risk-informed analysis have created significant increases in safety. Unfortunately that's being used as an excuse to reduce the safety of the future reactors.

DR. APOSTOLAKIS: No, no.

CHAIR BLEY: Let's go on.

DR. APOSTOLAKIS: There are too many stakeholders in this. You being one, the staff being another one, the industry, the international community.

If there is any of abuse anywhere it will be pointed out. It's not that three of us decide and go this way. I mean everything comes before this Committee and the Commission and NRR, NRO.

There are too many, at 10^{-19} that you mentioned earlier we would be dead on arrival. Nobody would believe that.

MEMBER MARCH-LEUBA: For a single reactor.

DR. APOSTOLAKIS: I think Karl has a lot to present and we are taking a lot of his time.

CHAIR BLEY: Let's go ahead. Karl, let's do your first set of slides and then we'll take our break. I think this could be the one that bogs us down even more.

MR. FLEMING: Okay, thanks. The first thing I want to say as an overview is that as we try to convey a description of our proposed approach here we're not taking anything away from the traditional engineering and judgmental processes that have gone

into licensing.

We're expanding the role of PRA to inform the judgments that we're trying to make. I also want to pick up on a thought here is that if I can characterize the traditional approach to describing DBAs, design-basis accidents as a set of judgments to come up with limiting, bounding scenarios for the Chapter 15 analysis that would be appropriate to, you know, form the basis for the licensing process and form a basis for safety related SSEs.

Well one says bounding, okay, I have a bounding event. The next question ought to be bounding with respect to what? What was considered when you declared the large break LOCA bounding?

And what we're trying to do with LBE aspects, LB selection aspects of this approach is that we're trying to make use of one of the great capabilities of PRA in providing a systematic process for enumerating a very large set of scenarios from which to select the bounding event.

So that's what we're trying to do. We're trying to supplant the judgment that this is a bounding event without maybe skipping the step of figuring out what are the possibilities before you consider it bounding.

The second part is that in the PRA world we like to start with a realistic assessment of the behavior of the plant on these events. And that's as opposed to necessarily a conservative analysis.

And that's a big burden in effect because to do a realistic assessment it requires you to capture and understand all the phenomena going on, you know, in the scenario.

And it's interesting to note, I would like to point out one of the things we learned about the large break LOCA is that after all the work was done on that bounding event on the large break LOCA it took an event at Barseback to point out there was an important phenomenon that was not in fact bounded by the traditional deterministic safety analysis, the sump plugging issue and so forth.

So in the PRA we try to capture the evidence that we have including the evidence from the other reactors. In this slide this is, this slide in a snapshot tries to identify the key points of our risk-informed approach that we're trying to introduce.

And not to take anything away from the deterministic method but to help the deterministic judgments form a complete risk-informed process. And when we say risk-informed we don't mean risk-based.

We're just trying to use what the capabilities of PRA are to inform the decisions. Also supplemented with deterministic approaches such as our approach to defense-in-depth which we hope to spend some time on.

The way the process works and this is, we're not weeding anything out, we use a design specific PRA to define what we call AOOs, anticipated operations occurrences, DBEs and BDBEs.

Now to answer one of Dennis' questions, when you put these LBEs together we group the sequences that are modeled in the PRA based on similarity of challenge to the plant and initiating event type challenges, similarity of a plant response to the events.

And if we happen to have a release similarity of the mechanistic source terms. So it's a grouping of event sequences. And the grouping process is intended to eliminate the abuses by subdividing sequences and putting them further and further down the sequences.

So that's the first process. Now we, the AOOs, DBEs, BDBEs are evaluated against a frequency consequence target which I'll get to in the next couple of slides.

It's not a design requirement, I'm sorry, it's not a regulatory requirement. But it's a design objective to control the risks across the whole accident spectrum or the event spectrum from the anticipated events that are high frequency events, low consequence events to the lower frequency beyond design basis events.

MEMBER CORRADINI: Karl, can I break in? Maybe you're going to get to it later and you can postpone this.

I'm still trying to understand how you logically bundle individual sequences that then move it, I'll just put it in graphable terms, moves it in the y axis to higher frequencies or in the x axis to higher or lower doses. I'm still unclear about the logic of bundling them.

MR. FLEMING: Well I guess the --

MEMBER CORRADINI: And if you're going to do this later I'll wait.

MR. FLEMING: Okay, well I think I tried to address that earlier but maybe didn't communicate well. We group together similar sequences. When the sequences come out of the PRA we group them based on the, you know, the similarity of the plant response.

For example, you know, if you have a, you

may have a turbine trip-induced transient and you may have a feedwater reduction transient and a loss of condenser vacuum transient that all basically create the same set of sequences.

So we would organize those and we would sum those up especially if they have the same end state and the same plant response. So we don't permit you to subdivide sequences that basically look identical with different flavors of initiating events for example. So we don't --

MEMBER CORRADINI: So what you're saying is it's not just necessarily the initiator. I just don't lump all the station blackouts together. I lump or I bundle things relative to how they involve the accident analysis.

MR. FLEMING: Absolutely, absolutely. So we don't, we just don't subdivide based on --

MEMBER CORRADINI: I'm sorry, I didn't mean to interrupt you. I'm sorry.

MR. FLEMING: Yes, we don't permit the abuses of just subdividing the same sequencing to smaller sequences. And there is a lot of reasons for doing this because we never standardized the level of detail of a PRA.

Some people develop more detailed entries

and some people have more simplified entries. That's never been standardized. So I think the white papers tried to describe the criteria for if, the whole plant response has to be similar for it to be given to the same LBE.

MEMBER CORRADINI: So let me ask my question this way and then I'll stop because I'm sure we're behind. Dennis is watching the clock. So I think I understand what you're saying in the y axis and how I would bundle them with similar initiators or damage basis.

But you're also, the way I heard you say that is how source term, whatever the source term is that would be released to the environment you're looking to have a common source term or a range of source terms? I'm more interested in --

MR. FLEMING: A common source term. If it has a different source term we would break it out as a separate LBE. And that would indicate it was a different plant response.

CHAIR BLEY: And that implies you're developing essentially scenario specific mechanistic source terms?

MR. FLEMING: Absolutely, absolutely.

MEMBER REMPE: But in that grouping

there's probably some that are larger and typically people pick the bounding one for that grouping for the source term, right?

MR. FLEMING: Well we try to avoid putting dissimilar sequences with different source terms.

MEMBER REMPE: But you might, from experience you might have, I don't know, four or five different ones and you'll say well this one is the bounding one, you would pick that. Just to clarify instead of saying the characteristic one.

MR. FLEMING: Yes, if we decide to put somewhat dissimilar sequences in the same LBE we would be use the bounding one.

MEMBER MARCH-LEUBA: Mike, you always interrupt me in trying to say, explain what I said. Let me explain to you what he's saying.

If I take a large break LOCA and now I subdivide it into two events large break LOCA at the left side of the plant and large break LOCA of the right side of the plant. Suddenly the frequency of large break LOCA is half.

MR. FLEMING: No, in our approach we would combine those --

MEMBER MARCH-LEUBA: I mean exactly. So to prevent that subdivision of left side and right

side of the plant which makes absolutely no sense, you combine them to get the maximum frequency possible. Now you have to do it right. We're giving you the, but if you took that out you guys do it right.

MR. FLEMING: Yes, that's the intent is we don't subdivide arbitrarily just to get lower frequencies. If we have different, we only subdivide to get different consequences.

DR. APOSTOLAKIS: That has been an issue for a long time since Faulkner published his curve what is a sequence.

MR. FLEMING: Now the other thing that is a little bit different from the way PRAs have done for light water reactors is that the frequency consequence target and I'm going to show you what the target is in a second.

The frequency consequence target is used to look at the frequencies and consequences of individual LBEs. And that's because of the application where you want to select from these LBEs the design basis accidents.

And we have a set of rules that we use so that people would end up with a consistent and reproducible set of DBAs given the same input set of LBEs.

MEMBER CORRADINI: So may I break in one last time because something you mentioned in all of this that I want to get clear. You said that to do this you need a mechanistic source term.

MR. FLEMING: Yes.

MEMBER CORRADINI: So is the alternative source term in current light water reactors mechanistic?

MR. FLEMING: Well I don't know that much about the alternative LWR source term. But our non-light water reactor PRA standard has requirements for what's mechanistic.

So the answer to your question what is mechanistic, it's to meet the requirements in the standard. And it's also to suggest that we're not just going to arbitrarily use the equivalent of a TID-14844 source term.

We're going to try to make it scenario specific and capture the mechanisms that are important to calculating the releases.

MEMBER CORRADINI: So because, so here's where my question comes and I'm still on the x axis.

MR. FLEMING: Right.

MEMBER CORRADINI: I can't deal with the y axis in my mind. I will leave it to you guys that

understand the PRAs. But a mechanistic source term implies analysis of experiments.

Experiments imply I've done fuels testing. That tells me there's a whole range of evaluation of or validation of fuels testing that either is going to be done or has been done that can arrive at a mechanistic source term since after decades with the light water reactor I'm still sitting with an alternative source term that doesn't strike me as mechanistic.

MR. FLEMING: Well the goal is to have a mechanistic source term that captures the evidence that we have to back up the mechanistic source term. And that means it's done with uncertainty treatment.

MEMBER CORRADINI: I'm just, where I'm coming from is I think the burden of proof for a mechanistic source term is much higher than the alternative source term we currently have and/or you're going to have a very wide range of uncertainty.

MR. FLEMING: Yes. Well the approach does not prescribe a reduced level of uncertainty mechanistic source term as you're describing. But it does call for a reasonable capture of the state of knowledge about what's behind the mechanistic source term.

We were showing some examples to the staff in a little training session we had yesterday. And if you look at how the MHTGR exercise was done in some of their mechanistic source terms the uncertainty was three to four orders of magnitude.

MEMBER CORRADINI: Okay, all right.

MR. FLEMING: But in those cases it didn't matter because they were still five decades away from the frequency consequence curve. So you can have a very, very large uncertainty. But it doesn't necessarily matter.

MEMBER CORRADINI: Okay, thank you for helping me there.

MR. FLEMING: Now we also --

MEMBER REMPE: Also when calculating the source term is the intent that whether it's an AOO or a DBE they should always do it for 30 days --

MR. FLEMING: Yes.

MEMBER REMPE: -- a day or, 30 days for all of them?

MR. FLEMING: It's a 30 day EAB dose calculated EAB for 30 days.

MEMBER REMPE: Okay. And we'll get to --

MR. FLEMING: TEDE, TEDE dose.

MEMBER REMPE: Later, but some of the

regulatory requirements like 10 CFR 20 has a two hour limit. You've picked an annual 100 millirem limit. The two hour limit could be more restrictive.

So if you do this process are you going to meet all the regulatory requirements because again, you may not have covered all of it?

MR. FLEMING: Again, the purpose of the frequency consequence target is to evaluate the risk significance of LBEs. That's all it's for. It's not to meet regulatory requirements.

We'll still have to meet the regulatory requirements that the various regulations require. So if there is a two hour dose calculation for something. So the frequency consequence target is simply to look at the risk significance of individual LBEs.

And we wanted to have a uniform consequence metric so that we could have a consistent comparison, we could compare AOOs, DBEs and BDBEs on the same graph. It's not a regulatory requirement application.

This is something that we throw in, in addition as a tool to help us select the design basis events. Now as we get down --

MEMBER REMPE: I think it would be good to clarify that in your document that even though they

may be well below this boundary on your plot it doesn't guarantee you've met all regulatory requirements --

MR. FLEMING: It's not intended to.

MEMBER REMPE: Yes, it wasn't obvious to me because again, back in the old days of MHTGR we took the two hour limit and made that the AOO boundary instead of the annual limit. So you've got a much less restrictive boundary.

MR. FLEMING: Yes. One thing we clarified in this project, I think there was some confusion in the NGNP project because in some documents the curve was described as regulatory criteria, top level regulatory criteria.

And early in this project we came to an understanding with the staff that, no, this is a design target. And we used the term target to be explicit as not use the word requirement.

The regulatory requirements are still expected to be met, whatever they are. As we look at the DBEs and what we call high consequence BDBEs to determine what we call the required safety functions, and that's the term for our approach here and we're working with the staff to avoid some of the terminology issues that we have because sometimes we

use similar words or different words to mean the same thing.

CHAIR BLEY: Karl --

MR. FLEMING: The required safety functions are the functions that we have to, we determine are necessary to keep the DBEs and the high consequence BDBEs inside the frequency consequence target.

Those are required safety functions and those are, that's a tool we use to come up with our safety related SSEs.

CHAIR BLEY: Karl, you slid past one bullet there at least for me.

MR. FLEMING: Yes, the collective thing.

CHAIR BLEY: Yes, the collective one. If, as I read the material you're essentially, you've got a PRA. You have a risk curve from the PRA. And it looks like for the collective risk you're picking specific points off of the risk curve essentially and comparing them to a specific criteria.

MR. FLEMING: Right.

CHAIR BLEY: There's no overall look at the risk curve to look at a collective acceptability.

MR. FLEMING: Well for all of our collective criteria and I think we may have a slide on

that. But for the collective criteria --

CHAIR BLEY: I'll be happy to wait for that if you have a slide on it.

MR. FLEMING: Yes, we do integrate against all the LBEs. But we have one particular criteria that's intended to capture the risks of the AOOs.

And we use the 10 CFR 20 limit now in the terms of an aggregated measure. And then we use the two, the QHOs from the safety goals which are really only going to be exercised in a significant way for lower frequency.

CHAIR BLEY: So the collective are some kind of mean value against a criteria?

MR. FLEMING: Yes, that's right.

DR. APOSTOLAKIS: Can I make a comment?

MR. FLEMING: Or exceedance frequency, go ahead.

DR. APOSTOLAKIS: I think we need to clarify what the F-C curve means. Certainly 50.34 is a regulatory requirement as I understand it, right. So if a sequence goes to the right of the curve it is unacceptable.

The designer has to do something about it. If it's to the left of the curve Joy is right. That doesn't mean it's acceptable. There may be other

things that have to be satisfied.

So I think that understanding is important here. To the right unacceptable, to the left we'll look at it again and work up other criteria. I mean if you've got --

CHAIR BLEY: That makes good sense to me. But I will point out on your slide you kind of talk about that way to the left it's decreasing risk. In the reports though that area to the left is called risk insignificant which I suspect you might be modifying I hope in the future.

DR. APOSTOLAKIS: Yes, yes. Originally the staff objected and I think they were right. We agreed to saying that if it's above it's unacceptable, if it's below it's acceptable. And then we changed the technology.

CHAIR BLEY: Risk insignificant bothered me for anything less than 10^{-4}.

DR. APOSTOLAKIS: No, you're right.

MR. FLEMING: Well, okay. One thing I want to clarify though is that when this came up we had a long discussion about this with the staff yesterday.

Again, I'll go back and repeat. The purpose to the frequency consequence curve is to

evaluate the risk significance of individual LBEs period.

Now we have taken to come up with the anchor points on that curve and I guess we should maybe move on here and not come back, come up with the anchor points on this curve we have interpreted front regulations on things like annual dose limits from 10 CFR 20, PAG level doses for triggering off site responses, 10 CFR 50.34 for design basis type of considerations and the QHOs.

While we've used those limits with an interpretation of assigning them to a frequency which is similar to what was done in the previous curves we, although there is, my point is where there is regulatory limits and safety goal objectives used to derive this curve, again the only purpose of our curve is to evaluate the risk significance of individual LBEs.

When we go back and select the DBAs what we do is after we figure out these required safety functions that these are the ones that I need to keep the DBEs inside the frequency consequence curve and if I have high consequence BDBEs, i.e. BDBEs with more than 25 gram doses I have to figure out what functions do I have to fulfill to make sure those sequence,

those points don't migrate outside the consequence chart.

And those are declared as required safety functions. And then what I do is I go back to my DBEs and I see what SSEs were available to support each of my required safety functions for each of the DBEs.

And normally the designer will then have choices. They can decide, there may be different choices he may have as to which SSEs he wants to declare safety related so that I have at least one safety related SSE to cover each required safety function for all the DBEs and the high consequence BDBEs.

Then after the designer selects those we construct a DBA working to be consistent with the way the Chapter 15 analysis is currently done. We force failure of all the non-safety related SSEs that perform these required safety functions so we can come up with an event set that has the same characteristics in the current Chapter 15 analysis.

We don't use the frequency to select the DBAs, only indirectly as they come through the DBEs. And in some cases these DBAs that we select have been screened out of the PRA.

We show an example in the MHTGR where some

of their DBAs were assessed in the PRA at less than 10^{-8}. But that result comes from this prescriptive approach of basically forcing failure of all the non-safety related SSEs on the incoming DBEs.

So once we get into Chapter 15 we're, we don't, we're off the frequency consequence chart. So now we use the rules of 50.34 and we come up with conservative dose calculations to meet 25 gram.

CHAIR BLEY: Karl, I read two different things. And one makes sense is you use the DBEs to help define the DBAs.

MR. FLEMING: Yes.

CHAIR BLEY: Somewhere else it said that all of the DBEs become DBAs. Is that, did I misread or is that the intent?

MR. FLEMING: They're all considered in formulating. But what happens is you'll find and we showed examples yesterday, the MHTGR ended up with 11 DBEs.

Now they had an underlying PRA with hundreds and hundreds of sequences. And they bend them down by the time they have been down the DBE range they end up with only 11.

And those map to eight DBAs because you'll have several different DBEs that only vary by what the

-- point. And when you force the safety related SSEs to fail they sort like bully and reduce, if you will down to the smaller set.

So that's what, that was the example for the MHTGR.

MEMBER CORRADINI: So can I ask a question, Karl, because I, this is the other part that I was trying to understand. So once you choose the HGTR numbers that you said, once you have the 11 that broke down to the eight you then from a design standpoint decide which of the systems you want to declare as safety systems that will maintain their functionality.

The rest are assumed to have failed. And therefore because of a mechanistic source term these groupings will move to the right. Again, you said you're not using the F-C curve.

But I'm still trying to think of it this way. It moves to the right so the source term increases, changes. Is that correct?

MR. FLEMING: No, well when you go from DBEs to DBAs there will be one DBA to match up with each of the DBEs. They will have the same mechanistic source term.

But when we got into Chapter 15 we're

going to do a conservative analysis versus a realistic with uncertainty analysis that's in the PRA.

MEMBER CORRADINI: Okay. What does that exactly mean? You're going to fail all the non-safety related systems the designer has chosen to be non-safety and you're going to do something to a mechanistic source term calculation that bounds it?

MEMBER REMPE: In the grouping there probably was one sequence that only had the safety related equipment working and that source term is what they used back from when I was a lot younger I remember.

If I can answer for you, sir. I have a question though.

MEMBER CORRADINI: Well wait a minute. Before you answer for him, is she saying it correctly? I want to understand the procedure of deriving the source terms for the DBAs.

I understand what Joy is saying. But is that what's happening?

MR. FLEMING: The source term, the only difference between the source term of the DBE and the DBA it maps into, the only thing that's different is the ground rules for conservatism in the calculation. So --

MEMBER CORRADINI: But when you say that --

MR. FLEMING: It's the same mechanistic source term.

MEMBER CORRADINI: -- it's more than just choosing the safety system?

MEMBER REMPE: Your response indicated that they had to do more conservative calculations and that's not I think what's done.

MR. FLEMING: Okay, let me back up. When you, when the designer is confronted with choices to select their safety related SSEs he has to pick among those SSEs that are available on all the DBEs.

So you don't, so when you map a DBE to a DBA you basically have the same source term. It's just that when we do the PRA we do realistic with uncertainty treatment on the source term and when we do the Chapter 15 analysis we do an acceptably conservative analysis of the source term. And --

MEMBER CORRADINI: Okay, but --

MEMBER REMPE: What would change? What assumptions?

MR. FLEMING: The only thing that would change is what systems were assumed to be available.

MEMBER REMPE: Right, so it's one of the

sequences that you had in that group.

MR. FLEMING: Yes, that's right.

MEMBER REMPE: So I think my answer is correct, Mike. But I have a question that pertains to one of your backups. You mentioned the word about the fundamental safety functions.

And you have back in one of your back up slides control heat generation, control heat removal and retain radionuclides. Why do you have nothing in there about control reactivity and the ability to shut the reactor down because that was always, it's in one of your white papers?

That was always one of the fundamental safety functions back at GA and --

MR. FLEMING: Control reactivity is considered to be part of control heat generation.

MEMBER REMPE: We've had a lot of discussions about being able to shut down the reactor and having diverse systems. I would argue with you that you might have different evaluations about ATWS and other things that if you don't have that as one of your fundamental safety functions.

Again, we've talked about this with having, meeting the GDCs and the ability to have two diverse site shut down systems.

MR. FLEMING: Well in our framework control room reactivity is considered to be part of control heat generation. Right, that's how we --

MEMBER REMPE: But you could have just gone with retain, control radiation release because frankly heat generation and reactivity affect how much radiation is released. So why did you pick two instead of three then, I guess?

MR. FLEMING: You know, all of these hierarchies of safety functions, I mean there is a hierarchy. I mean in principle the fundamental safety function you could define in just one.

MEMBER REMPE: Right.

MR. FLEMING: Which is control, you know, control radionuclide inventory. Control heat generation and control heat removal are considered to be necessary for that. So they're not really separate, you know, they're not really separate and independent.

And what, the only reason why we refer to those as fundamental is that's what the IAEA calls them, okay. And in our approach what we identify is that each reactor has to figure out what their safety functions are and what their required safety functions are.

And we just observe that they're all going to be somehow related to those three functions.

MEMBER REMPE: When I think of trying to help designers of what to consider in selecting their sequences in the PRA I would really like to see controlling reactivity as something that they should think of just like heat removal and radiation release.

And so I'm not sure that's a good thing to not just explicitly state --

MR. FLEMING: Okay, that's good feedback.

MEMBER REMPE: -- in this higher level document. I know it's in the white papers because you have the example with the MHTGR and there were several fundamental safety functions there. So please think about that.

MR. FLEMING: That's good feedback. That's good feedback. Thank you very much.

MEMBER MARCH-LEUBA: So what do you say by weeding down the DBAs into smaller number of DBAs? Why not run all of the DBAs with the fail of non-safety related SSEs and make sure the rest is okay?

MR. FLEMING: That's what we do. That's what I tried to describe. But the last phrase without crediting the non-safety related SSEs that is the DBAs. It's the same thing.

MEMBER MARCH-LEUBA: No, but you do it for all DBEs.

MR. FLEMING: But some of the DBEs have non-safety systems working in them and that's what they collapse. They don't account for any of the non-safety systems. They're all in the PRA.

MEMBER MARCH-LEUBA: So you --

MR. FLEMING: But they're not in the deterministic analysis.

MEMBER MARCH-LEUBA: Design basis events which is complete or not complete one can argue. And then you run it with everything working. Say the worst are these eight.

And then you run those eight with the non-safety related things fail.

MR. FLEMING: Right.

MEMBER MARCH-LEUBA: But maybe before you are doing the procedure with the non-safety related fail are now bad. Why not run all of them? What do you save by weeding them?

MR. FLEMING: I'm not exactly sure if I follow how, what you're describing as different from what we're --

MEMBER CORRADINI: I think all he's saying is you dropped three. Those three could be done. At

least that's what I thought he meant.

MEMBER MARCH-LEUBA: From 11 to eight.

MR. FLEMING: Yes, the, those sequences would come out with exactly the same source term. The only thing that's going to be, because in addition to these, to the safety related SSEs working there's also another non-safety related system operational which sort of takes the demand off.

There wouldn't be any difference in the consequences. I mean --

CHAIR BLEY: I think there's a little confusion. Let me try saying it and tell me if I'm wrong.

MR. FLEMING: Okay, thanks.

CHAIR BLEY: Say there are four DBEs, one of those because it's in the PRA has all of the non-safety systems already failed. Some of the others, some of the non-safety systems are working.

Once you fail all the non-safety systems all four of those are the same sequence.

MEMBER MARCH-LEUBA: Is that how it is collapsed?

MR. FLEMING: Yes.

MEMBER MARCH-LEUBA: Is that the only way it's collapsed?

MR. FLEMING: The only way it's collapsed.

DR. APOSTOLAKIS: And if necessary you look at all of them.

MEMBER MARCH-LEUBA: That's why I'm saying why not look at all of them?

DR. APOSTOLAKIS: It doesn't say you have to do it. It just happened in MHTGR and --

MEMBER MARCH-LEUBA: Analysis is cheap. Let's just look at all of them.

MR. FLEMING: Well we are going to look at all of them.

DR. APOSTOLAKIS: If necessary, yes.

MR. FLEMING: In fact the analysis that we do over on the PRA side is going to have a lot more information because it's going to have the realistic assessment with the full quantification of uncertainty.

MEMBER MARCH-LEUBA: You cannot do a PRA analysis unless you've run TRACE to tell you what the sequence was. So you start with an analysis.

MR. FLEMING: Yes, we are running the consequences of all the LBEs. And we're rerunning them in Chapter 15 using different ground rules that adhere to the regulations.

MEMBER MARCH-LEUBA: Not for all the DBEs.

You're running only for a subset.

MR. FLEMING: Well this is our way of replacing the judgment that, you know, we consider the large break LOCA, the bounding event for Chapter 15. This is the process where we are using the events above 10^{-4} for plant year as an engine and a reproducible process to create a set of DBAs that are reproducible for each plant.

We're trying to do something that will create a consistent level of treatment for different types of technologies, different types of designs.

MEMBER MARCH-LEUBA: Analysis is cheap. I don't see why not do it comprehensive.

MR. FLEMING: Yes, if necessary it would be done.

MEMBER MARCH-LEUBA: It's easier to run them then you don't have to use judgment.

MR. FLEMING: Okay, appreciate your comment. The frequency consequence curve a couple of comments. Do we want to stop for a break? Let me finish this slide and we can go on.

The frequency consequence curve, we have a couple of anchor points. We've made some adjustments to the version that was in the NGNP project which is the starting point.

We had some issues with the staircase character of some of the other attempts to do this because the staircase shapes somehow permit a higher risk as you go down in frequency which didn't seem to make much sense.

There's some language up in the SRP, standard review plan, Chapter 15 that talks about different frequency, different levels of frequencies of AOOs.

And there's a statement there that in principle the dose limits for postulated accidents and the AOOs could be equivalent and by following an iso-risk contour what we decided to do is sort of connect the dots on our points between the AOO region and the BDBE region rather than having these various staircase aspects to what NGNP had.

We moved over the dose limits for the AOOs, the lower frequency AOOs based on an interpretation of something that we found in the standard review plan which talks about lower frequency AOOs could have higher doses than 10 CRF 20 which was the limit used in the NGNP project.

And we moved the AOO limit over a decade from 100 millirem to one rem. But that's basically the frequency consequence chart and how it came up.

And then for looking at individual LBEs using sort of some precedent set in the PRA standards where if you go into the PRA standards to define event sequences that are risk significant there's a one percent criteria used in the standards for saying if you have a, in an LWR case if you have a sequence that contributes more than one percent of the core damage frequency that's considered to be a risk significant sequence.

So using that kind of idea and precedent we set an uncertainty bar, well not an uncertainty bar but a zone of risk significance below the frequency consequence target by two decades down in frequency. And we also took, we took a look at is there a level of dose that we could consider to be not significant in terms of consequence.

And we're suggesting that a 2.5 millirem limit might be a reasonable threshold for not worrying about very, very low doses because that would be about ten percent of the background radiation that this person that's taking the 30 day dose is going to get during the 30 days.

So does it make sense to worry about fractions of background radiation over a 30 day period? So now the reason for setting this is, you

know, we, LBEs that are defined as risk significant, they're going to get extra scrutiny and attention in the defense-in-depth evaluation we can talk about after the break.

And also we're going to come up with SSE risk significance criteria that are tied to these LBE criteria. So in risk significance we're going in two dimensions rather than one. Yes.

MEMBER CORRADINI: Okay. I just want to make sure I understood. So on the, on Slide 17 the y axis you've increased by two decades I understand. And the logic of changing the dose by, I'm trying to estimate what it was, but it's more than a factor of ten, less than a factor of 100 was based on what?

MR. FLEMING: What I was referring to is the, you know, this cliff edge that we have at one rem and 10^{-2} where you have this vertical line on the previous consequence chart in the AOO region. That's based on an interpretation of something that we found in the standard review plan that basically says that doses can be higher than 10 CFR 20 for AOOs.

For lower frequency AOOs as long as you don't upset off site, you don't impact off site activities. So we interpreted that criteria to be one rem.

CHAIR BLEY: I'm going to interrupt for a second and just --

MR. FLEMING: The NGNP had a, they had a vertical cliff one decade over at 100 millirem. So that's what I was trying to say.

CHAIR BLEY: I'm going to interrupt for a minute. The details of this at least to me smell like something that in the end the staff is going to have to either agree or suggest you do something different.

I think in October, because I think we're going to run out of time today, really understanding where the staff falls on this and what you expect to have in your requirements is something we would want to delve into in quite a bit of detail with you. I'm going to, I just wanted to get that out there for them for the next time around.

MEMBER RICCARDELLA: Dennis, this is Pete Riccardella.

CHAIR BLEY: Just a minute, Pete. I'd like you to finish this set, the next three slides before we take a break. But do them real quickly. Go ahead, Pete.

MEMBER RICCARDELLA: Yes, just would you repeat what you said about the 2.5, the vertical line at 2.5 millirem. I just didn't understand it.

MR. FLEMING: Yes. So we wanted to see whether we could come up with a criterion for an insignificant dose from the, in the context of the uses of our frequency consequence curve in evaluating LBEs.

And the 2.5 millirem is basically, if you go into the NRC website and get the average U.S. value for background radiation and divide that down into what you would get in 30 days it turns out to be 25 millirem.

So we said let's take ten percent of that 25 millirem and say if I have a dose less than 2.5 millirem let's just agree that those are not, we shouldn't worry about the risk significance of the LBE if it's, has that low dose.

MEMBER RICCARDELLA: Why a factor of ten? Why not 25 millirem?

MR. FLEMING: It's a judgment. It's just an engineering judgment.

MEMBER RICCARDELLA: Okay.

MEMBER REMPE: So this is where I would like you to discuss why you didn't do something for the Part 52 folks to give them guidance about the site parameters that should be picked because we've had a design certification that came in that was valid for

one site in the U.S. that we're still evaluating.

And to me what was done years ago in the MHTGR where they had this EPRI document that looked at all the sites around and came up with a bounding, I've forgotten it's been many years ago, like 90 percent of the sites have recommended the characteristics, why not go ahead and say to use this design approach use those assumptions for the site?

MR. FLEMING: Yes. When we get into things like external events and things like that we do, you know, we do recommend that you define a site parameter envelope that you want to, based on your business case for your reactor where you want to have it licensed and operational for.

And then you use that information from a site parameter envelope to do site specific factors.

MEMBER REMPE: But even dose requires some assumption about weather too.

MR. FLEMING: That's right. If you, one option that you can use if you haven't even selected a site parameter envelope is you can use regulatory guide weather assumptions with this approach to come up with a dose.

MEMBER REMPE: It's just silent in the document about what should be done. Why not give some

guidance to people?

MR. FLEMING: Yes, we have, we've gotten some feedback from the staff that we need to say more about how you do these dose calculations. That's a good comment.

MR. AFZALI: Sorry, if I may request I do understand October the staff are going to come with their own portfolio. But between now and then any feedback you have on our approach would be --

CHAIR BLEY: We only give the ACRS opinions through our letters after a full Committee meeting. You hear individual comments here and that's the way you should take as individual comments. Thank you.

MR. FLEMING: The, this Slide 18 has the cumulative risk targets. And this is to recognize that we have to look at the summation of the risk across all the LBEs.

And basically what we're using is the two QHOs for the safety goals the latent cancer and the early fatality safety goal metrics. And so we're just adopting those as goals.

And when you do these calculations these are going to be exercised primarily by the lower frequency higher consequence events. And to capture

the higher frequency events and to also recognize that we've used, we've done, we've stepped outside the real meaning of 10 CFR 20.

10 CRF 20 is an annualized limit that's summed up over all the releases that happen in a year. So in this case we're capturing maybe the better interpretation of the intent of 10 CFR 20, not to look at individual events like we do in the previous consequence chart but the sum of the over all the events.

So we basically do an exceedance frequency curve to make sure the total frequency of exceeding 100 millirem does not exceed once per plant year. And then it ends up taking care of the AO overage.

So those are the cumulative risk metrics that we use. And then the couple, just a couple of thoughts about the PRA, we just have one slide on that.

We recommend early introduction of the PRA into the design process although it's not required. There is flexibility in the approach when the designer wants to do this.

But the earlier he gets the PRA in the design process he can help the designers incorporate risk insights in the design long before he, the

designer even starts talking to the regulatory bodies about the licensing process.

But when it's, the earlier you introduce the PRA in the design process the more simplified the PRA is in terms of scope and level of detail. You make, you know, sensible judgments to incorporate detail and scope in terms of hazards until you have the design and site information that makes it meaningful to do those.

So you start probably with internal events and full power operation. And then as more information becomes available you expand to other operational states.

You bring in fires and floods when you have general site layout information, cable tray layouts and things like that. You introduce seismic and external hazards when you have a seismic design when you have decided what your seismic design is and you have enough structural and planning information to support a meaningful external hazards PRA.

So I want to get back, you know, this PRA process is not a one shot deal. We don't like figure out at an early stage what the DBAs are and then go away and everything goes away.

This is, one of the sort of challenges to

applying this process is that in each stage of design and site and licensing development you're building on your PRA, you're updating it and you're going back and revisiting your previous risk-informed decisions that are influenced by the PRA.

So this thing that's happening today with the operating plants where plants are coming in with applications for license amendments and based in part on some PRA inputs, than those decisions are subject to review and revision as the PRA unfolds even in the site operation.

MEMBER MARCH-LEUBA: You're saying that the plant manager is going to let you run a PRA that would challenge his license, that may challenge his license? I can assure you, George should be the one talking about that.

DR. APOSTOLAKIS: Definitely they will do it.

MEMBER MARCH-LEUBA: If they're doing it generally by Part 21 they need to do it.

DR. APOSTOLAKIS: When they come here they will not challenge that site. Dennis and I saw it in the early days where the PRAs that were published and were reviewed by the NRC didn't show that there were any problems.

But I remember in internal meetings the fire risk in one of the plants was really unacceptable and the utility decided to do something about it. That was not published.

That's a problem because when I was an academic we were looking for PRAs and examples of this. You can't get those. Those are internal. But they never come before you and say, I might have a problem here.

CHAIR BLEY: Well you might see --

DR. APOSTOLAKIS: But you guys may identify the problem.

CHAIR BLEY: -- license amendments. It's happened.

DR. APOSTOLAKIS: It could. But in general these things are done internally.

MEMBER MARCH-LEUBA: I thought Part 21 prevented you from doing that?

MR. FLEMING: Now Dennis earlier was asking a question about advances and maybe things that might be different than when this kind of thing came up before. One, back in 2006 the ASME Board of Nuclear Codes and Standards decided that we needed a PRA standard for non-light water reactors.

So I was chair of that group. And we

issued a trial use standard in 2013. And to capture the input from all the non-light water reactor developers that were involved in that project team it included representatives from the HGTR family, the liquid metal fast reactor family and just recently getting into, getting some involvement from the molten salt reactor family.

The, everybody wanted to make sure that they captured the risk of multi module scenarios. So the PRA standard and the PRA is intended to capture event sequences that may involve one or more reactor modules.

And there may even be some risk significant non-core sources that are also included depending on what the characteristics of the reactor are. So multi module is sort of captured explicitly in this approach.

And they're included in the LBEs. We don't expect to have any in the DBA region. But one of the motivations for introducing the PRA early in the design is to let the designer be aware of the possibility of multi module scenarios and make sure he has design features built into the plant to ensure that they don't become risk significant in the end.

The other thing, the final comment on this

slide is that we're not really, we're not advocating a risk based approach. We recognize the limitations and uncertainties associated with the PRA.

The PRA doesn't quantify everything. It's never complete. But it's intended to capture the current state of knowledge about events and reactor safety characteristics.

And so we augment the insights from the PRA with traditional deterministic methods and most of that is captured in this framework for the defense-in-depth framework which we hope to have some time today to cover.

CHAIR BLEY: Thanks, Karl. We are certainly running out of time. We're going to take a 15 minute break and come back at ten until. I'm going to give you 25 minutes to finish up the next two sections.

So think about what you really want to talk about and what you're going to pass on because you, at least for me I would put like ten minutes on the next section and 15 on the one after.

MR. FLEMING: Okay.

CHAIR BLEY: Either way, when the time runs out we're going to go to the staff. So pick your most important ones. So at this time we'll recess

until ten until. Thanks.

(Whereupon, the foregoing matter went off the record at 10:33 a.m. and went back on the record at 10:49 a.m.)

CHAIR BLEY: We are back in session. We're going under the SSC safety classification, and Karl is on Slide 24, for the people listening in.

MR. FLEMING: Right. And my goal in time management space is to have abbreviated talk on the safety classification. Just talk about, a little bit what's the same or different than what came out of the NGNP process so we have ample time to get well into the defense in depth discussion.

The NGNP process came up with three safety classes for SSCs. That was safety-related class which we've already covered how we get those. Those are tied into the process for, you know, putting together our design basis accidents based on several different options.

The middle category is called NSRST in our framework, it's non-safety-related with special treatment. And with those we want to pick up other risk-significant SSCs as well as SSCs that might perform an important defense in depth role which make up the safety significant SSCs. So our use of the

term risk-significant and safety significant is pretty much in alignment with the way these terms have been used in the 50.69 world.

However, the criteria we use for risk significance is by definition has to be different because we have to capture more of a technology neutral way to do that. The risk-significant SSCs are basically defined in terms of those SSCs that are responsible for producing risk significant LBEs, and there's a lot of detail provided in the paper on how to get those.

Basically, if an SSC performs a function that's necessary to keep one or more LBEs inside the frequency consequence curve, beyond those already picked up in the safety related SSCs, those are also considered to be risk-significant.

And also, if we look at the accident sequences where an SSC has failed, if those sequences comprise more than one percent of one of our cumulative risk metrics, than that's another way for an SSC to be called risk-significant.

And then later on I'm going to talk about additional considerations from the defense-in-depth criteria that can produce additional SSCs that may not be risk significant but may provide an important

defense-in-depth role. And then we have the rest of the SSCs modeled in the PSA and then of course outside the universe of possibilities we have all the SSCs in the plant.

And this diagram was inspired by some interaction we had with the staff to try to get an idea of, you know, how you put these things together. And the way this is put together, it's intended to be each oval inside is expected to be a sub-set of the outer ovals.

Well, a feature of this approach is that by virtue of the process we used to select the safety related SSCs, they're all risk-significant because they're all needed to perform a function to keep one or more LBEs inside the risk consequence chart. There may be others up in the AOO region that have that same characteristic, but all the safety related --

So we don't have a risk category, what's it called, RISC-2 that in the 50.69 world where you have safety related, but not safety significant. We don't have those. They're all risk-significant and, therefore, safety significant.

One of the things that we've done that goes beyond what NGNP did is try to provide more guidance on how we migrate from safety classes to

special treatment requirements. And for the safety related -- and I'm going to get back to a question that came up about principle design criteria.

For the safety related SSCs, we come up with what we call functional design criteria. And these are reactor design specific criteria that are tied to the safety related SSCs along the LBEs that they're participating in.

So they're very, very design specific and you could have two different, say, molten salt reactors come in and they might have different functional design criteria because the designers may have selected a different package of SSCs to become safety related.

Karl, and on your PDC question, on your principle design criteria question, one of our ideas here is that when an applicant puts to forth an application for an advanced non-light water reactor, he'll have available to him what comes out of the ARDC world, which are not really design specific.

They may be family of design specific and the functional design criteria could be part of the principle design criteria depending on when it's proposed by the applicant.

CHAIR BLEY: Makes sense. Back to your

little Venn diagram. Can you give me examples that help me understand how you can be safety significant, but not risk-significant?

MR. FLEMING: Yes. So one of our criteria which I'll get to in the defense in depth session is that, you know, it comes from the literature on defense in depth where you don't want to have over-reliance on a single design feature to perform something that's really in important role.

So these required safety functions that we define are really, really important and it guides our definition of safe related SSCs and design basis accidents.

Those SSCs are very, very important, but they perform the function. It's so important, we don't want to rely on a single SSC to perform an important function. So there may be, for example on the MHTGR, it may select a passive RCCS as a safety related SSC for heat removal.

We may define a role for maybe one of the active shutdown cooling systems that have blowers and you may have defined that to provided one of these, not for one, criteria from defense in depth. And it may not necessarily be risk-significant and, you know, may or may not be risk-significant depending on how

the numbers come out.

So it's conceivable that there may be a defense in depth goal not to rely on a single element of design. So you have to declare one more thing to meet that criteria to be, meet the defense in depth criteria.

CHAIR BLEY: I'll have to study that a little and think more about it. I guess one thing it would do is it would keep some potentially really risk-significant SSCs from having a high risk achievement work, because even if they fail they have this other back-up that isn't showing up as risk-significant.

MR. FLEMING: You're right, well, I'll think about that some more. But that is one example.

MEMBER SKILLMAN: Excuse me. This is where I've been waiting to make my comment since we started this morning. It seems to me that the SSC discussion is really subordinate to the overall risk informed base guidance document.

And in that document, which is Version M on Page 36, these are the words that I bring to the record. The designer then selects one specific combination of available SSCs to perform each required safety function that covers all the DBEs in high

consequence BDBEs. These specific SSCs are classified as SR, safety related, and Task 5 Alpha and are the only ones credited in the Chapter 15 Safety Analysis of the DBAs.

MR. FLEMING: Right.

MEMBER SKILLMAN: So with that on the record, let me try to pull on your comment, maybe they are two different salt reactors. One salt reactor designer has chosen one set of equipment to perform a specific set of functions, whereas another might choose another set. Both are acceptable because they fulfil the functions.

MR. FLEMING: Right.

MEMBER SKILLMAN: But under this category then, now I'm moving into your SSC document, in your SSC document the author of this document used the word credited three times. And two occasions it's credited to Chapter 15 and one time it's credited to 50.34a, excuse me, 50.34, 50.34.

MR. FLEMING: Right.

MEMBER SKILLMAN: The word relied on is used nine times. And it appears to me, reading all my instances, relied on almost means credited in the Chapter 15 world. And safety-related or safety is used 126 times, non-safety related is used 40, hence,

86 others are safety-related.

Here's my point, at this very early stage of this very fine fabric that's been woven here, now's the time to get these terms and these words adjusted. And I make that comment to the advisory group and I make that comment to the staff.

MR. FLEMING: Right.

MEMBER SKILLMAN: I was one the people that was back in 1969, '70 and '71 trying to connect Chapter 15 to the equipment that would be credited and the equipment that would not be credited. It's important to get these terms correct now because the heartache we went back, that we invested back in those early years only became clear once REG Guides 126, 129 and now 1.201 would lay out the implementers actually do this.

But there's a catch to this, when you finally get your license, whatever it might be, it had good old 50.59, you can make the change. The way the text reads in 50.59 of what is a licensing change is very significantly impacted by the interpretation of those words.

Whether it was credited, whether it was relied on, whether it's safety-related, we still have good old 50.55a, important to safety. Then there are

the others who say well it's not important to safety. And all of those words mean something.

Now's the time to get the glossary adjusted so that we're all on the same page relative to what those terms mean. It will save gobs to the implementers. Now's the time to do it.

MR. FLEMING: That's really good input and we had recognized that problem and it's a work in process. One of the, your term, action items that our team has is to propose a glossary and clean up the terminology, eliminating synonyms where unnecessary and causing confusion.

If we mean something different, or well, if we mean the same thing as what's in the current regulatory documents, we use the appropriate term. So that's good input. We recognize we're not there yet and, you know, it's a work in process.

MEMBER SKILLMAN: Thank you. Okay.

MR. FLEMING: It's been a struggle for us, frankly, to get -- because there's a certain way these terms are used in the PRA world even for light-water reactors and a different way they're used in license process and we recognize that's work to be done.

MEMBER SKILLMAN: Thank you. Thank you.

MR. FLEMING: One final set of comments on

the safety classification, what we did in the current work on the LMP, we tried to move the ball down the field a little bit in terms of how do we go from safety classification to, you know, additional requirements.

And the way our process works is that for safety-related SSCs we have to come up with these functional design criteria that may find some usefulness in formulating the principle design criteria, depending on how the application is put together. As well as lower level design criteria that are specific to the SSCs that are performing the safety-related functions.

But for all of the safety significant SSCs in both the safety-related and non safety-related SCC categories, we start by setting reliability and capability performance requirements for all those SSCs that are tied to what reliability was assessed in the PRA and how much deviation from those reliability assessments would influence the decision making as far as targets.

And we talk about these as targets, as design targets, they're not necessarily requirements. We don't mean that they would regulatory requirements, but the idea is that we want to make sure that all the

special treatment that comes into play here somehow connects the dots to how reliable the equipment has to be and how capable it has to be in terms of margins and performance in order to keep the risk informed process hanging together, to keep LBEs from migrating from region to another, from getting too close to the frequency consequence curve, to getting too close to our cumulative risk matrix and so forth.

So that's the starting point for special treatment requirements. And then the rest of the decisions on what special treatment that any safety significant SSC gets really is determined by an integrated decision panel that's the same panel that's going to do the defense in depth evaluation.

So what goes into selecting the special treatment is, you know, what's necessary for reliability and capability performance, and then how much additional treatments do we need to basically do things like manage uncertainties and address limitations in the PRA and other considerations that come from our defense in depth criteria. And that's what informs the derivation of special treatment.

So we don't specify a specific list of special treatment. That's something that really has to be done on a design specific basis. It's very

difficult to postulate a technology inclusive set of requirements that would be appropriate for any given reactor.

MEMBER REMPE: So, I actually pulled NEI 00-04 to try and understand about this integrated decision panel and has it been used? I mean, there's a lot of nice words there of the breadth of the experts that should be involved and they get a lot of credit for making decisions like determining adequate margin is in your paper that you provided to us.

But has this panel ever been created and used for a 50.69 process. And I assume the panel is a paid panel of experts that's very familiar with the plant.

And when you have them with these paper designs, I'm not sure that they're be able to afford that level of experts and maintain them throughout this design process. And so, I'm just kind of wondering, was that discussed much with the staff and can you give me more details about what you expect? And maybe it ought to be documented in this report.

CHAIR BLEY: And try to make it concise because we're running out of time.

MR. AFZALI: So the panel for X Energy, for example, they did a tabletop exercise, the panel

consisted of external analyst, like solar nuclear development and the designers of that technology.

So I would not see this as a -- if I may choose a different venue to come up with a expert panel that they think qualify to make decisions. But that panel will not be substantially different than what we would use for a deterministic evaluation when we are trying to identify licensing basis event.

So we have had discussions, we do understand that the outcome of a lack of operating experience, so we have to consider that as part of our conversations. But we have not been prescriptive in nature of what that panel should look like.

I take your point that you need to, perhaps it would be advisable to have some guidance on the expert panel formation, the group that is going to be there, what expertise should be in there. We have all those conversations are part of 50.69, license amendment and we came up with a guidelines for that. Maybe we look at those guidelines and see how can we transfer that to a process like this.

MEMBER REMPE: So see NEI 00-04 does have a lot of good detail, I just am not sure that the start-up companies are going to be able to adhere to that level of detail.

MR. AFZALI: I agree. I'm just wondering what those start-up companies would do identify LBEs if they don't use this process. They still to need to form something and you have to have those conversations to make sure we don't increase anybody's burden, but they want to a have good realistic approach. I do agree. We will look at that option.

DR. APOSTOLAKIS: Maybe the Regulatory Guide can give some advice how to do this because it comes from the staff.

CHAIR BLEY: Karl, you're down to the last five or ten minutes and you're on Slide 27.

MR. FLEMING: Right. So let's go on to the defense in depth approach. We picked up where the NGNP process left off in terms of the DID approach. In our framework, what this approach leads to is that we decided to build on the integrated decision panel approach that was in 50.69.

It not only addressed the things that are addressed in 50.69 having to do with safety classification, but to give them the responsibility to put together a documented, from the designers point of view and the developers point of view, a documented basis for the designer's evaluation of defense in depth adequacy.

This document would be dated periodically as you go through the different design and licensing phases. At earlier phases, I'm sure, there will be open items that haven't been resolved because not enough design information and analysis information has been brought in. And it's a type of document that the NRC staff could audit to see what the point of view is from the developer on terms of defense in depth adequacy.

What inspired this earlier development of defense in depth was remembering the Exelon PBMR discussions with the NRC, there was, somebody made a comment that while this plant doesn't have a leak-tight containment and therefore it's not a defense in depth.

And back in those days we recognized that we need to find a better way to talk about defense in depth that is more meaningful for different kinds of reactor technologies that have out-catered the safety case to different elements of design.

So we picked up on what NGNP came up with on terms of this triangle diagram which the bottom two elements in the triangle is where the defense in depth exists, except there's some physical aspects in defense in depth which show up in the physical part of

the design, the plant capability to defense in depth.

And there's the programmatic elements that are put on to ensure that the design intent that was in the plan was actually realized when we construct the plant and as it's operated throughout the plant lifetime to give you confidence that the plant capability is actually delivered.

And the risk informed evaluation, means that we had deterministic analyses and probabilistic analyses that are going to be going on in parallel with the design evolution that would lead to feedback mechanisms to enhance the plant capabilities as needed and the programmatic capabilities as needed.

We came up with a set of attributes and, also, in building on one of the earlier questions, we did review Mary Drouin's fine review and bibliography on defense in depth, and we picked upon that the idea of talking about layers in defense.

And we thought that was an advantage in this approach because the whole concept of barriers looks quite a bit different in some of these reactor designs. So we thought that layers of defense versus levels of defense made a little bit of sense here.

We adapted from the IAEA, which really still talks about levels of defense, we adopted a

diagram that we modified a little bit here to make it more meaningful for beyond design, I'm sorry, for advanced non light-water reactors to talk about the layers of defense. And in this framework, this is really in a great alignment with the way we organize the definition of LBEs.

So some of our LBEs are arrested. In fact, some LBEs don't happen because we've done a good job preventing initiating events and we go into different layers and we terminate the LBEs at different layers, depending on the response of the plant and the levels of diversity and redundancy that have delivered that process.

So, we've adopted this type of a diagram. The defense and the IDP Panel then goes back and takes a look at what's coming out of the PRA in terms of the LBEs and takes a broader look at the LBEs in terms of identifying what wasn't really analyzed in the PRA, what are the limitations of the PRA and those type of things and factors that in to some recommendations on are there things that could be done to enhance the physical defense or the plant capability defense in depth or the programmatic defense in depth to improve the confidence that the safety case is going to be realized.

We also, then, think it's appropriate for this same panel to take the lead on coming up with a specific package of special treatment requirements that are appropriate to not only achieve the reliability and capability objectives or targets, but also to provide greater assurance and a greater degree of confidence that things that may not be adequately resolved in the PRA are addressed.

So this is all outside the PRA process, but it also does a critical look at what's coming out of the PRA to make sure that things that are not done very well or are resolved very well in the PRA are given some consideration. We have a set of attributes for each of the parts of our triangle on the plant capability defense in depth--

CHAIR BLEY: We're on Slide 30, by the way.

MR. FLEMING: Yes. We've gone on to Slide 30. We've defined a set of attributes that, and some things that are considered in the evaluation for each attribute to be able to take a look at these defense in depth characteristics.

And one of the things that, in terms of reliability, we recognized that we're migrating away from a reactor technologies that are relying on

primarily active redundant safety systems to more passive, utilization of passive and inherent safety functions and so forth.

So, we've broadened the idea of looking at redundancy and diversity to considering a combination of inherent characteristics that may be responsible for part of the safety function passive SSCs as well as active SSCs that are performing those functions. That's sort of the focus of that evaluation.

These are little bit out of order. I'm going to skip to Slide 32. We have in the programmatic area, we focus on what do we have to do to assure that there is sufficient quality and reliability in our safety significant SSCs in being able to deliver these performance targets.

And the IDEP basically takes the lead in setting what these performance targets should be, based on looking at what's coming out of the PRA, considering how far off the reliability might be from what was assumed or assessed in the PRA, as well as the capabilities to mitigate the accident. So they set the performance requirements and then they do a lot of critical look at the uncertainty treatment.

The PRA's going to do its best to quantify the range of uncertainty and the frequency and

consequence assessments that are associated with the current state of the art of PRA as well as leaving all the requirements in the PRA standard.

It's just going to look beyond that to look at other unknowns that just aren't jumping out and addressed, the same kind of thought process that the NRC Staff would normally use to take a look at a license application. But the idea is to build up a set of attributes and evaluation criteria that can be audited by the Staff.

Now, back to one of George's suggestions here. We're trying to give some kind of an idea on some evaluation criteria that can be used to established when is enough, enough. And one of the tools that we came up with to look at that is this table that basically is used to examine all the LBEs that are coming out of the PRA in terms of the layers of defense, organized by layers of defense.

And we have both quantitative and qualitative criteria for each layer of defense, well for most of them. For the first layer we just have a qualitative semi-quantitative target to make sure that we keep the frequencies of upset transients under control.

Then for each of the layers of defense, we

need to make sure we keep the LBEs in the right frequency range because it effects the decisions we're going to make, which class that they're assigned to.

And we also want to meet some qualitative criteria that minimize the frequency of challenges to our safety-related SSCs, but we also want to adopt the no undue reliance on the single element of design to perform an important safety objective.

So, this is where we might get a safety significant SSC added into the mix that may not necessarily be risk-significant. And we also have criteria that go cross the entire frequency consequence spectrum that, again, brings up the not relying on the single element design.

So, this was one of the things that went beyond what NGNP came up with that's intended to help reach a conclusion by the integrated decision panel on when they believe there is sufficient defense in depth.

There are judgments made as to when it makes sense to begin this process and it sort of depends on the stage of the PRA, stage of design development and so forth.

But at some point in the early stages of design, there'll be a baseline evaluation which will

create a document. And this baseline evaluation and document will be updated periodically as the different stages of design and licensing evolve.

What they will come to conclusion on, this integrated panel, is they'll come to a resolution of is the plant capability DID considered to be adequate? Are the criteria on this previous Table, that would be 5.2 in the document, are satisfied?

Review of the LBEs completed with satisfactory result with critical review especially on the risk-significant LBEs? Is the programmatic DID deemed to be adequate?

What are the performance targets that have been set for the reliability, capability of all the safety significant SSCs? Are the sources of uncertainty in selecting and evaluating the LBEs identified and have they been adequately addressed in these protective strategies?

And then, finally, the panel, the very, very, important outcome is what special treatment requirement should be selected for each of the safety-related and non-safety-related SSCs.

So, that's the process. It's done by an integrated panel and it'll create a report that will be part of the defense in depth evaluation and can be

reviewed or audited by the NRC Staff at any stage of the licensing process.

CHAIR BLEY: Karl, thanks. I think we're going to hold any questions here to the end. Can you gentlemen stay until the end of the meeting?

MR. FLEMING: Yes.

CHAIR BLEY: Okay, good, because I want to talk about what comes next and what we might want to revisit. But at this time I think we want to move to the Staff and hear what they have to say. We'll probably go a little fast, but they say they don't have much to say so what do we do? They will in October for sure. Thank you.

MR. FLEMING: Thank you.

MR. RECKLEY: Okay, thank you. My name is Bill Reckley with the Staff, and John Segala is here as well. We're going to talk about our plans going forward starting with what you've seen in terms of Revision M of the licensing modernization what we expect to get in an NEI Guidance.

And then our development of the associated draft Guide of 1353 Guidance for Technology-Inclusive, Risk-Informed, Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications and Approvals.

So you'll start to hear, I think, a little bit of a difference in emphasis in that the REG Guide is intended to -- the rule to which the REG Guide applies is 50.34, 52.79 on the content applications.

And so, what Karl was describing in terms of how the design was done, obviously there's a close correlation between how the design is done and what gets put into a licensing application, but our focus is going to be more on the license application.

I'll go quickly through the background, a lot of this has been mentioned. Proposals very similar to this one had been brought to the Commission and even to the ACRS. As Dr. Bley mentioned, NUREG 18-60, some similarities. NGNP, obviously, even more similarities.

In terms of recent activities, John mentioned earlier, we had come to the ACRS with the vision in strategy and implementation action plans and then more recently with REG Guide 1.232 in the functional containment paper. All of those related to this overall concept of how will non-light-water reactors do design and then from our point of view, make applications.

One of the things coming up are additional visits to the ACRS. One of the things that I try to

keep in mind is kind of an integrated or holistic approach. And we often talk about safety and whether this design is more safe, less safe. I prefer to talk about not more or less, but how they get to where they are.

For large light water reactors, you cannot overlook that part of the safety case for large light-water reactors is the ability to move the people out of the way. And so you get emergency planning in terms of the mitigating strategies, it's an important mitigating strategy.

As we move forward on advance reactor design, the commission policy statement on advance reactors is, let's put a little less emphasis on moving people out of the way or having operators have to act quickly or increase thermal margins so reactor protection systems don't have to act in a matter of seconds or things go badly fairly quickly if they don't.

Increase the thermal capacity of the system we were talking about earlier, that's graphite and sodium. The advantage those coolants bring, they have disadvantages, I'm not trying to make a case one sided here. But one advantage is that they burn is the larger thermal capacities in terms in comparison

to water. And so all of those things keep in mind that are holistic or integrated approach.

So, we're here today to line up the discussion of licensing modernization. You have had more recent discussions on the advance reactor design criteria. We talked to you about functional containment, which kind of crosses between both prevention and mitigation. In August --

CHAIR BLEY: Is there a paper up at the Commission?

MR. RECKLEY: Almost. Shortly. You'll hear in August the proposed emergency planning rule for small modular reactors and non-light-water reactors or other new technologies. So we're trying to keep this holistic thing in mind as we go forward and that's part of the challenge.

Dr. Apostolakis mentions security. We are in advance reactor space and small modular reactor space, even bringing some security in with some potential consequence based security measures.

So getting back to my point about content applications. This isn't even all, this isn't all inclusive, but basically if you take the 19 Chapters of the FSAR and you take some other aspects or parts of applications as they come in, this is a partial

picture of everything that a designer or a license applicant needs to bring.

For large light-water reactors, this puzzle has largely been defined. It's been modified and clarified over the years, but we're at a fairly stable point where this picture is defined for large light-water reactors.

For non-light-water reactors and even for small modular reactors as you get into the new scale designs, we'll start to see focuses change like much of the guidance that's prepared, and I'll just pick one out, Chapter 8 on electric power.

That's been largely defined because for large light-water reactors using, at least for the operating fleet, using active components to provide the cooling, you need power. And so all of the, or much of the guidance related to off-site and on-site back-up power's been developed with that particular model in mind, the importance of diesel generators and so forth.

As you switch over to small modular reactors and non-light-water reactors with the larger thermal capacities, the importance or the need for immediate back-up power or reliance on active systems is diminished. And so, it changes, I'm not going to

say it's zero, but depending on the plant design, it's going to change.

So, what we need is a way in order to redefine the puzzle for non-light-water reactors. And in addition to that particular challenge, each non-light-water technology and each design within a technology can be different. So it's going to be very difficult to simply say we're going to replace.

People talk about replacing NUREG 800 or Reg Guide 1.206 with something for non-light-water reactors. That would just be taking a prescriptive approach for large light-water reactors and saying we're going to repeat that for however many designs might face us. So, we're really looking at more of a methodology.

CHAIR BLEY: Bill, before you go on. Both Dr. Apostolakis and you brought up security. I vaguely remember, and it's probably something that we saw. I thought for somewhere in this new reactor area there was or was to be a paper on integration of safety and security.

We had a briefing from NSIR a year ago, a year and a half ago on vulnerability assessments which are, at least they're comprehensive kinds of analysis on PRAs. Is there any of that that is getting

factored into the process you guys are working on and is that something that will come here?

MR. RECKLEY: We are trying, at least on the security basically gets broken down into theft and diversion and then sabotage. So I'll limit the discussion to sabotage because it can more closely align with just external events and so forth.

CHAIR BLEY: Exactly.

MR. RECKLEY: So, in the area of sabotage, NEI submitted a paper on a consequence based approached basically saying how can a sabotage event lead to a core damage in a potential off-site release and what's the timing of those?

And that is going to be in a paper going up the Commission about the same time as functional containment where we ask the Commission to undertake a rulemaking to define that.

So, it's somewhat related to what Joe Rivers came and talked to you about in terms of the integration. But that was also, I think, including the operating fleet where --

CHAIR BLEY: Well, it was at that time.

MR. RECKLEY: Yes. We can be a little more focused on just non-lights and small modular light-water. So the methodology I mentioned in how to

put these puzzles together is what we see coming out of the licensing modernization. So I took liberty with the NGNP graphic on defense in depth and kind of say how we can see this coming about.

So you have the LMP focus, which is really on the defense in depth, the Chapter 15 traditional deterministic design basis accidents and Chapter 19, which is the probabilistic risk assessment insights and some other related discussions and you take that as being the assessments that are done.

And you're going to use those assessments to sharpen really what's the heart of a nuclear design, which is Chapters 4, 5 and 6, the reactor, the reactor coolant system and engineered safeguards and retention of fission products.

And this is iterative. One of the things I think got mentioned in the earlier discussion, but is just imperative that people keep in mind is this is not a linear process.

This is iterative both by the designers, well iterative by the designers. Hopefully, by the time they're making an application they've gone through all the iterations such that they've made their choices.

But, you have not only the plant

capability defense in depth arguments that Karl mentioned, but the programmatic. And we really are looking to see how all of these fit together because, again, you need to take this holistic view.

A particular designer, when they're looking at a reactor coolant option, they can try to design away any concerns or they can use a combination of design and programmatic controls to provide the same level of comfort or assurance that that system is going to work.

So this isn't really any different than what evolved for the large light-water reactors. But that evolved over a long period of time and what we're trying to do is make sure that when the applications come in, we're already well along on that process.

So all of this has to be thought about by the designer by the time they're coming in for a design. And I bring up the importance of the programmatic and physical defense in depth measures just because, again, especially for non-light-water reactors, my personal view, the problematic controls are going to be imperative to make up for some of the lack of operating experience or sparseness of operating experience.

And so, when they come in they really have

an option of how much testing they've done to say I don't need to do any additional surveillances once I move over into operations or as part of a business risk, I've done a little less testing ahead of time and I'm going to do online surveillances to make sure it behaves the way I thought. And, again, the business risk is if it doesn't, oops.

But, from a public safety point of view, the two can be made equivalent. From the business case, maybe not so much. But that's the advantage of being on the NRC side of the table is we don't have to worry about that aspect.

MEMBER CORRADINI: Bill, can I clarify what you just said a different way. So if a designer, vendor, owner all together want to do this, they could take a prototype route and do a power ascension to prove on the device as it's coming up in power -- but they take a business risk. But this would be potentially just an acceptable way of going through it.

MR. RECKLEY: From a public health and safety point, yes.

MEMBER CORRADINI: Okay, that's what I thought you were getting at.

MR. RECKLEY: Okay.

MS. CUBBAGE: This is Amy Cubbage. I just want to interject that we're not necessarily seeing would have to be a prototype. If the Staff can make a reasonable assurance based on the information available, plus the programs that are included in the license, then that would be a potentially a non-prototype situation.

MR. RECKLEY: Yes. It would be a prototype or it could be just a combination of technical specifications and in-service inspection and all of the things that go into monitoring a plant once it gets built.

We talked about support systems, what I call support system, instrumentation, electrical power, auxiliary systems, power conversion, all of those things. The level of detail in the FSAR would be informed by and determined by what the actual safety functions and the risk insights that come out of the LMP process to inform that part of the application.

And, again, it'll be different for different technologies, it'll be different for different designs within a technology.

CHAIR BLEY: Bill, looking ahead, I don't see any slides that go through the comments you made

so far. We've seen some of those. Mostly they seem to me they're kind of detailed questions, some open ended questions and some we think we might prefer some other approaches.

Do you consider those well developed at this time or where do you think this is heading? By October you expect to have a document.

MR. RECKLEY: By October we expect to have a document. So, let me just skip to Slide 7 real quick. Noting again the demarcations and the cutoff remain under discussion and that's one of the things.

Now, when I say we're going to be back in October, that should be a bit of a hit that I don't think we're night and day apart. But whether things shift by a half a decade or something within the curve, that's one of the points we'll discuss and we'll either agree and the industry will change or if we think strongly enough about it, we would take an exception in the REG Guide.

One of the things that I wanted to mention because I bring up the cutoff or the lower bound, we're also coordinating this with other activities. For example, NuScale has come in with a report on trying to define credible in order to inform their source term used for various regulatory questions.

We obviously see the relationship between that activity and something like a lower bound for the beyond design basis events here. Not to say the answer will be the same, but we need to make sure that we're at least cognizant of simpler regulatory decisions being made in two different areas, if you will, the light-water small modulars and the non-lights.

And just to reemphasize, and this is the Staff's bullet that they put into the Draft M, the target values shown on the graph are not acceptable, unacceptable, they're a frame of reference. The way I like to think about it, it's a frame of reference.

So, you can take safety functions, you can take structure systems and components and you can start to do the assumptions on whether they fail and then that tells you where you're moving on the graph.

And the target line, I generally agree with the observation that if you're on the right side of that line or above, you're probably want to give a lot of thought before coming in with an application if you've got things on the other side of the graph.

But on the left and lower side, really it's just providing a frame of reference so you can see, hey I need to make that safety function or that

SSC much more reliable. Maybe I need to add redundancy or diversity in order to make sure that the reliability of that function is there. Or maybe I need to change and add another wall because I'm going to try to address it from the consequence side of the equation.

But the designer is using this to make design decisions and obviously the expense comes in. Is it more cheap or is it cheaper to add diversity and redundancy to improve reliability or is it cheaper to add a wall to lower the consequence? So from the overall perspective of the Staff, either one of those might provide adequate protection, so it's up to the designer to propose.

MEMBER REMPE: So I still would bring up what I brought up this morning that you may not be able to meet some regulatory criteria that have two hour limits on those values and their just making decision on the design.

MR. RECKLEY: And as Karl emphasized then and I'll emphasize as well, this does not mean you meet all, this is populating Chapters 15 and 19. All right? You still have the equivalent of Appendix I, that's for light-water reactors, but even without that you have --

MEMBER REMPE: There's a 10 CFR 20 requirement

(Simultaneous speaking.)

MEMBER REMPE: -- why not put that on this plat if you're making design decisions.

MR. RECKLEY: Well, again, it's a frame of reference for evaluating events and how much you move. It's not saying that if all of my Chapter 15 and 19 events fall a particular way that I've met all of the other requirements like are in Chapters 11 and 12 or in Appendix I or even in the EPA effluent requirements, all of those things still apply.

Much of those, including Part 20, and this is one of the age old questions of bringing even Part 20 into it, Part 20 is really meant for normal effluence and that's -- so it's kind of artificial to even bring in to assess events.

But you had to bring something in and this might be, again, the Staff's not willing to say yet, but you needed to bring something in as a frame of reference at the lower doses and Part 20 has been a proposal since NGNP to use.

MEMBER REMPE: And then, of course, if they're designing it and they want to have an economic plant, they're going to want to reduce margins. And

so, I would again emphasize what's an acceptable margin, because that's going to be a discussion in having this Panel making the decision as indicated by one of the slides we just saw.

MR. RECKLEY: Right.

MEMBER REMPE: It's open ended.

MR. RECKLEY: It is, and again, from looking at it from an event standpoint, we can do this. From the other side of the business equation, to say that a designer is going to go out and say I've done this on the cheap and I'm going to release as much radioactive material as the regulator would possibly allow me to do and I want to put it next to your house, you know, that's another aspect of the business case that might not work out. So, all of that would remain to be seen.

So, going to what the Staff has as some, a few remaining items to work out between now and September. The F-C target figure, we would like to come to an agreement and the ball is in the Staff's court on that, if we're going to propose anything different that the Staff has to propose.

I mentioned the lower range, we are looking at the decisions that are being made in other areas so that we can be consistent. There's some

remaining questions on the consequence analysis and the ACRS numbers that we're asking some questions of that as well in terms of the source term and how it's used. Consideration of uncertainty is obviously, that's a big area.

The role of the non-light-water reactor PRA standard? We think we have that worked out. In large part the NRC is on board of saying we plan to review and hopefully endorse that standard as it's finished.

But one of the things that we have to look at as we're building this particular construct is standards sometimes take a long time to develop too. And so, our process if we're building in a dependency on a future standard, we just have to work out exactly the ramifications of that. The terminology, we agree that it's imperative. We really want to get that right from the start.

We've had some feedback on making sure that this system has the flexibility for smaller and simpler designs. The number of designs keeps growing. Some of them are relatively simple. And so, we just, again, we're not saying we see an issue, but we just need to review it and make sure that it would be beneficial for them.

External hazards we think needs to be clarified how it's written. I don't think we have an issue, but it just needs to be a little more clear in the write-up.

And then interface with other requirements, such as emergency planning. Again, going back, we would like an integrated approach and so we would like to know how all these pieces fit together.

And there are areas where the report mentions how it might be used, for example, to show that the doses are less than a certain amount and, therefore, that might help support the discussion on emergency planning zones.

We just need to make sure that gets clear. If not in the guidance, then that's an area we would pick up in the REG Guide. And then, although this is largely a design process, we really are curious how it moves into the operations phase so that we have a continuity. That's an area that for the operating fleet I think is not worked out optimally, I can say that.

One item I want to add quickly, and this will go to Dr. Bley's suggestion that we make this a full day in October, is there's really another product

that the Staff envisions which is a related Commission paper in that some of the things like the frequency consequence curve and once we agree on the demarcations, we think it's likely that that might be a policy matter.

If it's not a commissioned policy decision, it's at least something the Commission is going to be interested in. And so we really see three products being discussed in October, the Industry Guide, the related Regulatory Guide, draft Regulatory Guide and a related Commission Paper in which we bring to the Commission's attention anything that we think they need to be informed of. And, personally, I think there will be some of those to cross over into something the Commission will want to vote on.

CHAIR BLEY: Back in the days of 18-60, there was almost rulemaking.

MR. RECKLEY: Yes.

CHAIR BLEY: There was almost an application project with a new design.

MR. RECKLEY: Yes.

CHAIR BLEY: And there was a Commission Issues Paper that went up on a lot of these things.

MR. RECKLEY: Right.

CHAIR BLEY: Wasn't that included at that

time? Did the Commission respond?

MR. RECKLEY: To some of the issues --

CHAIR BLEY: To the F-C curve, in particular.

MR. RECKLEY: I don't think for the F-C.

CHAIR BLEY: It wasn't in there? Okay.

MR. RECKLEY: Because that --

CHAIR BLEY: It didn't go back --

MR. RECKLEY: That was the 18-60 and the advanced notice of proposed rule making and so I think, my memory is the Commission would have said go ahead and propose, but they didn't accept it.

CHAIR BLEY: There was an issue paper separate from the AMPR.

MR. RECKLEY: Right. Right, beforehand.

CHAIR BLEY: But you don't think this was in there. Okay. Or they didn't respond to it.

MR. RECKLEY: Or they didn't respond.

CHAIR BLEY: Okay.

MEMBER REMPE: So in the document they gave us they refer to the criteria that you had for multi-modular risk and they said that those had almost been approved. What is the status on that?

MR. RECKLEY: That's in interim Staff Guidance document. If we can, I forget the number,

28? I'm making that up.

MEMBER REMPE: But you had issues, but --

(Simultaneous speaking.)

MR. RECKLEY: For light-water small modular reactors we usually --

MEMBER REMPE: Just the light-water ones.

MR. RECKLEY: Well, that was the focus. We'll have to look and this is part of the activity that we'll need to do to make sure that it fits, but that was issued with reactors like NuScale in mind which has 12 reactors to a plant.

MEMBER REMPE: But you will be evaluating if applicable as part of what we'll see by October?

MR. RECKLEY: Yes.

MEMBER REMPE: Okay.

MR. RECKLEY: And then last bullet on here is there was a more recent SECY paper 18-60, is that coincidence, I guess, SECY 18-60. That is the result of the more recent activities in considerations of a NRC transformation team. One of the recommendations in there, for example, was that we go ahead and pursue a Part 53, the technology neutral rule.

MEMBER CORRADINI: So can I interject, Bill? What is your view of that? That seems to be a needless years long approach.

MR. RECKLEY: I would say the Commission is going to tell me what my view of that is.

MEMBER CORRADINI: I mean, Dennis brought it up in 18-60 when that was going to be there, but that would be ten years ago and probably five of it would have been taken up and using it. I'm very concerned about this pushing it down the road.

MR. RECKLEY: I will just chime in that what we're doing now, if we were directed to do a technology neutral rule Part 53, what we envision is taking what we're doing now as the heart of it. And so, it would not be -- it would be kind of like a relay race where we would say okay, now let's take what we've agreed to, maybe we've issued this draft Guide.

I think Amir mentioned the tabletops that we'll be doing, some before and some after the issuance of the draft Guide, we'll get some lessons from that. As we go forward that will put us in a better place to do a rule making, I think, if we're directed to do that.

And then lastly, just the schedule we've talked about. October 30th is the next subcommittee meeting. I think I would agree that a full day would probably be needed especially if we're throwing in a

paper. It is a draft Guide and so in terms of ACRS, that might give you a little flexibility in that you would, as you did for the Advance Reactor Design criteria, you get kind of two bites at that apple.

Really, from my point of view, at the draft REG Guide you would just be looking for fatal flaws but not, we could revisit at the issuance of the final Guide more specific areas. But the SECY and the policy issues would also be including some recommendations that you would probably want to write a letter on.

CHAIR BLEY: I think so. I mean all of this is really significant. And giving it some time is important.

MR. RECKLEY: Right. And we can work out between now and then if there's any other interactions. I don't know if we have time for another meeting, but certainly we can share things with you between now and the end of September. Although, that's not that far away.

And so, after the full committee meeting in December, we would plan to issue the draft REG Guide later that month. Our goal is to try to do it by the end of the year. The SECY, we would complete in early 2019. And then the final REG Guide is a

little juggling here, because it's going to be informed by the Commission, the ACRS, the tabletops and any number of other things that will be going on at the time. So, with that --

CHAIR BLEY: At this time, I want to talk a little bit about that October meeting and if all of you or one of you wants to come up, or just Amir? At least from my point of view, if the OMP group could come back, I think it would be extremely useful, especially somebody to talk about details.

And the ones that jump at me as I went through the white papers and the main document, I think if whoever did that pulled out the flow charts from all of those, that would be a good place to walk us through the whole process on each of them.

And then we could go into other details, and we would want back-up material to support that. But we've kind of glossed the surface and I think we need some time to really dig in.

So if you can support that, I think it would be useful if the Staff presents it from their review, you don't get your voice in here and I think this is a significant kind of feel, I think that would be useful.

MR. AFZALI: We would be happy to do so.

CHAIR BLEY: Okay. And all of you will work with Derek Widmayer on our Staff to try to focus all together. The date you have up there, September 28th is really important.

I mean, really important, because this stuff is significant, and I don't know if you're going to have any revisions by that time. We need them a month ahead and if, I don't want to slip your schedule, but if we don't get them a month ahead given the significance, I think we ought to slip.

MR. RECKLEY: That's actually why I put that on there. That's a forcing function for us to have everything done, because October 30th sounds, that gives us an extra month. But we really don't have that.

CHAIR BLEY: For us, you don't have a month. We need a month to look at it.

MR. RECKLEY: Right. And so that --

(Simultaneous speaking.)

MR. RECKLEY: -- really puts us at the end of September and that's the reason for putting that on there.

CHAIR BLEY: Amir, do you expect substantial changes in drafts that we would see beginning of October, end of September?

MR. AFZALI: I do not expect significant changes. Our conversation with the Staff may result in some numerical changes here or there, but in terms of our approach and the contents.

CHAIR BLEY: Yes. I think most of us are going to need to study those white papers some more to really get comfortable with the detail in there.

MR. FLEMING: If I might just add a comment to Amir's is that one of the things that we are going to try to work on is the terminology. We're working on putting together a glossary and we want to get an agreement with the NRC Staff on the glossary. And then we need to do a better job of, you know, getting the language right for the right words, crediting and, you know --

CHAIR BLEY: Maybe we should be talking about March or April, because somehow glossary is one of the hardest things to agree on.

MR. FLEMING: We won't claim we'll resolve the issues, but we're going to work on it. Okay?

CHAIR BLEY: I'm sorry, Amir?

MR. AFZALI: As you have spent time a little bit on is that this margin question that has a significant conversation about user margins, if you see the margins. So we want to provide some

clarification of how the margins are presented and how those could be used as part of decision making.

CHAIR BLEY: I think that's going to be very important. People will be interested -- Dick, was it you? I'm trying to think. Please go ahead.

MEMBER SKILLMAN: Yes. Thank you, Dennis. My question is for Bill. And my question is on the topic of terminology, how wide a swath do you see you will be taking?

And here's the reason for my question. If I look at the wording in 50-59 and I look at other documents that men and women that work the plant sites use, that's where the terminology issue becomes critical. And it becomes critical in operability determinations, it becomes critical in requests for exigent expect changes.

And I know this is a long way down the line, but since were in the embryonic stage of the new reactor designs, now's the time to make sure that even though subordinate or other important licensing regulatory documents line up with the vernacular that's being used in the new design.

And so I know that that will take time, but as we use these new words or get aligned on the terminology it needs to be aligned not only in the

design documents, but in the implementing documents in the regulations.

MR. RECKLEY: No. I agree. And that's, again, when I had the bullet that says how does this carry into operations that's --

MEMBER SKILLMAN: Thank you, Bill. That's my point.

MR. RECKLEY: And Mike was asking, although I'll take his question as being asking my personal opinion, that's one of the reasons why I don't dismiss Part 53 as quickly, is because even within this discussion that you've had here, you've seen differences between how the very similar terms are used in licensing modernization as they are in comparison how they're used for the operating fleet. And that will be a constant source of issue.

Whereas, if we started somewhat with a clean slate and said these reactors are on Part 53, they go their own terminology. Don't confuse it with the 50 year history of the operating fleet, there's some advantage. I know as Mike was saying, there's disadvantages to the rule making, but there's also potential advantages.

MR. SEGALA: And we've also had a meeting on LMP a couple weeks ago where we talked about the

glossary and the Staff provided feedback on certain terms that we identified that weren't being used consistently. And they started flagging them and then they counted, similar to what you had done, they counted the number of times all those words were used in the documents.

MR. RECKLEY: They even used the term anti-glossary. There's a glossary and there's a anti-glossary on words to avoid using.

CHAIR BLEY: I had one other item I wanted to mention, I didn't raise it when Karl was talking. On the process for selecting and evaluating licensing basis events, and Jose touched on this. As you said, it's a iterative process. You have go round and round and process many times.

But there are parts of the PRA, they cannot be really complete until you've got all of your abnormal procedures, your emergency procedures, you've got a crew and a trained crew and, you know, it's pretty far on the design. It's after, at least under the current processes, it's after the licenses have been issued.

I think you need to think about more the possibility that in that process new licensing basis events might come into your list from this finalizing

this PRA as everything gets more and more complete both from the HRA and there might be more external things that evolve. And think of what kind of process you can have so you don't need a licensing amendment.

Something built into the program before you load fuel that would allow incrementally adding some SSC, safety-related SSCs and LBEs as such that we're not caught in a spot that bringing this thing to conclusion before start-up put you in a spot, you need a new license. And I hope you've thought that through by October.

MR. FLEMING: Yes, that's a very, very good question and a very valid concern. Our thought on that question is that the parts of the PRA that lead to the definition of safety-related SSCs in design basis accidents, we have some confidence that that will be stable throughout the process.

That, sure, there'll be changes to our PRA, they'll be maybe new LBEs that show up, probabilistic LBEs that will show up, but the robustness that we need in the PRA for selecting LBEs is just, you know, according to our frequency criteria that we have here is ten to minus four per plant year and there's a little bit better handle on stability of the LBEs up in that range than there would be down the

BDBE region.

CHAIR BLEY: I certainly believe that, but, you know, some confidence is different than complete confidence and the real world can always surprise us. So I think any thought about it ahead of time and having a way out if this should arise is helpful. I think I heard Harold trying to get in. Harold?

MEMBER RAY: Yes, Dennis, before you went on to something else, I just want to say what's related in my mind here is I would like us to be able to touch on a future, is you now got our eyes focused on different categories of SSCs, you just mentioned safety-related, but we know how to, on what basis we take confidence in our assumptions about the safety-related SSCs in terms of tech specs and all the assurances and so on.

I would like to have, at some point, talk about how we're -- life of a plant, how we're going to have confidence in our assumptions about the other SSCs, which all play a role in the new analysis approach that taking.

So I just wanted to lay that on the table and say what is it, is it just experience with these things that are going to the be basis of our

assumptions or are we going to have a meet-in-school kind of application that applies to them throughout their life? What is it that we're going to do that's comparable to what we already have high confidence in, in terms of our understanding for safety-related SSCs?

MR. RECKLEY: Right.

CHAIR BLEY: Okay. Thanks, Harold.

MR. RECKLEY: Yes, this is Bill. Karl mentioned before the reliability and capability aspects that'll go into the special treatment definitions and it's a good question. How do we make those fit once we move over into operations?

And, again, it would depend somewhat if we have to try to force fit it into something like the maintenance rule because we're sticking with existing regulations or if we think we might move into a new regulation. That be a little actually, a little easier to define how we did that. In the absence of a rule, we could always do it as part of the license or as part of a design certification.

CHAIR BLEY: Okay. Yes.

MR. FLEMING: Also, I wanted to make a sort of a parallel analysis of if one followed a traditional ad hoc process you come up with your licensing basis and just go through some of the

history that George was mentioning. We had a couple of ATWS events that happened and we had to overlay on the licensing basis some new requirements to deal with ATWS because we saw it in experience, station blackouts occurred at different plants and so forth.

So both processes, the risk informed and the traditional deterministic basis, have to face when new evidence arises that challenge the judgments that went into it. So it's not like this is only going to be happening with PRA. And it is true that the PRA is a, it's a state of knowledge animal and the state of knowledge is not frozen in time. And we'll have to have process for dealing with new insights.

CHAIR BLEY: Well before I go for public comments, is there anything else from Member of the Committee?

MEMBER MARCH-LEUBA: Are me going to have round table.

CHAIR BLEY: Yes. After the public formats.

MEMBER MARCH-LEUBA: I'll wait for the round table.

CHAIR BLEY: Mr. Brown, Theron Brown, if you can open the phone line, we'll go there. Is there anybody in the room who would like to make a comment? If so, please come to the microphone and tell us your

name and who you're with.

(No audible response.)

CHAIR BLEY: I hear no noise. I'm not sure the phone lines open, but if there's anybody on the phone line, the public's line --

MR. BROWN: It's open.

CHAIR BLEY: -- who would like to make a comment, please identify yourself and give us your comment.

(No audible response.)

CHAIR BLEY: I guess we have none, so at this time I would like to go around to all the Members. I'm going to do it in reverse alphabetical order just for a change. Matt Sunseri.

MR. SUNSERI: Thank you, Dennis. Let me start of by saying I appreciate the challenge or skepticism that's been expressed by my colleagues here today. I think we all have the common goal of wanting to achieve reasonable assurance of adequate protection and that's a pretty clear common goal across the board.

So I find it always interesting when the Staff, you know, request the Commission to direct the Staff to come up with some kind of risk informed performance based licensing initiative. So when that

happens it creates an expectation that such a process will be provided. Okay?

So, here comes along license modernization with an approach to satisfy, in part, part of this risk informed performance based process, which in my mind can lead to a situation of group think, right? So the Staff has an expectation. Here's a way that we can satisfy this expectation. Everybody gets on board and moves forward.

So our role is to be somewhat skeptical, I mean, by design. We're here to challenge and you should want that challenge and you need that challenge because the last thing that you want, Staff or industry or ACRS for that matter, is to end up with a process that is less that is, I mean, it's a knowledge that the existing process is not perfect. The new process will not be perfect as well. But the challenge here is that the new process is untried also.

So at the end of the day we want to make sure that we have, if we decide to move to something new, that it is as effective as the old of providing reasonable assurance of adequate protection. And so today's presentation, at least in my mind, was designed to stop increasing our confidence level in

the new thing so that at the end of the day, we all have confidence that we are going to achieve reasonable assurance of adequate protection.

So, I appreciate that. Keep in mind that when we ask our provoking questions, we're not intentionally trying to, you know, antagonize you, but sometimes it comes out that way. All right?

But that's just, you know, trying to get at the heart of the issues, the hard issues that's going to make this better at the end of the day. So I appreciate all the presentations and comments that have been made. Thank you.

CHAIR BLEY: Thank you. Mr. Skillman.

MEMBER SKILLMAN: Thank you, Mr. Chair. First of all, thank you to the Southern Team, to the NRC team and to all of those who have brought this process and the oversight team or the consultant team who brought this to this stage of maturity.

I found going through the underlying documents logical, coherent, the language was clear to me and I can draw on my some years of experience to identify where I think slight changes will make a huge increase in effectiveness and reduction of ambiguity. So, I commend the individuals who have been involved here for having done a very thorough job, for

providing a logical process that I think will bring consistency to new non-light-water reactor designs.

I also find that some of the lessons that might come out of this are very applicable to any new actions that you take on the light-water reactors. I think there's benefit on both sides of the equation. But overall, thank you very much for a great comprehensive piece of work. Thank you.

CHAIR BLEY: Thank you, Dick. Dr. Riccardella.

MEMBER RICCARDELLA: Yes. Thank you, Dennis. I guess I have a concern about what I asked about earlier, the two and a half millirem cutoff. It bothers me a little. I mean, why do we need to consider an event significant that the maximum consequence is only a factor of ten below normal background radiation. I mean, that just seems unreasonably low to me.

I wonder, as an industry, why we keep doing stuff like this to ourselves. I just wonder. The response was well it's an engineering judgment. I just wonder if maybe a little more consideration of that engineering judgment. That's all.

CHAIR BLEY: Thank you. Dr. Rempe.

MEMBER REMPE: Well, I appreciated

everyone's presentations and I guess my questions today were trying to point at areas where I think additional clarification is needed because I would like to have confidence in this process. And so I hope, I mean I can repeat them, but I think I don't need to waste your time on that. But I hope you'll look at the rap and you'll address the comments I made.

CHAIR BLEY: Thank you, Joy. Mr. Ray.

MEMBER RAY: I don't have anything more at this time, Dennis, other than to say that we do need to be focused and give ourselves time to work with the Staff and others on it as we move forward.

CHAIR BLEY: Thank you. Dr. March-Leuba.

MEMBER MARCH-LEUBA: Thank you, Dennis. First, Matt is much more polite and political than I am so I wanted to say to what he said, me too. Exactly, I share in his thoughts.

With that said, I make a little impression that I don't like that approach. I like the F-C target approach very much. It's logical, I didn't even call it rational. My problem is with implementation. And my problem with implementation, especially on the Y axis, calculating the frequency of loss events.

I would like for the Staff to insure that it is bolded, underlined, italics, that the quality of the PRA calculation must be insured to an extremely high level. Not a level we are used to. If you are going to use it for this purpose, this is a different PRA, it has to be better.

Let me give you some samples. All right? I took some numbers from one of your reports and I'm looking at an event tree. It says the probability of losing force cooling on the ML, ten percent. The probability of force cooling via SUSD failing, ten percent. The probability of pump -- system failure, ten percent.

What those numbers tells me is that the input data that went into this calculation was at best an expert elicitation. We don't really know what the probability those failures have. And all the numbers are like this, probability of failure, two to the minus five. Probability, I mean, they're round numbers which we don't really know how good they are.

Once you process them you get numbers with insignificant digits and you start then to start to believe them. And what's worse, we always ask for an uncertainty. And whereas the CSAU method which we all know at this side of the table, maybe you guys are not

familiar, Washington thermal hydraulic calls because we know what the friction coefficient is, we just know it is a plus minus ten percent area. But we know what the friction coefficient is.

The probability of force cooling on ML being ten percent is just an expert number. So, there has to be a lot of review. If we are going to use this frequency access on a definite curve, the F-C target, we need to have confidence on that frequency that we have there.

Second point, other than the quality of the PRA, we need to make sure we review the completeness of the PRA. What did we forget? The industry are experts and you are going to be running together with a bunch of experts, but I know for a fact, we review a reactor now I found a serious problem with a scram system that nobody even knew about it. And you have to get a big body of expertise to make sure you do not forget anything.

And that is my major bone with using probabilistic risk analysis for serious consequence term. Every time we have had a severe accident, it was because there was an event we did not analyze or we chose not to analyze. In that sentence, I mean, we need to go see the completeness of the PRA and also

the completeness of the DBE list.

I'm looking through here, and this is a gas reactor, I don't see any event that leads to ingress of air for this particular event. I don't mind the probability is ten to the minus 43, I like to have a sequence that leads to ingress of air into the core accounted for, and tell me the probably is ten to the minus three, forty three. But it was completely ignored. Okay? Calm down.

I don't see it here on this small break, the one that I'm looking at. Okay. So, what we have to make sure is that the list of DBEs is thoroughly reviewed and it has to be an adversarial, someone who doesn't believing in it, like me. Okay? That's it.

And we did decide on time for question? Maybe we can follow-up after, unless it is something factual. Right? So with that, I get, leaving room for size, the F-C target curve is really good. It's a good concept, it's logical and rational. Implementation is my problem.

CHAIR BLEY: Thank you. Professor Corradini?

(No audible response.)

CHAIR BLEY: Professor Corradini? Going once. He must have -- he's retired again.

MEMBER RICCARDELLA: Yes, there was an email from him that said he had to leave at noon.

CHAIR BLEY: Okay.

MEMBER RICCARDELLA: He sent you some comments, Dennis.

CHAIR BLEY: Oh, good. I haven't seen them yet. Just a second. Dr. Chu? Thank you. Professor Ballinger?

MEMBER BALLINGER: I guess I would like to echo Pete's caution because I hope we don't Rockwell ourselves in the sense that we paint ourselves into a corner using 2.5 millirems. I just don't understand that.

Also, if we were to never build a future plant, no advance system or anything, I think the output of this is kind of a stealth back door method to feedback on the existing system, which I think is a very good thing. So the exercise itself I think will serve a very good purpose. Thank you.

CHAIR BLEY: Mr. Brown.

MEMBER BROWN: Obviously you don't know about alphabetizing. Alphabetically done. I'll spit that out since Ballinger does not come before Brown. I'll withstand and bypass the embarrassing --

(Simultaneous speaking.)

CHAIR BLEY: But Charlie's earlier than Ron so that's okay.

MEMBER BROWN: That's okay. Anyway, I don't have anything else to say. I just couldn't pass up the opportunity to add some interesting humor back into this very stealthy, complicated conversation.

CHAIR BLEY: Certainly, I appreciate your comments. I would like to echo thanks to everybody from the LMP and from the Staff. Most of the things I wanted to say I've already said, except, and this is close what Jose said, I'll just say it a different way.

We need, and especially when we think about the defense in depth, we need a way to force the next people, I'm sure you do it great, but the next people who do this, to really make sure they are both honest and very thorough in identifying the sources of uncertainties because those are essential to doing the PRA right and to having a good basis for the residual, I'll call it defense in depth.

For the defense in depth that we had beyond what we've already designed into the plan. And it needs to be a process that really makes people think and reexamine their basis. It's the kind of thing that PIRTs are supposed to do, but they don't.

People doing them don't always do it. And you really need to categorize where the holes are in your knowledge as you do this stuff. And I hope you talk about that come October.

The other thing I would say is we might be -- I think the arguments for the multi-unit plants might be overly optimistic. And I think you need to make sure you have a way to deal with those and I think you do. Should you not be able to make sure they don't come up into your top list because there could be a design where there is no way around that. And the idea that you can always get them down could be good.

The area that we might be overly optimistic is in the ability to define mechanistic source terms that at a level that we really believe them and have considered all the uncertainties there and have enough experimental evidence that could back up what we're doing. Other than that, I think it's well on its way and I really look forward to the next round on this material.

Thanks to one and all, we are adjourned.

(Whereupon, the foregoing matter went off the record at 12:22 p.m.)

Licensing Modernization Project Guidance Document Introduction

Amir Afzali- LMP Project Technical Lead Southern Company

Dr. George Apostolakis- Member of the Advisory Team

Karl Fleming- LMP Senior Technical Lead

ACRS Future Plant Designs Subcommittee

June 19, 2018

Meeting Purpose and Agenda

Purpose: To introduce the Licensing Modernization Project's (LMP) proposals and the basis for the proposals

Agenda:

- Introduction
  - (Amir Afzali)
- High Level Comments on the Proposal's Feasibility
  - (Dr. George Apostolakis)
- Detailed Description of the Current Proposals and Their Technical Basis
  - (Karl Fleming)

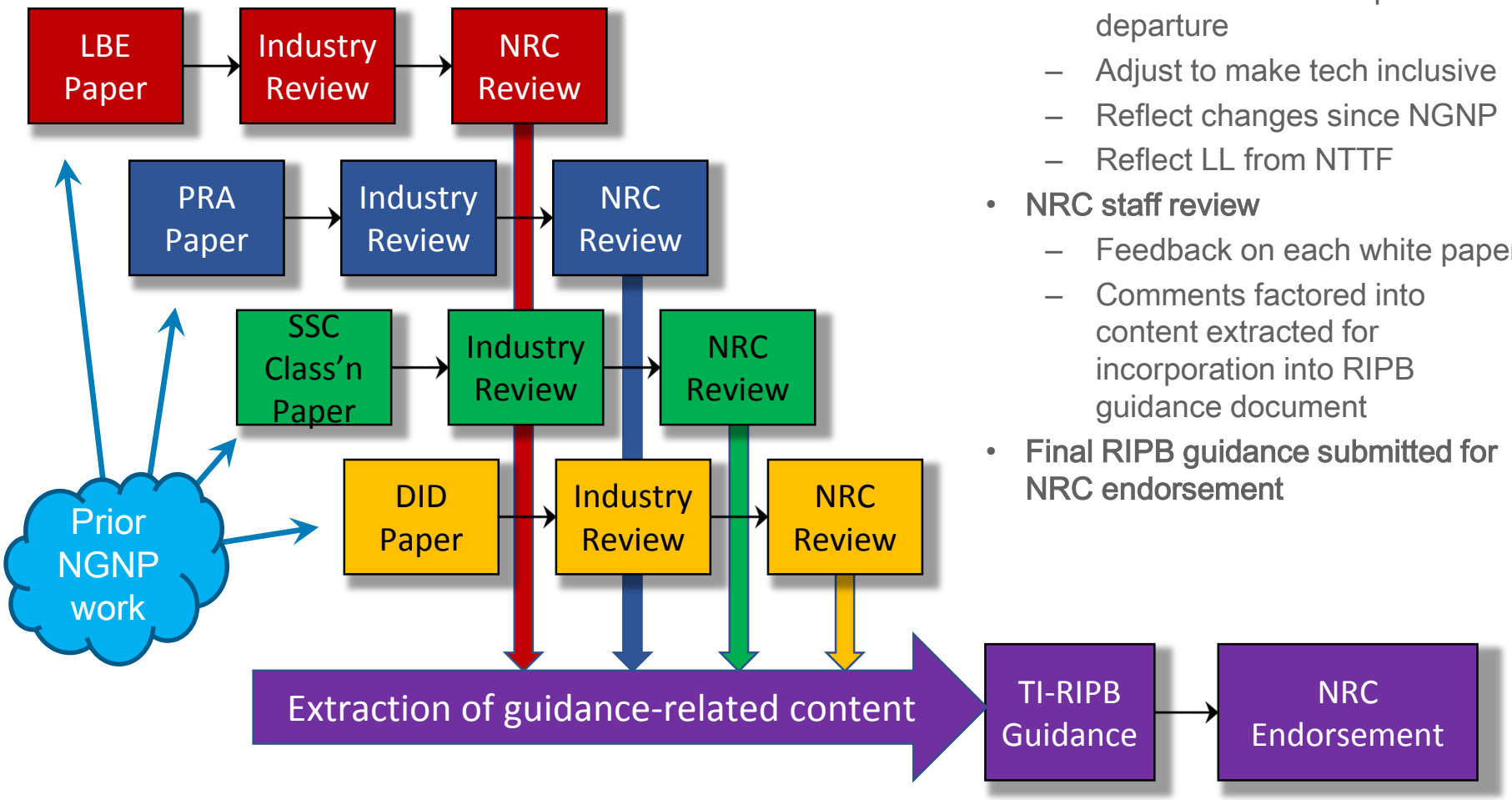
Principle LMP Objectives

- Create foundation for an integrated approach to licensing modernization embracing three highly interdependent risk-informed and performance-based topics
- Integrate new advances in RIPB methods and applications that can be used in a technology-inclusive manner for advanced reactor design and licensing
- Reflect the culmination of methods and practices available today to operationalize technology-inclusive RIPB practices recognized across decades of policy and incremental progress
- Pave a coherent path to efficient and effective licensing of advanced reactors

Presentation Objectives

- Familiarize the ACRS subcommittee with key aspects of the LMP TI-RIPB approach as described in the draft integrated guidance document
- Review LMP processes for:
  - **Selection and evaluation of licensing basis events**
    - **Systematic RIPB process to identify DBAs**
  - Safety classification and performance-based requirements for SSCs.
    - As part of this structured SSC classification process, establish better RIPB-focused special treatment that includes input from DID adequacy evaluation process
  - **Defense-in-depth adequacy determination**
    - **Mechanism to apply RIPB practices to determining DID adequacy and design and programmatic sufficiency (i.e., When is enough, enough?)**

Document Development Review Approach



- Discrete topic papers
  - Start with NGNP as point of departure
  - Adjust to make tech inclusive
  - Reflect changes since NGNP
  - Reflect LL from NTTF
- NRC staff review
  - Feedback on each white paper
  - Comments factored into content extracted for incorporation into RIPB guidance document
- Final RIPB guidance submitted for NRC endorsement

NEI 18-04

Quantitative Risk-Informed Decision Making

- LMP proposals present a formal and transparent risk-informed and performance-based process for making key licensing decisions
- A PRA for non-LWRs is an essential element of the proposed RIPB LMP framework.
- Very often, criticisms are focused on PRA without discussing the shortcomings of the traditional “deterministic” system.
- ASME/ANS RA-S-1.4-2013, Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants, 2013.

Historical Perspective

- The situation regarding advanced reactor PRAs is similar to that for large LWRs in the early 70s
  - No operating experience was available to support WASH-1400
- Failure data were collected from around the world.
- Expert judgment was used, especially for human errors.
- The WASH-1400 methods and insights regarding internal events have largely stood the test of time.

One of the most consequential PRAs was completed with minimal operating experience

Insights from PRAs

- The “deterministic” Maximum Credible Accident was a LBLOCA + LOOP + one active single failure.
- WASH-1400 (1975)
  - Major risk contributors: Small LOCAs and transients
  - Human errors and support systems are important to risk
- Zion/Indian Point PRAs (1981-1982)
  - Earthquakes and fires are among the dominant risk contributors
- Early Rules
  - Anticipated Transients without Scram (ATWS), 10 CFR 50.62, (1984)
  - Station Blackout (SBO), 10 CFR 50.63, (1988)
- Objectivity, Flexibility, and Burden Reduction
  - ROP; AOT extension; RI-ISI

A systematic risk assessment improves safety while reducing unnecessary burden

The Commission's 1995 PRA Policy Statement

- The Commission's 1995 PRA Policy Statement:
  - "A probabilistic approach to regulation enhances and extends this traditional, deterministic approach, by:

    (1) Allowing consideration of a broader set of potential challenges to safety,

    (2) Providing a logical means for prioritizing these challenges based on risk significance, and

    (3) Allowing consideration of a broader set of resources to defend against these challenges."
- Part 52 and the anticipated Part 50 requirement demand PRA models to be developed.

The proposed LMP approach is consistent with the this Policy Statement and builds on the current NRC licensing requirements.

Achieving Modern Risk-Informed Regulation
SECY-18-0060, May 23, 2018

- The staff recommends that the Commission direct the staff to:
  - "develop an agency wide process and organizational tools to expand the systematic use of qualitative and quantitative risk and safety insights; thereby, enabling staff to scale the scope of review and the level of detail needed in licensing to make a finding of reasonable assurance of adequate protection of public health and safety, beginning with licensing reviews for reactors."
  - "develop a performance-based, technology-inclusive regulation as an alternative approach for licensing for non-light-water reactors"

The staff's recommendations are consistent with the LMP proposed framework.

ACRS Letter on the Technology-Neutral Framework (September 26, 2007)

- We concur with the staff that a set of licensing-basis events (LBEs) is needed as part of the licensing basis to structure the interactions between the staff and the applicant and to focus the conduct of mechanistic analyses.

- Identifying the LBEs by using the probabilistic risk assessment (PRA) reduces the risk that licensing-basis requirements will divert attention from events of real safety significance.

- The use of a frequency-consequence (F-C) curve is an appropriate way to establish a range of regulatory requirements to limit radiation exposure to the public.

LMP Advisory Group Position on LMP

- Letter to S. Kuczynski by Apostolakis, Merrifield, and Meserve (2/20/2018)
  - "Although we are not in a position to comment on the technical adequacy of the reports generated by the LMP, we enthusiastically endorse the effort. In particular, we believe that the focus on a systematic and predictable *process* for early resolution of fundamental technical issues in the licensing of advanced reactors can reduce uncertainty in the development of a design."
  - "We believe that the work lays the foundation for guidance that can be endorsed by the NRC and we encourage the continuation of the effort."

LMP Advisory Group Position on DID (12/11/2017)

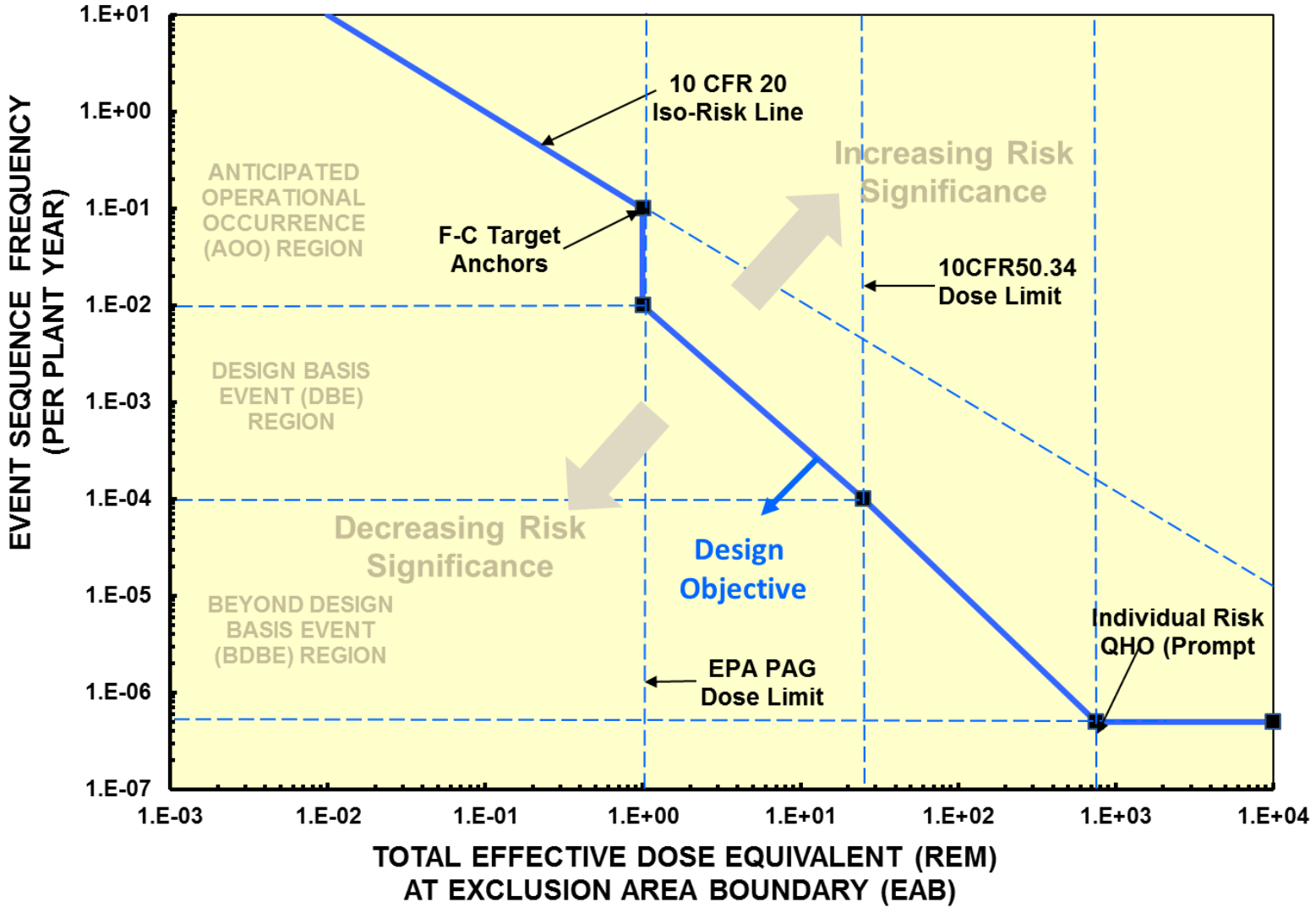
- "Given the significantly reduced risks associated with many of the advanced reactor designs as compared to LWRs, a non-risk-informed application of DID could result in excess conservatism in safety reviews."
- "Moreover, while we believe that adopting a TI-RIPB DID framework will generally reduce excess conservatism and provide a more effective means to limit unnecessary regulatory burden, like all risk-informed tools, it could also result in the identification of areas where additional requirements are necessary."
- "The great value of the LMP DID proposal is that it is a first step toward converting what is currently an ambiguous DID philosophy to a concrete DID process."

Selection And Evaluation Of LBEs

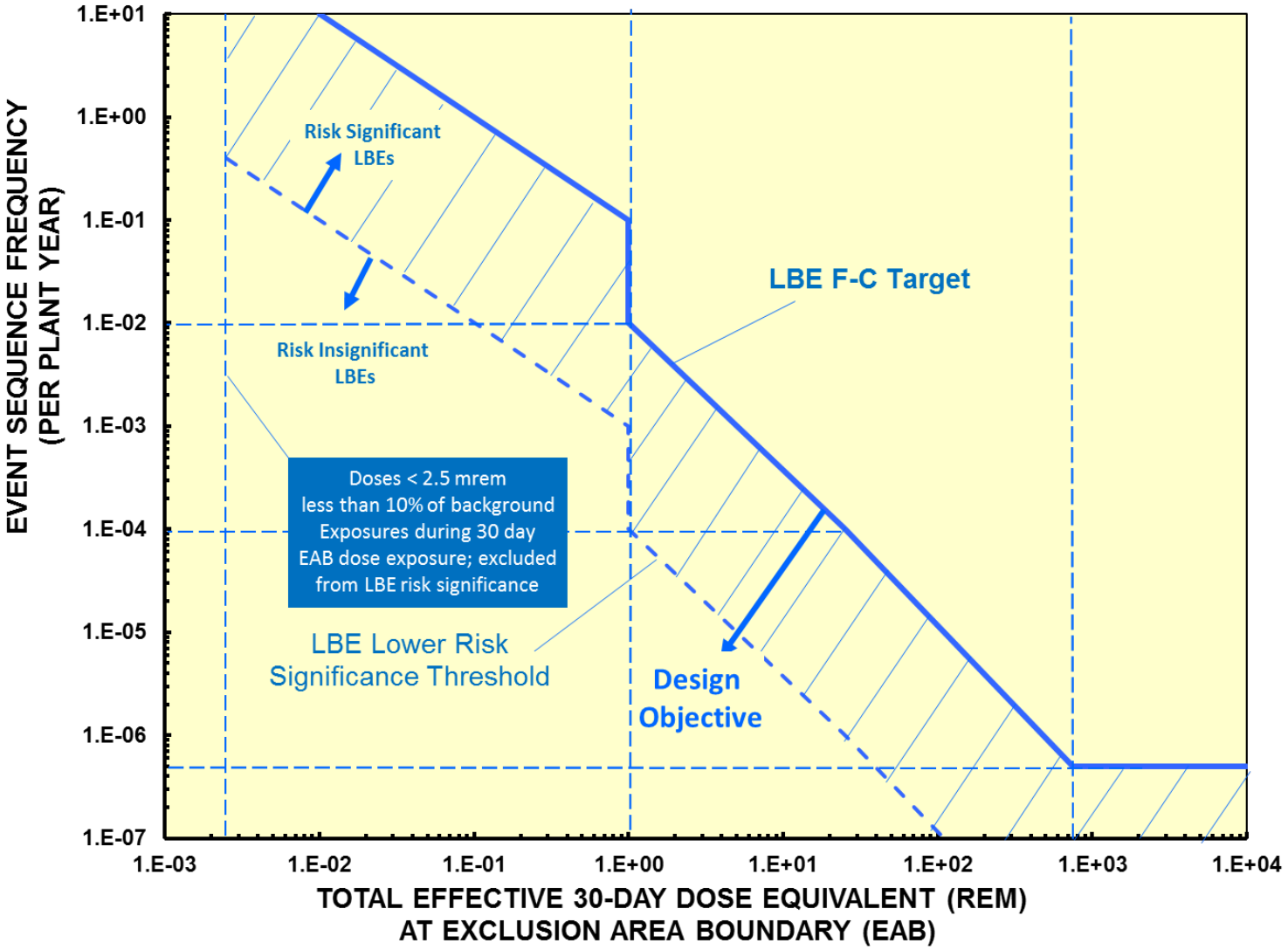
Selection and Evaluation of LBEs

- AOOs, DBEs, and BDBEs are defined in terms of event sequence families from a reactor design-specific PRA
- AOOs, DBEs, and BDBEs are evaluated:
  - Individually for risk significance using a Frequency-Consequence (F-C) chart against a F-C Target
  - Collectively by comparing the total integrated risk against a set of 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 SSCs to perform required safety functions among those available on all DBEs
- DBAs are derived from DBEs by assuming failure of all non-safety related SSCs and evaluated conservatively vs. 10CFR50.34

F-C Target


EVENT SEQUENCE FREQUENCY (PER PLANT YEAR)
1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
TOTAL EFFECTIVE DOSE EQUIVALENT (REM) AT EXCLUSION AREA BOUNDARY (EAB)
10 CFR 20 Iso-Risk Line
ANTICIPATED OPERATIONAL OCCURRENCE (AOO) REGION
F-C Target Anchors
Increasing Risk Significance
10CFR50.34 Dose Limit
DESIGN BASIS EVENT (DBE) REGION
Decreasing Risk Significance
Design Objective
BEYOND DESIGN BASIS EVENT (BDBE) REGION
EPA PAG Dose Limit
Individual Risk QHO (Prompt

LBE Risk-Significance Criteria



LBE Cumulative Risk Targets

- The total frequency of exceeding an offsite boundary dose of 100 mrem shall not exceed 1/plant-year to ensure that the annual exposure limits in 10 CFR 20 are not exceeded.
- The average individual risk of early fatality within the area 1 mile of the EAB shall not exceed $5x10^{-7}$/plant-year to ensure that the NRC Safety Goal Quantitative Health Objective (QHO) for early fatality risk is met
- The average individual risk of latent cancer fatalities within the area 10 miles of the EAB shall not exceed $2x10^{-6}$/plant-year to ensure that the NRC safety goal QHO for latent cancer fatality risk is met.

PRA Development

- Early introduction of PRA into design process facilitates risk-informing design decisions
- Scope and level of detail consistent with scope and level of detail of design and site information and fit for purpose in RIPB decisions
- PRA event-sequences include those involving single and multiple reactor modules and risk significant non-reactor sources
- Supporting non-LWR PRA standard specifically designed to support LMP PRA applications
- Limitations and uncertainties associated with PRA addressed in the evaluation of defense-in-depth adequacy

SSC Safety Classification And Performance Requirements

SSC Approach Highlights

- Adopts three SSC safety classification categories in NGNP SSC white paper
- Proposes criteria for SSC risk significance based on absolute risk metrics
- Incorporates concepts from 10 CFR 50.69 and NEI-00-04 in the context of a “forward fit” process
- Includes SSC requirements to address single and multi-module risks
- Expands on guidance for deriving performance requirements beyond those in NGNP SSC white paper

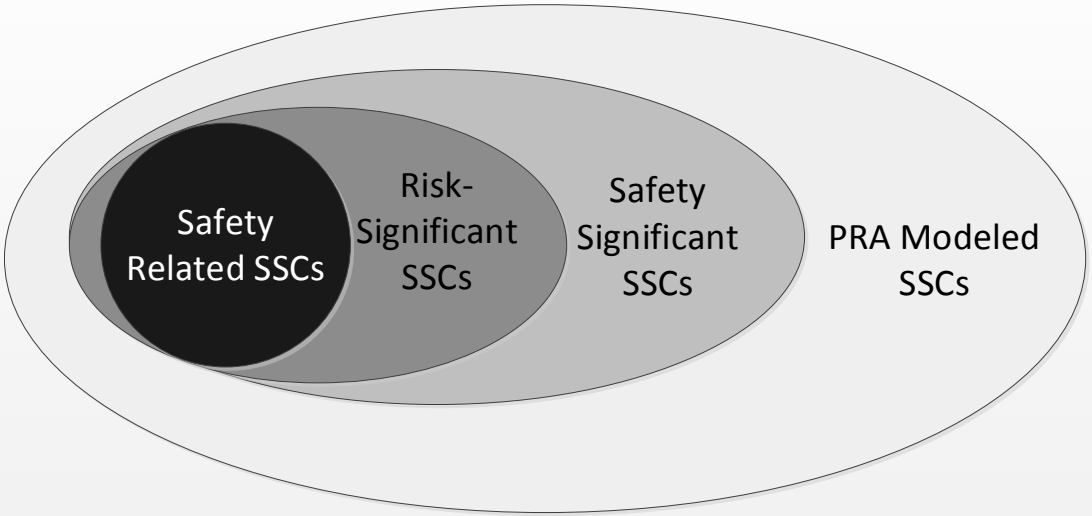
LMP Proposed SSC Safety Categories

- **Safety-Related (SR):**
  - SSCs selected by the designer to perform required safety functions to mitigate the consequences of DBEs to within the F-C target, and to mitigate DBAs to meet the dose limits of 10 CFR 50.34 using conservative assumptions.
  - SSCs selected by the designer to perform required safety functions to prevent the frequency of BDBEs with consequences greater than 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 keep LBEs 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.

SSC Risk Significance

- **A prevention or mitigation function of the SSC is necessary to meet the design objective of keeping all LBEs within the F-C target.**
  - The LBE is considered within the F-C target when a point defined by the upper 95%-tile uncertainty of the LBE frequency and dose estimates are within the F-C target.
- **The SSC makes a significant contribution to one of the cumulative risk metrics used for evaluating the risk significance of LBEs.**
  - A significant contribution to each cumulative risk metric limit is satisfied when total frequency of all LBEs with failure of the SSC exceeds 1% of the cumulative risk metric limit. The cumulative risk metrics and limits include:
    - The total frequency of exceeding of a site boundary dose of 100 mrem < 1/plant-year (10 CFR 20)
    - The average individual risk of early fatality within 1 mile of the Exclusion Area Boundary (EAB) < 5×10^{-7}/ plant-year (QHO)
    - The average individual risk of latent cancer fatalities within 10 miles of the EAB shall not exceed 2×10^{-6}/plant-year (QHO)

SSC Hierarchy



Derivation of Special Treatment Requirements

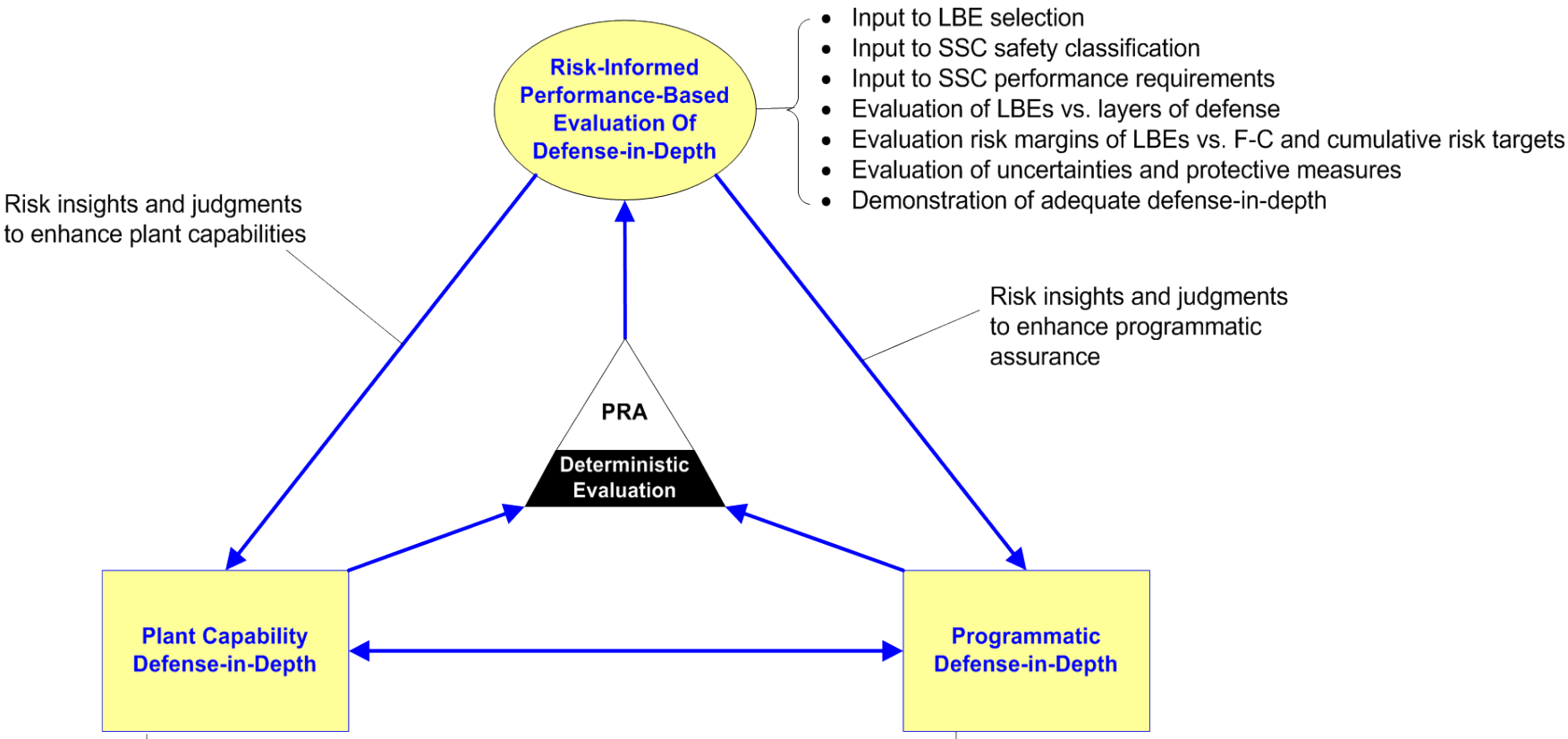
- SR SSCs
  - Functional Design Criteria derived from required safety functions
  - Lower level design criteria derived from SRDC
- SR and NSRST SSCs
  - SSC reliability and capability performance targets
  - Focus on prevention and mitigation functions from LBEs
  - Integrated decision making process to derive specific special treatment requirements
  - Reflects concepts from 10 CFR 50.69 and NEI-00-04 from existing reactors from a “forward fit” perspective
  - Reflects Commission’s expectations for risk-informed and performance based regulation from SRM to SECY 98-0144

Defense In Depth Adequacy Evaluation

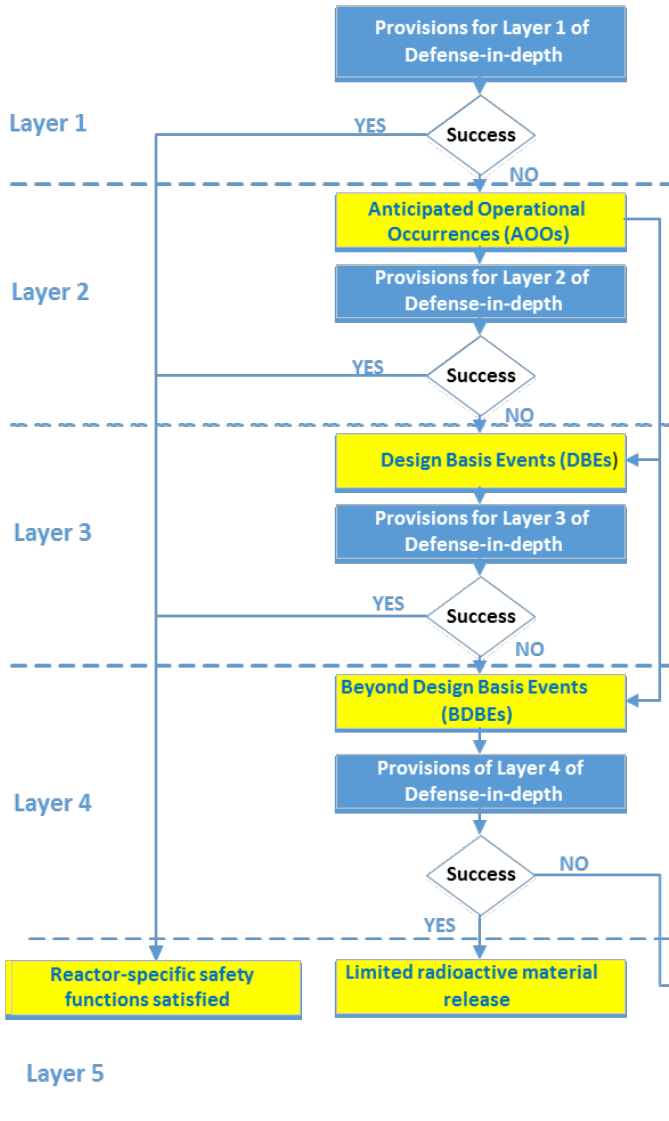
LMP DID Adequacy Approach

- Builds on NGNP DID approach also reflected in ANS-53.1
- Evaluation of DID adequacy is both risk-informed and performance-based.
- The “layers of defense” and attributes of the NRC and IAEA DID frameworks are more visibly represented.
- DID attributes for plant capability and programmatic DID have been enhanced for consistency with the measures defined in the LMP Guidance Document
- This process is used to evaluate each LBE and to identify the DID attributes that have been incorporated into the design to prevent and mitigate accident sequences and to ensure that they reflect adequate SSC reliability and capability.
- Those LBEs with the highest levels of risk significance are given greater attention in the evaluation process.
- The practicality of compensatory actions for DID purposes are considered in the context of the individual LBE risk significance and in a cumulative manner across all LBEs

DID Adequacy Framework



Layers of Defense Adapted from IAEA



Objective:
Control of disturbances and transients
Success:
Prevention of abnormal operation, initiating events, and AOOs

Objective:
Detection and control of abnormal operation and AOOs, identification of cause, and corrective actions
Success:
Return to normal operation, prevention of DBEs.

Objective:
Control of DBE plant conditions within the design basis
Success:
Perform required safety functions, prevent BDBEs

Objective:
Control of severe plant conditions, including on-site accident management, mitigation of accident consequences
Success:
Maintain critical safety functions for the retention of radioactive material

Objective:
Anticipatory emergency planning and off-site accident management to mitigate accident doses to the public
Success:
Prevent adverse public health and safety impacts

Plant Capability Defense-In-Depth Attributes

Attribute	Evaluation Focus
Initiating Event and Accident 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

RIPB Decision-Making Attributes

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

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

Guidelines for Establishing Adequacy of Plant Capability Defense-in-Depth

Layer[a]	Layer Guideline		Overall Guidelines	
	Quantitative	Qualitative	Quantitative	Qualitative
1) Prevent off-normal operation and AOOs	Maintain frequency of plant transients within designed cycles; meet owner requirements for plant reliability and availability[b]		Meet F-C Target for all LBEs and cumulative risk metric targets with sufficient[d] margins	No single design or operational feature,[c] no matter how robust, is exclusively relied upon to satisfy the five layers of defense
2) Control abnormal operation, detect failures, and prevent DBEs	Maintain frequency of all DBEs < 10^{-2}/ plant-year	Minimize frequency of challenges to safety-related SSCs		
3) Control DBEs within the analyzed design basis conditions and prevent BDBEs	Maintain frequency of all BDBEs < 10^{-4}/ plant-year	No single design or operational feature[c] relied upon to meet quantitative objective for all DBEs		
4) Control severe plant conditions, mitigate consequences of BDBEs	Maintain individual risks from all LBEs < QHOs with sufficient[d] margins	No single barrier[c] or plant feature relied upon to limit releases in achieving quantitative objectives for all BDBEs		
5) Deploy adequate offsite protective actions and prevent adverse impact on public health and safety				

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.

[d] The level of margins between the LBE risks and the QHOs provides objective evidence of the plant capabilities for DID. Sufficiency will be decided by the IDP.

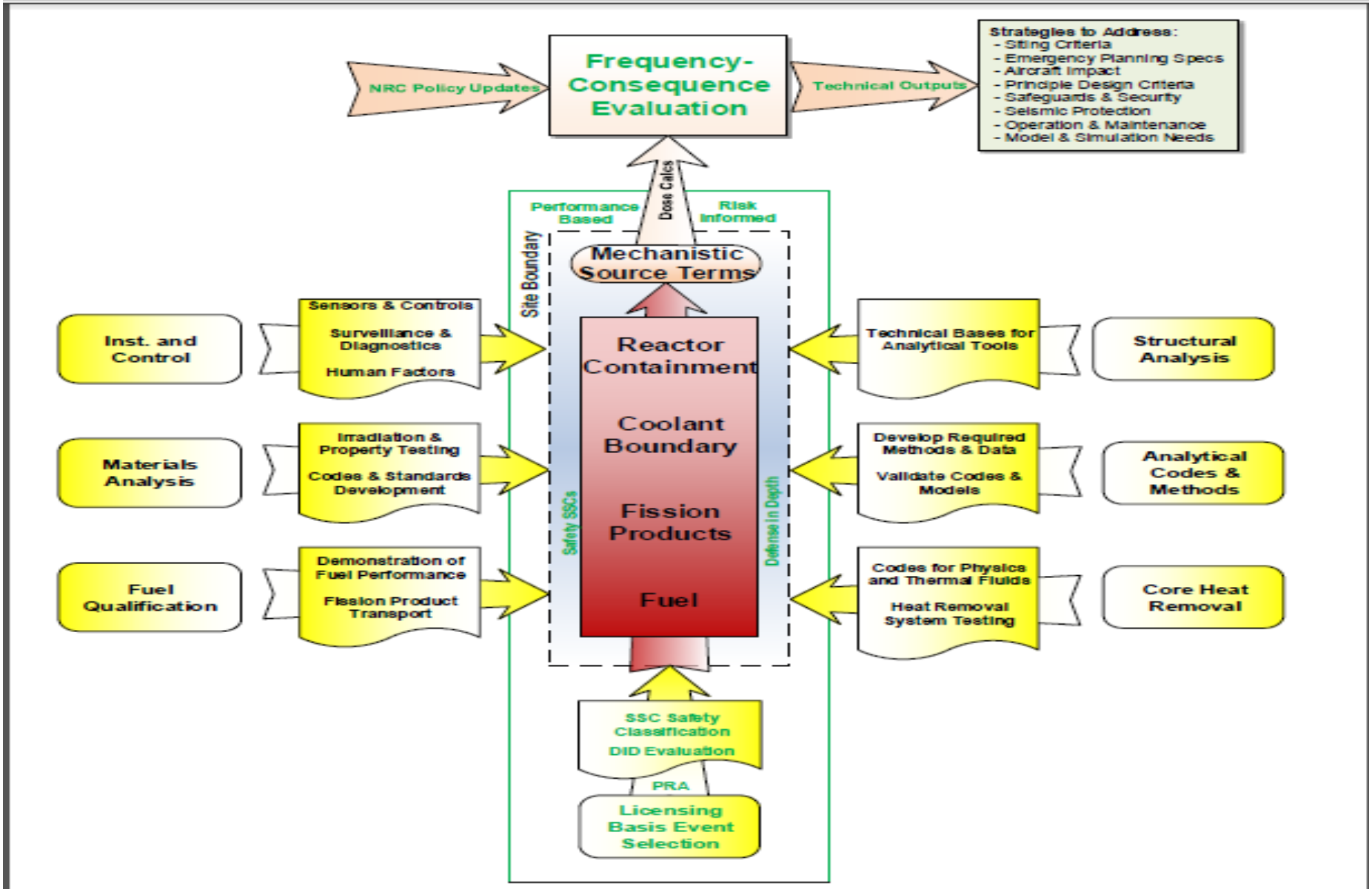
DID Adequacy Evaluation Process

- DID Baseline Evaluation documented by Integrated Decision Panel (IPD) and updated during each design/licensing phase
- Defense-in-depth is deemed by IDP as adequate when:
  - Plant capability DID is deemed to be adequate.
  - Plant capability DID guidelines in Table 5-2 are satisfied.
  - Review of LBEs is completed with satisfactory results.
  - Programmatic DID is deemed to be adequate.
  - Performance targets for SSC reliability and capability are established.
  - Sources of uncertainty in selection and evaluation of LBE risks are identified.
  - Special treatment for all SR and NSRST SSCs is sufficient.

Questions?

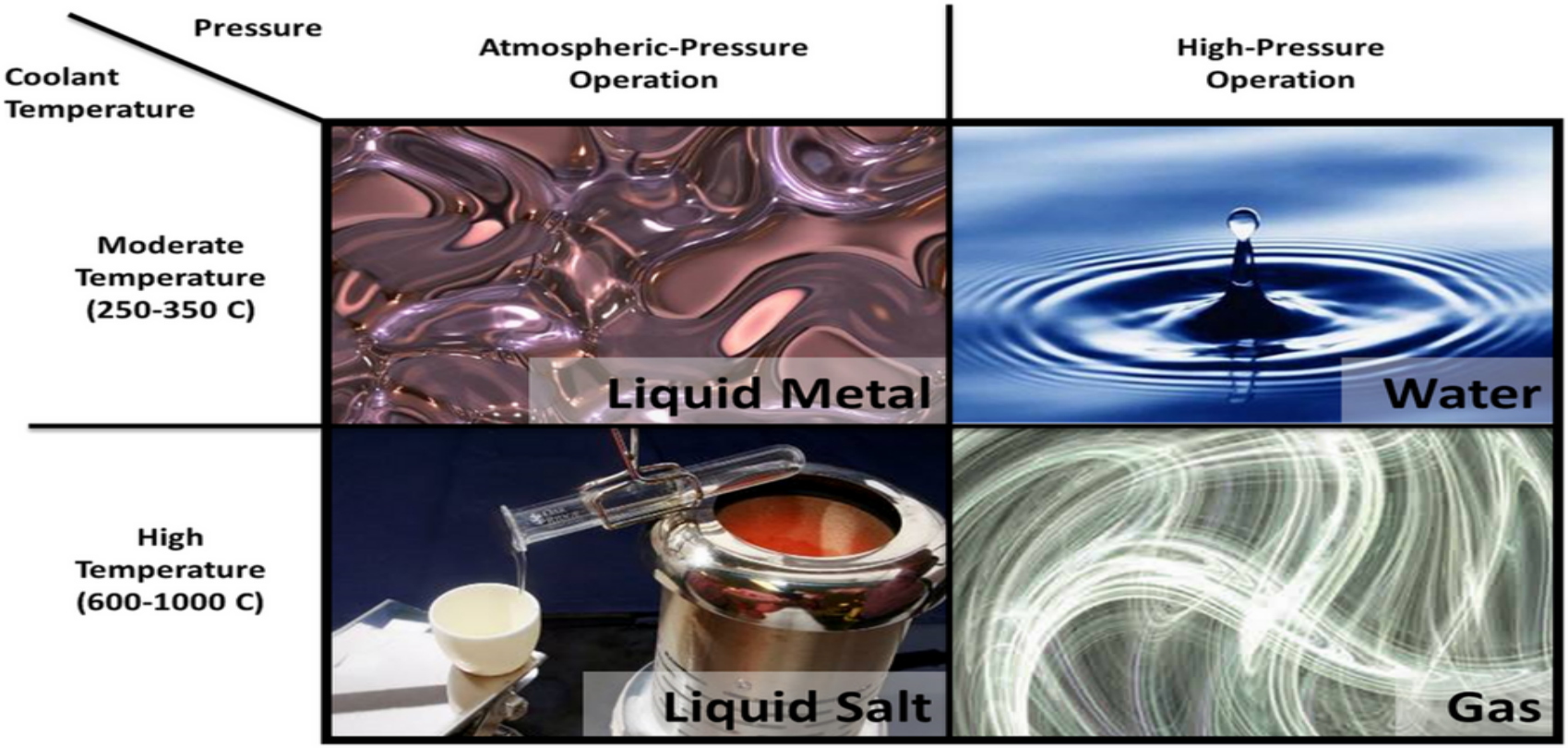
BACK-UP SLIDES

LMP RIPB Framework



Systematic, Wholistic, Technology Inclusive Licensing is a Must

COOLANT CHOICE



Risk-Informed, Performance-Based Method is the Logical Solution

Licensing Basis Events (LBEs)

- LBEs are defined broadly to include all the events used to support the safety aspects of the design and to meet licensing requirements. They cover a comprehensive spectrum of events from normal operation to rare, off-normal events.
- Categories defined as Normal Operations (NO), Anticipated Operational Occurrences (AOO), Design Basis Events (DBE), Beyond Design Basis Events (BDBE) and Design Basis Accidents (DBA)
- LBE definitions generally consistent with NGNP white papers
- Limited differences with NRC definitions to create consistency with LMP process

LBE Categories

Anticipated Operational Occurrences (AOOs). AOOs encompass planned and anticipated events whose frequencies exceed 10^{-2}/plant-year where a plant may be comprised of one or more reactor modules. The radiological doses from AOOs are required to meet normal operation public dose requirements. AOOs are utilized to set operating limits for normal operation modes and states.

Design Basis Events (DBEs). DBEs encompass unplanned off-normal events not expected in the plant's lifetime whose frequencies are in the range of 10^{-4} to 10^{-2}/plant-year, but which might occur in the lifetimes of a fleet of plants. DBEs are the basis for the design, construction, and operation of the structures, systems, and components (SSCs) during accidents and are used to provide input to the definition of design basis accidents (DBAs).

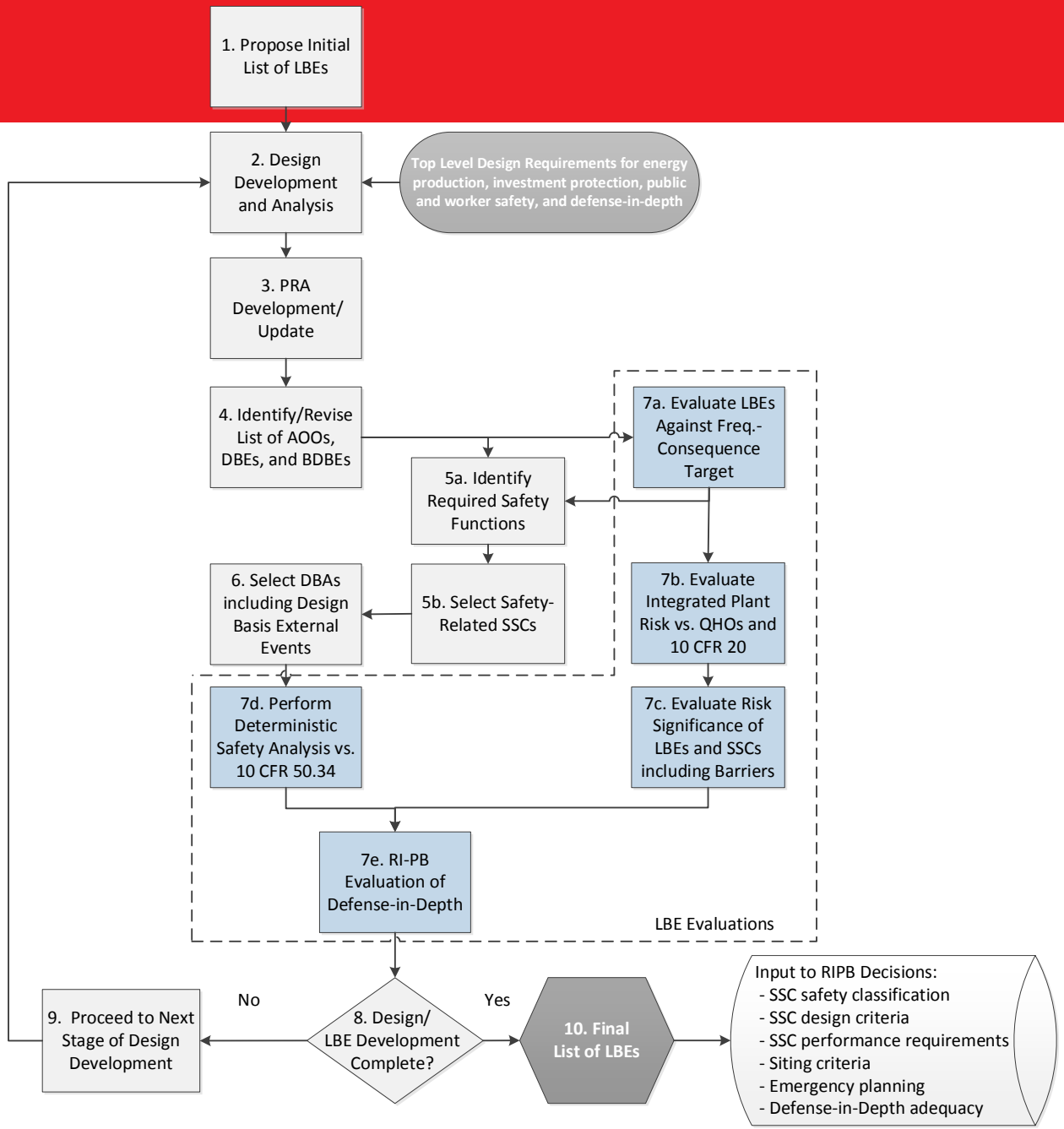
Beyond Design Basis Events (BDBEs). BDBEs which are rare off-normal events whose frequencies range from $5x10^{-7}$/plant-year to 10^{-4}/plant-year. BDBEs are evaluated to ensure that they do not pose an unacceptable risk to the public.

Design Basis Accidents (DBAs). The DBAs for Chapter 15, "Accident Analyses," of the license application are prescriptively derived from the DBEs by assuming that only SSCs classified as safety-related are available to mitigate the consequences. The public consequences of DBAs are based on mechanistic source terms and evaluated using conservative or best estimate approaches with appropriate accounting for uncertainties.

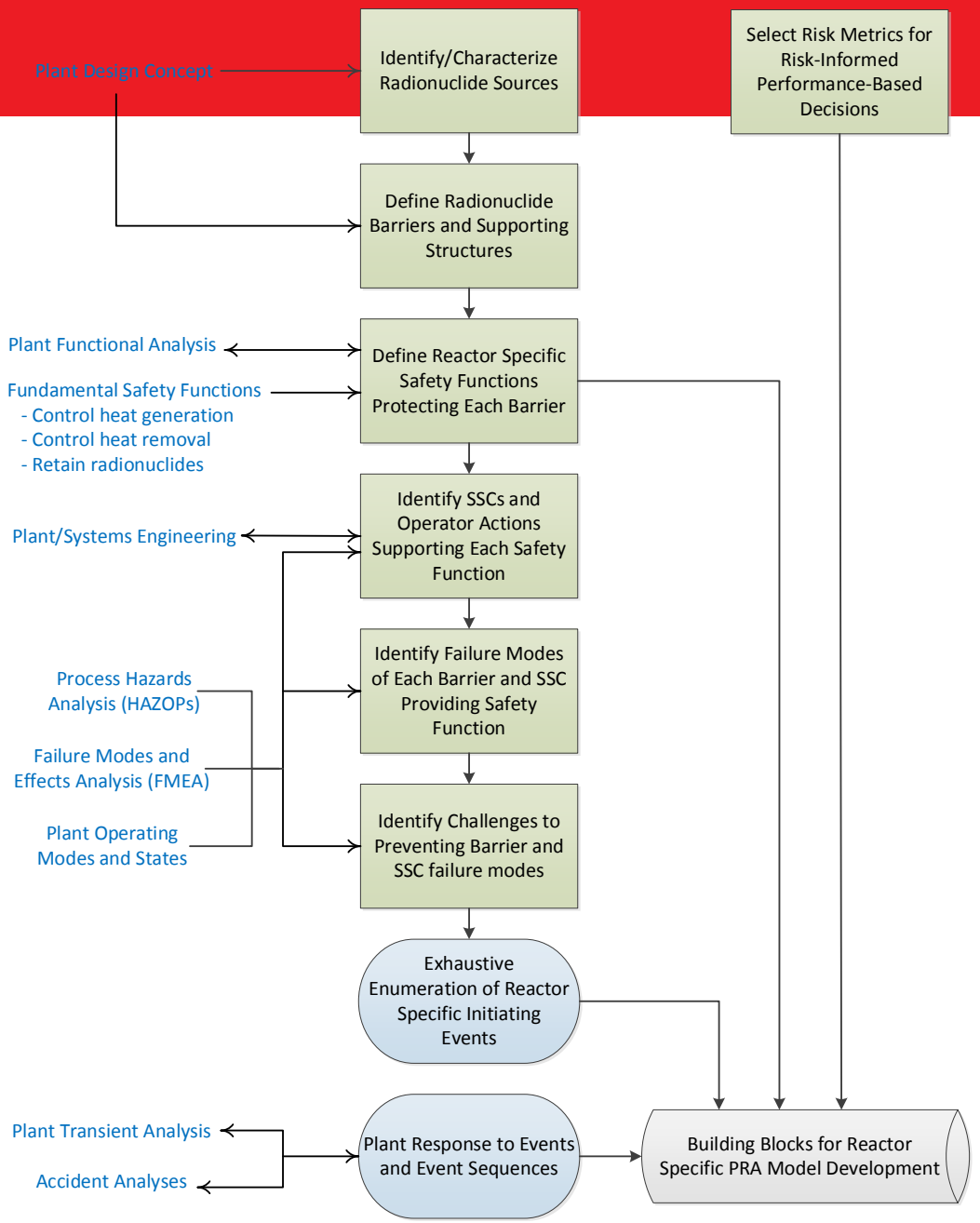
Frequency-Consequence (F-C)Target

- Purpose is to evaluate risk significance of individual LBEs and to help define the RSFs
- Derived from the NGNP F-C Target and frequency bins for AOOs, DBEs, and BDBEs
- Addressed Staircase feature
- F-C Target anchor points based on:
  - 10 CFR 20 annual dose limits and iso-risk concept
  - SRP Chapter 15.0 insights on dose limits for lower frequency AOOs
  - 10 CFR 50.34 dose limits for DBAs (and DBEs)
  - QHOs for prompt fatality individual risk

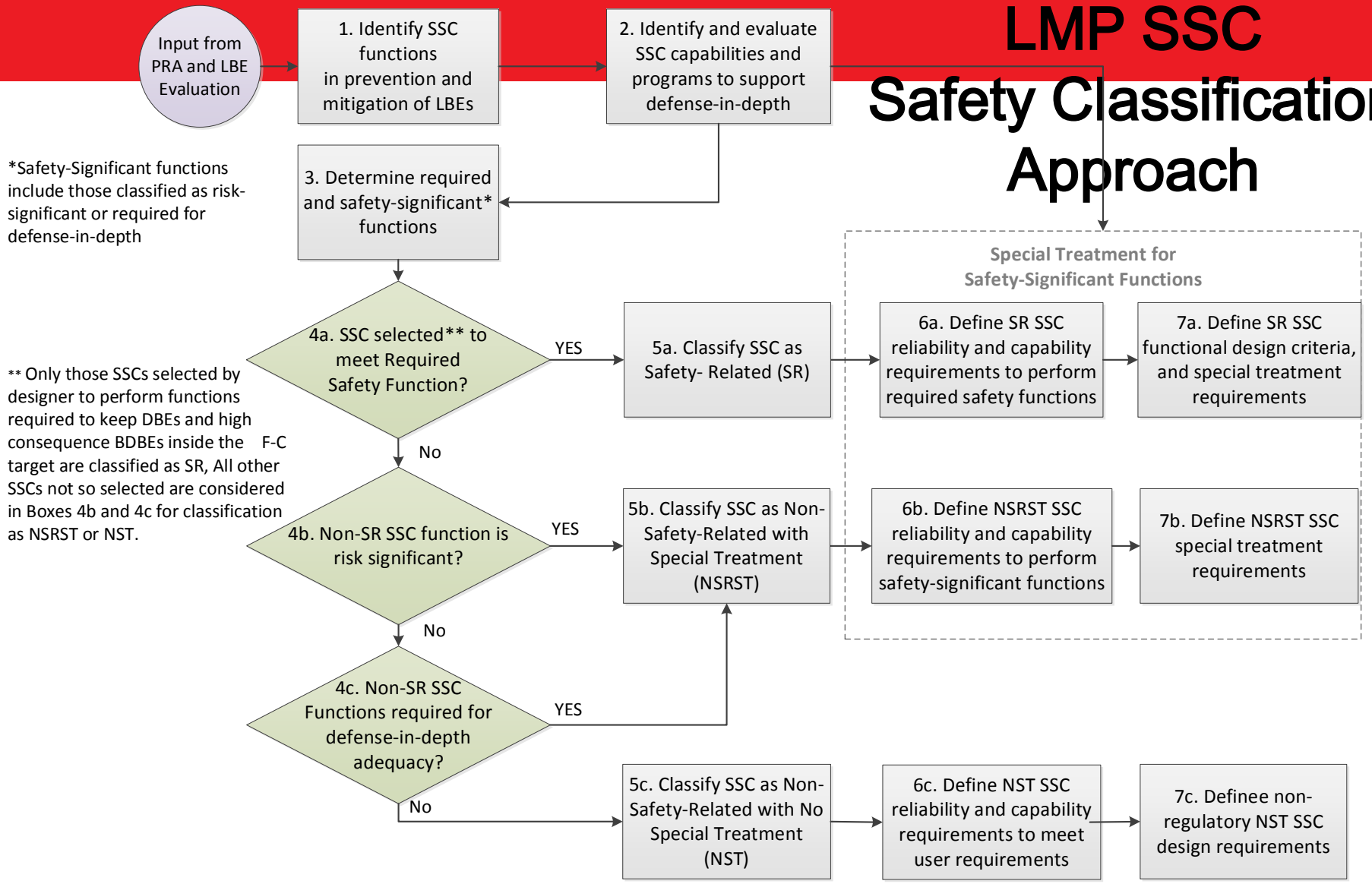
LBE Selection and Evaluation Process



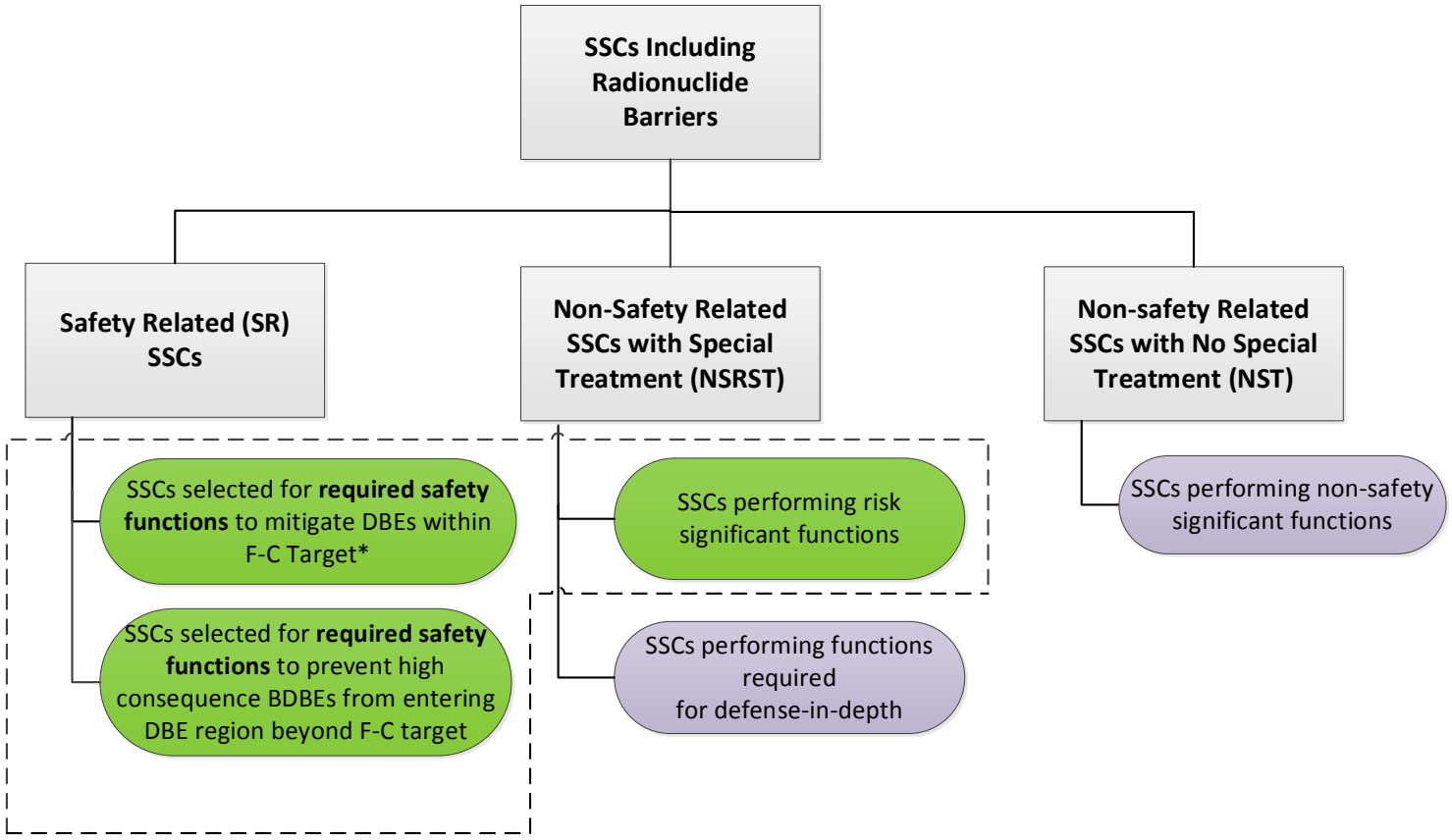
Design and PRA Development Interfaces



LMP SSC Safety Classification Approach



LMP Proposed SSC Safety Categories

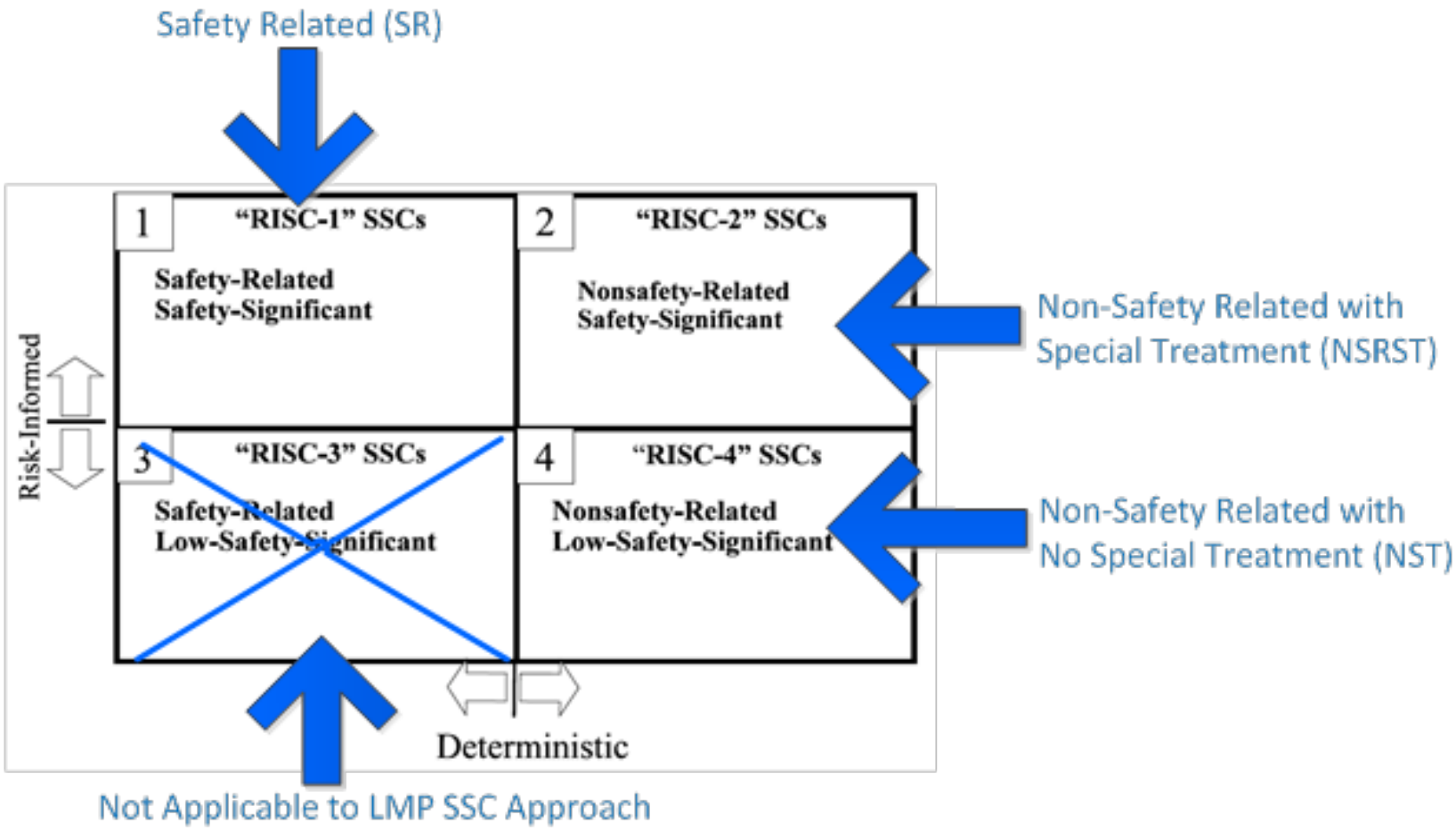


* SR SSCs are relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions

Non-Risk Significant SSCs

Risk Significant SSCs

Comparison of LMP and 10 CFR 50.69 SSC Safety Categories



SSC Classification Summary

- LMP retains the NGNP SSC safety categories of SR, NSRST, and NST
- All safety significant SSCs classified as SR or NSRST
- Absolute risk metrics proposed for SSC and LBE risk significance
- All SR SSCs are classified as 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 accidents
- Special treatment defined via integrated decision panel using “forward fit” 10 CFR 50.69 process

DID Evaluation Baseline Summary Concept

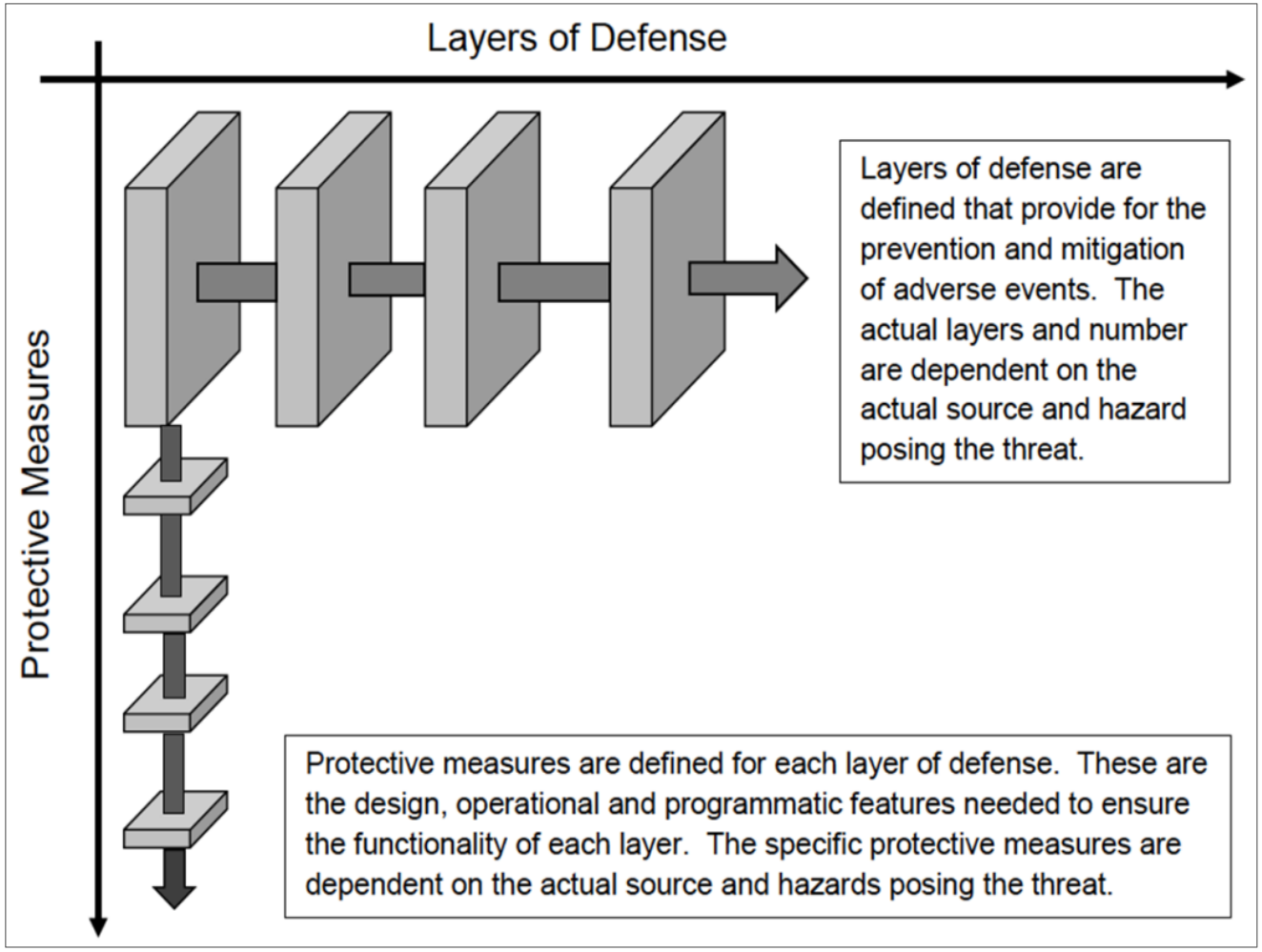
Qualitative Evaluation of Plant Capability DID

LBE IE Series Name	Functional			Physical	
	Margin Adequacy	Multiple Protective Measures	Prevention and Mitigation Balance	Functional Reliability	No Single Feature Relied Upon
Normal Operation	√			√	
AOOs	√			√	
DBEs	√	√	√	√	√
BDBEs	√	√	√	√	√
DBAs	√	√	√	√	√

Evaluation Summary – Qualitative Evaluation of Programmatic DID

LBE IE Series Name	Quality/Reliability: Design, Manufacturing, Construction, O&M	Compensation for Uncertainties			Offsite Response: Emergency Response Capability
		Human Errors	Mechanical Failures	Unknowns	
Normal Operation	√	√	√	√	
AOOs	√	√	√	√	
DBEs	√	√	√	√	√
BDBEs	√	√	√	√	√
DBAs	√	√	√	√	√

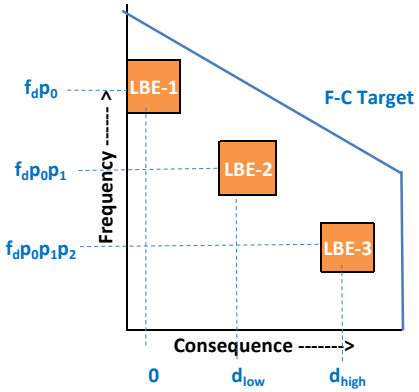
DID Concept from NUREG/KM-0009



Roles of SSC 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	$f_d p_0$	0
		p_1 No	Yes	2	Fuel damage w/ limited release	Layer 3	$f_d p_0 p_1$	d_{low}
			p_2 No	3	Fuel Damage w/ un-mitigated release	Layers 4 and 5	$f_d p_0 p_1 p_2$	d_{high}

[1] See Figure 2-4 for definition of defense-in-depth layers



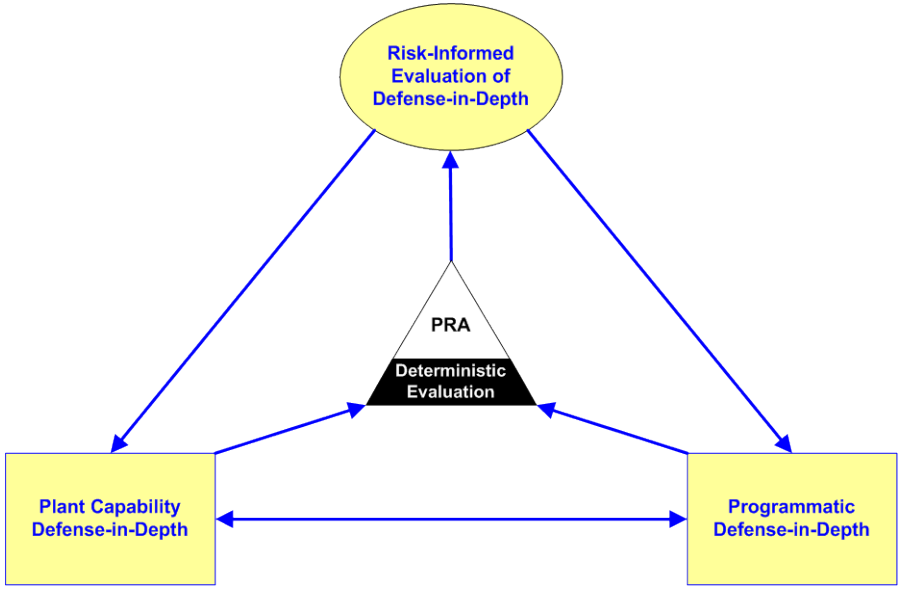
SSC	LBEs	Function	SSC Performance Attribute for Special Treatment
Plant	N/A	Prevent initiating event	Reliability of plant features preventing initiating event
SSC_1	1	Mitigate initiating event	Capability to prevent fuel damage
	2	Prevent fuel damage	Reliability of mitigation function
	3	Help prevent 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

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.

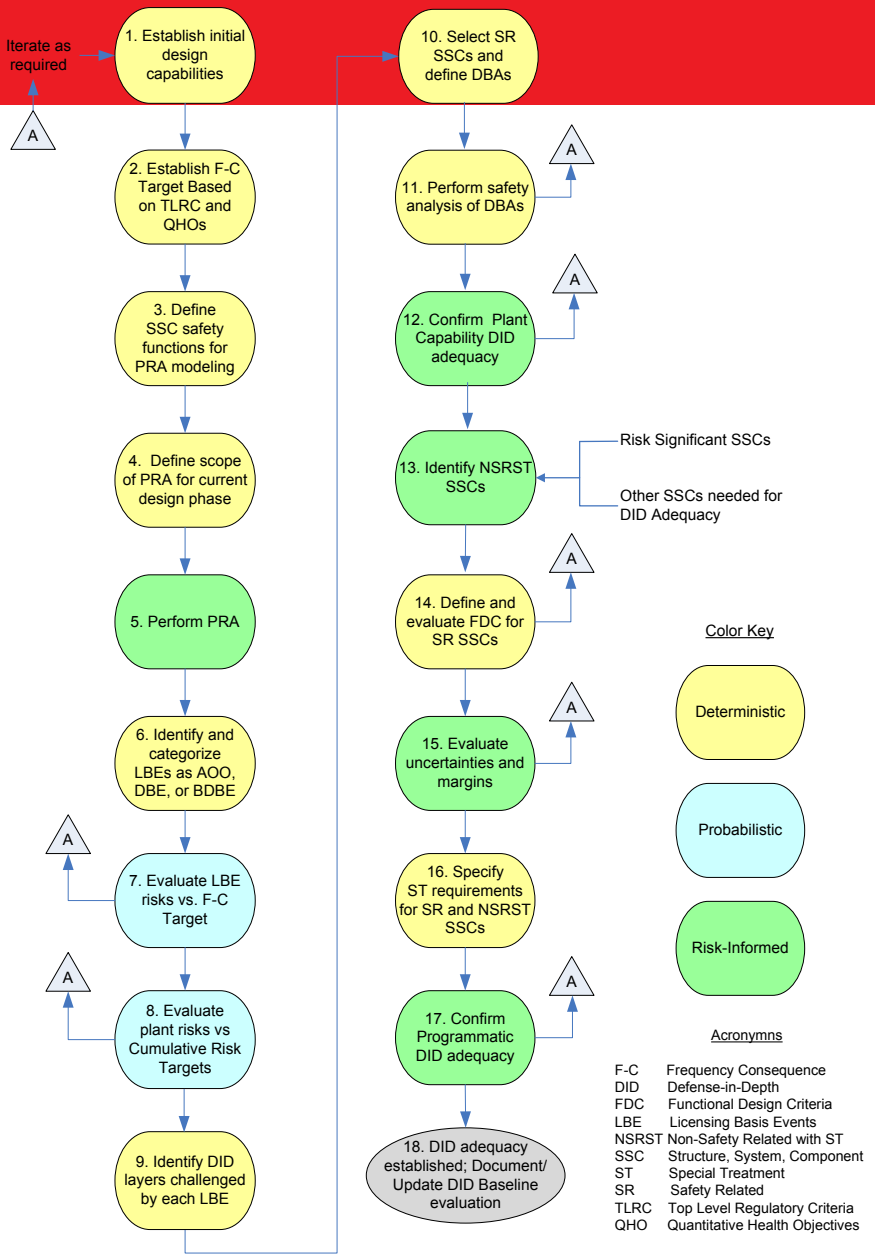
Defense In Depth Adequacy Basic Structure

Risk-Informed Evaluation of DID

This element provides a systematic, holistic, integrated, and transparent process for examining the DID adequacy achieved by the combination of plant capability and programmatic elements. This evaluation is performed by a risk-informed integrated decision-making (RIDM) process to assess and establish whether DID is sufficient to enable consideration of different alternatives for achieving commensurate safety levels at reduced burdens. The outcome of the RIDM process also establishes a DID baseline for managing risk throughout the plant lifecycle.

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.



Hon. George Apostolakis
Hon. Jeffrey S. Merrifield
Hon. Richard A. Meserve

December 11, 2017

Stephen Kuczynski
President and CEO
Southern Nuclear Operating Company
42 Inverness Center Parkway
Birmingham, AL 35242

Subject: Risk-Informed and Performance-Based Evaluation of Defense-in-Depth Adequacy

Dear Mr. Kuczynski:

As you know, we act as advisors in the effort to develop a modernized framework for licensing advanced nuclear reactors, otherwise referred to as the "Licensing Modernization Project" ("LMP"). In our view, the LMP effort, which is intended to develop a technology-inclusive, risk-informed, performance-based ("TI-RIPB") process for licensing the next generation of non-light water reactors, is making substantial progress and represents the direct application of the risk-informed principles that the NRC has pursued for the last 20 years.

Over the last six months, industry representatives have been actively engaged with the staff of the NRC to discuss the LMP effort and develop a framework that will be acceptable for future consideration by the Commission. A key element of the LMP is the development of a framework and associated guidelines for establishing, evaluating, confirming, and documenting the adequacy of defense-in-depth (DID) for advanced non-light water reactor (non-LWR) technologies. This effort is focusing on non-LWR technologies because of the need for transparent and principled guidance for the advancement of the multiplicity of novel designs that are being developed. There are many precedents that serve to provide guidance for the application of DID to LWRs, but that same experience does not exist for non-LWR designs.

The concept of defense-in-depth has been a cornerstone of NRC decision making for decades. It serves as an approach to designing and operating a nuclear facility that "prevents and mitigates accidents that release radiation or hazardous materials"…with the intention of …"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."[1]

Throughout its history, DID has served the NRC, the industry and the public well by providing layers of protection to prevent and mitigate accidents. LWRs typically have a significant source term, residual decay heat, and complex designs; DID provides the robustness to ensure the reasonable assurance of adequate protection of public health and safety. That said, the DID philosophy has not been without criticism. Some have found it overly conservative and prescriptive, while others have claimed it is too subject to inconsistent application by different members of the NRC staff. Perhaps the most severe criticism is that there is no guidance as to how to implement the DID philosophy and, in particular, to determine how much DID is sufficient. Excessive application of DID can lead to unnecessary regulatory burden. On the other hand, too little DID could lead to an inappropriate increase in risk. The risk-informed initiatives that have been promulgated in the last two decades have attempted to remove unnecessary burden while ensuring adequate protection of the public. The LMP effort seeks to bring this philosophy to the application of DID to advanced non-LWR reactors.

Given the significantly reduced risks associated with many of the advanced reactor designs as compared to LWRs, a non-risk-informed application of DID could result in excess conservatism in safety reviews. That is, it could result in unduly prescriptive regulatory requirements well beyond what is needed to provide reasonable assurance of adequate protection. Moreover, while we believe that adopting a TI-RIPB DID framework will generally reduce excess conservatism and provide a more effective means to limit unnecessary regulatory burden, like all risk-informed tools, it could also result in the identification of areas where additional requirements are necessary.

We agree that DID should continue to play an important part in the NRC's licensing framework. That said, the development of the LMP for advanced reactors provides an opportunity for the Agency and its stakeholders not only to make DID more risk informed and performance based, but to do so in a manner that is implementable and repeatable. The framework developed by the LMP utilizes existing U.S. and international definitions and philosophies of DID and builds on a DID framework developed in the U.S. Department of Energy Next Generation Nuclear Plant project. While we are not in a position to comment on the specific technical features of the LMP DID proposal, we enthusiastically endorse the effort. We believe it can serve as a positive launching point for establishing a more standardized and principled approach for the application

[1] https://www.nrc.gov/reading-rm/basic-ref/glossary/defense-in-depth.html

of DID. The great value of the LMP DID proposal is that it is a first step toward converting what is currently an ambiguous DID philosophy to a concrete DID process.

We encourage you and the Southern team to continue work on this most important matter.

Sincerely,

George Apostolakis
Commissioner, U.S. NRC
(2010-2014)

Jeffrey S. Merrifield
Commissioner, U.S. NRC
(1998-2007)

Richard A. Meserve
Chairman, U.S. NRC
(1999-2003)

Hon. George Apostolakis
Hon. Jeffrey S. Merrifield
Hon Richard A. Meserve

February 20, 2018

Stephen Kuczynski
President and CEO
Southern Nuclear Operating Company
42 Inverness Center Parkway
Birmingham, AL 35242

Re: Licensing Modernization Project

Dear Mr. Kuczynski:

As you know, we serve as advisers to the "Licensing Modernization Project" (LMP), an effort to develop a modernized framework for the licensing of advanced nuclear reactors. This effort is intended to deal with some of the technical issues associated with the licensing of advanced reactors through the application of a technology-inclusive, risk-informed, and performance-based approach (TI-RIPB). To date, the project has developed several technical reports.[1] We are writing to provide our assessment of the project.

Although we are not in a position to comment on the technical adequacy of the reports generated by the LMP, we enthusiastically endorse the effort. In particular, we believe that the focus on a systematic and predictable *process* for early resolution of fundamental technical issues in the licensing of advanced reactors can reduce uncertainty in the development of a design. It thereby can enable a vendor to avoid the substantial expenditures (hundreds of millions of dollars) required under the current process to develop a detailed design without knowledge of the criteria it must satisfy. We believe that the work lays the foundation for guidance that can be endorsed by the NRC and we encourage the continuation of the effort.

It is helpful to view the LMP in the context of the evolution in the licensing process. The Atomic Energy Commission (AEC) first licensed commercial reactors in the 1960s at a time during which knowledge about nuclear reactors was limited. Licensing focused on assuring that the reactors could survive certain design basis events, such as a loss-of-coolant accident, by establishing both the need for and the specifications for safety systems. The intention was to select a suite of Design Basis Accidents (DBAs) that encompassed some of the possible events that could disrupt the operation of a nuclear reactor. As the utilities and their regulator gained greater experience, as well as a better understanding of the gaps in licensing, the regulatory

[1] The technical papers cover PRA development for licensing basis event selection, approach to PRA for RIPB risk management applications, the SSC safety classification and performance requirements approach, and defense-in-depth adequacy. We have previously commented on the defense-in-depth paper.

system evolved to encompass a broader suite of circumstances and requirements than had originally been contemplated. When the AEC first licensed these reactors, they applied deterministic analytical techniques and imposed prescriptive requirements that were frequently based on judgment; probabilistic techniques were unknown at the time the basic regulatory structure was established.[2]

Beginning in the early 1990s, the nuclear industry began to utilize Probabilistic Risk Assessments (PRAs) to assess and manage nuclear units. These PRAs treated the plant as an integrated system and enabled utilities to identify accident sequences and assess their frequencies. Eventually, PRAs were used to evaluate the risk associated with design or operational changes in an existing plant and later in providing a risk-informed means for changes in a plant's licensing basis (e.g., Regulatory Guide 1.174). PRAs had a profound impact on the understanding of the utilities and the NRC about reactor safety. For example, the PRAs identified the risk significance of human errors and accidents not included initially as DBAs, such as anticipated transients without scram and station blackout. The result is that the current regulatory structure at the NRC consists of deterministic requirements with an overlay of probabilistic elements; this framework provides an extensive and complicated set of largely prescriptive requirements.

Because most of the commercial nuclear units were large light water reactors (LWRs), the NRC's regulatory requirements were tailored to the risks that LWRs presented. Moreover, because the requirements are largely prescriptive, they provide a large measure of assurance and predictability to vendors and utilities of the specific regulatory requirements that must be satisfied. However, many of the requirements in the existing regulatory system are not necessarily appropriate or relevant for advanced reactors. Such reactors, many of which use coolants other than water, may present entirely different risks from LWRs and, indeed, some of the LWR requirements make no sense in application to these designs. For example, requirements for emergency core cooling in LWRs that result from the behavior associated with rapid depressurization of high-pressure water are inapplicable to reactors operating at or near atmospheric pressure, such as those cooled by liquid metal or molten salt. Moreover, there are accident sequences associated with some advanced reactors, such as those involving sodium fires, that are not part of the LWR regulatory framework. Current regulations are based almost exclusively on low-enriched ($\leq$ 5%) uranium oxide fuel in zirconium alloy cladding, whereas a number of advanced reactors have a variety of other fuel and/or cladding materials and, in some cases, propose to utilize high-assay low-enriched uranium with enrichments up to 19.7%.

The LMP is intended to close gaps in several foundational areas where the current regulations and regulatory guides are either silent or provide inadequate guidance for non-LWR designs. Because the state of knowledge regarding the operation of nuclear power plants has advanced considerably over the period in which the current regulatory structure was developed, the NRC has an opportunity to use new understandings and methods as the foundation for a

[2] Probabilistic Risk Assessments for nuclear power plants had their origins in the WASH-1400, or 'Reactor Safety Study' that was authorized by the Atomic Energy Commission and published in October of 1975.

revised regulatory system and avoid the serious challenges that attend an effort to adapt regulatory requirements developed for LWRs to reactors of very different types. This is the focus of the LMP.

One of the serious challenges in applying the existing regulatory requirements to advanced reactors arises from the uncertainty that is associated with identifying appropriate design basis events and developing the associated requirements to meet them (such as the requirements that must be satisfied by structures, systems and components). The vendors are required to provide costly design details at a point in the regulatory review process when it is uncertain whether the NRC would eventually find the design to be acceptable.

Although the NRC staff is prepared to undertake substantial pre-application consultation with a vendor and to provide guidance, the current regulatory paradigm results in substantial uncertainty about regulatory design requirements until late in the design review process. The process creates regulatory uncertainty for both the vendor and the regulator because the fundamental considerations that should guide design decisions are not well defined and require a large measure of judgment. The result is a process that is both unpredictable and costly and requires a vendor to undertake substantial expenditures (hundreds of millions of dollars) to develop a detailed design without confidence that it will be satisfactory to the NRC.

The LMP seeks to address this situation through the development of a systematic and principled *process* to define the critical regulatory elements. The effort involves a blend of deterministic and probabilistic inputs in a structured and logical process to refine the foundations for licensing. The LMP is intended to establish these regulatory elements at the earliest possible stages in the evolution of a design and thereby enable the NRC and the vendor to engage in a predictable and cost-effective licensing review. The development of the LMP builds on an LBE white paper for DOE's Next Generation Nuclear Plant (NGNP) that has been reviewed by the NRC staff and the Advisory Committee on Reactor Safeguards. It has appropriately involved extensive consultation across the nuclear industry and with the NRC staff – an effort that is still underway. The aim is the eventual development of guidance documents that the NRC can utilize to review advanced reactor designs.

Reactor developers are currently using PRA as a design tool for new plants to ensure that the risks are acceptably low. The proposed LMP licensing process starts with the identification of a set of Licensing Basis Events (LBEs) using probabilistic methods and relevant regulatory requirements. This approach for selecting LBEs is designed to ensure that an appropriate set of limiting accident sequences for each reactor technology are reflected in the selection of DBAs and that the full set of LBEs define the risk-significant accident sequences. The use of PRA to identify the broad set of LBEs and the resulting structured selection of the DBAs are consistent with the Commission's 1995 Policy Statement:

> "A probabilistic approach to regulation enhances and extends this traditional, deterministic approach, by: (1) Allowing consideration of a broader set of potential challenges to safety, (2) Providing a logical means for prioritizing these challenges based

on risk significance, and (3) Allowing consideration of a broader set of resources to defend against these challenges."

In addition to being risk informed, the proposed approach is performance based because it uses quantitative risk metrics to evaluate the risk significance of accident sequences and leads to the formulation of performance requirements on the capability and reliability of systems, structures and components to prevent and mitigate accidents. It, thus, avoids the overly prescriptive nature of current requirements. Since it focuses on performance, the proposed approach is technology inclusive and, therefore, very valuable to the designers of the various reactor designs under development.

In addition to the long-term benefits of the proposed licensing approach, we are pleased to note that there are short-term benefits as well. A recent Draft White Paper issued by the NRC staff[3] states that the performance criteria for what are termed "functional containment" design features are tied to radionuclide release limits for various event categories. Recognizing that an integrated approach is needed, the staff, as a starting point, proposes to use the LMP structure of LBE identification. The staff states further: "The structure is sufficiently defined to show the categories and how related acceptance criteria would be derived along with additional consideration of deterministic methods to address uncertainties and ensure sufficient defense in depth."

In order for this project to be successful, it will be essential to develop guidance that is acceptable to the NRC. Given that the proposed process is new and represents significant change from the current licensing process, we anticipate that the development of satisfactory guidance will not be easy and that modifications in early applications may be necessary. However, we believe that guidance based on the essence of the proposed LMP approach is endorsable by the NRC. Moreover, the full and successful implementation of the process may eventually require modifications of licensing procedures (not included as part of the LMP), as well as the development of further guidance to fill in gaps that extend beyond the current technical papers. The LMP should be viewed as an important start to necessary change and we would expect that there would be significant interactions between the LMP team, the NRC staff and interested industry and external stakeholders to develop and implement the guidance needed to implement this important effort.

We have met, individually, with a number of stakeholders regarding the LMP effort, including some individuals at the NRC, and we believe that this effort is worth pursuing and could provide a very beneficial framework not only for the NRC, but also for the utilities and companies that seek to develop advanced reactor technologies. Success in this effort will require significant and ongoing engagement with stakeholders both within and outside the NRC.

[3] Draft White Paper "Functional Containment" Performance Criteria, November 2017 Draft – Released to Support Public Discussions.

We appreciate the opportunity to participate in this important project. Please feel free to contact us if you seek any further advice.

Sincerely,

George Apostolakis
Commissioner, U.S. NRC
(2010-2014)

Jeffrey S. Merrifield
Commissioner, U.S. NRC
(1998-2007)

Richard A. Meserve
Chairman, U.S. NRC
(1999-2003)

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

ACRS Future Plant Designs Subcommittee

Draft Regulatory Guide (DG) 1353

Guidance for a Technology-Inclusive, Risk-Informed, Performance-Based Approach to Inform the Content of Applications for Licenses, Certifications, and Approvals for Non-Light Water Reactors

June 19, 2018

Advanced Reactor Program

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Background

- Advanced Reactor Policy Statement
- Commission Papers (e.g., SECY-93-0047)
- NUREG 1860
- Next Generation Nuclear Plant (NGNP)
- Recent Activities
  - Vision and Strategy
  - Implementation Action Plans
  - Regulatory Guide 1.232 (Principal Design Criteria)
  - Functional Containment Performance Criteria

Advanced Reactor Program

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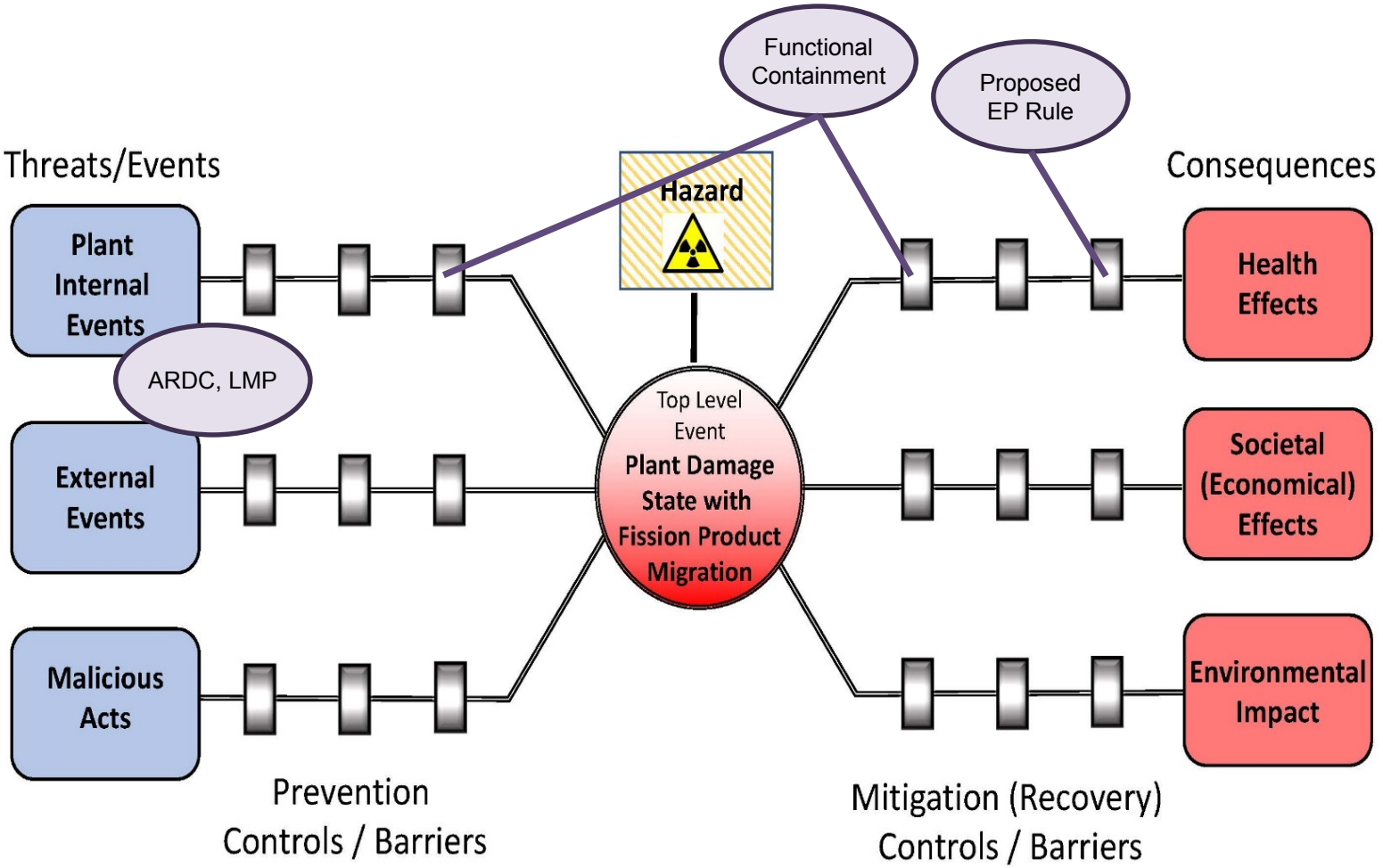
Integrated Approach to Design and Licensing



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Content of Applications

- General Description of the Plant
- Site Characteristics
- Design of SSCs and Equipment
- Reactor
- Reactor Coolant and Connecting Systems
- Engineered Safety Features
- Instrumentation and Controls
- Electric Power
- Auxiliary Systems
- Steam and Power Conversion System
- Radioactive Waste Management
- Radiation Protection
- Conduct of Operations
- Verification Programs
- Transient and Accident Analyses
- Technical Specifications
- Quality Assurance and Reliability Assurance
- Human Factors Engineering
- Probabilistic Risk Assessment/Severe Accident Evaluation
- Emergency Planning
- Security
- Staffing
- Mitigating Strategies
- Aircraft Impact Assessment
- Environmental Report
- Financial
- Inspections, Tests, Analyses, and Acceptance Criteria
- Insurance
- Fuel Cycle
- Other (design or technology specific)

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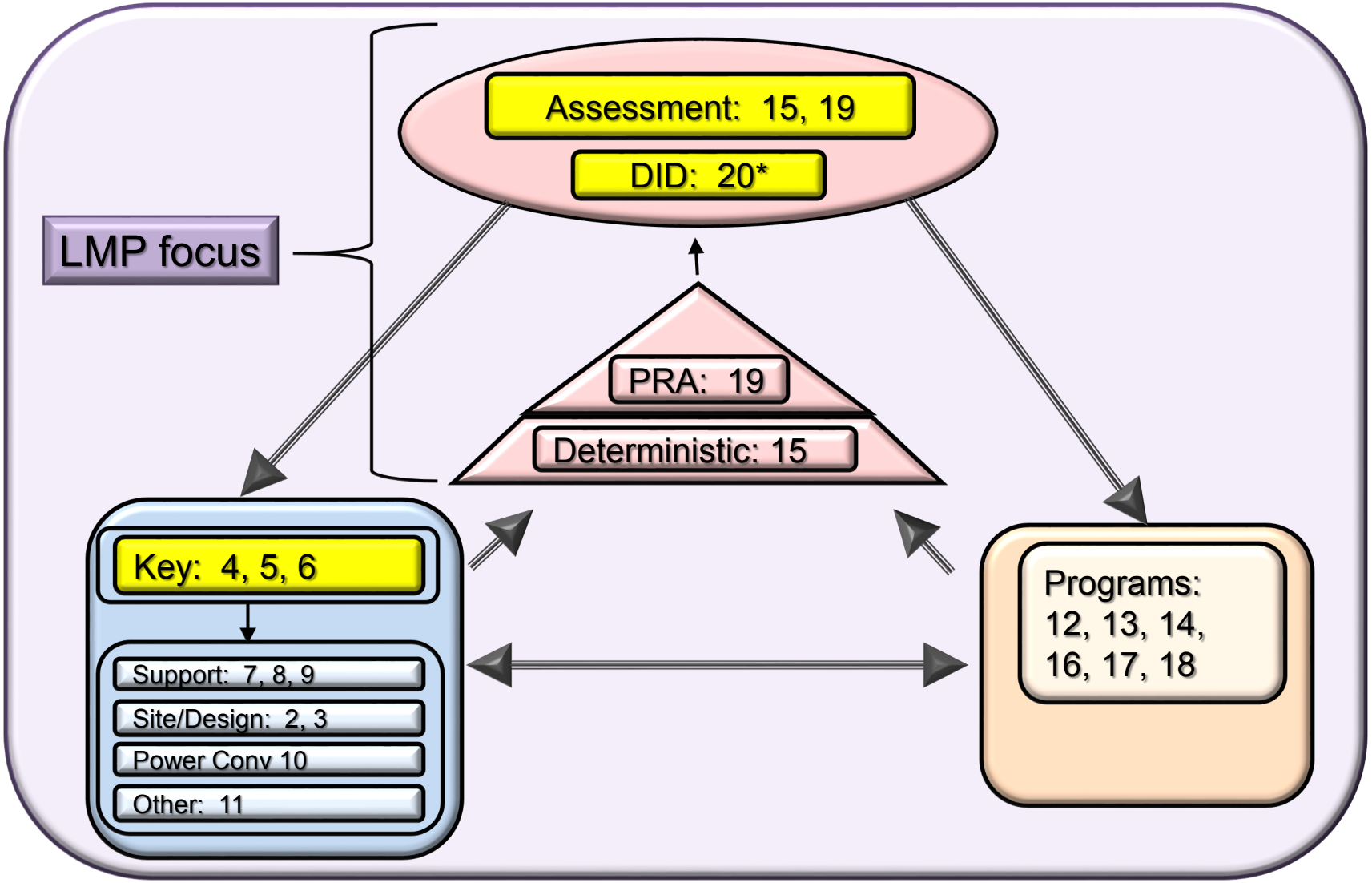
Informing Content of Applications (scope and level of detail)



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Consolidated Guidance

- Licensing Basis Events
  - Probabilistic Risk Assessment
  - Deterministic
- Safety Classification
  - Function and Risk Considerations
    - Safety Related
    - Special Treatment
- Defense in Depth Assessment
  - Structures, Systems and Components
  - Programmatic

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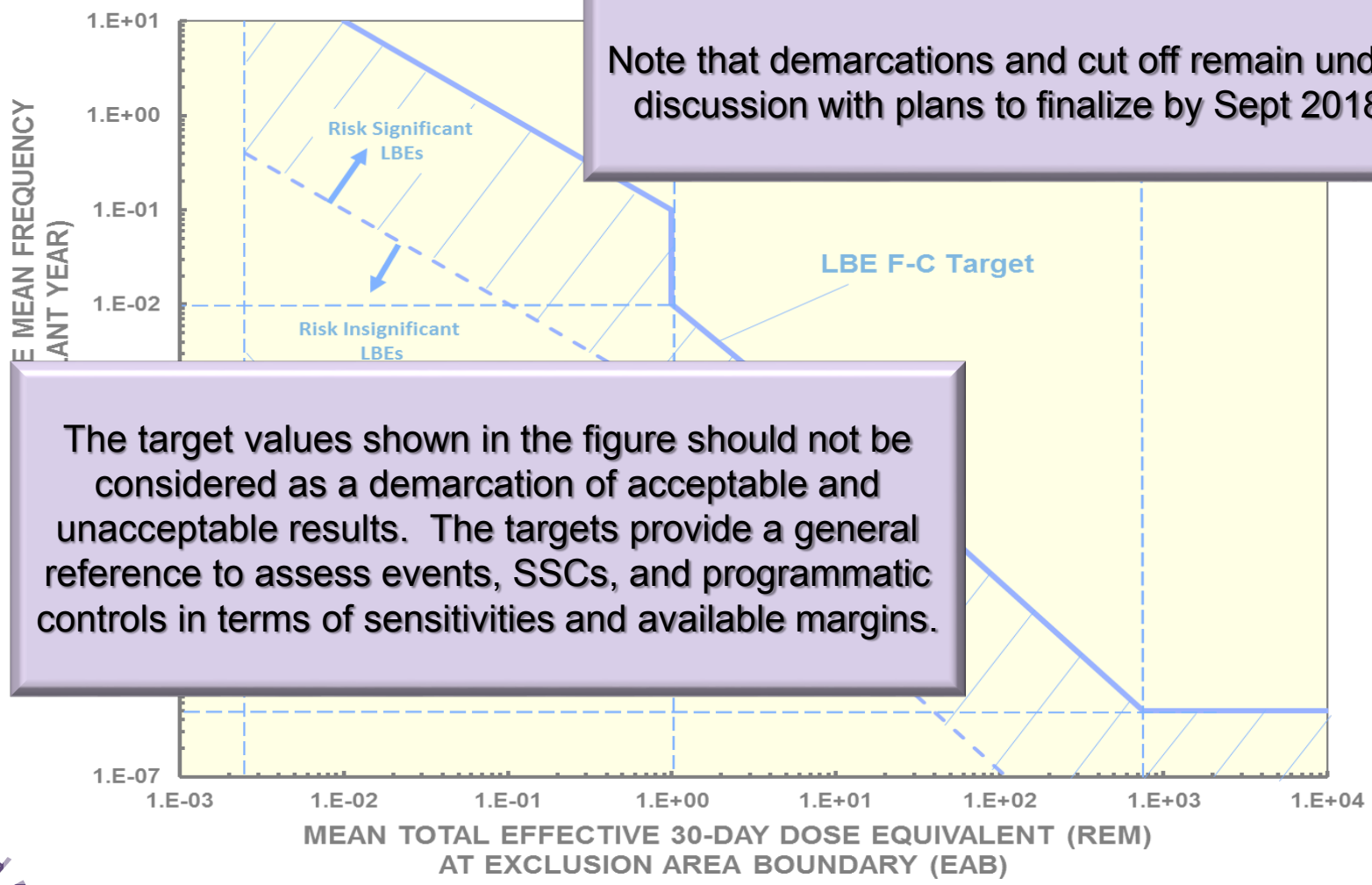
Identifying Measures to Prevent and Mitigate Events



Note that demarcations and cut off remain under discussion with plans to finalize by Sept 2018

The target values shown in the figure should not be considered as a demarcation of acceptable and unacceptable results. The targets provide a general reference to assess events, SSCs, and programmatic controls in terms of sensitivities and available margins.

Advanced Reactor Program

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Remaining Discussion Items

- F-C Target Figure
  - Demarcations (including lower range for BDBEs)
  - Consequence Analyses
  - Consideration of Uncertainties
  - ASME/ANS Non-LWR PRA Standard
- Ensure Consistent Terminology
- Flexibility for smaller, simpler designs
- Clarify approach for external hazards
- Interface with requirements for areas such as emergency planning, operations, etc.

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Related Commission Paper

- Details of Approach
  - Technology Inclusive, Risk Informed, Performance Based
- Event categories and related demarcations on the F-C Target figure (including lower range for BDBEs)
- Expected relationships with NRC requirements
- Possible relationship to recommendations made by NRC Transformation Team (SECY-18-0060)

Advanced Reactor Program

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Future ACRS Interactions

Tentative Timeline	
June 19	ACRS SC Meeting
September 28	Draft LMP Guidance, draft RG, draft SECY to ACRS
October 30	ACRS SC Meeting
December 6	ACRS FC Meeting
Mid-December	Issue draft RG for comment
Early 2019	Complete SECY
TBD-2019	Final Regulatory Guide

Advanced Reactor Program